COMMENT-RESPONSE DOCUMENT (CRD) TO NOTICE OF PROPOSED AMENDMENT (NPA) 2011-03

for amending Decision 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes (‘CS-25’)

‘Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions’

EXECUTIVE SUMMARY

NPA 2011-03 proposed to update large aeroplanes Certification Specifications (CS-25) for flight in icing conditions. The aim of the proposal was to address 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.

The Agency analysed the comments received and made some changes to the proposed amendment as described in the Explanatory Note below. The Agency also communicated with the FAA to ensure that technical changes are in line between both agencies. The revised CS-25 text retains the same principles as we initially proposed. Therefore, some differences will remain compared to the FAA proposal in their NPRM[1] as already described in NPA 2011-03.

In addition to responding to each comment received, this CRD provides a revision of the NPA 2011-03 Explanatory Note (see paragraph V) and the resulting text amending CS-25 (see paragraph VI).

[1] Docket No FAA-2010-0636; Notice No 10-10, dated 29 June 2010.

[2] As last amended by ED Decision 2012/008/R dated 6 July 2012 (CS-25 Amendment 12).

Explanatory Note

I. General

1. The purpose of the Notice of Proposed Amendment (NPA) 2011-03, dated 21 March 2011, was to propose an amendment to Decision 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003 on Certification Specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes ('CS-25')[2].

II. Consultation

2. The draft Executive Director Decision amending Decision 2003/2/RM was published on the website (http://easa.europa.eu/agency-measures/agency-decisions.php) on 22 March 2011.

   By the closing date of 5 August 2011, the European Aviation Safety Agency (hereafter referred to as the 'Agency') had received 209 comments from 28 national aviation authorities, professional organisations and private companies.

III. Publication of the CRD

3. All comments received have been acknowledged and incorporated into this Comment-Response Document (CRD) with the responses of the Agency.

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

   - **Accepted** — The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially accepted** — Either the comment is only agreed in part by the Agency or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** — The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not accepted** — The comment or proposed amendment is not shared by the Agency.

   The resulting text highlights the changes as compared to the current rule.

5. The Executive Director Decision on amending Decision 2003/2/RM will be issued at least two months after the publication of this CRD to allow for any possible reactions of stakeholders regarding possible misunderstandings of the comments received and answers provided.

6. Such reactions should be received by the Agency not later than **29 January 2013** and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt.

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2 As last amended by ED Decision 2012/008/R dated 6 July 2012 (CS-25 Amendment 12).

7. The Agency made some changes to the proposed CS-25 amendment material taking into account the comments received and other considerations. In addition to editorial corrections, the most important changes made are summarised hereafter:

— CS 25.21(g)(2) list of exceptions: CS 25.207(e)(1) is added. Indeed the proposed Appendix O, Part II, paragraph (b) does not define take-off ice accretions for aeroplanes not certified for take-off in Appendix O conditions.

— CS 25.21(g)(3) list of exceptions: CS 25.121(a) is added. The initial flight segment covered by CS 25.121(a) does not have to be met with appendix O ice accretions. This flight segment does not last long enough for significant ice accretions to occur, even in Appendix O icing conditions.

— The title of CS 25.1093 is changed to 'Powerplant Icing'. This better reflects the applicability of this paragraph which is not limited to the engine air intake system.

— In CS 25.1093(b)(2), the term 'if any' is added to reflect that there may not be a minimum ambient temperature limitation.

— CS 25.1326(a) is revised to reflect that the alert must conform to Caution alert indications. The introduction paragraph of CS 25.1326 is also improved to reflect that the alerting system must also alert when the heating system is not functioning normally, as already specified in paragraph CS 25.1326(b)(2).

— CS 25.1420: Some wording improvement of CS 25.1420(a) to clarify that the detection means must not be located outside the aeroplane.

— CS 25.1521: The term 'if any' has been added in paragraph CS 25.1521(c)(3) because the applicant may demonstrate that there is no minimum ambient temperature limitation.

— CS 25.1533 is updated to stress that an aeroplane must not only exit all icing conditions after encountering Appendix O conditions for which it has not been certified, but it must also not be intentionally flown in those non certified Appendix O conditions (this includes take-off and landing flight phases).

— An amendment to CS 25J1093 is provided outlining similar specifications for essential APUs air intakes as the ones required from engines air intakes through amendment to CS 25.1093(b). The specification for non-essential APUs air intakes remains unchanged except that it now refers to Appendices C, O and P. These changes were omitted in NPA 2011-03 (the rule amendment was drafted based on the FAA draft rule structure, which considers paragraph 25.1093 also applicable to APU, as they have no equivalent to CS 25J1093).

— Appendix C and Appendix O: the definitions of Take-off Ice and Final Take-off Ice are amended so that the ice accretion begins at the end of the take-off distance not at the point of lift-off. 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. Appendix C part II, paragraphs (a)(1), (a)(2), and (d)(2), as well as Appendix O, part II, paragraphs (c)(1) and (c)(2), are revised.

— Appendix O introduction paragraph now refers to 'CS-25 specifications' since it incorrectly referred to Subpart B only.

— Appendix O, part I(c): the equation defining the liquid water content scale factor is added.

— Appendix O, part II, paragraph (b)(2) (holding ice): a sub-paragraph (iii) is created to clearly state that the total exposure to holding ice conditions does not have to exceed 45 minutes.

— Appendix O, part II, paragraph (b)(5)(ii) (pre-detection ice): the last sentence is deleted. This statement was proposed in error. It was not our intent to add this requirement in addition to what is specified in the amended CS 25.143(j) and CS 25.207(h). We have checked with FAA that this was also a mistake in their NPRM.

8. The resulting text amending CS-25 Book 1 is provided in chapter VI below.

9. Comments received on NPA 2011-03 also concerned its explanatory note. Then the Agency accepted to make some changes, and the amended explanatory note is provided in chapter V below.

IV. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*20* comment by: *Luftfahrt-Bundesamt* The LBA has no comments on NPA 2011-03.
response	*Noted*

comment	*50* comment by: *Cessna Aircraft Company* Attachment #1 Please see the attached file for Cessna Aircraft Company's comments.
response	*Noted* Comment on CS 25.207(h): We have discussed this point with FAA; the recommendation of the FTHWG for pre-activation ice accretions for 25.1420(a)(1) ('detect-and-exit') aeroplanes was that the most conservative of the Appendix C and O ice accretions should be used. The reason is that one would not necessarily know which type of icing was being encountered before it was detected and the ice protection system activated. 'Detect-and-exit' aeroplanes are prohibited from taking off in Appendix O icing conditions. Therefore, there is no Appendix O take-off ice accretion identified for these aeroplanes and no need to consider an Appendix O ice accretion for compliance with 25.207(h) in the take-off phase of flight. However, your statement on SLD ice pre-activation accretions is valid for the landing phase: pre-activation Appendix O ice accretions must be considered for compliance with 25.207(h) during this phase. Comment on CS 25.1324: We understand your concern on the test facilities capabilities. However, such conditions exist, have been encountered and shall be assessed. Extrapolation of the heating performance of the probe could be envisaged. Pending validation of the Appendix P envelope by flight tests characterisation (e.g. the High Ice Water content international research programme), EASA proposes such an assessment in the AMC 25.1324. EASA is involved in the EUROCAE working group 89 and is considering their recommendation when drafting the AMC. Comment on CS 25.1326: Not accepted. The analysis required under CS 25.1322 will cover this issue. In particular, the alerting function must be designed to minimise the effects of false and nuisance alerts. Comment on CS 25.1420(b): Accepted Comment on Appendix O, Part II: Accepted. We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being we retain the IPHWG proposal and follow the FAA decision for harmonization. Comment on the RIA, Cessna 560 Eagle River event: Not accepted. The Agency acknowledges that this point was discussed in the IPHWG and that

no consensus was reached on the removal of the Cessna 560 event (See Task 2 report including phase IV, page 730 (Attachment A to L374-44-09-001)). Nevertheless, the investigation concluded that icing conditions were a contributor to the event, and persons on ground reported that freezing rain and sleet were falling at the time of the accident. So the Agency keeps this event in the list of accidents which would benefit from the rule.

comment

57 comment by: *Swedish Transport Agency, Civil Aviation Department (Transportstyrelsen, Luftfartsavdelningen)*

The Swedish Transport Agency, Civil Aviation Department is supporting Option 1 (*Amend CS-25 by updating the atmospheric environment (icing and snow) required for certification of large aeroplanes*.) of the NPA 2011-03.

response

Noted

comment

58 comment by: *Goodrich Sensors and Integrated Systems*

Goodrich Sensors and Integrated Systems (GSIS) is a manufacturer of aircraft ice protection, ice detection, and air data systems and components. GSIS believes that the proposed rule changes will have a major impact on the development, design and certification of these systems and components. Following are GSIS comments to the referenced Notice of Proposed Amendment (NPA):

General Comments:

1. The environments listed in Appendix D are difficult to replicate in wind tunnels. Scaling methods for Appendix D in particular do not have common scaling 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. Altitude is an important parameter in Ice crystal testing and may need to be accounted for.
2. GSIS believes that the concentrating effect of ice crystals by the fuselage must be accounted for, similar to the effect on liquid water droplets. Depending on aircraft size and probe location, the IWC at the probe may be significantly higher than freestream values. Therefore, GSIS recommends language in the regulation which specifies that this effect must be accounted for. Ice crystals are different than water droplets in that the crystals tend to be non-spherical and interact differently when impacting the fuselage. As a result there are no validated methods for predicting IWC concentrations around an aircraft. However, GSIS recommends adding language which specifies that the use of liquid water impingement analysis tools (with spherical diameters and density appropriate to ice crystals) be acceptable until validated tools for ice crystals become available.
3. Some of the specific requirements within this NPA, particularly Supercooled Large Droplet (SLD), ice crystal, and freezing rain environments, will likely exceed the current capabilities of existing test facilities available to industry. How does EASA plan to address this limitation in testing capabilities when companies are required to certify to the requirement?
4. Due to numerous under-defined conditions within the NPA, additional research should be conducted and useful data published by EASA, FAA, NASA, et al. Following are some comments regarding that issue:
    a. Data regarding the SLD capabilities and limitations for acceptable

test facilities needs to be compiled and published for potential users as well as Appendix O icing cloud data produced by airborne tankers.

b. Definitions for acceptable characteristics of SLD (Appendix O) ice shapes used for certification should be provided. Such characteristics should include ice shape, roughness, height and location.

c. Standards regarding the acceptable duration of exposure to Appendix O conditions prior to exiting should be developed and published.

d. Acceptable simulations means should also be identified. For instance can LEWICE (and LEWICE Thermal) be used to accurately simulate ice shapes derived from Appendix O and Appendix D conditions including mixed phase icing?

response

Noted

Comment 1. Noted.

Comment 2. Accepted. We fully agree with the comment. The AMC 25.1324 will address this issue. It will give flexibility to the applicant for proposing an appropriate tool to determine the local conditions both in liquid and glaciated conditions.

Comment 3. Noted. We understand your concern on the test facilities capabilities. However, such conditions exist, have been encountered and shall be assessed. This is explained in detail in our proposed AMC material.

Ice crystals: Testing may not be possible at extremely low temperature due to simulation tool limitations. However, the presence of Ice Crystals has been observed and it is anticipated that an extrapolation of existing test data at higher temperature should allow assessing the predicted performance of the probe heating down to this minimum temperature.

SLD: 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.

Rain conditions: EASA intend to follow EUROCAE WG89 recommendations to improve the proposed table.

Comment 4.

1: Accepted. EASA expects EUROCAE and the SAE to compile such information.

2: This is product specific, such an assessment should be performed by the applicant.

3: This time will depend on the detection means and the aircraft characteristics. It should be determined by the applicant.

4: Agreed. Simulation means of compliance shall be proposed by the applicant and accepted by the Agency.

comme *64* comment by: *Pratt Whitney Canada* nt

Attachment #2

Please find in attachment the comments to NPA 2011-03.

COMMENT #1

Affected paragraph and page number

Page: 9
Paragraph: 14. Discussion of the CS-25 rule change proposal
c. EASA certification interim measures
- 4th paragraph

And

Page: 16
Paragraph: 14. Discussion of the CS-25 rule change proposal
h. Engine and engine installation requirements
- 5th paragraph

What is your concern and what do you want changed in this paragraph?

Page 9, paragraph 14(c), 4th:
"Freezing fog: a generic CRI is used in order to avoid any unsafe conditionsresulting from prolonged exposure to freezing fog beyond the conditionsdemonstrated during compliance demonstration to CS-25. The conditionsdefined in current CS 25.1093(b)(2), in terms of time and temperature**, ifany,** are considered as limitations necessary for the safe operation in freezingfog, as per CS 25.1501, and they must be available to the crew in the AFM."

Page 16, paragraph 14(h), 5th:
"This limitation is necessary since currently we do not have any specificrequirements for run-up procedures for engine ground operation in icingconditions. The engine run-up procedure, including the maximum timeinterval between run-ups from idle, run-up power setting, duration at power,and the minimum ambient temperature**, if any,** demonstrated for that run-upinterval proposed in CS 25.1521, would be included in the Aeroplane FlightManual in accordance with existing CS 25.1581(a)(1) and CS 25.1583(b)(1)."

Why is your suggested change justified?

JUSTIFICATION:

Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1,Condition 1, rime ice condition test temperatures, a more critical point does not exist. Ifappropriate, no temperature limitation would then be needed in the Airplane Flight Manual.

COMMENT #2

Affected paragraph and page number

Page: 58
Paragraph:

What is your concern and what do you want changed in this paragraph?

CS 25.929 Propeller de-icing
(a) For aeroplanes intended for use where If certification for flight in icing maybe expected is sought, there must be a means to prevent or remove hazardousice accumulations that could form in the icing conditions defined in AppendicesC **and O** on propellers or on accessories where ice accumulation wouldjeopardise engine performance.
…

Why is your suggested change justified?

JUSTIFICATION: The changes to the proposed rules for engine and engineinstallations reflect the conclusions of the ARAC Engine Harmonization Working groupthat no in flight engine events have been recorded in SLD. This is accepted by theworking group as a result of rigorous compliance for Appendix C. The proposed rulestherefore have no new requirements for engines and engine installations in flight, but dohave a new CS 25.1093 condition for ground taxi operations in SLD.

COMMENT #3

Affected paragraph and page number

Page: 58
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1093 Air intake system de-icing and anti-icing provisions

What is your concern and what do you want changed in this paragraph?

"CS 25.1093 Air intake system de-icing and anti-icing provisions
…
(b) Turbine engines
Each engine, with all icing protection systems operating, must:
(1) Operate throughout its flight power range, including the minimum descent idl**eing speeds**, in the icing conditions defined in Appendices C, **O** and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following: . . . ."
[revisions indicated per prior comment]
Concern: An applicant can't comply with the requirements for ice crystal envelope withoutadvisory material allowing certification by similarity analysis in the interim until analytical tools areavailable.

Why is your suggested change justified?

JUSTIFICATION:
The current state of the art relative to understanding the impact of ice crystal icing conditions onturbine engines is very immature. As a result, there is a critical and sensitive relationship betweenthe newly proposed engine regulations and the corresponding guidance material. Withoutadequate time to review the revised AC contents and the proposed means of compliance alongwith the draft regulations, it is extremely difficult to formulate comments on the proposed enginerules. Furthermore, the ARAC committee recognized that there are technology needs not yetaddressed in order for an applicant to comply with the mixed phase and ice

crystal environment.

In order to allow for near term certification to Appendix P, a process of certification by similaritymust be provided, as the FAA has done in AC 20-147. The upcoming revisions to the guidancematerial must provide a similar process in order that the industry can reasonably showcompliance until the technology gaps are closed.

COMMENT #4

Affected paragraph and page number

Page: 59
Paragraph:

What is your concern and what do you want changed in this paragraph?

Table 1-ICINGCONDITIONSFOR GROUNDTESTS Condition	Total airtemperature	Waterconcentration(minimum)	Meaneffectiveparticle diameter	Demonstration
(i) Rime icecondition	-18 to -9°C(0 to 15°F)	Liquid—0.3g/m3	15–25microns	By test,analysis orcombination ofthe two.
(ii) Glaze icecondition	~~-7 to -1°C (20 to 0°F)~~ **>-9 to -1°C (>15 to30°F)**	Liquid—0.3g/m3	15–25microns	By test,analysis orcombination ofthe two.
(iii) Large dropcondition	-9 to -1°C(15 to 30°F)	Liquid—0.3g/m3	100 **- 3000**microns~~(minimum)~~	By test,analysis orcombination of the two.

Why is your suggested change justified?

JUSTIFICATION:
The temperature revisions are suggested to eliminate a gap between glazeand rime ice temperatures. Expanding the upper limits of droplet size rangeswill allow flexibility in test demonstrations

COMMENT #5

Affected paragraph and page number

Page: 61
Paragraph: B(I). Draft Decision amending CS-25

	CS 25.1521 Powerplant limitations - paragraph (c)(3) ***What is your concern and what do you want changed in this paragraph?*** "(3) Maximum time interval between engine run-ups from idle, run-up powersetting, duration at power, and the associated minimum ambienttemperature**, if any,** demonstrated for the maximum time interval, forground operation in icing conditions, as defined in CS 25.1093(b)(2)." ***Why is your suggested change justified?*** **JUSTIFICATION:** Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1,Condition 1 rime ice condition test temperatures, a more critical point does not exist. Ifappropriate, no temperature limitation would then be needed in the Airplane Flight Manual. Seerelated comments elsewhere in this document.
response	*Partially accepted* Comment#1: Accepted. The text has been clarified as follows: "…associated minimum ambient temperature, <u>if any</u>,..." Comment#2: Not accepted. We refer to FAA Advisory Circular AC 20-73A, Appendix J, which documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to Appendix C conditions. Moreover, the Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore the entire Appendix O has to be retained. Comment#3: Not accepted. Idling speed: not accepted, we retain this wording to maintain harmonization with the FAA regulatory text. Removal of Appendix O: not accepted. The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore the same icing environment applies and Appendix O is retained for this paragraph. Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience. Comment#4: Not accepted. We keep the IPHWG table and harmonization with FAA. Comment#5: Accepted.

comment	86 comment by: *AIRBUS* The rule has been published without the associated AMC/GM. The Airbus comments on the rule may change when the AMC is issued as the rule is difficult to interpret and comment upon without the guidance contained within

	the AMC. Airbus requests EASA to reopen the public comment period once the AMC is available. Reopening the comment period will be beneficial in ensuring consistency between the rule and the means of compliance thus aiding the consistent application of the rule.
response	*Not accepted*

comment	*117* comment by: *Claudio Mauerhofer* *Applicability* This NPA is applicable to CS-25 products; nevertheless, SLD, mixed phase, and ice crystal icing conditions may be relevant to some CS-23 products (e.g. commuter category or jets flying high and fast). Given that current icing certification requirements for CS-23 aircraft extensively rely on CS-25 and associated AMC&GM, is it foreseeable that (some) CS-23 products may have to show compliance with Appendix O? If so, has an assessment been conducted to take into consideration the effects that the proposed requirements may have on CS-23 aircraft?
response	*Noted* The proposed rule is applicable to CS-25 only. In the future, the Agency may propose an equivalent rulemaking task dedicated to CS-23.

comment	*129* comment by: *FAA* Attachment #3 We agree with EASA that this rulemaking is necessary and also believe that it will improve the level of safety for airplanes flying in icing conditions. We are intending to make changes to our regulations proposed in FAA notice 10-10 as a result comments received during the NPRM process. The comments we are providing are intended to add clarity or identify areas that EASA may want to consider revising for harmonization purposes. If additional information or clarification is necessary with regard to these comments, please contact Robert Hettman, Aerospace Engineer, at 425-227-2683, or robert.hettman@faa.gov. FAA comments to EASA NPA 2011-03, “Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions” 1. The FAA recognizes the hard work and effort by EASA in preparing this NPA and we appreciate the opportunity to provide comments. We agree with EASA that this rulemaking is necessary and also believe that it will improve the level of safety for airplanes flying in icing conditions. As EASA noted, we initiated a similar rulemaking action, Notice of Proposed Rulemaking (NPRM), notice 10-10 contained in United States Federal Docket FAA-2011-0636. Our NPRM was published for public comment on June 29, 2010 and we are in the process of preparing a final rule which is currently scheduled for publication in the first quarter of 2012. We are intending to make changes to our regulations as a result comments received during the NPRM process. The comments we are providing are intended to add clarity or identify areas that EASA may want to

consider revising for harmonization purposes.

2. Proposed appendix O paragraph (b) does not define takeoff ice accretions for airplanes not certified for takeoff in appendix O conditions. Therefore, Certification Specification (CS) 25.207(e)(1), which defines stall warning requirements for takeoff with ice accretions, should be added to the list of exceptions specified in CS 25.21(g)(3).

3. CS 25.121(a) should be added to the list of exceptions in CS 25.21(g)(4) so that the initial flight segment covered by CS 25.121(a) does not have to be met with appendix O ice accretions. This flight segment does not last long enough for significant ice accretions to occur, even in appendix O icing conditions.

4. The definitions of takeoff ice and final takeoff ice should be revised in part 25 appendix C and appendix O such that the ice accretion begins at the end of the takeoff distance not at the point of liftoff. This change would align the definition of takeoff and final takeoff ice with that of the takeoff path used for determining takeoff performance under CS 25.111, 25,113, and 25.115. We suggest using the following definition for Takeoff Ice in part II of appendix C and appendix O:

"Takeoff ice is the most critical ice accretion on unprotected surfaces and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, occurring between the end of the takeoff distance and 400 feet above the takeoff surface, assuming accretion starts at the end of the takeoff distance in the takeoff maximum icing conditions defined in part I of this appendix." We also propose revising the last sentence in the definition for Final Takeoff Ice to read as follows: "Ice accretion is assumed to start at the end of the takeoff distance in the takeoff maximum icing conditions of part I of this appendix."

5. Page 11 of the NPA advised that EASA is considering the possibility of using similarity and in-service experience to demonstrate compliance with the proposed rule and comments were invited specifically on the topic. The FAA considers that the use of similarity and in-service experience may be a viable method for many of the regulations discussed in the NPA, such as those involving components or systems. However, the FAA has concern with the proposed use of similarity to demonstrate performance and handling qualities using ice accretions defined in appendix O part II. As noted by EASA, accidents involving supercooled large drop (SLD) icing conditions essentially involved airplanes with a maximum take-off weight less than 27000 kg (60000 lbs), reversible flight controls, and de-icing boots. Aircraft of this type used in passenger carrying operations have had FAA airworthiness directives applied for many years that require procedures to exit severe icing conditions once the conditions are identified by the flight crew. Allowing the use of similarity implies that applicants with all new aircraft designs would have the opportunity to demonstrate that the airplane can maintain flight in severe icing conditions without ever actually performing flight testing with simulated or artificial ice shapes to demonstrate safe performance and handling in such conditions. We do not agree with this approach because positive in-service history often consists of no reported accidents or incidents. While most aircraft have encountered icing conditions, we are unsure of which conditions each airplane has experienced. In addition, ice accretions that may have developed on a similar airplane during routine service have not been well documented, or documented with a subjective pilot report of light, moderate, or severe icing. Experience indicates that different ice accretions can have a significant effect on

the performance and handling qualities of the airplane. There are many variables that should be considered if similarity is used to show compliance to the regulations discussed in this NPA. Variables that should be considered include parameters such as the extent and location of IPS coverage, peak/average temperature capability of the IPS, cycle time of the IPS, de-icing boot inflation/deflation times, temperature rise time in thermal systems, segmentation of the IPS, airplane weight and/or wing size, airfoil shape, de-icing boot or leading edge material and construction, high lift devices, speed/AOA range per flight phase, operating envelope, etc. If compliance by similarity will be allowed, the rule and related guidance should discuss how the applicant will be expected to show that they have successfully demonstrated safe performance and handling with the ice accretions defined in part II of appendix O. In addition, EASA should define a minimum level of service history in SLD conditions that will be needed to demonstrate safe performance and handling. We are concerned because had the use of similarity been acceptable in the past, it is possible that the ATR-72 would have been considered to have sufficiently good enough service history to be used to certify a similar airplane prior to the 1994 Roselawn accident.

6. Page 14 of the preamble discusses proposed new paragraph CS 25.1324 and provides, in advance, a table that includes rain conditions that EASA intended to publish in AMC 25.1324. We understand the table has been published in various EASA certification review items (CRI's). We also noted in NPRM 10-10 that we were considering the same table. We concur with inclusion of heavy rain requirements into CS 25.1324. If water drainage is insufficient, residual water may freeze as the airplane climbs into freezing ambient temperatures following takeoff and render the component inoperative. The data presented in the table is comparable to rainfall data presented in MIL-STD-210 C, Military Standard: Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment (January 9, 1987). MIL-STD-210C was superseded by MIL-HDBK-210 in June of 1997. The data from MIL-STD-210C was used for the Aerospace Industry Association Propulsion Committee Study, Project PC 338-1 which is documented in our Title 14 Code of Federal Regulations (14 CFR), Part 33, appendix B. However, we encourage EASA to provide justification for the narrow temperature range just below freezing that is proposed in the table. The proposed temperature range with a temperature at or below freezing implies that the rain conditions in the table are icing conditions and the table includes water contents that greatly exceed those depicted in appendix O for the same temperatures.

7. We agree with the intent of the proposed revision to CS 25.929 to require consideration of the icing conditions defined in appendix O. FAA Advisory Circulary AC 20-73A, Appendix J, documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions. If CS 25.929 were revised as proposed, propellers would need to consider all of appendix O during the certification process, rather than the icing conditions for which they have been approved. We propose that CS 25.929 be revised to require a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in appendix C and the portions of appendix O for which the airplane is approved for flight. If the airplane is certified to detect appendix O conditions and then exit, it should be acceptable to consider the appendix O conditions that could be encountered

during that limited duration rather than icing conditions that would be encountered if the airplane were holding in appendix O conditions.

8. Proposed CS 25.1093(b)(2) should be revised to reflect that an acceleration to takeoff power or thrust should be in accordance with the procedures defined in the aircraft flight manual. The engine runup procedures are generally accomplished in collaboration between the airframe manufacturer and the engine manufacturer and may be defined on the basis of engine certification or development test results. Referring to procedures in the aircraft flight manual provides adequate conservatism in the rule and documents where the procedures are contained.

9. The proposed CS 25 appendices O and P were not applied to auxiliary power unit
(APU) installations. The FAA believes that an applicant should demonstrate that an essential APU can be safely operated in the new icing conditions and that a non-essential APU operating in those icing conditions will not affect the safe operation of the airplane. Therefore the FAA recommends revising CS 25J1093 to include the proposed icing conditions of appendices O and P. Additionally, a common installation of an APU has an inlet located in the empennage section of the airplane fuselage that can generate a shadowing effect, preventing large icing droplets (SLD) and ice crystals from directly entering the APU inlet. For this type of installation, compliance with appendices O and P may be demonstrated by an acceptable validated analysis that shows these icing conditions are less severe than the icing conditions defined in appendix C. The FAA recommends revising the corresponding advisory materials for CS 25J1093 to include this method of compliance.

10. Proposed CS 25.1093(b)(2) should also be revised to reflect recent developments on the cold ground fog conditions. The choice of ambient temperature for the ground freezing fog rime ice demonstration should be driven by critical point analysis to show that at colder temperatures a more critical point does not exist. The analysis should also be used to show safe operation of the engine at temperatures below the required test demonstration. If an applicant does not show unlimited cold temperature operation then the minimum ambient temperature that was demonstrated through test and analysis should also be a limitation defined in the aircraft flight manual.

11. The applicability of § 25.1420 was discussed within the IPHWG and consensus could not be reached. A discussion of this issue was provided in FAA NPRM 10-10 under the heading "Differences from the ARAC Recommendations." The FAA's position as discussed in FAA NPRM 10-10 is unchanged and we recommend that CS 25.1420 apply to airplanes that have been most effected by flight in icing conditions, specifically, airplanes with a maximum takeoff weight of less than 60,000 pounds or equipped with reversible flight controls.

12. Proposed CS 25.1533(c) requires an operating limitation to require that airplanes certified in accordance with CS 25.1420(a)(1) or (a)(2) exit all icing conditions if they encounter appendix O conditions that the airplane has not been certified to operate in. It is unclear if the operating limitation is intended to include takeoff and landing into known SLD conditions, such as freezing drizzle or freezing rain. The FAA contends that airplanes which have been certified to exit SLD conditions if they are encountered should not takeoff or land into known SLD conditions, which includes freezing drizzle and freezing rain. We understand that many existing ground de-icing programs include holdover times in freezing drizzle and freezing rain. We also understand that

some operators of airplanes known to have had accidents or incidents in severe icing conditions dispatch into freezing drizzle and freezing rain in accordance with their approved ground de-icing program.

13. Proposed appendix O part II, section (b)(2)(ii), states that the total exposure to icing conditions need not exceed 45 minutes. We understand that EASA intended to apply the total exposure time to all of subparagraph (2), not just subparagraph (ii). Since subparagraphs (i) and (ii) are being added to the holding ice exposure already defined in (b), it would be accurate to remove the total exposure to icing conditions statement from subparagraph (ii) and create a new subparagraph (iii) which states: "Except the total exposure to icing conditions need not exceed 45 minutes." Otherwise, it implies that the total exposure time only applies to subparagraph (ii).

14. There is a typographical error in the proposed appendix P figure 3. The lowest value on the X axis should be 1, and the lowest value on the Y axis should be 0.6. 15. Proposed appendix P is identical to the FAA proposed appendix D to Part 33, which originated from ARAC recommendations. EASA noted that they are aware of incidents of temporary erroneous airspeed indication which happened at high altitude with static air temperature (SAT) below the current proposed appendix P limit of -60°C. For the reasons discussed in the preamble, EASA is envisaging an extension of the proposed appendix P ice crystal environment, figure 1 envelope to encompass all the known occurrences, with a minimum temperature of -75°C. FAA comments on the subject are provided as follows. Appendix P proposed by EASA describes ambient environmental data and is based on a theoretical atmospheric model. Temperature and altitude are only two of the parameters described in figure appendix P. Figure 2 of appendix P describes total water content as a function of altitude and EASA did not describe how figure 2 would be revised. During the loss of airspeed events, it is unknown what the total water content actually was because it was not measured. If appendix P were to be expanded, it should be equally important to expand or otherwise revise the total water content depicted in appendix P figure 2, as well as the horizontal extent depicted in figure 3 accordingly. The FAA is continuing to support the research necessary to validate the ice crystal environment with flight test data. We believe it would be premature for EASA to expand the environmental conditions in appendix P until additional environmental data can be collected to substantiate the conditions.

response

Partially accepted

Comment 1: Noted.

Comment 2: Accepted. The rule is updated.
Note: We understand you inadvertently refer to 25.21(g)(3) instead of 25.21(g)(2), probably because of the difference between FAA and EASA numbering.

Comment 3: Accepted. The rule is updated.
Note: we understand you inadvertently refer to 25.21(g)(4) instead of 25.21(g)(3) because of the difference between FAA and EASA numbering.

Comment 4: Accepted. The definitions in Appendix C and Appendix O have been updated accordingly to state that the ice accretion starts at the end of the take-off distance. Also our proposed AMC 25.21(g) is changed consistently.

Comment 5: Noted. The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging

a design similarity analysis to support the demonstration of compliance to CS 25.1420.
In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

Comment 6: Accepted. EASA has no justification for the narrow temperature range, and rely on the EUROCAE WG89 to make a proposal for updating the temperature range.

Comment 7: Not accepted. The Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore the entire Appendix O has to be retained.

Comment 8: Accepted. We add the text proposed by Airbus:
"…by an acceleration to take-off power or thrust <u>in accordance with the procedures defined in the aircraft flight manual."</u>

Comment 9: Partially accepted. We propose an amendment of CS 25J.1093 similar to what has been proposed to amend CS 25.1093.
However, it does not seem feasible that "compliance with Appendices O and P may be demonstrated by an acceptable validated analysis that shows these icing conditions are less severe than the icing conditions defined in Appendix C".

Comment 10: Accepted. The text has been clarified as follows:
"…associated minimum ambient temperature, <u>if any</u>, ..."

Comment 11: Noted.

Comment 12: Accepted. We acknowledge that today some operators dispatch their aircraft in icing conditions for which the aircraft is not certified, taking credit from anti-icing fluid hold over time. However, as soon as the aircraft has lifted off, it is not anymore protected by anti-icing fluid. Therefore for aircraft certified vs CS 25.1420(a)(1), take-off in SLD conditions should be forbidden. It is anticipated that applicants will chose the option of CS 25.1420(a)(2) to allow departure in light freezing rain/drizzle as it is done today; in this case the applicant will have to demonstrate safe aircraft performance within the Appendix O portion chosen for certification.

For landing, we understand that this case should be treated like any in flight encounter of SLD conditions. Therefore, the aircraft should be diverted to an alternate airport when landing icing conditions are outside the certified envelope.

We have amended CS 25.1533 to bring clarifications on these aspects.

For aeroplanes certified in accordance with CS 25.1420(a)(1) or (a)(2), an operating limitation must be established to:

1) Prohibit intentional flight, including take-off and landing, into icing conditions defined in Appendix O for which the aeroplane has not been certified to safely operate; and

(2) Require exiting all icing conditions if icing conditions defined in Appendix O

are encountered for which the aeroplane has not been certified to safely operate.

Comment 13: Accepted. The last sentence of sub-paragraph (ii) is deleted, and a new sub-paragraph (iii) is created to indicate that the total exposure to holding ice conditions does not need to exceed 45 minutes.

Comment 14: Accepted.

comment

185 comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

Attachment #4

Gentlemen,

Embraer appreciates the opportunity to send the following comments already sent to FAA for your consideration in NPA 2011-03 about Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions.

CS 25.1420

Paragraph 25.1 420(b) uses the phrase "simulated icing tests" and "simulated ice shapes" in various subparagraphs, but the FAA's Advisory Circular 25-XX defines simulated ice as fabricated ice shapes. To be consistent with this definition, subparagraphs CS 25.1420(b)(1) and (b)(2) should use the phrase "artificial ice" as defined in FAA AC 25-XX.

CS 25, Appendix O, Figures 2 and 5

To aid the reader to understand Figures 2 and 5 of Appendix O to CS 25 Embraer proposes to add a definition of Cumulative Mass:

Percentage of total water mass made up of drops whose median volume droplet diameters are less than or equal to a certain value.

CS 25, Appendix O, Part Il(b)(l)(ii)

To make clear in the definition for en route ice that the applicant needs to consider only the conditions within Appendix O intended for operation, Embraer suggests to revise Appendix O, Part I l (b) (1) (ii) to state:

(ii) The ice accumulated during the transit of one cloud with a horizontal extent of 17.4 nautical miles in the most critica1 of the icing conditions for the defined operational envelope in patt I of this appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in appendix C of this patt.

CS 25, Appendix O, Part Il(b)(2)(ii)

Embraer believes that that the total exposure time to holding ice should be limited to 45 minutes, therefore the last sentence in Appendix O, Part II, Subparagraph (b)(2)(ii) should be applicable to the whole of Subparagraph (2), and not just to the transit time through one appendix O cloud and one appendix C cloud. This would be better shown as a separate subparagraph (2)Ciii) that says "The total exposure to the icing conditions need not exceed 45 rriinutes."

CS-E, Appendix D

Because engine sensors can be equally affected by ice crystals as airframe components like airspeed sensors, Embraer recommends that the conditions of Appendix D to CS-E be modified to encompass the ice crystal conditions of Table 1 of 25.1323. Without this modification, the engine sensors, like Pano probes can be subject to the same ice crystal effects as pitot-static systems.

response *Partially accepted*

CS 25.1420: Not accepted. “Simulated icing test” means a test simulating icing conditions (e.g. icing tunnel, icing tanker), which is different from “simulated ice shape” which means the simulation of ice accretion on a surface (shape made from wood, plastic,…). The terms used in CS 25.1420 must also be consistent with the existing CS 25.1419. Therefore we keep those terms but we add definitions in our proposed AMC 25.1420.

Appendix O Figures 2 and 5: Not accepted. The cumulative mass graph shows the water mass distribution as a function of drop diameter. It represents a fraction of the LWC. We keep our text harmonized with FAA.

Appendix O Part II (b)(1)(ii) and (b)(2)(ii): Partially accepted.

En route ice: Not accepted. Part II para. (b)(1)(ii) is applicable to aircraft certified in accordance with CS 25.1420(a)(1).

For aircraft certified in accordance with CS 25.1420(a)(2), Part II para. (c)(3) applies and it is limited to the portion of Appendix O selected by the applicant for safe operation of the aircraft.

Holding ice: Accepted. The last sentence of sub-paragraph (ii) is deleted, and a new sub-paragraph (iii) is created to indicate that the total exposure to holding ice conditions does not need to exceed 45 minutes.

"CS-E, Appendix D": Partially accepted.
Note that there is no table providing ice crystal conditions in our proposed CS 25.1323 or CS 25.1324, and there is no Appendix D to CS-E but an Appendix P to CS-25.

The engine sensors must be considered as facing the same icing environment as aircraft probes. The engine manufacturer is required to analyse the effect of engine probe icing on the engine control. If the engine probe failure is critical then the probe must be protected (i.e. heated) and demonstrated to function correctly in icing conditions (applicable Appendices C, O and P). We will add guidance material on engine probe icing failure analysis in the proposed AMC E 780.

comment *204* comment by: *Pratt & Whitney*

See attachment.

response *Noted*

Sorry, there is no attachment corresponding to this comment.

comment	205 comment by: *Next Generation Aircraft (Rekkof)*
	Attachments #5 #6
	Please regard the attachments as part of the comments of Next Generation Aircraft, these are the papers at comment 187 as well as paper no 48-SA-41 mentioned at comment 81.
response	*Noted*

comment	206 comment by: *Gulfstream Aerospace Corporation*
	Gulfstream appreciates the opportunity to review and provide comments on the subject draft document. The proposed change implementation to the Appendix C icing envelope by adding Supercooled Large Droplets in response to accidents that mainly resulted from ice accretion beyond the impingement limits of protection systems designed for droplets in the Appendix C size range. These accidents which occurred have been on smaller, commuter-sized aircraft, primarily turboprop aircraft with pneumatic boot de-icing gear and reversible flight control systems. It is acknowledged that large aircraft fly in the same atmosphere, but they have not been susceptible to large droplet issues because they typically use bleed-air ice protection, irreversible control systems, and ice accretions are proportionally smaller on the leading edges because of the size and scaling laws. The ARAC Ice Protection Harmonization Working Group disagreed on whether the application of new rulemaking on SLD should include all aircraft or exempt the larger aircraft found not to be susceptible to SLD issues. In the end, the FAA NPRM sided with the minority position and exempted large aircraft from the new 25.1420/Appendix O SLD envelope and regulations. For Gulfstream, this meant that our large cabin aircraft would be exempt. Our aircraft have been flying in natural icing conditions for decades with no problems, so the exemption by the FAA was appropriate. The icing atmosphere has not changed, so there should be no reason for our safe and effective designs to change. The proposed change by EASA takes the majority position that no exemptions will be made from the new rules for large aircraft, which is not harmonized with the FAA NPRM, as stated in section 15a of NPA 2011-03, page 17. Gulfstream stresses that the FAA position is the correct position based on all evidence and certainly with regard to fleet history of Gulfstream aircraft. The lack of harmonization is a problem, as the EASA position would impose a huge and unnecessary burden on US aircraft manufacturers who desire to have their aircraft certified in Europe. Since the rules allow several levels of SLD capability, the impact would range from a re-design of the ice protection systems to something less severe but still unacceptable, such as limiting flight into icing conditions that are currently allowed. Gulfstream does not see a way forward under the proposed EASA rule that would allow current flight-into-known-icing capability to be maintained without massive cost and time investment, design change impacts on other systems, and/or aircraft performance loss in general. None of which can be justified by the service history of our aircraft which have been certified to the current Appendix C conditions. Additionally, Gulfstream would like to stress another issue with the proposed rule dealing with SLD icing certification. Last year at the FAA/NASA Icing Workshop in Toronto, another aircraft manufacturer presented preliminary ice accretion calculations on their nose radome in these new SLD conditions. Under Appendix C conditions, the nose radome accretes only a few pounds of ice,

	whereas in the Appendix O SLD conditions, the calculation resulted in 300 lbs of ice. The discrepancy in results between Appendix C and Appendix O are an unrealistic two orders of magnitude higher and will be nearly impossible to certify to. The assumptions behind the calculations need to be reviewed, such as the assumption that ice does not shed for 45 minutes. A more realistic assumption of intermittent shedding needs to be considered so that the above example of 300 lbs of ice can be reduced down to a realistic amount. We trust that these comments will be given due consideration.
response	*Noted* As proposed on page 11 of the NPA (under "C) Similarity analysis"), the Agency will propose in an AMC material the possibility for applicants to use the positive service experience gathered on their previously type certificated aeroplanes, to support their means of showing compliance to the new SLD rule. This would decrease the impact of the new rule on some aeroplanes which use designs similar to aeroplanes that have proven safe operation in SLD icing conditions. Concerning your comment about the presentation of preliminary Appendix O ice accretions on the radome from another manufacturer, this result seems to be over conservative and inconsistent with existing service experience; therefore there is a need to correct or improve the simulation code (or its input parameters, assumptions…) that was used to generate those accretions.

TITLE PAGE p. 1

comment	*134* comment by: *Boeing* GENERAL COMMENTS: **1. EASA-FAA Harmonization.** Boeing appreciates the efforts on the part of EASA to harmonize this NPA with the corresponding NPRM. However, we consider that the lack of harmonization on the critical issue of applicability will have adverse effects on the viability of new large transport programs due to potentially insurmountable compliance requirements and associated prohibitively high costs and program risks. The FAA had to consider the same issues and concerns as has EASA, but they came to the inescapable conclusion that application of the SLD performance and handling qualities requirements to fleet types with certain specific characteristics would incur extensive costs, for reasons discussed below, without the expectation of a commensurate safety benefit. Boeing firmly believes that the FAA approach is appropriate and should be adopted by EASA; however, within our detailed comments we also propose an alternative applicability approach for consideration by both EASA and the FAA in the frame of achieving a harmonized regulation. **2. Regulatory Impact Assessment.** Both the costs and benefits aspects of EASA's Regulatory Impact Assessment must be re-evaluated using realistic estimates and assumptions. Among the items that need to be accounted for considered include: the full implications of the cost of compliance for aeroplane systems; the costs for SLD ice detection system design, qualification, and certification; and the cost and risk implications for derivative airplane certification projects.

	We maintain that the financial impact to the larger aeroplane industry is so extreme with no valid safety benefit, that there is no justification for imposing a burden that could well impede the future of the industry. The FAA recognized this fact when it considered including larger transports in the applicability of its parallel rule: *"Alternative 1: Make all sizes of aircraft applicable to the proposal. Not all the requirements in this proposal extend to larger transport category aircraft (those with a maximum takeoff weight greater than 60,000 pounds). Under this alternative, the proposed design requirements would extend to all transport category aircraft.* ***This alternative was rejected because this alternative would add significant cost without a commensurate increase in benefits****."* [emphasis added] In that the RIA uses the same type of data to perform the same type of benefits analyses as the FAA's Regulatory Flexibility Determination, we question how EASA arrived at a conclusion so different from the FAA. **3. Methods of Compliance.** We are disappointed that corresponding guidance material has not been available for concurrent review with the NPA. Without it, we have found it difficult to adequately assess and provide meaningful comments on the proposals contained in this NPA. Given this situation, however, we assume -- and therefore request -- that the planned AMC will be substantially the same as the FAA's draft AC 25-XX, "Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions," with potential differences as noted in the NPA. We encourage EASA to harmonize on this guidance. **4. Availability of SLD Tools and Test Facilities.** The plan established by the FAA, JAA, DOT Canada, NASA, industry and other stakeholders via the IPHWG several years ago was to align the timing of the new regulations with the availability of validated engineering tools and test capabilities for SLD conditions. However, the tools and test facilities necessary to enable manufacturers to determine SLD ice shapes during the critical aeroplane initial design phase are not available, as was recognized by the IPHWG during their Phase IV review. Without these tools, a manufacturer will incur great risk in attempting to design the wing and empennage layout and structure, including high lift systems and control surfaces, not to mention attempting to design an effective SLD detection and ice protection system. With today's multi-billion Euro large transport development programs it would be foolhardy either to employ highly conservative approaches to estimating SLD ice shapes or to wait until the results of exhaustive flight testing in extremely rare meteorological conditions late in the program to determine if certification for flight in SLD conditions will be achieved. This is particularly problematic for applicants desiring to operate without restriction in Appendix O conditions, and this situation will surely put a great chill on new large transport development - without improving safety.
response	*Noted* Comment 1: Noted. Comment 2: Noted. The Agency used the best available data to make the impact assessment. Regarding the actual impact of the new rule to a given project, this will depend on the design chosen by the applicant. If the design of

	the aircraft is similar to an already certificated aircraft which has proven good service experience when flying in icing conditions, the Agency may take this into account in the demonstration of compliance, which will decrease the cost for the applicant. This principle will be mentioned in a proposed AMC material, and it will not be limited to an aircraft weight category. Some CS-25 light jets aeroplanes have also proven a positive service experience in icing conditions, therefore the Agency sees no reason why this should not be recognized. However, our RIA considered the conservative assumption that all of the new larger CS-25 aeroplanes will incur the full certification costs. Comment 3: Noted. Comment 4: Not accepted. The IPHWG discussed during phase IV (finishing in 2009) about engineering tools and test capabilities. Some engineering tools and test facilities are available although they have some limitations, in particular for the simulation of freezing rain. Simulation of freezing drizzle appears to be demonstrated. As long as engineering tools and/or wind tunnel facilities are not able to simulate all Appendix O conditions, it is agreed that flight testing in natural SLD Appendix O conditions would be required, especially when the applicant wishes to certify the aircraft for unrestricted flight in the entire Appendix O.

A. Explanatory Note - I. General p. 3

comment	*184* comment by: *Swiss International Airlines / Bruno Pfister* SWISS Intl Air Lines accepts the NPA 2011-03 without further comments.
response	*Noted*

A. Explanatory Note - II. Consultation p. 3-4

comment	*27* comment by: *E. Bakker (Fokker Services)* We would like to extend the comment period, due June 22, 2011 for this NPA with at least two months, this is because: 1. The consequences and impact on aircraft currently under design cannot be established with any accuracy 2. The SAE icing conference in Chicago mid June, where at least 4 papers will be presented on this very issue. We believe it will be in the interest of safety to extend the comment period as indicated above. ----- -Meanwhile, information has been received that comment period has been extended-
response	*Partially accepted* The commenting deadline was extended until 05 August 2011.

A. Explanatory Note - IV. Content of the draft Opinion/Decision	p. 4-6

comment	*28* comment by: *E. Bakker (Fokker Services)* Fokker Services has reviewed the NPA contents. Although we understand the background of the proposed amendments there are some points that need consideration before rulemaking is pursued. Some of the detailed points are made throughout the text of the NPA, but we have the following overall comments: • First of all we would like to stress that the impact of the proposed amendments is such that it must be absolutely sure that existing aircraft certicates will not be affected, i.e. no retro-applicability. • Fokker Services also has serious hesitations as to the practicality of full Appendix O certification, as well as to the practicality of the means of detection to be developed if no full Appendix O certification is pursued. We feel that the technology required for this purpose has probably not sufficiently matured yet. In that respect we wish to note the international icing conference to be held in the USA 13-17 June. It is strongly recommended to incorporate the insights from that conference in the NPA. This will be of great benefit to the final rule. • Meteo offices definitions and criteria for various levels of in flight icing conditions shall be aligned with those applied in regulations.
response	*Noted* The proposed rule is applicable to new designs (or some major changes of existing designs if applicable).

comment	*29* comment by: *E. Bakker (Fokker Services)* Comment on the sentence: "*It is the objective of the Agency to harmonise as much as possible with FAA regulation. Meanwhile, some differences exist compared to the FAA proposal and they are identified and explained on the following pages."* Fokker Services would like to stress that the aviation business is an international working environment and that worldwide standards should be pursued. Working with different standards only diffuse the anticipated goal.
response	*Noted*

comment	*49* comment by: *E. Bakker (Fokker Services)* Wording suggestion on the sentence: "*A new icing environment is proposed that includes supercooled large drops, mixed phase and ice crystal icing conditions.*" We suggest the following wording: "*A new **theoretical** icing environment is proposed that includes supercooled large drops, mixed phase and ice crystal icing conditions.*"
response	*Not accepted* This environment exists and is not purely theoretical.

comment	*72* comment by: *Next Generation Aircraft (Rekkof)*

	NGA would be very much interested on which engine type this potential exists, since there might be potential analogy with proposed F100NG designs where the NPA states "*Service experience of different engine types installed on CS-25 aircraft has also identified the potential for a multiple engine failure during take-off, after prolonged ground operation in freezing fog. A multiple engine failure during take-off would compromise safe flight and landing.* NGA would be very much interested on which engine & APU types this potential exists, since there might be potential analogy with proposed F100NG designs where the NPA states: "*Although snow conditions can be encountered on the ground or in flight, there is little evidence that snow can cause adverse effects in flight on turbojet and turbofan engines with traditional Pitot style inlets where protection against icing conditions is provided. However, service history has shown that in-flight snow (and mixed phase) conditions have caused power interruptions on some turbine engines and APUs with inlets that incorporate plenum chambers, reverse flow, or particle separating design features.* .
response	*Noted* As explained, the potential exists on non-Pitot style engine inlets; typically, the issue appears where the design offers areas where the air stream is deviated, creating ice accretion zones.

comment	*119* comment by: *Mitsubishi Aircraft Corporation* The proposed amendment are written only at higher level and public comments should be accepted during an appropriate period after corresponding Book 2 advisory material has been published and relatively detail acceptable means of compliance clearly established.
response	*Not accepted*

comment	*135* comment by: *Boeing* **Page: 4 of 77** **Paragraph: 8. Summary** **- 4th paragraph** **----------------------------------** The text states: "The present NPA addresses the rule in Book 1 of CS-25. The Agency will publish another NPA dedicated to the related Book 2 advisory material (new material and modification of the existing material). The publication is expected during the second quarter of 2011." **Concern**: Without the corresponding guidance material being available for concurrent review, it is difficult to adequately assess and provide meaningful comments on the proposals contained in this NPA. Given this situation, we must assume and therefore request, that the AMC will be substantially the same as the FAA's draft AC 25-XX, "*Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions*," with potential differences as noted in the NPA.

response	*Noted*

comment	*136* comment by: *Boeing* **Page: 4-5** **Paragraph: 10. Background** **- 2nd & 3rd paragraphs** **And** **Page: 20** **Paragraph: V. Regulatory Impact Assessment** **1. 1.1. What is the issue?** **- 2nd & 3rd paragraphs** **Revise the text as follows:** "On 31 October 1994, near Roselawn, Indiana-USA, an accident involving an Avions de Transport Régional ATR 72 occurred in icing conditions believed to include freezing drizzle drops. Indeed, the accident investigation led to the conclusion that freezing drizzle conditions . . . . ***[new paragraph]*** ~~The~~ **Freezing drizzle and freezing rain are** atmospheric conditions ~~(freezing drizzle) that may have contributed to the accident is~~ **that are** outside **of** the existing CS-25 Appendix C icing envelope that is used for certification of large aeroplanes. **[no new paragraph]** ~~Another atmospheric icing condition which aeroplanes may experience and that is outside of the Appendix C icing envelope is freezing rain. These kinds of icing conditions~~ **Freezing drizzle and freezing rain** constitute an icing environment known as Supercooled Large Drops (SLDs)." **JUSTIFICATION:** Despite the proposed text essentially having been provided via the IPHWG's Working Group Report, we recommend reducing the emphasis on the Roselawn conditions being outside of Appendix C, since they are believed to have been so extreme that they were also outside of proposed Appendix O. Our suggested revisions decrease the potential for misinterpretation by the reader.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 12. Existing operational regulation in the European Union for flight in icing conditions p. 6-7

comment	*3* comment by: *Transport Canada Civil Aviation Standards Branch* Application of the proposed certification requirements will probably lead to some new aeroplane types being limited (CS 25.1429(a)(1) and (a)(2), whereas older aeroplane types will have no such limitations. This has potential for causing confusion amongst pilots and operators of both newly certified aeroplanes and the older aeroplanes, and as disruption to airport and air traffic operations. It is suggested that operational requirements should be developed which address take-off and in-flight safety of currently certified aeroplanes in Appendix O conditions.
response	*Noted*

Such existing aeroplanes were certified against Appendix C icing conditions, therefore they shall not be dispatched in Appendix O icing conditions.

Mandatory actions (airworthiness directives) have been taken in the past to require those aeroplanes presenting a high safety risk (aeroplanes with unpowered flight controls or pneumatic de-icing systems) to exit severe icing conditions when visual cues indicate that these icing conditions exceed the capabilities of the ice protection system.

Concerning future Types, the same principle will apply: either they will have the same kind of limitation, or they may be approved for a part or the full Appendix O.

We have clarified these limitations in CS 25.1533.

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - a. General p. 7-8

comment 90 comment by: *AIRBUS*

Airbus agrees with the NPAs objective to harmonize as far as possible with FAA rule. However the EASA proposal, if adopted, would lead to a significant disharmonisation after a long and thorough rulemaking process in which EASA did not participate.

The FAA is required by US law to justify a rule on the basis of costs and benefits and hence to allow the SLD rule to become part of 14 CFR Part 25, it was necessary to focus the rule on the aircraft designs or types that have been shown to be susceptible to SLD icing. It should be noted that, as commented by AIA and Airbus, the FAA analysis includes several omissions and hence significantly underestimates the costs for large aircraft certifications.

The FAA defined an exemption for aircraft with MTOW greater than 60klbs and non-reversible flight controls because it provides a simple means to focus the rule on aircraft likely to be prone to SLD icing conditions by including criteria based on other design features such as thermal anti-ice systems and leading edge high lift devices.

Larger Part 25 aircraft (the fleet of large transport aircraft with MTOW>60 klbs exceeds 10,000 aircraft) have not experienced the kinds of serious events that led to the development of Appendix O and CS25.1420. These aircraft currently operate in a manner consistent with the "unrestricted" option of CS25.1420(a). To certify to this option, Appendix O ice shapes must be accurately defined to allow the aerodynamic impacts of the shapes and the ice protection system design and performance to be well understood early in the process. The IPHWG developed an interim means of compliance based on the maturity of the currently available tools. These tools have been developed after a long and considerable effort by research organisations and Governments in Europe and North America. However, despite these efforts, this means of compliance does not address unrestricted operation in SLD conditions and only applies to detect and exit strategies. The SLD engineering tools (icing codes, icing tunnels, instrumentation) necessary to define Appendix O ice shapes for unrestricted operation do not currently exist. In future it is expected that these tools will be available but due to a refocusing of research activities to other areas and budget reductions, the required tools are unlikely to be available before the rule

	becomes effective. This leaves manufacturers' unable to realistically certify new aircraft for unrestricted operation due to the very high cost and risk. In this context the position of EASA is not justified and not commensurate with the risk posed by SLDs. However it is recognized that even for aircraft with MTOW< 60klbs many have never experienced in-service problems in SLD conditions. A means of compliance based on similarity and good in-service experience of the "similar-to" designs can be expected to ensure that the good in-service experience continues for such "similar-to" new designs. Detailed guidance would be required in the AMC to define what evidence is required to support such a strategy. Augmenting the MTOW criterion to include additional design features such as thermal anti-ice systems and leading edge high lift devices would also benefit the rule or AMC.
response	*Accepted* As proposed on page 11 of the NPA (under "C) Similarity analysis"), the Agency will propose in an AMC material the possibility for applicants to use the positive service experience gathered on their previously type certificated aeroplanes, to support their means of showing compliance to the new SLD rule. This would decrease the impact of the new rule on some aeroplanes which use designs similar to aeroplanes that have proven safe operation in SLD icing conditions.

comment	*120* comment by: *Mitsubishi Aircraft Corporation* Regarding to FAA NPRM Notice No.10-10, the FAA requests to apply §25.1420 on airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls. Limiting the application of the proposed FAA SLD rulemaking to airplanes of smaller scale (as characterized by maximum takeoff weight) and with reversible flight control systems is based on the in-service safety record in SLD icing conditions. Limiting the application of proposed 14 CFR § 25.1420 to 14 CFR part 25 air transports having maximum takeoff weights greater than 60,000 pounds. and/or having non-reversible flight controls is acceptable since there are no icing accidents, hence no safety basis, that justify promulgating SLD rulemaking for this class of air transports. EASA NPA 2011-03 requests to apply CS25.1420 for all transport category airplanes. Although applicants can select a way from (a)(1) through (a)(3), but in either case, it requests more analysis, laboratory testing and flight testing, and it forces undue burden for applicants.
response	*Noted*

comment	*137* comment by: *Boeing* **Page: 7** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **a. General** **- 1st paragraph** **And** **Page: 8** **Paragraph: 14. Discussion of the CS-25 rule change proposal**

b. Review of accidents and incidents lessons
- 1st paragraph

And
Page: 17
Paragraph: 15. Differences compared to the FAA NPRM
a. The applicability of the FAA proposed § 25.1420 (Supercooled Large Droplet (SLD) icing conditions) to a certain category of aeroplanes
- 7th paragraph

And
Page: 20
Paragraph: V. Regulatory Impact Assessment
1.1 What is the Issue?
- 1st paragraph
And
Page: 20
Paragraph: V. Regulatory Impact Assessment
2. Objectives
- 2nd paragraph

And
Page: 20
Paragraph: V. Regulatory Impact Assessment
6.1 Comparing the options
- 3rd paragraph

Revise these paragraphs as follows:

[paragraph 14.a., 1st paragraph]
"It is proposed to amend CS-25 to better protect large aeroplanes certificated for flight in icing conditions. The new icing environment**s** would include Supercooled Large Drops, Mixed Phase and Ice Crystals." *[underscore added]*

[paragraph 14.b. 1st paragraph]
"The IPHWG reviewed icing events involving large aeroplanes and found accidents and incidents that are believed to have occurred in icing conditions that are not addressed by the current regulations. Therefore these icing conditions must be considered for introduction in the Certification Specifications for large aeroplanes." *[underscore added]*

[paragraph 15.a., 7th paragraph]
"Operational experiences in SLD indicate that CS-25 Appendix C icing conditions standards are no longer sufficient and that the icing conditions standards of CS-25 should be expanded to include SLD, mixed-phase and ice crystal icing envelope without any exclusion of aeroplane class." *[underscore added]*

[paragraph V.1.1., 1st paragraph]

"It has been evidenced that the icing environment used for certification of large aeroplanes and turbine engines needs to be expanded in order to improve the level of safety when operating in icing conditions." *[underscore added]*

[paragraph V.2. , 2nd paragraph]
"The specific objective of this proposal is to better protect large aeroplanes

	certificated for flight in icing conditions. The new icing environment would include Supercooled Large Drops . . . ." *[underscore added]* [paragraph V.6.1., 3rd paragraph] "Although there are no documented fatal accidents in the EU caused by the specific severe icing environment, we consider that the safety threat is present with an equivalent probability as established by the FAA and that Certification Specifications must be updated to better protect new aeroplane types." *[underscore added]* **JUSTIFICATION:** Boeing does not concur with the general nature of these conclusions. Most large aeroplanes already have an exemplary level of safety when operating in icing conditions and therefore have no safety need of expanded certification requirements to provide "better protection" for flight in SLD icing conditions. Since the aeroplanes that have experienced accidents and incidents in SLD icing conditions are limited to a very small portion of the CS-25 large aeroplane fleet (i.e., only three models have had accidents, p. 24), Boeing suggests that EASA's use of CRIs and Special Conditions for model types similar to those with a history of concern [as described in paragraph 14(c), EASA certification interim measures] is adequate and preferable to revising CS-25. EASA has not indicated that its CRIs and Special Conditions have been inadequate. Indeed, for flight in SLD conditions, no applications have been received for aeroplane models to which the CRI would apply. By adding the proposed new SLD requirements to CS-25 for all large aeroplanes, EASA will be imposing a significant burden upon aeroplane types for which there is no history of safety concern – so little concern, in fact, that it has not even been deemed necessary to levy a CRI for similar models. Therefore, we request that EASA reconsider the need for introduction of SLD requirements into CS-25. Re paragraph 14.a. – SLD icing, mixed-phase, and ice crystal conditions are specified as three different environments (plural).
response	*Noted* As proposed on page 11 of the NPA (under "C) Similarity analysis"), the Agency will propose in an AMC material the possibility for applicants to use the positive service experience gathered on their previously type certificated aeroplanes, to support their means of showing compliance to the new SLD rule. This would decrease the impact of the new rule on some aeroplanes which use designs similar to aeroplanes that have proven safe operation in SLD icing conditions.

comment	*142* comment by: *Boeing* **Page: 7** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **a. General** **-3rd paragraph** **And** **Page: 10**

Paragraph: 14. Discussion of the CS-25 rule change proposal
e. The new requirements in SLD icing conditions
A. General
-1st paragraph

And

Page: 17
Paragraph: 15. Differences compared to the FAA NPRM
a. The applicability of the FAA proposed § 25.1420 (Supercooled Large Droplet (SLD) icing conditions) to a certain category of aeroplanes

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Pg. 7, paragraph 14.a., 3rd paragraph:
Revise text with the following considerations:

"Our proposal mainly differs from the FAA's proposal on the following points:

[Option 1]
~~- The new proposed SLD environment would be applicable to all new large aeroplanes (not limited to a category of large aeroplane),~~"

[Option 2]
- The new proposed SLD ~~environment~~ **requirements of CS 25.1420** would **not** be applicable to all new large aeroplanes ~~(not limited to a category of large aeroplane),~~ **however, the FAA's 60,000 lb. criterion is eliminated and replaced by the design features of wing thermal anti-icing systems and leading-edge high-lift devices.**"

Pg. 10, paragraph 14.e.(A), 1st paragraph:
Revise text with the following considerations:

"The proposed new CS 25.1420 would add safety requirements that must be met in SLD icing conditions for **certain** large aeroplanes to be certified for flight in icing conditions. This change would require evaluating the operation of these aeroplanes in the SLD icing environment; . . . ."
* * *
"Specifically, the proposed CS 25.1420 would allow three options:
- Detect Appendix O conditions . . . .
- Safely operate in a selected portion . . . .
- Operate safely in all . . . ."

Add one of the following new paragraphs:
Option (1):
The proposed new CS 25.1420 would apply to aeroplanes with either (1) a takeoff maximum gross weight of less than 60,000 pounds, or (2) reversible flight controls.
or

Option (2):
The proposed new CS 25.1420 would apply to aeroplanes with reversible flight controls or without either (1) thermal wing anti-icing ice protection systems or (2) wing leading-edge high-lift devices.

And

Pg. 10, paragraph 15.a.:
Either delete entire section per **Option 1**, or revise as follows per **Option 2**:
"The FAA proposed the exclusion of aeroplanes with certain attributes (aeroplanes with a maximum takeoff weight (MTOW) less than 60,000 lbs or with reversible flight controls) from the §25.1420 rule requiring the evaluation of the aeroplane in the SLD conditions of the proposed Appendix O. ~~This exclusion is not supported by EASA. Indeed, SLD large drops impinge and freeze farther aft on aeroplane surfaces than the drops defined in the current Appendix C and this may affect the aeroplane's performance, handling qualities on all type of aeroplane.~~
EASA reviewed the IPHWG Task 2 Report Rev A dated December 2005, which provides explanation on the "minority position" proposition for this exclusion. The main argument put forward by the "minority position" is that safety record of the class of aeroplanes proposed for exclusion support that the current airworthiness requirements of FAR Part 25/CS-25 for flight in icing certification have proven to be sufficient to provide the desired level of safety.
It is agreed that many aeroplanes have been flying safely in SLD conditions for decades.
It is also recognised that existing large aeroplanes designs are less sensitive to **contamination of** lifting surfaces ~~contamination~~ than aeroplanes designs not covered by the proposed exclusion~~, but we cannot assume that the design will not change on future aeroplanes and that past service experience will remain applicable. The proposed Certification Specifications will be in application for the next decades, and it is difficult today to predict design evolutions~~. **It is quite reasonable to assume that aeroplane manufacturers will design future aeroplanes and systems that are at least as safe as and likely even safer in icing conditions than current models. This is already being driven by the recently increased stringency of flight-in-icing certification requirements for Appendix C conditions.**
However, EASA does not agree with the FAA's 60,000 lbs. exemption criteria as a discriminator. Instead, EASA is proposing that CS 25.1420 apply to aeroplanes with reversible flight controls, or without thermal anti-icing wing ice protection systems, or without wing leading-edge high-lift devices. The addition of the thermal IPS and leading-edge high-lift devices criteria will effectively result in proposed CS 25.1420 being applicable to aeroplane designs similar to those that have had events in SLD conditions, which are those for which EASA's interim CRI was intended.
~~EASA agrees with~~ **Contrary to** the IPHWG "majority position" (ALPA, CAA/UK, FAA/FAA Tech Center, Meteorological Services of Canada, NASA, SAAB, Transport Canada/Transport Development Center) in the Appendix F of the IPHWG task 2 report rev A, "Response to exclusion from §25.1420 for aeroplane with certain design features"**, EASA believes that both of the additional design features have merit in assessing the safety of an aeroplane design. It is recognized that aeroplanes with thermal anti-icing systems, as opposed to de-icing boot systems, have an excellent safety record in SLD conditions. It is also recognized that the same is true for aeroplanes with leading-edge high-lift devices (slats and Krueger flaps), which provide increased protection from the effects of contamination.**

EASA believes that these criteria, although different, will essentially achieve harmonization with the FAA's § 25.1420 exemption.
~~Moreover, new on-going large aeroplane projects already tend to use different anti-icing systems compared to previous usual systems: either based on electrical power architectures or they use engine bleed air anti-icing systems in~~

~~a different way (e.g. running wet instead of fully evaporative). This, combined with different aeroplane aerodynamic characteristics, makes it difficult to anticipate the aeroplane behaviour when flying in the Appendix O environment.~~
~~Operational experiences in SLD indicate that CS-25 Appendix C icing conditions standards are no longer sufficient and that the icing conditions standards of CS-25 should be expanded to include SLD, mixed phase and ice crystal icing envelope without any exclusion of aeroplane class.~~
~~EASA therefore proposes a CS 25.1420 rule applicable to all CS-25 large aeroplanes.~~"

JUSTIFICATION:

Boeing stands behind the Minority Position contained in Appendix F of the IPHWG Working Group Report. We maintain that application of proposed CS 25.1420 to all CS-25 aeroplanes is unnecessary and unwise. We believe that it will have the unintended effect of inhibiting the viability of new "larger" large aeroplane programs due to insurmountable compliance requirements and associated prohibitively high costs and program risks.

Following years of harmonization effort and opportunity, the lack of harmonization with the FAA's proposed § 25.1420 on such a fundamental and critical issue is unacceptable. Therefore, we prefer our suggested revision "Option 1" to accomplish harmonization.

However, we acknowledge EASA's issues with the 60,000 lb. weight criterion. Therefore, we are alternatively proposing "Option. 2" for consideration by both EASA and the FAA. Option 2 would eliminate the weight discriminator, maintain the reversible controls criterion, and add the additional criteria of thermal anti-icing wing ice protection systems and wing leading-edge high-lift devices. We consider that this combination of design features will result in CS 25.1420 being applied to only to those aeroplanes with similar design features as those that have had accidents and incidents in SLD icing conditions. The result would be similar to EASA's interim CRI philosophy by focusing on aeroplanes with design features of potential concern. We request that EASA and the FAA jointly, and favorably, consider harmonization based on Option 2. We note the FAA's statement in its NPRM*: ". . . EASA has a project similar to SLD on its rulemaking inventory and our intent is to harmonize these regulations."* (75 FR 37320, 29 June 2010).

It is clear that reversible controls have contributed to accidents in SLD conditions, but no aeroplane with irreversible controls has had an in-flight SLD event. Similarly, no aeroplane with a thermal anti-icing ice protection system and leading-edge high-lift devices has had an SLD event, but some aeroplanes with "de-icing boot" ice protection systems and "hard" leading edges have had events. We submit that reconsideration of these design features as discriminating criteria for the applicability of proposed CS 25.1420 is warranted. We also note that relative to EASA's consideration of accepting similarity and service history as means of compliance, it is these very types of design features that would establish similarity with predecessor models. To accept their value via means of compliance but deny the same in application of the rule would be illogical.

The EASA concern that future designs may not result in the same level of exemplary safety ignores the fact that recent models meet far more stringent performance and handling qualities requirements for flight in Appendix C icing conditions, due to recent CS-25 amendments, than the majority of the current larger aeroplane fleet that has accumulated the excellent safety record in icing conditions. Thus, it is prudent and reasonable to assume that any new larger aeroplanes that achieve certification to the latest Appendix C icing requirements, even with novel designs, will have to be at least as safe for operation in all icing conditions as current models.

Current flight operations for the ”larger” large aeroplane types are consistent with the "unrestricted" option of proposed CS 25.1420(a)(3). Since that is the way that these aeroplanes have operated safely for decades, the airlines and the flying public expect no less in the future. Certification via this option, as well as for the “approved portion” of option (a)(2), requires extensive knowledge of estimated Appendix O ice shapes very early in the airplane design phase in order to ensure compliant aerodynamic and ice protection system characteristics. This was emphasized in the Minority Position on natural SLD flight testing contained in the IPHWG Working Group Report. Using natural SLD flight testing as a tool during the aeroplane design phase is simply unrealistic.

It is well known that despite lengthy efforts by government research agencies within Europe, Canada, and the U.S., the SLD engineering tools and methods (icing codes and icing tunnels) necessary to reliably determine "operation in Appendix O” ice shapes are not currently available. Furthermore, due to research budget cutbacks, these necessary tools are not likely to become available until long after the proposed regulations take effect. As a result, the IPHWG produced simplified interim means of compliance during their Phase IV activity (contained in an Appendix to the FAA’s draft AC 25-XX). However, due to the FAA’s lack of confidence in the currently available engineering tools and methods, simplified means of compliance are proposed to only be applicable to the SLD "detect and exit" certification options of proposed CS 25.1420(a)(1) and (a)(2) for the unapproved portions.

Per the FAA’s draft guidance material, certification to operate within Appendix O will require significant flight testing in natural SLD conditions as means of compliance. Thus, manufacturers desiring to certify new models for operation in SLD conditions will face prohibitively high development and certification costs, and in addition will face very high levels of risk. Both are unacceptable from an industry business perspective and may result in the elimination of new product programmes. (For more on the economics, see separate comments on the Regulatory Impact Assessment section.) While we do not believe that it is EASA’s intention to force the industry into an “insignificant-change derivatives only” future, we believe that could be the consequence of proposed CS 25.1420.

Another option which manufacturers of large airplanes are forced to strongly consider is to operate new large jets as “detect and exit” aeroplanes. The impact on industry-wide operations of such a drastic change could become severe. Consider, for example, in the case of FZDZ at a major airport – mass diversions, emergency landings, and cancellations. This could create an even more hazardous situation than the icing conditions. As undesirable as the “detect & exit” option is for larger aeroplanes, at this time, we are not certain whether certification for unrestricted operation in SLD conditions will be feasible for the foreseeable future.

Regarding paragraph 14.a., 3rd, the revision from “SLD environment” to “the SLD requirements of CS 25.1420” reflects the fact that the SLD environment per Appendix O is proposed to apply to other requirements not affected by the applicability of proposed CS 25.1420.

response	*Not accepted* See our response to comment #137

comment	*197* comment by: *Snecma* Please see in Snecma letter 2764-RC : comment n°5 page 5 and part of comment n°9 page 8. Letter is in comment for rule CS 25.1093
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - b. Review of accidents and incidents lessons p. 8-9

comment	*30* comment by: *E. Bakker (Fokker Services)* The sentence: "*Although the events did not result in accidents, they are considered as a serious safety threat.*" is a very loosely based conclusion.
response	*Not accepted*

comment	*59* comment by: *Goodrich Sensors and Integrated Systems* 1. On page 8, section b, paragraph 7, the NPA would require any flight instrument to "operate normally" in the new ice crystal & mixed environments. Goodrich proposes that EASA work with industry to establish what "operate normally" means. <u>Goodrich believes that the final amendment should address the safety intent but allow for some performance degradation at condition extremes.</u> 2. On page 8, section b, paragraph 8, the NPA identifies that better monitoring of the Pitot probe heating systems for abnormal behavior is required. Please clarify what EASA intends for this requirement. Because there are different heating methods implemented in the industry for Pitot probes that may make this requirement difficult to implement, is it sufficient to monitor for a minimum current draw?
response	*Accepted* 1: Accepted. This question will be discussed by the EUROCAE WG89 which includes representatives from industries and authorities. EASA will then consider their recommendations. 2: Accepted. The Agency will propose an AMC 25.1326 which will explain what is expected.

comment	*138* comment by: *Boeing* **Page: 7** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **a. General** **- 3rd paragraph, 2nd item**

And

Page: 8
Paragraph: 14. Discussion of the CS-25 rule change proposal
b. Review of accidents and incidents lessons
- 7th paragraph

Revise the text as follows:

Pg. 7, paragraph 14.a., 3rd paragraph, 2nd bullet

" - The mixed phase and ice crystals environment for flight instrument external probes: we propose to use the Part 33 Appendix D proposed by the IPHWG, which would be applicable to all flight **critical** instrument external probes (not limited to Pitot tubes and Angle of attack sensors),"

And

Pg. 8, paragraph 14.b., 7th paragraph:
"The proposed rule would therefore require any flight **critical** instrument external probe to operate normally in a new ice crystal and mixed phase environment (proposed Appendix P of CS-25)."

JUSTIFICATION: Boeing does not agree that certain probes, such as temperature sensors, which are not flight critical, be included in the expanded requirement. The applicant should show the criticality of the measurement, and then apply the regulation as appropriate.

response

Not accepted

We maintain the specification that all flight instrument external probes must function normally in all icing conditions.
Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in our proposed AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

comment

139 comment by: *Boeing*

Page: 8
Paragraph: 14. Discussion of the CS-25 rule change proposal
b. Review of accidents and incidents lessons
- 1st and 2nd paragraphs

Revise text as follows:

"The IPHWG reviewed icing events involving large aeroplanes and found accidents and incidents that are believed to have occurred in icing conditions that are not addressed by the current regulations. . . .

	These icing conditions resulted in flight crews losing control of their aircraft and, in some cases, engine power loss. The IPHWG events review found hull losses and fatalities associated with SLD conditions **for some smaller-sized large aeroplanes**, but not for ice crystal and mixed phase conditions. The proposed rule would provide a SLD environment in an Appendix O to CS-25." **JUSTIFICATION:** The use of the phrase "large aeroplanes" throughout this NPA per CS-25 (as opposed to CS-23 aeroplanes) may be misleading to readers by incorrectly implying that SLD events have involved the larger jets. Qualifying that SLD accidents and incidents have been experienced by only a few smaller-sized aeroplanes, a very limited portion of the "large aeroplane" fleet, correctly clarifies this aspect for the readers. We also note that the "large aeroplane" fleet is categorized into small, medium, and large for the Regulatory Impact Assessment, so it is likewise logical to be more specific in the text of the NPA.
response	*Accepted*

comment	*143* comment by: *Boeing* **Page: 7-8** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **b. General** **- 3rd paragraph** **And** **Page: 14-15** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **g. Component Requirements** **- 9th paragraph** **And** **Page: 18** **Paragraph: 15. Differences compared to the FAA NPRM** **d. Flight instrument external probes heat indication system** **--** Boeing requests deletion of these paragraphs: Pages 7-8, paragraph 14.b., 3rd paragraph, 3rd bullet: "Our proposal mainly differs from the FAA's proposal on the following points: * * * ~~- We propose to clarify and extend the existing provisions requiring alerting flight crews when an installed flight instrument external probes anti-ice or de-ice system is not operating normally."~~ And Page 14-15, paragraph 14.g., 9th paragraph: ~~"In addition, we propose to revise the existing CS 25.1326 *Pitot heat indication systems*. The objective is to explicitly cover abnormal functioning of the heating system, since incidents evidenced that some failures of the Pitot probe heating resistance may not be detected by the low current detection system. This is~~

	~~considered as a clarification since CS 25.1419(c) already requires that "Caution information, such as an amber caution light or equivalent, must be provided to alert the flight crew when the anti-ice or de-ice system is not functioning normally". Consistently with the creation of the new CS 25.1324, paragraph CS 25.1326 would be modified to extend the scope of the requirement to all Flight Instrument External Probes including, but not necessarily limited to Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes and temperature probes."~~ And Page 18, paragraph 15.d.: ~~"Some incidents evidenced that some failures of the Pitot probe heating resistance may not be seen by the low current detection system on aircraft. In some conditions, an out of tolerance resistance, failing to provide a proper Pitot probe de-icing could not be detected. EASA thus proposes to address failures, such as found in Pitot probes that may not be seen by the low current detection system on aircraft, by modifying the existing CS 25.1326 "Pitot heat indication systems" to explicitly cover abnormal functioning of the heating system. This is considered as a clarification since CS 25.1419 (c) already requires that "Caution information, such as an amber caution light or equivalent, must be provided to alert the flight crew when the anti-ice or de-ice system is not functioning normally". CS 25.1326 is also proposed to be modified to extend the scope of the requirement to all Flight Instrument External Probes including, but not necessarily limited to Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes and temperature probes.~~ ~~This change has not been proposed by FAA."~~ **JUSTIFICATION:** Boeing does not recommend changes to CS 25.1324 and 25.1326 to address system functionality or systems failures via this specific NPA. EASA's comments indicate regulatory concerns with a particular system or type of equipment. Existing CS 25.1301, 25.1309 and 25.1419 are adequate to address system functionality, failure indication, and hazards in a way that does not pre-suppose system architecture or equipment.
response	*Not accepted* Service experience on particular design may happen on other designs. The Agency considers that the issue shall be clearly identified in the rule so that no concern would appear on new aircraft Types.

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - c. EASA certification interim measures	p. 9

comment	*51* comment by: *Pratt & Whitney* Page: 9 Paragraph: 14. Discussion of the CS-25 rule change proposal c. EASA certification interim measures - 4th paragraph

	Page 9, paragraph 14(c), 4th: "Freezing fog: a generic CRI is used in order to avoid any unsafe conditions resulting from prolonged exposure to freezing fog beyond the conditions demonstrated during compliance demonstration to CS-25. The conditions defined in current CS 25.1093(b)(2), in terms of time and temperature**, if any,** are considered as limitations necessary for the safe operation in freezing fog, as per CS 25.1501, and they must be available to the crew in the AFM." **JUSTIFICATION:** Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1, Condition 1, rime ice condition test temperatures, a more critical point does not exist. If appropriate, no temperature limitation would then be needed in the Airplane Flight Manual.
response	*Accepted*

comment	*73* comment by: *Next Generation Aircraft (Rekkof)* NGA would be very much interested on which engine type this potential exists, since there might be potential analogy with proposed F100NG designs where the NPA states: "*Finally, service experience of different engine types has identified the potential for a multiple engine failure during take-off, after prolonged ground operation in freezing fog. A multiple engine failure during take-off would compromise safe flight and landing".*
response	*Noted* All turbine engines can potentially be affected by this hazard.

comment	*144* comment by: *Boeing* **Page: 9** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **c. EASA certification interim measures** **- 4th paragraph** **And** **Page: 16** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **h. Engine and engine installation requirements** **- 5th paragraph** **--** **Revise the text as follows:** Page 9, paragraph 14.c., 4th: "Freezing fog: a generic CRI is used in order to avoid any unsafe conditions resulting from prolonged exposure to freezing fog beyond the conditions demonstrated during compliance demonstration to CS-25. The conditions defined in current CS 25.1093(b)(2), in terms of time and temperature**, if any,** are considered as limitations necessary for the safe operation in freezing fog, as per CS 25.1501, and they must be available to the crew in the AFM."

	Page 16, paragraph 14.h., 5th: "This limitation is necessary since currently we do not have any specific requirements for run-up procedures for engine ground operation in icing conditions. The engine run-up procedure, including the maximum time interval between run-ups from idle, run-up power setting, duration at power, and the minimum ambient temperature**, if any,** demonstrated for that run-up interval proposed in CS 25.1521, would be included in the Aeroplane Flight Manual in accordance with existing CS 25.1581(a)(1) and CS 25.1583(b)(1)." **JUSTIFICATION:** Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1, Condition 1, rime ice condition test temperatures, a more critical point does not exist. If appropriate, no temperature limitation would then be needed in the Airplane Flight Manual.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - d. The Supercooled Large Drop (SLD) icing conditions: new Appendix O	p. 9-10

comment	*140* comment by: *Boeing* **Page: 9-10** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **d. The Supercooled Large Drop (SLD) icing conditions: new Appendix O** **and** **Page: 11** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **e. The new requirements in SLD icing conditions** **D) Ice protection system activation and operation** **- 2nd paragraph** **---** **Revise text as follows:** Paragraph 14.d.: "It is proposed to create CS-25 Appendix O which would provide a new SLD **icing** environment **to be used for aeroplane certification,** in addition to the existing CS-25 Appendix C icing environment. The Appendix O would be structured in two parts like the existing Appendix C. The first part would ~~define~~ **specify** the SLD icing conditions **to be used for aeroplane certification,** and the second part would define the ice accretions to be considered, based on **conditions provided in** the first part ~~conditions~~." And Paragraph 14.e.D), 2nd: "The proposed Appendix O ~~defines~~ **specifies the** SLD conditions **to be used for aeroplane certification**. . . . The IPHWG collected and analysed airborne measurements of pertinent SLD variables, developed an engineering standard

	to be used in aircraft certification, and recommended that standard to the FAA." **JUSTIFICATION:** Proposed Appendix O does not define all SLD icing conditions and does not perfectly define those that it is intended to represent. As noted, it is merely an engineering standard to be used for certification. Our suggested clarifications will improve accuracy and reader comprehension.
response	*Accepted*

comment	*150* comment by: *Boeing*

Page: 9-10
Paragraph: 14. Discussion of the CS-25 rule change proposal
d. The Supercooled Large Drop (SLD) icing conditions: new Appendix O

And

Page:11-12
Paragraph: 14. Discussion of the CS-25 rule change proposal
e. The new requirements in SLD icing conditions
D) Ice protection system activation and operation
- 2nd - 6th paragraphs

And

Page:12
Paragraph: 14. Discussion of the CS-25 rule change proposal
f. Performance and Handling Qualities
A) Description of the requirements
- 1st – 6th paragraphs

Revise the text as follows:

Page 9-10, paragraph 14(d) [with revisions shown here per prior comment]:

"It is proposed to create CS-25 Appendix O which would provide a new SLD **icing** environment **to be used for aeroplane certification,** in addition to the existing CS-25 Appendix C icing environment. The Appendix O would be structured in two parts like the existing Appendix C.

The first part would ~~define~~ **specify** the SLD icing conditions **to be used for aeroplane certification,** and the second part would define the ice accretions to be considered, based on **conditions provided in** the first part ~~conditions~~."

Move the sections below to follow above text, as shown; and delete from their original location.

From paragraph 14(e)(D), 2nd – 6th paragraphs revisions shown here per prior comments, except subparagraph A) title

A) Appendix O, Part I – The SLD Standard Environment

"The proposed Appendix O ~~defines~~ **specifies the** SLD conditions **to be used for aeroplane certification**. . . .

"~~The SLD conditions defined in~~ **Proposed** Appendix O Part I ~~include~~ **would provide standards for SLD conditions as two specific environments:** freezing drizzle and freezing rain ~~conditions~~. The freezing drizzle and freezing rain environments are further divided into ~~conditions~~ **categories** in which the drop median volume diameters are either less than or greater than 40 microns. Appendix O consists of measured data that was divided into drop distributions within these four icing ~~conditions~~ **categorizations**. These distributions were averaged to produce the representative distributions for each ~~condition~~ **category**."

The distributions of drop sizes are defined as part of Appendix O. ~~The need to include the distributions comes from the larger amount of mass in the larger drop diameters of Appendix O~~. **The distributions are included because they are necessary to capture the bimodal nature of the SLD environment. That is, there tends to be one mass concentration in smaller drop sizes and a second in larger drop sizes. Both the larger and smaller drops contribute to the total mass** ~~The water mass of the larger drops affects the amount~~ of water that impinges on aeroplane components, the drop impingement, icing limits, and the ice build-up shape.
Appendix O also provides a liquid water content scale factor that would be . . . .
Note: Figure 7 of Appendix O Part I ("Horizontal Extent") is slightly different . . . .

From paragraph 14.f.(A), 1st – 6th paragraphs; these are new revisions shown here:

B) Appendix O, Part II - Ice Accretions
"The ice accretion definitions in the proposed Appendix O Part II ~~and the proposed revisions to the performance and handling qualities requirements for flight in icing conditions~~ are similar to those currently required for flight in Appendix C icing conditions. ~~The proposals address the three options allowed by proposed CS 25.1420(a).~~ The proposed Appendix O Part II**(a)** would contain **information regarding which ice shape** definitions **should be used relative to the CS 25.1420(a) certification options.** ~~of the ice accretions appropriate to each phase of flight.~~

The proposed Appendix O Part II(b) would define the ice accretions **to be used by applicants certifying to proposed CS 25.1420(a)(1) or (a)(2) for detecting and exiting** ~~used to show compliance with the performance and handling qualities requirements for~~ any portion of Appendix O in which the aeroplane is not certified to operate.
The proposed Appendix O Part II(c) would define the ice accretions **to be used by applicants certifying to proposed CS 25.1420(a)(2) or (a)(3)** for any portion of Appendix O in which the aeroplane is certified to operate.

The proposed Appendix O Part II(d) would define the ice accretion in Appendix O conditions before the airframe ice protection system is activated and is performing its intended function to reduce or eliminate ice accretions on protected surfaces **("pre-activation ice")**. This ice accretion would be used in showing compliance with the controllability and stall warning margin requirements of CS 25.143(j) and CS 25.207(h), respectively, that apply before the airframe ice protection system has been activated and is performing its intended function.

	Even if the aeroplane is certified to operate only in a portion of the Appendix O icing conditions, **or in none of the Appendix O icing conditions,** the ice accretion used to show compliance with CS 25.143(j) and CS 25.207(h) must consider all Appendix O icing conditions (indeed, the initial entry into icing conditions may be into Appendix O icing conditions in which the aeroplane is not certified to operate). To reduce the number of ice accretions needed to show compliance ~~with CS 25.21(g),~~ the proposed Appendix O Part II(e) would allow the option of using an ice accretion defined for one flight phase for any other flight phase if it is shown to be more critical than the ice accretion defined for that other flight phase." **JUSTIFICATION:** These paragraphs would be much better placed in paragraph 14.d., "The Supercooled Large Drop (SLD) icing conditions: new Appendix O," with Part I and Part II subparagraphs as indicated. The Part I SLD environment standard is relevant for more than just IPS activation and operation, and the Part II ice shape scenario definitions are used for more than just compliance with performance and handling qualities requirements. Therefore, it would benefit reader comprehension to describe both parts of Appendix O in the paragraph 14 section. The descriptions for Parts II(a) through (c) are incorrect in some respects. For example, the first sentence is both incorrect and incomplete – the proposed revisions to the requirements are not "similar to those [revisions] required for flight in Appendix C icing conditions; rather, the revisions would make the consideration of and/or requirements for flight in Appendix O icing conditions similar to those for flight in Appendix C icing conditions. Our suggested changes are meant to provide more accurate descriptions and enhance reader comprehension.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - e. The new requirements in SLD icing conditions	p. 10-12

comment	*21* comment by: *UK CAA* **Page No:** 11 **Paragraph No:** 14.e.C) **Comment:** The concept of formally allowing applicants to take into account service experience on other types of their design is questioned. This may not be a totally novel concept but it should be carefully considered for a new rule for which there would be no compliance data for previous types. It is expected that practised applicants would in any case expect to include this as part of their substantiation but formalising this with AMC material may be difficult. New applicants with 'conventional' designs may feel aggrieved if they are subjected to expensive and uncertain tests and analysis which their larger competitors may 'automatically' avoid. In addition, if such a process is formalised, there may be pressure to include criteria such as number of aircraft

	in service, accumulated hours, even geographical areas of operation, as well as potentially complex definitions of what constitutes 'similarity' and 'conventional' design. Criteria for using service experience need to be clear within the AMC, ensuring the need to distinguish between those parameters critical for SLD that are 'similar' between aircraft types and those that are 'dissimilar'.
response	*Noted* The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420. In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

comment	*25* comment by: *Dassault Aviation* Dassault-Aviation Comment on § Proposed mean of compliance : <u>Similarity analysis (§A/IV/14/e/C – page 11):</u> "The Agency is considering the possibility of taking credit from in-service experience to demonstrate compliance with the proposed rule, (…). This option could be explained and included in the AMC material." <u>Comment:</u> Such a mean of compliance is already acceptable to demonstrate subpart B requirements compliance in the icing conditions of appendix C to CS-25 (as described in CS-25 book 2 – AMC 25.21(g) - § ancestor aeroplane analysis). In the same way, it is considered that taking credit from in-service experience to demonstrate compliance in SLD conditions by a similarity analysis should be retained and introduced in the AMC material. <u>Requested Change:</u> It is proposed to introduce this option in AMC material.
response	*Accepted*

comment	*31* comment by: *E. Bakker (Fokker Services)* Comment on: "- *Detect Appendix O conditions and then operate safely while exiting all icing conditions (CS 25.1420(a)(1)).*" Hypothetically considering the existence of on-board measuring equipment (including the flightcrew themselves) that functions properly when installed to detect these "Appendix O" icing conditions, Fokker Services is of the opinion that the main consideration should be the planning of flights, proper piloting and foremost the interaction of ground-based equipment (radar, ATC etc etc) linked with on-board equipment. One of the conclusions of the NTSB of the Jannuary 9, 1997 Monroe accident does support this: ***"The Safety Board is also concerned that the current icing certification process is overly dependent upon pilot performance; the FAA has long***

	based its icing certification policies and practices on the assumption that pilots will perform their duties without error or misperception. FAA icing-related publications indicate that if ice formations other than those considered in the certification process are present, the airplane's airworthiness may be compromised. After an airplane is certificated by the FAA for flight in appendix C icing conditions, it becomes primarily the pilots' responsibility to ensure that the airplane is operated in icing conditions for which it was certificated. However, as noted during the investigation of the ATR-72 accident at Roselawn, during normal flight operations, pilots often cannot tell the difference between icing conditions that fall within the appendix C envelope and icing conditions outside the appendix C envelope. (For example, a pilot cannot differentiate between 40 micron droplets and 100 micron droplets.) Because pilots often cannot determine whether icing conditions are consistent with "those considered in the certification process" (i.e., limited points within the appendix C certification envelope), or not (i.e., SLD icing conditions, or other potentially hazardous conditions that were not subjected to testing, analysis, or demonstration during icing certification work), it is virtually inevitable that the airplane will unknowingly be operated in icing conditions that fall outside the certification envelope, or in which the airplane had not demonstrated that it could operate safely." And one of the conclusions of the NTSB of the October 31, 1994 Roselawn accident: ***"The Safety Board acknowledges the efforts of atmospheric research in the meteorological community and hopes that its important findings will eventually provide the aviation industry with a better understanding of the freezing drizzle/rain phenomenon. The Safety Board concludes that the continued development of equipment to measure and monitor the atmosphere (i.e., atmospheric profilers, use of the WSR-88D and Terminal Doppler weather radars, multispectral satellite data, aircraft-transmitted atmospheric reports, and sophisticated mesoscale models), and the development of computer algorithms, such as those contained in the FAA's Advanced Weather Products Generator (AWPG) program to provide comprehensive aviation weather warnings, could permit forecasters to refine the data sufficiently to produce more accurate icing forecasts and real-time warnings. Therefore, the Safety Board believes that the FAA should continue to sponsor the development of methods to produce weather forecasts that define very specific locations of potentially hazardous atmospheric icing conditions (including freezing drizzle and freezing rain) and to produce short-range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less."***
response	*Not accepted* Even if some forecasting and detecting tools are being developed, there will always be coverage area as well as performance limits which cannot ensure that an aeroplane will not encounter SLD icing conditions, even on an inadvertent manner. Therefore, the safety of flight cannot rely on such systems and the aeroplane must be evaluated against this environment.

comment	*32* comment by: *E. Bakker (Fokker Services)*

	Comment on "*c) Similarity Analysis*" The NPA opens here a similarity approach possibility by the use of (good) in-service experience. What will be the definition of this good service experience?
response	*Noted* The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420. There is not yet a specific definition of what is an acceptable in-service experience and the Agency would review each submission made by an applicant. In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

comment	*33* comment by: *E. Bakker (Fokker Services)* Comment on "*Many currently certified large aeroplanes have been proven by their field service experience to be safe to operate in these conditions.*" It is unknown to Fokker Services why this conclusion is made here, is in contrast with the rest of the NPA where new aircraft above 60000 pounds still have to comply with the new "Appendix O" icing environment. Next to that, Fokker Services would like to stress that the aviation business is an international working environment and that worldwide standards should be pursued. Working with different standards (e.g. FAA vs EASA) only diffuse the anticipated goal.
response	*Noted* The principle is that the SLD environment requirements are applicable to any CS-25 aeroplanes. Now the Agency recognizes the fact that safety issues have not appeared on all large aeroplanes. Therefore, the Agency has proposed on page 11 of the NPA (under "C) Similarity analysis"), the idea of an AMC material providing the possibility for applicants to use the positive service experience gathered on their previously type certificated aeroplanes, to support their means of showing compliance to the new SLD rule. This would decrease the impact of the new rule on some aeroplanes which use designs similar to aeroplanes that have proven safe operation in SLD icing conditions.

comment	*65* comment by: *Thales Avionics* Regarding C) Similarity analysis: In-service experience can be used for flight instrument external probe for SLD as SLD are not a key driver of the probe design face to Ice Crystal, Mixed phase and supercooled droplet. However, the use of in-service experience should be limited to the cases where the different parameters including the level of water content can be documented.
response	*Partially accepted* Severe ice crystal icing conditions have created in-service events on some probes; therefore, this kind of environment may indeed be the driver for probe

anti-icing protection system design.

The scope of paragraph C) on page 11 is about compliance with CS 25.1420 which is related to operation with SLD conditions. But the Agency does not intend to require a demonstration based on specific liquid water content values documented from in-service experience.

comment

74 comment by: *Next Generation Aircraft (Rekkof)*

NGA does not believe it is possible to visually establish that the aircraft has entered Appendix O conditions. This is quite apart from the fact that – even if it could be established visually - a certain ice shape maybe severe ice for a smaller transport aircraft, whereas it may be even a non event for a very large transport aircraft. There is no way that a pilot can reliably do such an assessment. We also believe a detector to detect appendix O conditions is not yet available.

NGA believes it is impossible to safely operate in all of the appendix O conditions because these very large ice droplets will impinge far aft of the normal protected area at the highest point on the wing, e.g. for the Fokker100NG say 1,5 m from the leading edge, hence certainly the smaller transport aircraft cannot be designed to sustain the severe icing conditions as given in Appendix O, unless radically new concepts are employed such as but not limited to wing upper surface heating using heat mats up to the wing highlight. Other alternatives that maybe considered are hydrophobic materials (not yet ready for service use) or electro mechanical de-icing. In addition, use of electrical devices in close proximity to the wing fuel tanks brings additional certification problems to meet the SFAR88 fuel flammability requirements.

response

Not accepted

For aeroplanes not certified for safe operation in the entire Appendix O environment, the Agency will propose in an AMC material some criteria and guidance to support the showing of compliance with the rule.

The general principle is that the method for determining whether the selected Appendix O icing conditions boundary has been exceeded can be accomplished using substantiated visual cues, an ice detection system, or an aerodynamic performance monitor. The AMC material will explain what is acceptable in term of visual cues; it is obviously not expected that a pilot is able to assess the size of the super cooled droplets or to measure the exact thickness of ice deposits.

comment

75 comment by: *Next Generation Aircraft (Rekkof)*

The NPA states on page 11 that "*The Agency is considering the possibility of taking credit from in-service experience to demonstrate compliance with the proposed rule, as explained here below. This option could be explained and included in the AMC material. <u>We invite stakeholders to comment on this option</u>.*

NGA believes there is ample evidence, see Clarence L. Johnson, " Wing Loading, Icing and Associated Aspects of Modern Transport Design", Journal of the Aeronautical Sciences, Volume 8, Number 2, December 1940, that provided the de-iced area extends far enough in chord-wise direction e.g. 15% on the upper wing surface and 10% on the bottom, that safe flight characteristics in icing conditions will be achieved. For boot equipped aircraft this has been shown in

25 million flights of the combined fleet F27, F50/F60 aircraft without a single ice related accident. In absence of a single ice related accident on the Bombardier Dash 8 fleet, for 24 million flights, it is reasonable to assume, that the boots on these aircraft have been designed to these same or close enough “Clarence L. Johnson” standards.

For evaporative ice protection systems, NGA believes that a sufficiently large protected area in chord-wise direction, combined with ample heating power has in the past also resulted in a sufficiently safe design for flight in icing conditions. In addition, there is ample evidence to suggest that safe flight in ice conditions outside Appendix C has in fact happened many times, this in absence of any in flight ice related accidents, especially on larger transport aircraft.

NGA therefore has concluded that Super Cooled Large Droplets already existed in 1940. Thus, there is no new environment that needs to be taken into account.

Using proper design standards for any type of anti/de-icing system will lead to sufficient protection for safe flight in all icing conditions. NGA suggests EASA to define appropriate design standards in an AMC to preserve essential safety knowledge from the past.

The NPA states also that *"New large aero planes designs, similar to those of which have proven safe operation in SLD icing conditions, would be allowed to show compliance by comparative analysis.*
This comparison would only be allowed with aeroplane types held by the same applicant.

NGA takes exception to this statement, because if an applicant can prove that it has access to all data of the previous design, that data and ensuing analysis should be eligible for certification.

response *Partially accepted*

The Agency does not intend to prescribe anti-icing or de-icing system design specifications.

The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420.

In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

comment *91* comment by: *AIRBUS*

The preamble discussion of use of the phrase "as found necessary" in CS25.1420(b) does not communicate the challenges of flight-testing in natural SLD conditions. The majority of the IPHWG (included regulatory participants – reference IPHWG Task 2 Report) acknowledged "the difficulties in flight testing in Appendix O conditions" and agreed that "flight testing in natural Appendix X conditions would not be required as in CS25.1419 for Appendix C icing conditions". Flight testing in natural Appendix O icing conditions was not excluded as a method of compliance, but it was agreed by the majority that alternate methods could provide sufficient confidence in lieu of flight-testing in natural SLD. This issue was discussed extensively within the IPHWG and documented in the WG report (IPHWG Task 2 WG Report, page D-22). The draft AC 25-XX contains the recommended guidance on when flight-testing in Appendix O conditions should not be necessary.

Given that preamble materials are occasionally used as interpretive materials, we recommend that this issue be clarified in the final rulemaking.

response *Accepted*

We modify the preamble to read:

"The majority of the IPHWG acknowledged the difficulties in flight testing in natural SLD icing conditions; for this reason, CS 25.1420(b) considers flight testing in natural Appendix O conditions as one of the available methods to support the required analysis."

comment *92* comment by: *AIRBUS*

Airbus recommends avoiding such a significant disharmonisation with the FAA NPRM and recommends retaining the 60,000 lbs exemption.

However, should EASA choose to create a rule that is not harmonized with the FAA, then a means of compliance based on similarity and good in-service experience may be the only viable alternative considering the maturity of the available engineering tools. This recognizes that many aircraft types operating today with millions of flying hours have experienced no in-service events linked to SLD icing conditions. Therefore, the list of requirement with which compliance may be demonstrated by good in-service experience and similarity should be increased to include all the relevant requirements which are: CS 25.773, CS 25.903, CS 25.1323, CS 25.1324, CS 25.1325 CS 25.1326, CS 25.1093b.

In addition a means of compliance based on similarity and good in-service experience should be extended to component certification. There are no known events that support a safety concern due to icing in SLD conditions aloft of components such as radomes, engine inlets, probes, windshields, etc. Therefore there is no quantifiable safety benefit of applying SLD to these components.

The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety. Future designs that can be shown to be similar or have similar performance to in-service designs that have demonstrated good in-service experience, can be expected to provide similarly exemplary in-service performance.

The associated AMC should therefore define clear guidance on the evidence required to demonstrate good in-service experience and design similarity.

Finally it should be noted that future advancements in technology are likely to provide aircraft performance and safety improvements. Therefore the AMC

	should include sufficient flexibility to allow new technologies to be certified with the current tools and at a cost that would not prohibit their introduction whilst ensuring that the good in-service experience remains valid.
response	*Not accepted* The scope of the similarity analysis would be limited to compliance with CS 25.1420. The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420. In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance). The Agency does not intend to certify a new technology based on the positive service experience of a previous different technology.

comment	*98* comment by: *AIRBUS* 14(e)B) Analysis and tests requirements: *"To establish that an airplane could operate safely in the proposed appendix O conditions described above, proposed CS 25.1420(b) would require both analysis and one test, or more as found necessary, to establish that the ice protection for the various components of the airplane is adequate. The words ''as found necessary'' would be applied in the same way as they are applied in CS 25.1419(b)."* The term "as found necessary" in CS25.1420(b) should have been more fully explained in the preamble to the rule. The current description implies that it can be used in just the same way as Appendix C. This does not reflect the conclusions of the IPHWG majority who agreed that flight testing in Appendix X (now Appendix O) conditions would not be required in the same way as for Appendix C due to the difficulties and impracticality associated with such a flight test campaign. The NPA statement does not reflect the difficulties of flight testing in SLD conditions and especially freezing rain conditions due to the difficulties of finding the conditions. The preamble should be modified to more accurately reflect the conclusions of the IPHWG majority and reflect the difficulties of flight testing in Appendix O.
response	*Accepted* We modify the preamble to read: "The majority of the IPHWG acknowledged the difficulties in flight testing in natural SLD icing conditions; for this reason, CS 25.1420(b) considers flight testing in natural Appendix O conditions as one of the available methods to support the required analysis."

comment	*118* comment by: *Claudio Mauerhofer* *Section 14.e C) "Similarity analysis" (page 11 of 77)* "If an applicant has adequate data, based on extensive experience from its own CS-25 aircraft in-service fleet, a similarity analysis may be used in lieu of the

analysis and tests required by CS 25.1420(b). […]
New large aeroplanes designs, similar to those of which have proven safe operation in SLD icing conditions, would be allowed to show compliance by comparative analysis. This comparison would only be allowed with aeroplane types held by the same applicant.

We believe that this sort of wording may lead to misinterpretations (not only for icing certification); moreover it is our understanding that it renders the harmonization between different projects, different applicants (e.g. TC vs. STC Holders) and processes applied by different PCMs (e.g. level of involvement) rather difficult. Although the intention behind the wording is understood, we consider it to be essential to better define the meaning of terms such as "adequate data", "extensive experience" and "comparative analysis".

Experience with certification projects has shown that the applicants intend to take credit from a "mix" of predictions, based on ice accretion programs, ice wind tunnel tests (maybe conducted on a similar product), similarity with other products and service experience. On the one hand this reflects the general fact that better simulation tools are available; on the other hand there is also an understandable attempt to reduce costs and save time. Under these assumptions, we think it is crucial that guidance is provided on what may be defined as "adequate data", particularly considering that we (the industry and the authorities) are dealing with a new set of requirements, design tools and test conditions.

The value of service experience is a function of the quality of experience; otherwise service experience may simply show an overall end-result, the meaning of which is questionable if the associated conditions are not known or not controlled. For example not all in-service aircraft may be exposed to the same icing threats, and not to the same extent. Moreover, given the significant impact that peculiar design characteristics may have on icing, it is questionable whether it is appropriate to generally refer to a "CS-25 aircraft in-service fleet". An applicant may for instance claim that aircraft "ABC" flew x-thousand FH without, say, any performance degradation which could be associated to icing; however the environmental conditions/power settings during the x-thousand FH may not be documented. It is therefore recommended to further define conditions and criteria to be satisfied to take credit from service experience.

We propose the use and suitability of "comparative analysis" to also be clearly linked to well defined conditions and prerequisites. A known example of "comparative analysis" as acceptable means of compliance is given by FAA AC 25.803-1, "Emergency Evaluation Demonstrations". In this case, it is clear that comparative analysis is reasonable in cases where the requirements being investigated are well known and test data are available from previous tests and analyses. In the case of Appendix O we are charting new territory and as such, from our point of view, it is questionable whether a sufficient level of knowledge is available to justify this type of approach. Moreover it should be considered that a comparative analysis involves a thorough evaluation of not only what is similar, but also of all differences among different products and that these differences may again require to be substantiated by means, say, of test data.

In summary we consider it to be important that comprehensive AMC&GM are developed and reviewed to support the proposal of giving credit to similarity, comparative analysis, and service experience to demonstrate compliance.

It is also worth mentioning that the similarity option (particularly for complex

	requirements such as icing) is rather attractive for some applicants (e.g. TC vs. non-TC Holders) who therewith may manage to show compliance with a significantly reduced effort, compared to what is usually expected by a TC Holder. This may put in discussion the principle of leveled playing field.
response	*Noted* The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420. In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

comment	*121* comment by: *Mitsubishi Aircraft Corporation* The effect of icing is more severe for small airplane than for large airplane. Therefore, data and in-service experience of CS-23 aircraft fleet of similar design should be accepted to be utilized for similarity analysis. In addition, the in-service experience should not be limited to airplane type certificates held by the same applicant as long as detail technical data is available.
response	*Not accepted* The envisaged design similarity analysis concept is applicable to aeroplanes certificated against CS-25 (or JAR 25). The applicant shall own all the data used to support the analysis, including certification data (like test reports).

comment	*141* comment by: *Boeing* **Page: 10** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **e. The new requirements in SLD icing conditions** **A). General** **- 1st paragraph** **------------------------------------** **<u>Revise the text as follows:</u>** [paragraph 14.e.A)] "This change would require evaluating the operation of these aeroplanes in the SLD icing environment; developing a means to differentiate between different SLD icing conditions, if necessary; and developing procedures to exit all icing conditions**<u>, if necessary</u>**. . . . The Appendix O icing conditions, if adopted, may affect the design of aeroplane ice protection systems." **<u>JUSTIFICATION</u>:** The requirement to exit all icing conditions following detection of unapproved SLD conditions only applies to CS 25.1420(a)(1) and (a)(2); it does not apply to (a)(3), and therefore it is appropriate to add "if necessary" relative to developing the exit procedures.

response	*Accepted*

comment	*145* comment by: *Boeing*
	Page: 10 **Paragraph: 14. Discussion of the CS-25 rule change proposal** **e. The new requirements in SLD icingconditions** **A) General** **- 2nd paragraph** **--** **Revise the text as follows:** "~~The~~ **Certification for flight in icing conditions would include** Appendix O SLD icing conditions**, and** ~~would be those in which~~ the aeroplane must be able to either safely exit **all icing conditions** following the detection of any or specifically identified Appendix O icing conditions, or safely operate without restrictions." **JUSTIFICATION:** Our suggested revision provides clarity and will improve reader comprehension.
response	*Not accepted* The proposed wording change does not bring more clarity.

comment	*146* comment by: *Boeing*
	Page: 10 **Paragraph: 14. Discussion of the CS-25 rule change proposal** **e. The new requirements in SLD icing conditions** **B) Analysis and tests requirements** ------------------------------------ **Revise the text as follows**: "To establish that an aeroplane could operate safely in the proposed Appendix O conditions described above, the proposed CS 25.1420(b) would require both analysis and one test, or more as found necessary, to establish that the ice protection for the various components of the aeroplane is adequate. The words "as found necessary" **are not intended to require flight testing in natural SLD conditions** ~~would be applied in the same way as they are applied in CS 25.1419(b).~~ During the certification process, the applicant would demonstrate compliance with the rule using a combination of analyses and test(s). The applicant's means of compliance would consist of analyses and the amount and types of testing it finds necessary to demonstrate compliance with the regulation. The applicant would choose to use one or more of the tests identified in paragraphs CS 25.1420(b)(1) through (b)(5). **The IPHWG acknowledged the difficulties in flight testing in natural SLD conditions, and agreed that it would not be required as in CS 25.1419(b) for Appendix C conditions. Advisory material was developed to provide guidance on when flight tests in natural SLD conditions should not be necessary.** Although the applicant may choose the means of compliance, it is

	ultimately the EASA that determines whether the applicant has performed sufficient test(s) and analyses to substantiate compliance with the rule. Similarly, the words "as necessary," which appear in CS 25.1420(b)(3) and (b)(5), would result in the applicant choosing the means of compliance that is needed to support the analysis, but the EASA would make a finding whether the means of compliance is acceptable." **JUSTIFICATION:** This discussion of the use of the phrase *"as found necessary"* in proposed CS 25.1420(b) does not communicate the challenges of flight testing in natural SLD conditions. The majority of the IPHWG (including regulatory participants) acknowledged *"the difficulties in flight testing in Appendix X conditions"* and agreed that *"flight testing in natural Appendix X conditions would not be required as in §25.1419 for Appendix C icing conditions"* (reference – IPHWG Task 2 Working Group Report). Flight testing in natural Appendix O icing conditions was not excluded as a method of compliance, but it was agreed by the majority that alternative methods could provide sufficient confidence in lieu of flight-testing in natural SLD. This issue was discussed extensively within the IPHWG and documented in the WG report (IPHWG Task 2 WG Report, page D-22). The FAA's draft AC 25-XX contains the recommended guidance on when flight testing in Appendix O conditions should not be necessary. We encourage EASA to harmonize on this guidance. Given that the NPA's descriptive text may be used as interpretive material, we recommend that this issue be clarified in the final rulemaking.
response	*Partially accepted* We modify the preamble to read: "The majority of the IPHWG acknowledged the difficulties in flight testing in natural SLD icing conditions; for this reason, CS 25.1420(b) considers flight testing in natural Appendix O conditions as one of the available methods to support the required analysis."

comment	*147* comment by: *Boeing* **Page: 11** **Paragraph: 14. Discussion of the CS-25 rule change proposal** **e. The new requirements in SLD icing conditions** **C) Similarity analysis** ------------------------------------ **Revise the text as follows:** "The Agency is considering the possibility of taking credit from in-service experience to demonstrate compliance with the proposed rule, as explained here below. This option could be explained and included in the AMC material. We invite stakeholders to comment on this option. If an applicant has adequate data, based on extensive experience from its own CS-25 aircraft in-service fleet, a similarity analysis may be used in lieu of the analysis and tests required by CS 25.1420(b)**, as well as the Appendix O requirements contained in CS 25.773, 25.1093 (except that compliance with Table 1 "Large Drop Condition" would be required for ground idle taxi conditions), 25.1323, 25.1325, and 25.1326**. Although SLD icing conditions ~~are~~ **can be** hazardous, accidents and incidents involving this type of

meteorological condition mainly concern certain types of large aeroplanes; events essentially involved aeroplanes with a maximum take-off weight less than 27000 kg (60000 lbs), reversible flight controls, de-icing protection systems (e.g. de-icing boots as opposed to thermal anti-icing systems). Many currently certified large aeroplanes **and their component systems** have been proven by their field service experience to be safe to operate in these conditions.
New large aeroplane designs with a general similarity to those which have a record of proven safe operation in SLD icing conditions would be allowed to show compliance by comparative analysis. This comparison would only be allowed with aeroplane types held by the same applicant. "General similarity" is intended to mean similarity at a high level of assessment such that the similarity approach may be used when the new aeroplane has new or improved component system types, or other changes from the parent models, that are intended, expected, and will be certified to result in equal or better aeroplane performance in Appendix C conditions than those of the reference model.
If this approach is retained, this would require adding a corresponding reference in CS 25.21(g)**, CS 25.773, CS 25.1093, CS 25.1323, CS 25.1325, CS 25.1326,** and CS 25.1420(b)."

Concern: Boeing appreciates the opportunity to comment on EASA's consideration of permitting the use of similarity and service history as means of compliance. We believe that this option is essential for manufacturers to be able to certify new aeroplane models to the proposed SLD requirements. This is primarily due to a combination of: the current immaturity and/or unavailability of engineering tools and methods; the immense impracticality of flight testing in natural SLD conditions as an experimental effort and as a means of compliance within the confines of a certification program; and the lack of viable engineering design solutions which could potentially make compliance with the performance and handling qualities requirements feasible. Even certification to reduced requirements for "detect and exit" per 25.1420(a)(1) would be an extremely expensive undertaking and destroy the business case for many new aeroplane projects. For certification to either 25.1420(a)(2) or (a)(3), with natural icing flight testing potentially being required, the situation is prohibitive. While we do not believe that it is EASA's intention, the lack of a similarity compliance option could well have the effect of ceasing any new large aeroplane program and effectively deterring the future of the industry. As a related concern, we believe that the systems component requirements should include similarity and service history as means of compliance in the AMC.

We strongly request EASA to include similarity and service history as means of compliance in the AMC.

JUSTIFICATION: The justification for our agreement with the EASA proposal to take credit from in-service experience to demonstrate compliance with the proposed rule is provided in our concern statement above. In addition to 25.1420 and for the same reasons, the systems component requirements for Appendix O, considerations should likewise include similarity and service history as means of compliance in the AMC (except for the one noted ground-idle engine test). While EASA acknowledges the safety of most in-service large aeroplanes for operation in SLD conditions relative to 25.1420, the component systems are not included in the discussion. They should be (in the event that our separate suggestions to exclude component systems from Appendix O consideration are not adopted) because there are no known events that support an in-flight safety concern for the component systems in SLD icing conditions aloft. The safety of these component systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs (including effectively equivalent new designs) in Appendix O conditions, should be acceptable to ensure future safety.

Specifying that "general, high-level similarity" is acceptable to apply this means of compliance is considered critically important. It is suggested that focusing on system and aeroplane performance and safety is the most appropriate approach. When new systems or other features are shown to provide equivalent or enhanced safety in Appendix C icing conditions, that should be a positive credit rather than have the negative effect of eliminating similarity as a MoC for SLD conditions. If changes and innovations cannot be made without negating similarity, then this MoC will not help in avoiding the unintended potential consequence of destroying the future of the airplane manufacturing industry via these proposed rules.

We encourage EASA to liaise with the FAA to harmonize on this topic.

The revision to the second sentence of the second paragraph quoted above is warranted because pursuant to the historical event record, not all SLD icing conditions are hazardous for all aeroplanes.

response

Partially accepted

The scope of the similarity analysis would be limited to compliance with CS 25.1420.

The Agency will propose some AMC material provisions indicating the key elements to be considered by the applicant when envisaging a design similarity analysis to support the demonstration of compliance to CS 25.1420.

In addition, the Agency decided to create a new rulemaking task (RMT.0572) with a Group of experts that will work on proposing more detailed guidance material (and eventually amendment of the Book 1 specifications introducing the similarity analysis option in the means of compliance).

The Agency does not intend to certify a new technology based on the positive service experience of a previous different technology.

comment

148 comment by: *Boeing*

Page:11
Paragraph: 14. Discussion of the CS-25 rule change proposal
e. The new requirements in SLD icing conditions
D) Ice protection system activation and operation
- 3rd paragraph

Revise the text as follows:

"~~The SLD conditions defined in~~ **Proposed** Appendix O Part I ~~include~~ **would provide standards for SLD conditions as two specific environments:** freezing drizzle and freezing rain ~~conditions~~. The freezing drizzle and freezing rain environments are further divided into ~~conditions~~ **categories** in which the drop median volume diameters are either less than or greater than 40 microns. Appendix O consists of measured data that was divided into drop distributions within these four icing ~~conditions~~ **categorizations**. These distributions were averaged to produce the representative distributions for each ~~condition~~ **category**."

JUSTIFICATION: The word "include" implies that there are also other environments in addition to FZDZ and FZRA. Our suggested revision eliminates this erroneous implication.

The subdivisions of the Appendix O FZDZ and FZRA regimes represented by the four different drop distributions are "categories" or "envelopes," rather than four point conditions or icing environments commonly referred to by different names, for example. Our suggested revisions are an effort to describe the subdivisions and four distributions in terms more distinctive and descriptive than "conditions," which would enhance reader comprehension.

response	*Accepted*

comment | 149 comment by: *Boeing*

Page:12
Paragraph: 14. Discussion of the CS-25 rule change proposal
e. The new requirements in SLD icing conditions
D) Ice protection system activation and operation
- 4th paragraph

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Revise the text as follows:

"The distributions of drop sizes are defined as part of Appendix O. ~~The need to include the distributions comes from the larger amount of mass in the larger drop diameters of Appendix O~~. **The distributions are included because they are necessary to capture the bimodal nature of the SLD environment. That is, there tends to be one mass concentration in smaller drop sizes and a second in larger drop sizes. Both the larger and smaller drops contribute to the total mass** ~~The water mass of the larger drops affects the amount~~ of water that impinges on aeroplane components, the drop impingement, icing limits, and the ice build-up shape."

JUSTIFICATION: The text in the NPA is not accurate. Our suggested revision will more accurately explain the reason for including the drop-size distributions.

response	*Accepted*

comment | 187 comment by: *Next Generation Aircraft (Rekkof)*

	Attachment #7
response	*Noted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - f. Performance and Handling Qualities p. 12-13

comment	*22* comment by: *UK CAA* **Page No:** 13 **Paragraph No:** 14.f.B) **Comment:** The moving of Part II of Appendix O is supported in principle for the reasons given. Although there was an understandable wish to develop a less objective and more prescriptive rule for flight in icing, it is considered that this material is not appropriate for the basic rule. Aircraft icing is a complex technical subject and requires assurance of adequate knowledge and experience on behalf of the applicant and also the authority. The material can be used for guidance but using it prescriptively as a means to demonstrate compliance could result in a too narrow approach restricting flexibility both by the applicant and the authority. However, the existing Appendix O Part II is written in a very prescriptive manner and may not be suitable for AMC in this form because applicants will use it and expect it to be accepted if it is followed 'word for word'. It is proposed therefore that, unless further discussion with FAA can make changes, a decision may need to be made whether to adopt the Appendix in its current form, delete it entirely, or write new AMC material.
response	*Accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*26* comment by: *Dassault Aviation* Dassault-Aviation comments on : "Consideration about Appendix O, Part II (page 13) and Appendix O - Part II (page 71)" Taking into account the fact that this Part II is very detailed and complex, the Agency is considering the option to move it in Book 2. Comment: The way the appendix is written is complex. Definition of a specific ice accretion is linked to the definition of other ones, with references to other paragraphs and sub-paragraphs of this Part II. Consequently, the text is not enough clear

	which might lead to misunderstanding. Moreover, the text is more written in the spirit of an AMC than in the one of a rule. So, Dassault considers that moving this Part II in CS25 Book 2 in an AMC could be a good option. In that case, only the generic list of ice accretions to be considered for the various flight phases could be kept in the Appendix O – Part II. Nevertheless, clarification of the presentation is needed whatever the decision to keep this Part II in Appendix O or to move it in CS25 Book 2 in an AMC. <u>Suggested Change</u> It is proposed to move this Part II in CS25 Book 2 in an AMC and to keep in the Appendix O the generic list of ice accretions to be considered. But, whatever the decision to keep this Part II in Appendix O or to move it in CS25 Book 2 in an AMC, it is proposed to clarify the text of this Appendix O Part II by using, as for example, a presentation based on tables.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*66* comment by: *Thales Avionics* Regarding B) Consideration about Appendix O, Part II Moving Appendix O, Part II to CS-25 Book 2 to become the AMC material seems clearer and easier to use.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*122* comment by: *Mitsubishi Aircraft Corporation* There seems to be no concern to move Part II of Appendices C and O to CS25 Book 2.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*151* comment by: *Boeing*

Page:12-13
Paragraph: 14. Discussion of the CS-25 rule change proposal
f. Performance and Handling Qualities
A) Description of the requirements
- 7th & 8th paragraphs

Revise the text as follows:

"The existing CS 25.21(g)(1) requires that the performance and handling qualities requirements of CS-25 Subpart B, with certain exceptions, be met in Appendix C icing conditions. The proposed CS 25.21(g)(~~2~~ **3**) would identify the performance and handling qualities requirements that must be met to ensure that an aeroplane certified to either the proposed CS 25.1420(a)(1) or (a)(2) could safely exit icing if the icing conditions of proposed Appendix O, for which certification is not sought, are encountered. ~~Such a~~ **An** aeroplane **certified to proposed CS 25.1420(a)(1)** would not be approved to take off in proposed Appendix O icing conditions and would only need to be able to detect and safely exit those icing conditions encountered en route. **An aeroplane certified to proposed CS 25.1420(a)(2) might not be approved to take off in some or all of the proposed Appendix O conditions, depending upon the applicant's selected portion. In cases where there is a portion of the Appendix O conditions for which certification is not sought, such airplanes likewise would only need to be able to detect and safely exit the unapproved conditions encountered en route.** Therefore, it is proposed that, in addition to the exceptions identified in the existing CS 25.21(g)(1), such ~~an~~ aeroplane**s** would not need to meet certain requirements for Appendix O icing conditions.

With ~~one~~ **two** exception**s**, for an aeroplane certified under proposed CS 25.1420(a)(1) or (a)(2), the same handling qualities requirements that must currently be met for flight in Appendix C icing conditions are proposed ~~for flight in~~ **during the detection and safe exit from the** Appendix O icing conditions for which certification is not sought. ~~That~~ **The** exception**s** ~~is~~ **are** CS 25.143(c)(1), which addresses controllability following engine failure during takeoff at V2**, and CS 25.207(e)(1), which addresses stall warning requirements with takeoff ice accretions**. Compliance with ~~that~~ **those** rule**s** would not be necessary **for an aeroplane certified under proposed CS 25.1420(a)(1) or not certifying for takeoff under proposed CS 25.1420(a)(2)** since the aeroplane would not be approved for takeoff in Appendix O icing conditions. ~~No justification for a relaxation of other handling qualities requirements could be identified.~~"

JUSTIFICATION:

Relative to certification to proposed CS 25.1420(a)(2), the NPA does not accurately reflect the potential variations in the applicants' selected portions for which certification may be sought. For an aeroplane certificated to proposed CS 25.1420(a)(2), takeoff would be permitted for those Appendix O conditions that constitute the approved portion. For example, if the approved portion were FZDZ per Appendix O, then takeoff would be permitted in FZDZ but not FZRA. If the applicant were to select phase-of-flight as the portion discriminator, then takeoff and climb could be permitted for all Appendix O conditions, with the unapproved "portion" being one or more of the other phases of flight. Therefore, revision of the explanatory text and CS 25.21(g) is necessary.

In the first sentence of the eighth paragraph of 14(f)(A), the description may be confusing for the reader by referring to "flight in" the unapproved portions of Appendix O, implying that the requirements apply equally to flight in both the approved and unapproved portions. Our suggested clarification will eliminate the potential for such confusion.

Regarding the last sentence (suggested deletion) of the 8th paragraph of 14.f.(A), it does not seem appropriate or necessary to point out a lack of additional exceptions.

response

Partially accepted

The change of reference to CS 25.21(g)(2) is not accepted as it remains valid.

For aircraft certified vs CS 25.1420(a)(1), takeoff in SLD conditions should be forbidden. It is anticipated that applicants will chose the option of CS 25.1420(a)(2) to allow departure in light freezing rain/drizzle; in this case the applicant will have to demonstrate safe aircraft performance within the Appendix O portion chosen for certification.

CS 25.1533 has be clarified to address the particular case of taking off in known SLD icing conditions.

About adding CS 25.207(e)(1) in the list of exceptions, it is accepted.

comment

152 comment by: *Boeing*

Page:13
Paragraph: 14. Discussion of the CS-25 rule change proposal
f. Performance and Handling Qualities
A) Description of the requirements
- 9th paragraph

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Revise the text as follows:

" . . . For continued operation in Appendix O icing conditions, there should effectively be no degradation in handling qualities **from the minimum standards established by the Subpart B requirements**, and any degradation in performance should be no greater than that allowed by the rules for Appendix C icing conditions."

JUSTIFICATION: Our suggested change would clarify that "no degradation" does not mean "no degradation from the clean aeroplane characteristics, nor from the impact on the aeroplane's characteristics with Appendix C ice accretion" (i.e., an aeroplane could perform above the minimum requirements with Appendix C ice accretion; a reduction from that but still meeting the regulatory minimums is acceptable).

response

Accepted

comment

153 comment by: *Boeing*

Page: 13
Paragraph: 14. Discussion of the CS-25 rule change proposal
f. Performance and Handling Qualities
B. Consideration about Appendix O, Part II

The text states:

"The Agency is considering an option of moving Part II of Appendix O to CS-25 Book 2. This would then become the AMC material used to show compliance with CS-25 Subpart B using the meteorological data in Part I of Appendix O.
This consideration comes from our assessment of Part II which appears to be relatively detailed and complex. Usually, rules are written at higher level and the possible detailed means of compliance are provided in an AMC. This could also provide more flexibility in the process of showing compliance when interpretation of the requirements is complex and subject to discussions or different views between the parties.

We therefore invite stakeholders to provide their comments about this option. If decided, the same change could be applied to Part I of Appendix C."

Boeing Response:

Boeing considers that there are potential advantages and disadvantages to both structures.

With Part II of Appendix O being part of the Book 1 regulations (and likewise for App. C), it is more likely that various manufacturers will be showing compliance with ice accretions based upon common, standard scenarios. This is an advantage for both the regulators in assessing compliance and for the industry as a whole in terms of consistency. It would be a disadvantage should manufacturers find it impossible or impractical to comply using the prescribed accretion scenarios due to the lack of appropriate SLD engineering tools. In this case, moving Part II of Appendix O to Book 2 as guidance material would allow for more flexibility. It may also permit consideration of similarity with regard to ice accretions (assuming that similarity is included as a means of compliance). The disadvantage is the loss of consistency across the industry, with various manufacturers perhaps negotiating compliance via different accretion scenarios.

response *Accepted*

We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA.

We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - g. Component requirements p. 13-15

comment	1 comment by: *Air France - Maintenance Quality Assurance* Consider to change the altitude range in meter between 0 to 3,000 in lieu of 30,000.
response	*Accepted*

comment	34 comment by: *E. Bakker (Fokker Services)* Comment on the first part of "*g. Component requirements*": EASA requires that the pilot should decide here if he is in an "Appendix C" icing environment, an "Appendix O" environment, a mixed environment or be just outside of these environments. Fokker Services likes to stress that this categorization of icing condition is hard to achieve on-board by the pilot (see the conclusions of the Roselawn and the Monroe accidents) and must (also) be done using earth-based systems like (doppler) radar, ATC and weatherforecasts and satellite based information.
response	*Partially accepted* Ground forecasting and detecting tools are considered useful to add information available to flight crews to plan their flight and eventually make a diversion decision or route adjustment. Concerning the in-flight detection of SLD icing conditions (for aeroplanes not certified for safe operation in the entire Appendix O environment), the Agency will propose in an AMC material some criteria and guidance to support the showing of compliance with the rule. The general principle is that the method for determining whether the selected Appendix O icing conditions boundary has been exceeded can be accomplished using substantiated visual cues, an ice detection system, or an aerodynamic performance monitor. The AMC material will explain what is acceptable in terms of visual cues; it is obviously not expected that a pilot is able to assess the size of the super cooled droplets or to measure the exact thickness of ice deposits.

comment	60 comment by: *Goodrich Sensors and Integrated Systems* On page 14, section g, paragraph 8, EASA is proposing extending Appendix P (same as Appendix D) to encompass all known occurrences, i.e., to -75°C. There are practical considerations that should be evaluated for effects on product designs (changes to MTBF, certification testing implications, etc.). Goodrich believes that the final amendment should address the safety intent but allow for some performance degradation at condition extremes.
response	*Noted* We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE Group 89.

comment	67 comment by: *Thales Avionics* The observation of events outside of the envelope in Appendix P figure 1 (particularly at SAT=-70°C, Altitude=45,000ft) make the extension of the envelope to these points mandatory. However, extending the envelope beyond SAT = -70°C should not be considered as not grounded by any observation and

	because of its unreasonable impact on probe designs, on their installation and of the resulting economic impact.
response	*Noted* We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE Group 89.

comment	*76* comment by: *Next Generation Aircraft (Rekkof)* NGA supports the suggestion to move part 2 (note, the Part I in the text is assumed to be a typo) of App C & App O to CS25 book II.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*93* comment by: *AIRBUS* *"The proposed revisions to CS 25.903 would retain the existing regulations and add new sub-paragraphs to be consistent with the proposed CS-E changes in CS-E 780 (please refer to NPA 2011-04). These revisions would allow for approving new aircraft type certification programmes with engines certified to earlier amendment levels. The proposed revisions would make it clear that the proposed CS-E changes would not be retroactively imposed on an already type-certified engine design, unless service history indicated that an unsafe condition was present."* The text should have been written differently to indicate that the proposed CS-E changes would not be retroactively imposed on an already type-certified engine design and nacelle, unless service history indicated that an unsafe condition was present and that if a new nacelle is designed for the already certified engine this nacelle need not be certified to Appendix O icing conditions but should be demonstrated to provide adequate ice protection in Appendix C icing conditions Justification: **Previously Certified Engines** If the engine need not be certified to the new Appendix O conditions then it is logical that the nacelle need not be certified to Appendix O conditions also. It is not feasible nor logical to certify a nacelle and aircraft to Appendix O but not require the engine to be certified to those conditions. Such a certification approach cannot be managed by the aircraft manufacturer. If the engine type has not experienced in service issues when installed in a nacelle compliant with the existing Appendix C icing conditions then it is evident that a different nacelle also designed and demonstrated to meet the requirements of Appendix C will also ensure safe operation when combined with the engine in question. **Certification by Similarity and In-service Experience** An AMC based on in-service history and design similarity to previous designs

with excellent in service record is strongly recommended for all component demonstrations in Appendix O icing conditions. There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

Air Data Probes
Air data probes have been shown in recent years to be sensitive to ice crystals. However tests and in-service experience show that SLD conditions are not critical for air data probe ice protection. Testing to Appendix C icing conditions will therefore continue to ensure adequate safety in SLD conditions. There are no known events that support a safety concern due to air data probe icing in SLD conditions aloft. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of the excellent service history of similar designs in Appendix O conditions, will provide acceptable insurance of future safety.

It is therefore recommended that SLD test requirements are either not applied to air data probes or a single test point be defined. Compliance by design should be allowed in the future AMC.

If needed, EASA can issue special conditions, in accordance with IR 21 to provide adequate safety standards in the unlikely event that [e.g., a future system design is dissimilar enough to warrant concern].

The clarification of the agency's interpretation of 1419c is welcome and Airbus supports this monitoring philosophy. It is noted that this level of monitoring is beyond that required by the existing requirement CS25.1326. Whilst 1419c provides the necessary flexibility it is helpful to have the additional requirement to clearly define requirements for the probe heat monitoring systems. The capability of existing technology and the feasibility of future designs must also be considered. Nuisance alerts shall be avoided as defined by AMC 25.703 in defining an adequate level of monitoring.

Airbus supports the application of CS25 App. P icing conditions to flight critical air data probes. However, there is no safety case for applying App P to non flight critical sensors. It is necessary to develop an acceptable means of compliance that considers the capabilities of the existing engineering tools (models, icing tunnels etc) and provide guidance on these new requirements. Considering that the currently available laboratories cannot achieve the full range of icing and flight conditions, an exemption may be required or specific scaling and test techniques developed.

In addition Appendix P was originally developed to address engine icing events and the means of compliance should consider any differences between the air data probe and engine icing phenomena.

	Significant improvements in one particular test facility have been made in recent years. However despite this progress there are currently no test facilities capable of reproducing the full range of icing conditions and flight conditions required by Appendix P. The existing test facility is also limited by the size of test article it can accommodate. The availability of only one test facility is also of concern. Considering the state of the art of the engineering tools there is a need for an agreed means of compliance. AoA vanes (mechanical means to measure AoA) are significantly less sensitive to crystal conditions than "pitot-static" means. Testing of flush mounted AOA vanes and static ports indicates that they are not sensitive to ice accretion in ice crystal conditions. Testing in supercooled water conditions is therefore normally adequate for mechanical AoA probes. AoA instruments that use air pressure measurements to determine aircraft AoA may be more sensitive to ice crystal conditions. Airbus supports an extension of Appendix P to include all reported in-service engine and airspeed events. In addition Appendix P should be reviewed when the HIWC project reports back on the ice crystal environment characterization flight tests planned for 2012 and 2013 (Refer also to commens on the proposed CS-25.1324 and App P).
response	*Partially accepted* This comment related to the nacelle is not relevant to CS 25.903(a). The nacelle is covered under CS 25.1093(b) and the Agency will propose in a new AMC 25.1093(b) a text explaining in which conditions credit from service experience may be used to show compliance.

comment	*123* comment by: *Mitsubishi Aircraft Corporation* The unit conversion between (km) and (NM) should be mathematically correct using the relation 1NM=1.852km. Specific definition and envelope should be proposed if Figure 1 of Appendix O is extended with ice crystal conditions envelope defined in AMC 25.1419 incorporated. In addition, acceptable means of compliance should be provided for the expanded low temperature conditions. These conditions are quite infrequent and no ground test facility is capable of simulating the proposed conditions.
response	*Noted* Units conversion: Noted. The values are indeed rounded and we do not need a high precision. This table and the horizontal extent values have been successfully used without concern. We understand that you refer to Appendix P instead of Appendix O. We understand your concern on the test facilities capabilities. However such conditions exist, have been encountered and shall be assessed. This is explained in detail in our proposed AMC material. Ice crystals: Testing may not be possible at extremely low temperature due to simulation tool limitations. However, the presence of Ice Crystals has been

observed, and it is anticipated that an extrapolation of existing test data at higher temperature should allow assessing the predicted performance of the probe heating down to this minimum temperature.

comment

154 comment by: *Boeing*

Page: 14
Paragraph: 14. Discussion of the CS-25 rule change proposal
g. Component Requirements

Revise the text that appears below the table as follows:

"Flight instrument external probes include but are not limited to Pitot tubes, Pitot-static tubes, static probes, angle of attack sensors, side slip vanes, and temperature probes ***if shown to be flight critical***."

JUSTIFICATION: Boeing does not agree that certain probes, such as temperature sensors, which are not flight critical, be included in the expanded requirement. The applicant should show the criticality of the measurement, and then apply the regulation as appropriate. See additional comments elsewhere in this document.

response

Not accepted

We maintain the specification that all flight instrument external probes must function normally in all icing conditions.

Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in the draft AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

comment

155 comment by: *Boeing*

Attachment #8

Page: 14
Paragraph: 14. Discussion of the CS-25 rule change proposal
g. Component Requirements
- 7th & 8th paragraphs

And

Page: 7-8
Paragraph: 14. Discussion of the CS-25 rule change proposal
General
- 2nd paragraph

And

Page: 17-18
Paragraph: 15. Differences compared to the FAA NPRM
b. The mixed phase and ice crystals environment proposed by FAA for Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

&

c. The applicability of the FAA proposed mixed phase and ice crystals which is limited to Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

See attached file for comments.

BOEING COMMERCIAL AIRPLANES
Comments on:

Page: 14
Paragraph: 14. Discussion of the CS-25 rule change proposal
g. Component Requirements
- 7th & 8th paragraphs

And

Page: 7-8
Paragraph: 14. Discussion of the CS-25 rule change proposal
General
- 2nd paragraph

And

Page: 17-18
Paragraph: 15. Differences compared to the FAA NPRM
b. The mixed phase and ice crystals environment proposed by FAA for Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

&

c. The applicability of the FAA proposed mixed phase and ice crystals which is limited to Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

Revise the applicable text as follows:

Page 14, paragraph 14.g., 7th & 8th paragraphs:

"The proposed Appendix P is identical to the FAA proposed Appendix D to Part 33, which originated from the ARAC recommendations. Based on EASA knowledge of service experiences with Pitot probes, the associated convective cloud ice crystal icing envelope (Figure 1 of Appendix P) would cover an important portion but not all of the occurrences. Indeed, EASA is aware of incidents of temporary erroneous airspeed indication which happened at high altitude with static air temperature (SAT) below the current proposed Appendix P limit of -60°C. One of these events happened at (SAT=-70°C, Altitude=45,000ft). Other events occurred at SAT above -60°C but at altitudes outside the proposed Appendix P, figure 1.

For this reason, EASA is envisaging an extension of Appendix P, figure 1 envelope to encompass all the known occurrences, with a minimum temperature of -75°C. This extension should also include the current AMC 25.1419 Ice crystal conditions envelopes. Any comments on this proposal are welcome."

And
Pages 7-8, paragraph 14(a), 2nd paragraph:

"Our proposal mainly differs from the FAA's proposal on the following points:

* * *
The mixed phase and ice crystals environment for flight instrument external probes: we propose to use the Part 33 Appendix D proposed by the IPHWG, which would be applicable to all flight instrument external probes which are shown to be flight critical (not limited to Pitot tubes and Angle of attack sensors),"

And
Pages 17-18, paragraph 15.b. and c.

b. The mixed phase and ice crystals environment proposed by FAA for Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

The conditions of FAA proposed environment (Table 1 of §25.1323) are already included in the current EASA AMC 25.1419. EASA has been using the proposed conditions for many years and got strong indications, based on recent in-service data, that the proposed Appendix D to FAR Part 33 does better cover the existing environment.

As recognised by FAA on page 37318 of the NPRM, the FAA proposed Table 1 of §25.1323 would not address some known events of airspeed indicating system malfunctions. EASA proposes to use the mixed phase and ice crystal environment provided in FAA Appendix D to FAR Part 33; these conditions are proposed as a new Appendix P to CS-25.

In addition, again based on in-service experience, EASA fully supports the inclusion of a new requirement to cover freezing rain conditions, as suggested by FAA on page 37318 of their NPRM. The EASA proposed rule includes these freezing rain conditions.

c. The applicability of the FAA proposed mixed phase and ice crystals which is limited to Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

As explained above, EASA has been using the FAA proposed conditions for many years and got strong indications that the proposed FAR Part 33 Appendix D does better cover the existing environment, which is applicable to any external flight critical probe fitted on an aeroplane. Consistently, EASA has recently issued a generic CRI "Flight Instrument External Probes – Qualification in Icing Conditions" which will be used on all new type certificate applications made after 31 January 2010.

Therefore we propose to have a specific requirement for Flight Instrument External Probes (new CS 25.1324) including, but not necessarily limited to Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes and temperature probes, if flight critical."

JUSTIFICATION:

1. Regarding ice crystals — The proposed preamble text acknowledges that new information is available to guide development of an ice crystal envelope appropriate for evaluation of airspeed indication systems. The proposed "Table 1" does not reflect the latest understanding of the ice crystal environment, nor does it cover known pitot icing events, which are published in "Interim Report No 2," Bureau D'Enquetes et D'Analyses pour la securite d'aviation civile (BEA) F-GZCP. We propose that if Appendix P were to be adjusted to reflect the altitude and temperature envelope where known pitot events have occurred, it would be appropriate.

Appendix D envelope was developed from engine powerloss event data by the ARAC Engine Harmonization Working Group. The event data was evaluated from a meteorological perspective and the weather was found to be deep convection with low radar reflectivity at flight level, supporting that it consists of high concentrations of ice crystals which are poor reflectors of radar energy. Further, when an ice detector was installed it did not detect super-cooled liquid. The boundaries of the ALT vs SAT (Appendix P Figure 1) envelope are defined by event data. Since the Appendix was developed in 2005, there have been at least 4 engine events outside this envelope, suggesting that the conditions where deep convection which causes engine events occurs is larger than previously understood. The envelope should be expanded to include these events.

Some pitot events, such as those listed in BEA interim report number 2 on the accident on 1st June 2009 and others known to Boeing have occurred at higher altitude and colder temperatures than the envelope. These also can easily be assumed to be associated with deep convection like that which causes engine events, because deep convection is the only weather present at these altitudes and temperatures.

However, in the Joint meeting Eurocae WG-89 / SAE AC-9C on "REVISION OF ETSO-C16A BASED ON SERVICE EXPERIENCE," other lower altitude events were brought to the committee. A meteorological assessment needs to show that these are indeed the same weather as defined by Appendix P.

Appendix P TWC was scaled to the 17.4 nmi exposure distance which was determined by event data to be a "typical" exposure distance for engines. The TWC envelope was then truncated to the boundaries of the ALT vs. SAT envelope for engine events. The pitot icing incidents known to Boeing have been very short duration, suggesting that the exposure distance relevant to the pitot icing phenomenon may be shorter distance scales at higher water contents.

If Appendix P is to be used for pitot events the following things must be accomplished:

1. Investigate events to ensure they are occurring in deep convection with high concentrations of ice crystals.

2. Revise the boundary of the ALT vs SAT envelope to accommodate new confirmed events.

3. Revise TWC envelope to new ALT vs SAT envelope (there is no data given outside the current envelope boundaries).

4. Determine the appropriate distance scale for pitots and provide advisory material. The standard distance scale can then be adjusted using the extent factor to obtain appropriate TWCs for shorter distance scales, if needed.

2. Regarding freezing rain — The proposed expanded parameters are far beyond anything presented in "An Overview of Appendix X: A Characterization of Aircraft Icing Environments that have Supercooled Large Drops," by Stewart G. Cober and George A. Isaac, which estimated extreme SLD LWC values less than 0.6 g/m^3 for an MVD < 40 ìm, and even the highest measured LWC was less than 1.0 ìm. Furthermore, the data show that LWC decreases as MVD increases; thus, the proposed icing condition with an MVD of 2000 ìm should have a lower LWC rather than an extremely high LWC. These proposed icing conditions (from an un-cited source) do not appear congruous with the hard data from extensive icing research. It is therefore poor judgment, coupled with an unscientific foundation, to propose regulations based upon unsupported and unsubstantiated data. The sources of the conditions must be known and understood, as well as the contradiction posed by many research flights in icing conditions that failed to find conditions remotely resembling these.

3. Regarding expansion of the icing requirements -- The expansion of the icing requirement for air data probes would require further consideration for compliance methods and the regulatory evaluation. The current compliance methods (icing tunnels) for air data instruments cannot produce the cold extremes defined by the Appendix P environment.

4. Regarding expansion of the requirements to all externally mounted probes: Boeing does not agree that certain probes, such as temperature sensors, which are not flight critical, be included in the expanded requirement. The applicant should show the criticality of the measurement, and then apply the regulation as appropriate. See additional comments elsewhere in our comments.

response *Not accepted*

We maintain the specification that all flight instrument external probes must function normally in all icing conditions.

Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in the draft AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

comment *156* comment by: *Boeing*

Page: 14-15
Paragraph: 14. Discussion of the CS-25 rule change proposal
g. Component Requirements
- 3rd & 10th-13th paragraphs

And

Page: 16
Paragraph: 14. Discussion of the CS-25 rule change proposal
h. Engine and engine installation requirements
- 2nd paragraph

Revise the text as follows:

Paragraph 14.g., 3rd & 10th-13th paragraphs:

"~~CS 25.773(b)(1)(ii), for pilot compartment view, would be revised to add requirements for operation in Appendix O icing conditions.~~
* * *
~~In the proposed revision to pilot compartment view requirements and in the proposed new requirements for flight instrument external probes, an aeroplane certified in accordance with CS 25.1420(a)(1) or (a)(2) would not be required to be evaluated for all of Appendix O. For aeroplanes certified in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to safely exit following detection must be considered. For aeroplanes certified in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in, and to safely exit following detection, must be considered. For aeroplanes certified in accordance with CS 25.1420(a)(3), all icing conditions must be considered. Aeroplanes not certified for flight in icing need not consider Appendix O.~~

~~The engine air intake system icing paragraph CS 25.1093 and the propeller de-icing paragraph CS 25.929 contain requirements for operation in icing conditions. As a conservative approach to ensure safe operation of an aeroplane in an inadvertent encounter with icing, the existing CS 25.1093 contains requirements for operation in icing conditions, even for an aeroplane that is not approved for flight in icing. Since proposed Appendix O defines icing conditions that also may be inadvertently encountered, CS 25.1093 would be revised to reference Appendix O in its entirety. This would maintain the conservative approach for this paragraph. CS 25.929 (propeller de-icing) would also be revised to reference Appendix O in its entirety. -~~The proposed revision to CS 25.929 ~~also~~ clarifies the meaning of the words ''for aeroplanes intended for use where icing may be expected.'' The intent has been for the rule to be applicable to aeroplanes certified for flight in icing.

CS 25.929 and CS 25.1323 generically reference icing instead of specifically mentioning Appendix C. Historically, the icing conditions specified in Appendix C have been applied to these rules. For clarity, CS 25.929 is revised to specifically reference Appendix C ~~and Appendix O~~. CS 25.1323 will reference CS 25.1324 which provides the icing conditions to be considered for all flight instrument external probes~~; similarly, the same reference is added to CS 25.1325 for static probes (and sub-paragraphs to CS 25.1325(b) are created for clarity)~~.

~~The proposed revisions to icing regulations for pilot compartment view, propellers, engine air intake system icing protection, flight instrument external probe systems would be applicable to all large aeroplanes to ensure safe operation during operations in icing conditions~~**.**"

Page 16, paragraph 14.h., 2nd paragraph, last sentence:

. . . The proposed rules would require engines and engine installations to operate safely throughout ~~the SLD conditions defined in the proposed new Appendix O~~, the newly defined mixed phase and ice crystal conditions defined in the proposed Appendix P, and in falling and blowing snow.

The changes to the proposed rules for engine and engine installations reflect the conclusions of the ARAC Engine Harmonization Working group that no in flight engine events have been recorded in SLD. This is accepted by the working group as being a result of rigorous compliance for Appendix C. The proposed rules therefore have no new requirements for engines and engine installations in flight, but do have a new CS 25.1093 condition for ground taxi operations in SLD."

JUSTIFICATION:

Boeing is very supportive of the ARAC process and the opportunity it provides to have industry work with the airworthiness authorities early in the rulemaking process to develop recommendations that enhance and improve the efficiency of the overall process. We commend the ARAC Ice Protection Harmonization Working Group (IPHWG) for all the work they did in developing their recommendations to the FAA, which have also been considered by EASA. However, at the June 2009 ARAC Transport Airplane and Engine Issues Group (TAEIG) meeting, Industry identified some significant impacts with the proposed IPHWG recommendations with regard to airplane systems. There was not adequate time to fully address these issues in the IPHWG report and, therefore, we are including them in our comments to the NPA as discussed below and elsewhere in this enclosure.

The IPHWG's review of all available accidents databases for events in icing conditions revealed no events in SLD conditions attributable to any of the subject components. The NPA's "Review of accidents and incidents lessons" accurately states that:

"The IPHWG reviewed icing events involving large aeroplanes and found accidents and incidents that are believed to have occurred in icing conditions that are not addressed by the current regulations. . . .

These icing conditions resulted in flight crews losing control of their aircraft and, in some cases, engine power loss. The IPHWG events review found hull losses and fatalities associated with SLD conditions, but not for ice crystal and mixed phase conditions. . . .
* * *
The incident history also indicates that flight crews have experienced temporary loss of or misleading airspeed indications in severe icing conditions . . . . Due to the way pitot or pitot-static tubes are usually mounted, they are prone to collecting ice crystals. Encountering high concentrations of ice crystals may lead to blocked pitot or pitot-static tubes . . . "

Thus, SLD conditions have resulted in loss of control, while ice crystal and mixed-phase conditions have resulted in power loss and airspeed-indication issues. The safety concerns related to loss of airplane control in SLD conditions are addressed by §25.1420. The engines and Pitot/Pitot-static probe concerns associated with mixed-phase and ice crystal conditions are addressed by proposed §§25.1093, 25.1323, and 25.1325, as well as proposed Appendix P. There are, however, no known events that support an in-flight safety concern for the subject component systems in SLD icing conditions aloft. The safety of these component systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

Lacking any quantifiable safety benefit (also see separate comments on the Regulatory Impact Assessment), we recommend that EASA not place such an immense and unnecessary burden on the large aeroplane industry. We suggest that if needed, EASA can issue a CRI to provide adequate safety standards in the unlikely event that a future system component design is dissimilar enough to warrant concern.

response

Not accepted

CS 25.773: Not accepted
We recognize that there have been no known events supporting the safety concern. However, the Appendix O icing conditions do not have the same effect than the Appendix C conditions (supercooled drops) in particular on side windows. A specific assessment will be required to justify the absence of openable windows. We have retained the IPHWG proposal on this subject.

CS 25.929: Not accepted
We refer to FAA Advisory Circular AC 20-73A, Appendix J, which documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions.

Moreover, the Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore, the entire Appendix O has to be retained.

CS 25.1093(b): We understand the concern and we will propose an AMC 25.1093(b) which will propose using credit from in service experience.

comment

157 comment by: *Boeing*

Page: 16
Paragraph: 14. Discussion of the CS-25 rule change proposal
i. Additional operating limitations

Revise the text as follows:

"A new CS 25.1533 sub-paragraph (c) is proposed to establish **the requirement for** an operating limitation applicable to aeroplanes that are certified in accordance with proposed CS 25.1420(a)(1) or (a)(2). The flight crews of these aeroplanes would be required to exit all icing conditions if they encounter Appendix O icing conditions **in which** ~~that~~ the aeroplane has not been certified to operate ~~in~~."

	JUSTIFICATION: Proposed CS 25.1533(c) would establish the requirement, rather than the limitation itself.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - h. Engine and engine installation requirements p. 15-16

comment	*52* comment by: *Pratt & Whitney* Page: 16 Paragraph: 14. Discussion of the CS-25 rule change proposal h. Engine and engine installation requirements - 5th paragraph Page 16, paragraph 14(h), 5th: “This limitation is necessary since currently we do not have any specific requirements for run-up procedures for engine ground operation in icing conditions. The engine run-up procedure, including the maximum time interval between run-ups from idle, run-up power setting, duration at power, and the minimum ambient temperature**, if any,** demonstrated for that run-up interval proposed in CS 25.1521, would be included in the Aeroplane Flight Manual in accordance with existing CS 25.1581(a)(1) and CS 25.1583(b)(1).” **JUSTIFICATION:** Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1, Condition 1, rime ice condition test temperatures, a more critical point does not exist. If appropriate, no temperature limitation would then be needed in the Airplane Flight Manual.
response	*Accepted*

comment	*77* comment by: *Next Generation Aircraft (Rekkof)* The NPA states on page 14: *"For this reason, EASA is envisaging an extension of Appendix P, figure 1 envelope to encompass all the known occurrences, with a minimum temperature of -75°C. This extension should also include the current AMC 25.1419 Ice crystal conditions envelopes. Any comments on this proposal are welcome".* NGA believes that only a few aircraft can get into temperatures as low as – 75 deg C, hence the regulation should allow the applicant to state that its aircraft cannot get at altitudes achieving these low temperatures. Another issue is: how to demonstrate compliance to these low temperatures. NGA suggests to harmonize with FAA App D.
response	*Not accepted* We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE Group 89.

comment	*94* comment by: *AIRBUS*

	An AMC based on in-service history and design similarity to previous designs with excellent in service records is strongly recommended. The CS-E requirements should be harmonized with the CS 25 requirements. There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety. The ground test table points are included in CS 25 but not CS-E. This is inconsistent and the table of engine ground test points (14CFR Part 33 §33.68 Table 1) proposed by NPRM 10-10 must be added to CS-E Book 1. Otherwise the critical interface between the engine and airframe will not function correctly leading to potential late certification problems or a reduction in safety due to the misalignment of the engine and airframe icing requirements. Regarding freezing fog it is noted that typically freezing fog is rarely a critical point for the engine intake. The freezing fog condition is primarily an important case for the engine itself. It is therefore critically important that the engine and airframe regulations are consistent and harmonized in this area. Safe operation of the power plant in icing conditions is a shared responsibility of the aircraft manufacturer, engine manufacturer and airworthiness authority requiring close co-ordination and disharmonized and inconsistent requirements should be avoided as far as possible. There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.
response	*Accepted* AMC based on in-service history and comments on "no known events that support a safety concern due to engine induction system icing in SLD": Accepted. We will propose an AMC 25.1093(b) which will propose using credit from in service experience. Ground test points table in CS-E: Accepted. We will propose a table in the AMC E-780 proposal.

comment	*97* comment by: *AIRBUS* The text should not refer to *minimum* ambient temperature. The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis as required by CS-E-780. This analysis should also be used to show that at colder temperatures below the AMC 780 Table Conditions (assuming the new AMC includes table conditions) test temperatures, a more critical point does not exist. The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Airplane Flight Manual.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 14. Discussion of the CS-25 rule change proposal - i. Additional operating limitations p. 16

comment	*78* comment by: *Next Generation Aircraft (Rekkof)* The NPA states on page 16 that: *"Based on EASA experience, there is at least one engine event which occurred outside the proposed Appendix P, figure 1 envelope (at approximately Altitude=42,000ft and SAT=-65°C). Therefore, as explained above when reviewing Pitot probes incidents, the EASA is considering the extension of Appendix P, figure 1 to encompass all the events".* NGA would like to know this single event. NGA is currently designing the Fokker100NG, this aircraft will be limited to 39,000ft altitude. We would like to be assured that the App P extension to – 75 deg C will not be applicable to the F100NG. We also suggest removing the wording from this NPA to avoid duplication with NPA2011-0 4.
response	*Noted* The event happened precisely at 41,000 ft / -63 Deg C. Our source for this information is the Boeing AERO magazine (QTR 04/07), article “Engine Power Loss in Ice Crystal Conditions”, figure 4. It was also provided by Boeing in their comment #183. The Flight Safety Foundation also published this article in June 2008.

comment	*95* comment by: *AIRBUS* the text should be: "*A new CS 25.1533 sub-paragraph (c) is proposed to establish <u>a requirement for an</u> operating limitation applicable to aeroplanes that are certified in accordance with proposed CS 25.1420(a)(1) or (a)(2). The flight crews of these aeroplanes would be required to exit all icing conditions if they encounter Appendix O icing conditions that the aeroplane has not been certified to operate in*." CS25.1533 does not establish the limitation but rather establishes a requirement for a limitation.
response	*Accepted*

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 15. Differences compared to the FAA NPRM p. 17-18

comment	*23* comment by: *UK CAA* **Page No:** 17 **Paragraph No:** 15 **Comment:** The differences from the FAA NPRM are agreed and the justifications accepted.
response	*Noted*

comment	*35* comment by: *E. Bakker (Fokker Services)* Comment on: "*EASA therefore proposes a CS 25.1420 rule applicable to all CS-25 large aeroplanes.*" Fokker Services would like to stress the importance of a worldwide standard without difference between the FAA and the EASA. Not working with a worldwide standard will have huge economic impact on aircraft manufacturers and can imbalance the industry.
response	*Noted*

comment	*61* comment by: *Goodrich Sensors and Integrated Systems* On page 18, section 15 d, Goodrich believes that industry study into the practicality of implementing a requirement for "abnormal function" indication of the Pitot heating system should be undertaken prior to incorporation of this requirement into the amended Decision.
response	*Not accepted* A study would be design specific and it is expected that it is performed for any new project.

comment	*79* comment by: *Next Generation Aircraft (Rekkof)* The NPA states on page 17: *"It is agreed that many aeroplanes have been flying safely in SLD conditions for decades.* *It is also recognized that existing large aeroplanes designs are less sensitive to lifting surfaces contamination than aeroplanes designs not covered by the proposed exclusion, but we cannot assume that the design will not change on future aeroplanes and that past service experience will remain applicable. The proposed Certification Specifications will be in application for the next decades, and it is difficult today to predict design evolutions".* This is contradictory to proposed text on page 11 where this is explicitly sought for. The NPA states *"Operational experiences in SLD indicate that CS-25 Appendix C icing conditions standards are no longer sufficient and that the icing conditions standards of CS-25 should be expanded to include SLD, mixed-phase and ice crystal icing envelope without any exclusion of aeroplane class.* *EASA therefore proposes a CS 25.1420 rule applicable to all CS-25 large aeroplanes.*

	NGA believes the above is not true, there is ample evidence that with a properly designed de/anti-ice system, safe flight into ice conditions, incl outside of Appendix C has been performed. In addition, the evidence of just 6 accidents, see our comments on page 25 as well as our comments on page 11, that suggest a deeper analysis into the matter is warranted.
response	*Not accepted*

comment	*80* comment by: *Next Generation Aircraft (Rekkof)* The NPA states on page 18: "*As explained above, EASA has been using the FAA proposed conditions for many years and got strong indications that the proposed FAR Part 33 Appendix D does better cover the existing environment, which is applicable to any external probe fitted on an aeroplane.* Since EASA exists since 2003, the "many years" statement must have meant incl JAA practice. This should be stated assuming this is what has happened. NPA: *"Figures 1 and 4 of the proposed Appendix O* *FAA proposed curves that are different compared to the IPHWG report.* *After discussion with FAA, it seems that these figures should not have been changed (mistake); therefore the EASA keeps the IPHWG report curves.* NGA would appreciate more clear text as to what is the intention.
response	*Noted* Yes it was our intent to refer to the JAA practice before EASA existed. Appendix O Figures 1 and 4: we use the same curves as provided in the IPHWG report.

comment	*89* comment by: *AIRBUS* Airbus agrees with the NPAs objective to harmonize as far as possible with FAA rule. However, the EASA proposal, if adopted, would lead to a significant disharmonisation after a long and thorough rulemaking process in which EASA did not participate. The FAA is required by US law to justify a rule on the basis of costs and benefits and hence to allow the SLD rule to become part of 14 CR Part 25. It was necessary to focus the rule on the aircraft designs or types that have been shown to be susceptible to SLD icing. It should be noted that, as commented by AIA and Airbus, the FAA analysis includes several omissions and hence significantly underestimates the costs for large aircraft certifications. The FAA defined an exemption for aircraft with MTOW greater than 60klbs and non-reversible flight controls because it provides a simple means to focus the rule on aircraft likely to be prone to SLD icing conditions by including criteria based on other design features such as thermal anti-ice systems and leading edge high lift devices. Larger Part 25 aircraft (the fleet of large transport aircraft with MTOW>60 klbs

exceeds 10,000 aircraft) have not experienced the kinds of serious events that led to the development of Appendix O and CS25.1420. These aircraft currently operate in a manner consistent with the "unrestricted" option of CS25.1420(a). To certify to this option Appendix O ice shapes must be accurately defined to allow the aerodynamic impacts of the shapes and the ice protection system design and performance to be well understood early in the process. The IPHWG developed an interim means of compliance based on the maturity of the currently available tools. These tools have been developed after a long and considerable effort by research organisations and Governments in Europe and North America. However, despite these efforts, this means of compliance does not address unrestricted operation in SLD conditions and only applies to detect and exit strategies. The SLD engineering tools (icing codes, icing tunnels, instrumentation) necessary to define Appendix O ice shapes for unrestricted operation do not currently exist. In future it is expected that these tools will be available but due to a refocusing of research activities to other areas and budget reductions the required tools are unlikely to be available before the rule becomes effective. This leaves manufacturers' unable to realistically certify new aircraft for unrestricted operation due to the very high cost and risk. In this context, the position of EASA is not justified and not commensurate with the risk posed by SLDs.

However, it is recognized that even for aircraft with MTOW< 60klbs many have never experienced in-service problems in SLD conditions. A means of compliance based on similarity and good in-service experience of the "similar-to" designs can be expected to ensure that the good in-service experience continues for such "similar-to" new designs. Detailed guidance would be required in the AMC to define what evidence is required to support such a strategy. Augmenting the MTOW criterion to include additional design features such as thermal anti-ice systems and leading edge high lift devices would also benefit the rule or AMC.

The following text is not correct: "*EASA agrees with the IPHWG "majority position" (ALPA, CAA/UK, FAA/FAA Tech Center, Meterological Services of Canada, NASA, SAAB, Transport Canada/Transport Development Center) in the Appendix F of the IPHWG task 2 report rev A, "Response to exclusion from CS25.1420 for aeroplane with certain design features."*

Moreover, new on-going large aeroplane projects already tend to use different anti-icing systems compared to previous usual systems: either based on electrical power architectures or they use engine bleed air anti-icing systems in a different way (e.g. running wet instead of fully evaporative). This, combined with different aeroplane aerodynamic characteristics, makes it difficult to anticipate the aeroplane behaviour when flying in the Appendix O environment. [...] EASA therefore proposes a CS 25.1420 rule applicable to all CS-25 large aeroplanes."

The use of systems that modulate bleed air flow to avoid extraneous bleed flows are neither novel or new with several aircraft models incorporating such systems. In addition such systems can actually provide greater protection due to the possibility to provide more flow when it is needed. The design of "running wet" systems is also neither novel or new with many manufacturers designing such systems. Furthermore even though the use of electrical power is currently relatively unusual, aircraft manufacturers will wish to demonstrate that such a system provides similar levels of protection in Appendix C icing conditions to more traditional systems. If this is achieved, then such systems could be expected to provide a similar level of safety to existing hot air thermal

	anti-ice systems. Significant typographical errors should be corrected. The exemption proposed by FAA is for aircraft with MTOW >60klbs and non-reversible flight controls and not for aircraft with MTOW < 60 klbs. The IPHWG identified no accidents related to SLD icing of windshields, air data sensors or engine intakes. SLD icing was implicated in the loss of control of several aircraft. There was, however, evidence that ice crystals and mixed phase icing conditions led to engine power loss or damage events (due to ice accretion in the turbomachinery or on splitters and stators) and air speed indication issues. The IPHWG and EHWG therefore recommended that mixed phase conditions need be addressed for pitot and pitot static probes (as well as engines). However for the remaining aircraft components the application of the existing appendix C requirements combined with an assessment of in-service history and similarity of future designs to ancestor aircraft can be expected to provide acceptable safety for future designs. Application of Appendix P to flight critical air data probes is supported by Airbus in general (see also later comment related to the proposed CS-25.1324 and App P). However, it is proposed that these test requirements need not be applied to probes that are not flight critical. For example on many aircraft failure of the TAT probes does not create a hazardous condition. In addition Appendix P was developed to address engine events where the overall ice accumulation is a more important factor than the peak Total Water Content (TWC) of the cloud. However for a heated air data sensor the peak TWC is a more important factor. It is therefore recommended to require the use of the peak value of TWC to define air data sensor test requirements rather than the TWC related to the 17.4 nm cloud values defined in Figure 1 of Appendix P.
response	*Partially accepted* Comment on the "means of compliance based on similarity and good in-service experience of the "similar-to" designs": Accepted, the Agency will propose such provisions in an AMC. Comment on the applicability of Appendix P to flight critical air data probes: Not accepted. We maintain the specification that all flight instrument external probes must function normally in all icing conditions. Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in the draft AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

comment	*124* comment by: *Mitsubishi Aircraft Corporation* Although FAA NPRM, Notice No.10-10 has been publically released, the final rule has not been promulgated. New EASE CS regulations should harmonize with parallel new FAA rules.
response	*Partially accepted*

EASA wishes to harmonize as much as possible with FAA, although in some areas we may have differences.

comment	*190* comment by: *Bombardier Aerospace*
	We concur with the statements of 15.a, that small to medium aircraft with reversible flight controls are not inherently at greater risk in severe icing conditions.
response	*Noted*

comment	*199* comment by: *Snecma*
	please see Snecma letter 2764-RC : comment n°9 page 8. Letter is in comment for rule CS-25.1093.
response	*Not accepted* Not accepted. We maintain the specification that all flight instrument external probes must function normally in all icing conditions. Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in the draft AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

A. Explanatory Note - IV. Content of the draft Opinion/Decision - 16. Alternatives to rulemaking p. 18-19

comment	*36* comment by: *E. Bakker (Fokker Services)*
	Fokker Services would like to add the conclusion of the NTSB from the ATR72 Roselawn accident to alternative 1: "***The Safety Board acknowledges the efforts of atmospheric research in the meteorological community and hopes that its important findings will eventually provide the aviation industry with a better understanding of the freezing drizzle/rain phenomenon. The Safety Board concludes that the continued development of equipment to measure and monitor the atmosphere (i.e., atmospheric profilers, use of the WSR-88D and Terminal Doppler weather radars, multispectral satellite data, aircraft-transmitted atmospheric reports, and sophisticated mesoscale models), and the development of computer algorithms, such as those contained in the FAA's Advanced Weather Products Generator (AWPG) program to provide comprehensive aviation weather warnings, could permit forecasters to refine the data sufficiently to produce more accurate icing forecasts and real-time warnings. Therefore, the Safety Board believes that the FAA should continue to sponsor the development of methods to produce weather forecasts that define very specific locations of potentially hazardous atmospheric icing conditions (including freezing drizzle and freezing***

	rain) and to produce short-range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less. "
response	*Not accepted* Alternative 1 deals with means of detecting or identifying icing conditions including SLD. This kind of technology is different from weather forecasts means. What you are quoting is more related to alternative 2, but this does not add information that would propose an additional alternative or change the conclusion of this chapter.

comment	*37* comment by: *E. Bakker (Fokker Services)* Comment on: "*However, this equipment would have limited coverage area.*": Although this equipment would have limited coverage, the equipment can solve a lot of problems for the most critical cases (e.g. near the ground where no room for error exists).
response	*Noted*

comment	*81* comment by: *Next Generation Aircraft (Rekkof)* *The NPA lists two alternatives: "a) Terminal Area Radar and sensors & b) Icing diagnostic and Predictive weather tools"* NGA believes this is where industry drive should be, even though they are not yet available. There will always be ice conditions well outside certification limits. A well documented example is the Lockheed Neptune ice testing in 1948, ref R. L Thoren, “Icing flight tests of the Lockheed P2V”, paper no 48-SA-41, presented at the semi-annual meeting, Milwaukee, Wisconsin, May 30 - June 4, 1948 of the American Society of Mechanical Engineers. The evidence of this test, a lot of drag was added, but the aircraft could keep flying due to its good de-icer design, suggests that conditions were certainly outside appendix C and probably even beyond the Appendix O Limits. Hence, tools for ATC and pilots to be able to exit the conditions in a timely fashion are what the industry needs.
response	*Noted*

comment	*99* comment by: *AIRBUS* It is recognized that terminal area forecasting and the other alternatives considered are long term projects. However it is now clear that developing the engineering tools required for SLD certification is also a long term activity. Although we anticipate the tools being available eventually they are not anticipated to arrive in the short term. When the alternatives to rulemaking were discounted as viable alternatives the great difficulties of providing adequate engineering tools was not fully appreciated. It was assumed that these tools would be developed quicker than has been possible despite huge efforts by NASA, EASA and other organizations.
response	*Noted*

comment	*158* comment by: *Boeing* **Page: 18-19**

Paragraph: 16. Alternatives to rulemaking

Both paragraphs "a. Alternative 1: Terminal Area Radar and Sensors" and "b. Alternative 2: Icing Diagnostic and Predictive Weather Tools" contain the following text, to which Boeing requests the indicated revision:

" … **EASA believes that** rulemaking would still be necessary to establish safety margins for inadvertent flight into such conditions and to provide an option for applicants to substantiate that the airplane is capable of safe operation in SLD conditions."

JUSTIFICATION: Our suggested revision eliminates any ambiguity regarding the fact that this is an opinion not universally shared. Operational solutions have proven to be extremely effective at managing weather-related risks (e.g., thunderstorms, wind shear, others). We consider that EASA should have been, or should start, placing at least as much emphasis on advancing alternatives to rulemaking as they do on creating new certification requirements.

In addition, we note that due to its tasking statement not including such options, the IPHWG did not thoroughly consider any alternatives to new rulemaking.

response *Noted*

A. Explanatory Note - V. Regulatory Impact Assessment - 0. Process and consultation	p. 20

comment *159* comment by: *Boeing*

Page: 20
Paragraph: V. Regulatory Impact Assessment
0. Process and consultation

And

Page: 23
Paragraph: V. Regulatory Impact Assessment
4.1 Applied methodology
- 1st paragraph
4.2 Data requirements
- 1st paragraph

And

Page: 38
Paragraph: V. Regulatory Impact Assessment
5.4.1.2 Certification costs for new projects
- 1st paragraph

Concern: The cost information contained in both the ARAC IPHWG

	recommendations and the FAA's Initial Regulatory Evaluation are incomplete and outdated. The IPHWG manufacturer inputs were estimated in the 2003-04 time period and assumed that industry would have available the necessary engineering tools and methods. That assumption is no longer valid, and thus the cost estimates provided are unrealistically low, as further discussed in separate comments. In addition, updated cost information for compliance with the systems requirements only was provided to the FAA both prior to publication of the NPRM and in our public comments. These are also addressed in separate comments. Industry also made several comments regarding the benefits assessment in the FAA's Initial Regulatory Evaluation, and similar revisions are proposed here in separate comments. Therefore both the costs and benefits aspects of EASA's Regulatory Impact Assessment must be re-evaluated using realistic estimates and assumptions, as discussed in more detail elsewhere in these comments. Although we understand that EASA is not bound by the results of the RIA, we believe that in this case, the financial impact to the larger aeroplane industry is so extreme with no real benefit, that there is no justification for imposing a burden that could well impede the future of the industry. **JUSTIFICATION:** Newer information indicates a much higher regulatory impact on industry than is provided in the NPA. As a result, the RIA should be reworked with the new information taken into account.
response	*Noted* The values were the best available to EASA and FAA.

A. Explanatory Note - V. Regulatory Impact Assessment - 5. Analysis of impacts - 5.1 Safety impact p. 23-31

comment	*38* comment by: *E. Bakker (Fokker Services)* Overall comment on the accident listing: Although the investigation in this NPA of the accidents could be seen as relevant, for most accidents listed here, there is not a clear 1-on-1 relation between the operation in the "Appendix O" icing environment and the cause of the accident: • For the most conclusive cases discussed in this paragraph, the ice build-up had suddenly progressed rapidly and due to other effects (procedures, distraction etc) this led to the actual accident. • All the cases concern aircraft with boot systems where the relatively short de-icing-boot-chord-length may have been an important factor. This is not further elaborated in the NPA. Fokker Services strongly recommends to further investigate the relation between boot length and icing accidents/incidents. • The aircraft mentioned here also all fall in the "smaller" or "medium" sized large aircraft category that should (following the idea in this NPA) in the future be designed to exit the "Appendix O" icing environment. It is uncertain that these aircraft would have enough time to exit the "Appendix O" icing environment (if detected) before the ice build-up has already become critical.

- It is unknown how the flightcrew should detect the "Appendix O" icing condition and differentiate this from the "Appendix C" icing condition in order to decide to leave the flight plan.

response

Noted

We will provide guidance in our AMC material on how the Agency expects detection of SLD icing conditions for which the aircraft is not certified.

comment

39 comment by: *E. Bakker (Fokker Services)*

Comment on the Pine Bluff accident:
Although the conclusion of the NTSB in the Pine Bluff accident is that ice accumulation during climb resulted in a stall at higher-than-normal speed, it was not the only attributing factor. The NTSB report states: "***While it is likely that the accretion of ice alone would not have led to a stall had the captain attempted to maintain a target airspeed instead of a target pitch attitude, the Safety Board cites the captain's inattention to ice accretion as a factor in the accident***". The report points out that the pilot (and also the co-pilot) in this case was distracted for prolonged periods of time and was not following (company) procedures. Also fatigue played a major role. Quote: "***The Safety Board believes that the captain's action was not only contrary to company procedures, but contrary to the principles of basic airmanship***". and "***The Safety Board concludes that the captain's inappropriate selection of the 'pitch hold' mode combined with the flightcrew's subsequent failure to maintain a safe airspeed was the primary cause of this accident***".

Conclusion of Fokker Services: Normal flight instruments and procedures could in essence have been sufficient to prevent this accident.

response

Noted

Ice accretion was identified as a substantial factor which contributed to the cause of the accident. Therefore, taking into account the involved kind of icing conditions into the specifications for the certification of the aircraft would have provided an upgraded level of safety and could have prevented the outcome of this flight.

comment

40 comment by: *E. Bakker (Fokker Services)*

Comment on the Roselawn accident:
The conclusions from the Roselawn accident state that, although it is recognized that flight in icing conditions outside of the Appendix C icing environment was encountered, no adequate information was available at all to the flight crew about the stability and control characteristics, autopilot and related operational procedures in icing conditions.
It is stated that the manufacturer could have disclosed information concerning previously known effects of freezing precipitation, which may have prevented this accident.
It is not stated that information about the conditions of the "Appendix O" environment alone could have prevented this accident, because also for the "Appendic C" environment the information was not readily available for the Aircrew.
Also, the loss of control happened at lower altitudes. Investments in ground based instruments could maybe also have prevented this accident.

response	*Partially accepted* The investigation concluded that the loss of control was probably caused by the accretion of a ridge of ice beyond the de-icing boots through the effects of freezing precipitation, which are outside the Part 25 Appendix C icing environment. Better information to the operators and pilots on the effect of such freezing rain/freezing drizzle may have prevented the accident. There is no identified issue related to information about Appendix C conditions.

comment	*41* comment by: *E. Bakker (Fokker Services)* Comment on the Eagle River accident: Following NTSB docket CHI96FA067, it is not clear whether this accident was caused by specifically an "Appendix C" icing environment.
response	*Partially accepted* The Agency acknowledges that this point was discussed in the IPHWG and that no consensus was reached on the removal of the Cessna 560 event (See Task 2 report including phase IV, page 730 (Attachment A to L374-44-09-001)). Nevertheless, the investigation concluded that icing conditions were a contributor to the event, and persons on ground reported that freezing rain and sleet were falling at the time of the accident. So the Agency keeps this event in the list of accidents which would benefit from the rule.

comment	*42* comment by: *E. Bakker (Fokker Services)* Comment on the Monroe accident (of which the date in the table and in the text do not match!): Although it cannot be excluded that this accident was caused by the "Appendix O" icing environment, the accident did happen in the descent or just before the approach procedure. In this area, it should be considered that ground-based systems could provide adequate information to flightcrew. One of the statements of the accident investigation was to "***require the broadening of the "Appendix C" icing environment to allow operation in those conditions or to avoid those conditions"***. It is however nowhere said how these conditions should be recognized and it is even stated that for flightcrew it is "***not possible to determine the allowable icing conditions"*** and thus to avoid the un-certified icing conditions. Next to that, during the event, operational procedures prohibited the flightcrew to activate the deicing boots (only to be activated when a thicker ice accumulation was observed). Also, because "***the pilots were operating the airplane with the autopilot engaged during a series of descents, right and left turns, power adjustments, and airspeed reductions, they might not have perceived the airplane's gradually deteriorating performance.***"
response	*Noted* The Agency expects that the pilots are provided with clear information of when the aircraft is entering into hazardous icing conditions for which it is not certified for safe flight. An AMC will provide guidance on how to comply. 9 January 1997 is the correct date of the accident.

comment	*43* comment by: *E. Bakker (Fokker Services)*

	Comment on the Pengu Island accident: One of the conclusions of the accident investigations is directed to the DGAC, France: "***Proactively develop a more sophisticated icing detection system to enhance the flight crews' understanding and awareness of icing condition. Evaluate a new system to provide flight crew additional warning when aircraft operates in icing environment with autopilot engaged to reduce the potential risk of pilot's failure of monitoring and maintaining airspeed. Continuously support and engage a research activity similar to Smart Icing System to reduce the accidents caused by severe icing.***" Fokker Services would like to know if any action on this item has been done.
response	*Noted* In order to improve flight crew situation awareness in icing conditions, ATR developed a function called Aircraft Performance Monitoring (APM) that has been mandated by the Agency on all ATR 42 and ATR 72 series through AD 2009-0170 dated 10 August 2009. The APM processes a collection of different parameters and in the end determines the aircraft performance degradation possibly due to abnormal ice accretion. When the performance degradation passes given thresholds, the APM alerts the flight crew to make them aware of potential severe icing conditions degrading the aircraft performance. This system complement the flight crew awareness, but the pilot procedures based on visual cues are still valid and mandated (AD F-1999-015-040 R2).

comment	*44* comment by: *E. Bakker (Fokker Services)* Comment on the Orlando accident: It is not known whether this accident happened due to the "Appendix O" icing environment.
response	*Not accepted* Meteorological data at the time of the accident indicate that Comair flight 5054 may have encountered an area of icing conducive to the formation of super-cooled large droplets (SLD). According to both pilots, shortly after cruise flight was established at 17,000 feet, the airplane entered a cloud and, shortly thereafter, the windshield frosted over with pebble-like rime ice. The first officer stated that immediately before the upset occurred, he switched the leading-edge de-icing system inflation cycles switch from "light" to "heavy" and the propeller de-icing system cycles switch from "norm" to "cold" because he saw "more ice accumulation than he had ever seen" on the wing and spinner. Such severe icing effects are typical of SLD icing conditions that are part of the proposed Appendix O.

comment	*45* comment by: *E. Bakker (Fokker Services)* Comment on the result "*We find a total cost of 245 million Euros, and an average cost per accident of 41 million Euros...*":

	As already indicated with the accident investigations, not all accidents can be correlated 1-on-1 to the absence of an "Appendix O" icing environment in the regulations. It is therefore not fair to include the full 100% of accident cost in this cost-benefit analysis.
response	*Not accepted*

comment	*82* comment by: *Next Generation Aircraft (Rekkof)* To facilitate reading our comments, the NPA text on page 25, as well as one additional accident has been reprinted below in italics, NGA comments and additions in normal text. *<u>30 December 1995</u>* ***Two fatalities*** *occurred as a result of a Cessna 560 colliding with the terrain at the Eagle River Airport, Eagle River, Wisconsin. The National Transportation Safety Board determined that the probable cause of the accident was the failure of the pilot to maintain airspeed while executing the circling approach. Factors were descent below minimum descent altitude, fog, low ceiling and icing conditions.* *Although the ice accretion was not described as consistent with large droplet icing, a sheriff's deputy reported freezing rain and sleet were falling at the time of the accident.* *<u>Justification for applicability:</u>* *Existing aeroplanes have not substantiated that they are capable of operating safely in Appendix O conditions (freezing drizzle and freezing rain). CS 25.1420 would require the aeroplane to be able to operate safely in Appendix O conditions or have a means of detecting Appendix O conditions and be capable of operating safely within those conditions for the purpose of exiting those conditions.* NGA would like to know the boot design incl. chord length on wing upper- and lower surface? *<u>01 September 1997</u>* *An Embraer EMB-120RT crashed while being vectored for approach to runway 3R at Detroit Metropolitan Wayne County Airport, which resulted in* ***29 fatalities.*** *The investigation revealed that it was likely that the aeroplane gradually accumulated a thin, rough glaze/mixed ice coverage on the leading edge de-icing boot surfaces, possibly with ice ridge formation on the leading edge upper surface.* *The National Transportation Safety Board determined that one of the probable causes was the failure to establish adequate aeroplane certification standards for flight in icing conditions.* *Justification for applicability:* *Existing aeroplanes have not substantiated that they are capable of operating safely in Appendix O conditions (freezing drizzle and freezing rain). The proposed CS 25.1420 would require the aeroplane to be able to operate safely in Appendix O conditions or have a means of detecting Appendix O conditions and be capable of operating safely within those conditions for the purpose of*

exiting those conditions.

NGA would like to know the boot design incl. chord length on wing upper- and lower surface?

19 March 2001
An EMB-120 encountered severe icing conditions while in cruise flight at 17,000 feet mean sea level (msl) and departed controlled flight, descending to an altitude of about 10,000 feet. The pilots recovered control of the aeroplane and diverted to West Palm Beach, Florida, where they landed without further incident. 2 flight crew members, 1 flight attendant, and 25 passengers were ***uninjured****, and the aeroplane sustained substantial damage to the elevators and the horizontal stabiliser.*

Justification for applicability:
The aeroplane encountered severe icing conditions and meteorological data indicated that supercooled large droplet icing conditions were probably present. The flight crew delayed exiting the conditions. The proposed CS 25.1420 would require the aeroplane be able to safely operate in Appendix O conditions or have a means of detecting Appendix O conditions and be capable of operating safely within those conditions for the purpose of exiting those conditions.

NGA: This aircraft was able to fly out of the ice conditions, what where the differences and similarities with the other EMB120 accidents?

21 December 2002
The ATR-72 cargo was flying to Macau and it encountered severe icing condition; when flying at FL180, a stall warning sounded and the stick shaker activated, followed by a large pitch angle and a large left bank angle. The autopilot was disengaged and the pilots tried to maintain control of the aeroplane. However, the aeroplane rapidly lost altitude until it crashed into the sea. ***Both crew members were killed.***

Justification for applicability:
The Aviation Safety Council of Taiwan investigation found that the crash was caused by ice accumulation around the aeroplane's major components, resulting in the aircraft's loss of control. The investigation concluded that the icing conditions were beyond the CS-25 Appendix C envelope (in term of liquid water content and maximum droplet size estimations). The investigation identified that flight crew did not respond to the severe icing conditions with the appropriate alert situation awareness and did not take the necessary actions. The proposed CS 25.1420 would require the aeroplane to be able to operate safely in Appendix O conditions or have a means of detecting Appendix O conditions and be capable of operating safely within those conditions for the purpose of exiting those conditions; Appendix O would provide a supercooled large drops icing environment.

NGA: ATR modified its boot length design following Roselawn, ref ATR information leaflet dated 11/05/1995. Had this aircraft modified boots, or was it still to the old design?

In addition, NGA would like to bring to the EASA attention another in-flight ice accident on

4 November 2010 – from http://aviation-safety.net/database/record.php?id=20101104-0

An ATR-72-212 passenger plane, registration CU-T1549, was destroyed in an accident near Guasimal, Sancti Spiritus Province, Cuba. All 68 on board were killed. The airplane operated on Aerocaribbean Flight 883 from Santiago-Antonio Maceo Airport (SCU) to Havana-José Martí International Airport (HAV). It took off from Santiago at 16:44 and climbed to a cruising altitude of FL180. At 17:36 the crew contacted Havana Control, requesting permission to climb to FL200.
During the climb the Total Air Temperature (TAT) dropped from +3°C to -1°C. The airspeed dropped from 196 kts to 176 kts.

At 17:44, at FL200, the ICING caution light illuminated on the instrument panel with an associated chime. This was followed by the illumination of the AOA light several seconds later. At 17:46 the crew toggled the anti-icing switches on the overhead panel and contacted Havana Control to request permission to descent to FL160 due to icing.

However, the controller reported conflicting traffic 30 miles ahead. The crew then requested vectors to enable them to descend. Clearance was given to change course from 295° to 330°. At 17:49, with an airspeed of 156 kts, the airplane commenced a right bank. Then suddenly the airplane banked left and right before banking 90° to the left again with a steep nose down attitude. The crew struggled to control the plane, which was banking turning and losing altitude. At 17:51:03 the airplane struck mountainous terrain.

After a six-week investigation, civil aviation officials concluded that "the flight was proceeding normally until it found itself in extreme meteorological conditions that caused the airplane to ice up severely at an altitude of 20,000ft (6,100m). This, in conjunction with errors by the crew in managing the situation, caused the accident."

NGA would like to know whether this aircraft had the modified ATR boot design or not.

response *Not accepted*

The Agency cannot publish protected design data. Please contact the aircraft manufacturers.

comment *160* comment by: *Boeing*

Page: 27
Section: V. Regulatory Impact Assessment
5. Analysis of Impact
- 2nd paragraph

Revise the text as follows:

"For larger aircraft we used the same assumptions to calculate the cost of an accident except that we also assume an average of 126 seats (same assumption as FAA in their RIA), therefore 126 averted fatalities. This results in an average cost per accident of 266.4 million Euros. **The historical accident rate for the larger aircraft is zero (0).**"

	Concern: The FAA estimate of the annual rate for preventable accidents per affected aircraft of 3.79×10-5 was for the small and medium size of aircraft only. **JUSTIFICATION:** The historical accident rate for the larger category of aircraft is zero (0). As the actual historical rate was used for small and medium aircraft, the actual historical rate should also be used for larger aircraft.
response	*Not accepted* The proposed statement, even if it is true, does not bring clarification to the explanation of the method and assumptions we used. See also our response to comment#161.

comment	*161* comment by: *Boeing* Attachment #9 **Page: 27** **Paragraph: V. Regulatory Impact Assessment** **5. Analysis of Impact** **- Table** Please see attached file for comment
response	*Not accepted* The Agency considered an average risk for all CS-25 aircraft. It is recognized that this may not be the best value applicable to all aeroplanes, for instance the largest CS-25 aeroplanes. Also in the smaller/medium aircraft category, some designs have not faced accidents and could claim that application of the 3.79*10-5 rate to them is not realistic. On the other hand, it should also be noted that we have considered costs assumptions for larger aeroplanes which may be lower in reality for manufacturers who will take benefit from similar analysis based on aeroplane types having a positive safe in-service experience in icing conditions (this would reduce the certification costs). Overall we consider that RIA assumptions are balanced.

A. Explanatory Note - V. Regulatory Impact Assessment - 5. Analysis of impacts - 5.4 Economic impact	p. 32-47

comment	*46* comment by: *E. Bakker (Fokker Services)* Comment on the conclusion of the small CS-25 aeroplanes on page 42: It seems that the cost for aircraft "without SLD ice detection system" is the cost for aircraft with SLD ice detection system without the certification and qualification costs. This is strange because when visual cues are used, this still should be certificated with the EASA to show sufficient compliance with the regulations.

response	*Not accepted* The difference in cost only corresponds to the cost presented on top of page 40 as "SLD ice detection system design, qualification and certification".
comment	*47* comment by: *E. Bakker (Fokker Services)* Comment on the conclusion of the medium CS-25 aeroplanes on page 42: It seems that the cost for aircraft "without SLD ice detection system" is the cost for aircraft with SLD ice detection system without the certification and qualification costs. This is strange because when visual cues are used, this still should be certificated with the EASA to show sufficient compliance with the regulations.
response	*Not accepted* The difference in cost only corresponds to the cost presented on top of page 40 as "SLD ice detection system design, qualification and certification".
comment	*48* comment by: *E. Bakker (Fokker Services)* Comment on the operational costs: Only the weight factor has been accounted for. Adding new ice detectors etc can also have an influence on the aerodynamics of the aircraft and the acoustical profile. These factors are not taken into account by the EASA.
response	*Partially accepted* This effect is difficult to anticipate as we do not know in advance the dimensions and shapes of the detectors or how they would be installed. There could be an effect on the aerodynamic performance but it is anticipated that it would be very small and this would not change the order of magnitude of the operating costs which are already low compared to certification and hardware costs.
comment	*83* comment by: *Next Generation Aircraft (Rekkof)* The NPA states on Page 38: "*These are the costs estimates provided by manufacturers for SLD detection system design, qualification and certification to show compliance with the proposed rule.* *The larger aeroplanes would not need to include this system as we assume that they will be certified for operation in the full Appendix O.* *Moreover, the industry estimates that roughly 50 % of the smaller and medium aeroplanes might be certified using visual cues and the remaining ones might be certified using detectors. Therefore 50 % of the smaller and medium aeroplanes deliveries would be affected".* NGA does not understand this, because the whole document does not provide any substantiation for this assumption, please clarify.
response	*Noted* This assumption is used in the calculations for small and medium aeroplanes, see pages 42 and 43. We have used this assumption by similarity with the FAA RIA.

	This was also a recommendation from the IPHWG Review of Draft Regulatory Evaluation (see task 2 report including phase IV, Attachment A to L374-44-09-001).

comment	*84* comment by: *Next Generation Aircraft (Rekkof)* NPA states on page 39: *- Aerodynamic wind and icing tunnel tests* *Wind and icing tunnel tests would be used by manufacturers to verify compliance of the aeroplane systems and performance; they would also limit the amount of natural icing flight test hours (for cost reason).* To NGA's knowledge, such icing tunnels do not (yet) exist *- Analysis* *Additional costs need to be considered for the analysis and showing compliance with the rule. The methods used are variable and depend on the manufacturer. This may include using icing codes or CFD (Computational fluid dynamics).* To NGA's knowledge, these CFD code's do not (yet) exist, especially there are no validated and accepted tools.
response	*Partially accepted* Icing wind tunnel facilities and ice accretion codes exist, although they have some limitations and may not be entirely validated in some aspects, in particular regarding simulation/production of freezing rain. However, it is expected that these tools will be further developed and improved when the new rule is applicable. The applicant will have to combine all available tools (wind tunnels, ice accretion codes, ice tanker flight test, flight test in natural icing conditions) with engineering judgement to form acceptable means of compliance with the rule.

comment	*162* comment by: *Boeing* **Page: 38** **Paragraph: V. Regulatory Impact Assessment** **5.4.1.2 Certification costs for new projects** **- 3rd & 4th paragraphs** ------------------------------------- **Revise the text as follows:** "- SLD ice detection system design, qualification and certification These are the costs estimates provided by manufacturers for SLD detection system design, qualification and certification to show compliance with the proposed rule**s.** ~~The larger aeroplanes would not need to include this system as we assume that they will be certified for operation in the full Appendix O.~~" **JUSTIFICATION:** In the 3rd paragraph, the word "rule" should be plural since there is more than one proposed rule in this NPA to be considered for SLD ice detection systems.

	The assumption that larger aeroplanes will be certified for operation in the full Appendix O is highly questionable at this time, given the limitations and costs associated with the lack of engineering tools and methods (see separate comments). In accordance with the extension of the IPS activation and operation requirements of CS 25.1419(e)-(h) via proposed CS 25.1420(c), an SLD ice detector will essentially be required for all aeroplanes regardless of the proposed CS 25.1420 certification option. The alternative would be to operate the IPS very conservatively, hence increasing the additional fuel burn costs. (This would also result in having to set stall warning triggers conservatively, causing unnecessarily high operating speeds – which is not an improvement to safety.) While this is a provided option, it is not a realistic one. Ice detectors for Appendix C conditions are currently used on all new larger models for the activation of automatic systems. We do not anticipate going backward. Therefore, costs for "SLD ice detection system design, qualification, and certification" for larger aeroplanes must be included in the RIA.
response	*Not accepted* The proposed rule does not itself impose an SLD ice detector for aircraft certified to fly in the full Appendix O. An applicant may decide to incorporate this function for some reasons like fuel saving, decreasing the exposure of structure to high temperature, … but this is not a cost mandated by the proposed rule.

comment	*163* comment by: *Boeing* Attachment #10 **Page: 39** **Paragraph: V. Regulatory Impact Assessment** **5.4.1.2 Certification costs for new projects** **- 6th – 8th paragraphs** See attached file for comment.
response	*Partially accepted* Icing wind tunnel facilities and ice accretion codes exist, although they have some limitations and may not be entirely validated in some aspects, in particular regarding simulation/production of freezing rain. However, it is expected that these tools will be further developed and improved when the new rule is applicable. The applicant will have to combine all available tools (wind tunnels, ice accretion codes, ice tanker flight test, flight test in natural icing conditions) with engineering judgement to form acceptable means of compliance with the rule.

comment	*164* comment by: *Boeing* Attachment #11 **Page: 38** **Paragraph: V. Regulatory Impact Assessment**

5.4.1.2 Certification costs for new projects
3) Larger CS-25 aeroplanes

See attached file for comments.

response

Not accepted

Your proposed cost for certification a new larger CS-25 aeroplane ($377,021,295 US) is enormously far from the order of magnitude provided inside the IPHWG and the one we calculated. There is a factor of approximately 37.5. There may be over conservative assumptions in your calculations that we cannot check.

You also probably did not consider the possibility of using similarity analysis for some aircraft, which could decrease the certification costs.

comment

165 comment by: *Boeing*

Page: 45
Paragraph: V. Regulatory Impact Assessment
5.4.1.3 Certification costs for derivatives
2) Derivative project involving changes which are significant under Part 21, 21.101

Revise the text as follows:

"2) Derivative project involving changes which are significant under Part 21, 21.101
Examples:
- Modification of the ice protection system involving significant change in the performance of the system or in the architecture of the system (e.g. adding new ice detectors, new ice protection devices),

- Significant changes which would require a complete analysis of the existing ice protection, such as a significant change of the wing profile or wing span.

- Installation of new engines with substantial performance change (typically more than 10 % thrust increase) and/or requiring a complete analysis of the engine anti-ice system.

In such cases, the Agency would require compliance with the last requirements for ice protection as provided in the proposed CS-25 rule.
~~Based on our experience, we believe that the majority of the applications would fall in Option 1.~~

~~The cases which would correspond to Option 2 are very rare, and nowadays manufacturers prefer to propose a completely new aircraft projects instead of proposing expensive modifications of old types. Therefore we consider that the corresponding costs impacts are included in our assessment for new project certification (see previous paragraph).~~ **Via the IPHWG, one industry representative provided estimated additional certification costs for derivative projects. Corresponding data was recently obtained from**

the other European manufacturers. The derivatives certifications are expected to be less complex overall than a new design. As such, manufacturers have provided a range of costs based upon the complexity of the project.

For larger derivative certification projects that might include a new engine installation, costs would be TBD Euros per derivative project. Less extensive derivative projects could be handled through analysis only with average cost of TBD Euros each.

Based on historical data, over a period of 10 years, manufacturers identified an additional TBD programs (beyond the 2.95 new type certificates), TBD larger derivatives at TBD Euros each and TBD less extensive derivates with an average cost of TBD Euros each. As such, the total cost for derivatives is TBD Euros (TBD Euros present value).

Adding the total Option 2 larger airplane derivative cost of TBD Euros (TBD Euros present value) to the new larger airplane Option 1 cost of TBD Euros (TBD Euros present value), the total estimated certification cost for larger airplanes is TBD Euros (TBD Euros present value)."

JUSTIFICATION:

Boeing does not concur with EASA's conclusion and accounting of certification costs for derivatives.

Historical data for derivative certifications were provided via the IPHWG for the FAA's Initial Regulatory Evaluation by one large European manufacturer. This data is available to EASA, and similar data for other larger European manufacturers should be obtained. Based upon our experience and the historical data available to date, Boeing does not concur with EASA's conclusion that the majority of applications will fall under Option 1.

We do note, however, that due to the cost and risk implications discussed elsewhere in these comments, derivative projects could cease (or at least decrease) for cases of the parent model having been certified prior to implementation of these proposed new requirements, unless compliance can be shown via similarity.

Should current and future derivative projects go forward, while the costs for complex projects could be conservatively similar to a completely new project (as EASA proposes), **there will be a significantly higher number of total certifications to account for** during the analysis period than the 2.95 currently estimated in the RIA.

Derivative certification costs are more appropriately estimated in the FAA's Initial Regulatory Evaluation [Lucas, Michael D., FAA Office of Aviation Policy and Plans, *"Initial Regulatory Evaluation, Notice of Proposed Rulemaking, Airplane and Engine Certification Requirements in Supercooled Large Droplet, Mixed Phase, and Ice Crystal Icing Conditions, 14 CFR PART 25 & 33,"* June 16, 2010], and Boeing requests that EASA revise the RIA accordingly.

response	*Not accepted*

Our impact assessment is based on the European fleet. We have not received new element showing that our assumption is not anymore adequate.

comment 166 comment by: *Boeing*

Page: 45
Paragraph: V. Regulatory Impact Assessment
5.4.1.4 Hardware costs

Revise the text as follows:

*"**5.4.1.4 Hardware costs***

The industry provided an estimate for the additional SLD ice detectors at 10000 US dollars, which is equivalent to 7143 Euros (in 2010).
Moreover, the industry estimates that roughly 50 % of the smaller and medium aeroplanes might be certified using visual cues and the remaining ones might be certified using detectors. Therefore 50 % of the smaller and medium aeroplanes deliveries would be affected.
For the larger aeroplanes, ~~we assume that all aeroplanes will be certificated to the full Appendix O, therefore there is no obligation of installing an SLD ice detector, and no~~ **all models are expected to be affected. In addition to ice detectors, hardware costs such as for radome ice protection and for increased engine anti-ice heating would be incurred. Therefore, 100,000 Euros** additional hardware cost **per aircraft** is to be considered.
Using our previous European fleet assessment, we find the following costs:

Smaller aeroplanes (126 aircraft): 900.000 Euros

Medium aeroplanes (116 aircraft): 828.571 Euros

Larger aeroplanes: ~~0~~ **(800 aircraft): 80.000.000** Euro

Total cost: ~~1.728.571~~ **81.720.571** Euros (Present value: ~~965.893~~ **TBD** Euros)"

Concern: The hardware costs do not include all large airplane costs.

JUSTIFICATION: EASA's consideration of "similarity analysis" [ref. paragraph IV.14.e.(C)] as means of compliance is proposed to apply to only CS 25.1420(b), and not to the sections that affect systems [CS 25.773, 25.1093, 25.1323, 25.1324, 25.1325, 25.1396, 25.1419). If our suggested revisions to include systems components are not incorporated [see separate comment on paragraph IV.14.e.(c)], design changes will be required and costs will be incurred, despite the excellent service history of the larger aeroplanes.

As shown in our comment on paragraph V.5.4.1.2.(3), the recurring costs per aeroplane (including the larger size category) are estimated to be in the range of $130,000 to $180,000. In addition, there are costs that could not be quantified in the time available, including changes to several systems (window heat, air data probes, power supply systems, and other).

Relative to our suggested revision of the third paragraph, at this time it is a questionable assumption that the larger aeroplanes will, or will be able to, certify for operation in all of Appendix O. In addition, even if they do, EASA's

	assertion of "no obligation" to install an SLD ice detector is not realistic. In accordance with the extension of the IPS activation and operation requirements of CS 25.1419(e)-(h) via proposed CS 25.1420(c), an SLD ice detector will essentially be required for all aeroplanes regardless of the proposed CS 25.1420 certification option. The alternative would be to operate the IPS very conservatively, hence increasing the additional fuel burn costs. (This would also result in having to set stall warning triggers conservatively, causing unnecessarily high operating speeds – which is not an improvement to safety.) While this is a provided option, it is not a realistic one. Ice detectors for Appendix C conditions are currently used on all newer large jet models for the activation of automatic systems. We do not anticipate going backward. Therefore, the recurring costs for SLD ice detection system hardware for larger aeroplanes must be included in the RIA. Note that commercially useable versions of SLD ice detectors (as opposed to research equipment) have not yet been developed. In addition to ice detectors, the effects of hardware items such as radome ice protection and hardware for increased engine anti-ice heating need to be included. The additional hardware costs estimates range from 88,000 Euros to 122,000 Euros per aircraft, with the range representing smaller- to larger-size models. For the purposes of the RIA, 100,000 Euros is suggested.
response	*Not accepted* For large aeroplanes certified in the full Appendix O, there is no obligation from the proposed rule to incorporate an SLD ice detector. So there is no additional cost involved on this item. Concerning radome and engine air intakes, we do not expect new issues or needs for new protection systems compared to existing aeroplanes (that have successful service experience).

comment	*167* comment by: *Boeing* **Page: 45-46** **Paragraph: V. Regulatory Impact Assessment** **5.4.1.5 Operating costs** **---------------------------------------** **Revise the text as follows:** "- Fuel costs The SLD ice detectors hardware would add weight and thus induce a fuel burn penalty. The estimated additional hardware weight is 19 pounds or 8.6 kilograms. 50 % of the smaller and medium aeroplanes and ~~none~~ **all** of the larger aeroplanes would be concerned. * * * 3) Larger CS-25 aeroplanes For the larger aeroplanes, ~~we assume that all aeroplanes will be certificated to the full Appendix O, therefore there is no obligation of installing an SLD ice detector, and no~~ **there is $7,000 to $9,000 additional fuel cost per aeroplane per year is estimated for the weight of SLD ice detectors.**

In addition, fuel costs will be incurred for design impacts potentially required for compliance with proposed CS 25.1420. This is estimated to be $50,000 to $230,000 (the range representing smaller to larger size models).

Thus, the total additional fuel cost for larger aeroplanes is $57,000 to $239,000 per year per aeroplane.
The total cost over the period of analysis is TBD Euros."

Concern: The fuel costs do not include all large airplane costs.

JUSTIFICATION:

As "similarity analysis" (ref. paragraph IV.14.e.C) of NPA 2011-03 is proposed to apply to only CS 25.1420(b), and not to the sections that affect systems (CS 25.773, 25.1093, 25.1323, 25.1324, 25.1325, 25.1396, 25.1419), design changes and cost will be required, despite the excellent service history for the larger size category aircraft.
At this time, it is a questionable assumption that the larger aeroplanes will, or will be able to, certify for operation in all of Appendix O. In addition, even if they do, EASA's assertion of "no obligation" to install an SLD ice detector is not realistic. In accordance with the extension of the IPS activation and operation requirements of CS 25.1419(e)-(h) via proposed CS 25.1420(c), an SLD ice detector will essentially be required for all aeroplanes regardless of the proposed CS 25.1420 certification option. The alternative would be to operate the IPS very conservatively, further increasing the additional fuel burn costs. (This would also result in having to set stall warning triggers conservatively, causing unnecessarily high operating speeds – which is not an improvement to safety.) While this is a provided option, it is not a realistic one. Ice detectors for Appendix C conditions are currently used on all new larger models for the activation of automatic systems. We do not anticipate going backwards. Therefore, the fuel burn costs associated with SLD ice detection system hardware for larger aeroplanes must be included in the RIA.

As shown in our comment on paragraph V.5.4.1.2.(3), the annual fuel burn per airplane due to additional ice detection system weight was in the range of $7,000.00 to $9,000.00. In addition, the fuel costs associated with potential design impacts required for compliance with proposed CS 25.1420 must be included. These are estimated to be from $50,000 to $230,000, with the range representing smaller to larger-sized models. Given the large spread, unlike a previous comment, here we have not suggested a median value. There would also be fuel costs due to changes to several systems (window heat, air data probes, power supply systems, etc.) that could not be quantified in the time available.

response *Not accepted*

Refer to our response to your comment #166.

comment *168* comment by: *Boeing*

Attachments #12 #13

Page: 46
Paragraph: V. Regulatory Impact Assessment
5.4.1.5 Operating costs

Revise the text as follows:

"- Other operating costs

Smaller and medium aeroplanes: as recommended by the IPHWG, other operating costs ~~could be~~ **are** added for aeroplanes not certified for operation in ~~severe icing conditions like~~ the SLD environment. These costs come from **operational effects such as** the requirement to make diversions when exiting from SLD conditions, diverting the aeroplane to an alternate airport, or from ~~cancellations of~~ flight~~s~~ **delays and cancellations**.

Meanwhile, today operators already follow procedures to avoid flying in or exit from severe icing conditions as required in Aeroplane Flight Manuals (using visual cues); Airworthiness Directives were published in the past years to address this subject.

~~Therefore operators already bear the cost of diversions or flight cancellations and this NPA does not need to consider this cost in its impact assessment.~~

However, an IPHWG assessment considered that not all SLD icing conditions are currently recognized as or considered to be "severe" icing for all affected aeroplanes. Thus, the current procedures and practices are not believed to be commensurate with the operational implications of the proposed rules. The presence of SLD icing conditions at both the point of departure and the destination need to be considered for dispatch for aircraft not certified to operate in the entirety of Appendix O. En-route SLD encounters will require immediate safe exit from all icing conditions, which may also result in flight diversions to alternate destinations. This assessment showed that there are significant costs due to increased in-flight diversions and flight cancelations. For the small and medium aeroplane fleets, the additional operational cost estimate totals TBD present value.

Larger aeroplanes: assuming that **only a percentage of** these aircraft will be certified to the full Appendix O **during the analysis period**, there will ~~not~~ be ~~any~~ additional cost from diversions ~~or~~ **and** cancellations. **The additional operational cost estimate totals 60,734,388 Euros present value.**

The combined additional operational cost estimate for all three fleets totals TBD Euros present value."

Concern: We do not concur with EASA's conclusions regarding current operating procedures of smaller aeroplanes, nor those regarding large aeroplane certifications. The RIA should include realistic industry operating costs resulting from the impacts of the proposed rules.

JUSTIFICATION:

While operators "might" recognize SLD conditions as "severe" icing, it is viewed as highly unlikely that all SLD conditions are currently recognized as severe icing. The proposed regulations require certified methods of recognizing or detection of SLD conditions. Thus, it is not clear how operators could currently understand the full breadth of how these proposed regulations are going to impact them operationally.

Except for smaller-airplane operators that are already prohibited from taking off into SLD conditions, in general, we do not believe that the operators which would be affected [i.e., those operating airplanes certificated to §25.1420(a)(1) or (a)(2)] are currently complying with the operational implications. Thus, there will be additional operating costs which must be accounted for in order to have a more accurate representation of the total industry costs associated with these proposed rules.

While "operators already follow procedures to avoid flying in or exit from severe icing conditions as required in Aeroplane Flight Manuals (using visual cues)," it is viewed as highly unlikely that the flight crews currently understand or monitor those visual cues and recognize all SLD icing conditions as severe icing conditions. Under the proposed new rules, flight crews would be required to recognize or otherwise detect SLD conditions (regardless of whether they are deemed "severe") and take appropriate actions. If an aeroplane is not certified for flight in the entirety of Appendix O conditions, the appropriate actions would include diverting to exit icing conditions. It is viewed as highly unlikely that there would be not be significant additional diversions due to the requirement to exit all icing conditions when SLD conditions are detected.

If an aeroplane is not certified for flight in the entirety of Appendix O conditions, the presence of SLD icing conditions at both the point of departure and destination would have to considered prior to departure. It is viewed as highly unlikely that there would be no greater rate of delays and cancellations due to the requirement to include SLD icing conditions in the dispatch criteria.

At this time, it is a questionable assumption that manufacturers of the larger aeroplanes will choose to, or will even be able to, certify for operation in all of Appendix O during the analysis period. In addition, there is a significant range of aeroplane types included in the "large" category (per Table 7), and it is doubtful that all of those manufacturers will make the same decisions for their certification projects. Thus, there are expected to be operating costs associated with diversions, cancellations, etc., for some (perhaps many) of the larger aeroplane fleet as well. It is anticipated that as the engineering tools and methods and processes are developed and mature over time, manufacturers may eventually be able to expand their certification options. For the purposes of the RIA, we propose that it is reasonable to assume as follows: 50 percent will certify to CS 25.1420(a)(1); 25 percent will certify to CS 25.1420(a)(2); and 25 percent will certify to CS 25.1420(a)(3).

Using 2003 industry-accepted values for the costs of cancellations and diversions, the present value of the operational impact is significant – nearly 15,000 Euros per "detect and exit" aeroplane annually (based upon the attached operational cost model spread sheet, which has not been corrected for out-of-date cost item assumptions such as fuel, flight cancellations, etc.).

Adjusting the spread sheet per the RIA scenario for large aeroplanes and the certification option percentages suggested above, the operational impacts could affect over 1.5 million large aeroplane flights annually. The cost estimate totals 60,734,388 Euros present value. These costs, as well as the corresponding

	costs for the small and medium fleets, must be included in the RIA to more adequately account for realistic costs to industry resulting from the proposed rulemaking. Please see the attached files, which represent the operational cost model spreadsheet as modified by the FAA and provided to the economist during the ARAC process.
response	*Not accepted* Concerning small and medium aeroplanes, AFM procedures are existing which requires exiting severe icing conditions such as SLD icing. It is assumed that flight crews (at least the very large majority of them) apply the AFM procedures. About the larger aeroplanes, we are still confident that they can be certified in the entire Appendix O.

comment	*188* comment by: *Bombardier Aerospace* By only considering aircraft designed, manufactured and operated in EASA countries in this analysis, the number of affected aircraft is underestimated. Costs will be overestimated for manufacturers in member states who export a portion of their production to non-member states. Costs for operators of aircraft produced in non-member states will be underestimated.
response	*Noted*

comment	*189* comment by: *Bombardier Aerospace* The first aircraft certified to a new requirement will bear the brunt of the development costs. If the implementation of the requirements could be staged so that no single aircraft program has to develop solutions to all new requirements at once, the economic impact would be greatly mitigated. We suggest that requirements that could be practically met without significant technological development could be mandated at the earliest date. Requirements dependent on test facilities (icing tunnels and icing tankers) capable of generating SLD/mixed-phase icing would require an additional interval of time to become operational, while requirements relying on as-yet unavailable technology such as the SLD/mixed-phase icing detection requirements of CS 25.1420(a) would be mandated at the latest date to allow sufficient time for development of what are currently immature technologies.
response	*Not accepted* We do not believe that specifying different compliance dates is a good solution. Concerning means of compliance, the applicant will have to combine all available tools (wind tunnels, ice accretion codes, ice tanker flight test, flight test in natural icing conditions) with engineering judgement to show compliance with the new specifications. We are confident that those means will mature and be improved when the new rule is published. The same applies to means of detection.

comment	*191* comment by: *Bombardier Aerospace*

	We question the accuracy of the time estimates for the conduct of flight tests in natural icing conditions. By definition, Appendix O conditions are uncommon, comprising approximately 1% of all icing conditions. At this rate of incidence, we would expect full demonstration of all performance requirements under Appendix O conditions to take nominally 100 times longer than under Appendix C conditions, and this does not seem to be reflected in the flight test cost estimates.
response	*Not accepted* The amount of flight test hours in natural icing conditions will depend on the using of other means like wind and icing tunnels, ice accretion simulation codes, ice tanker flight tests. We have used values similar to the FAA Initial Regulatory Evaluation, which are based on industry estimates for the approximate number ofhours required to demonstrate compliance with the proposed requirements.

A. Explanatory Note - V. Regulatory Impact Assessment - 5. Analysis of impacts - 5.6 Impact on regulatory coordination and harmonisation p. 47

comment	*85* comment by: *Next Generation Aircraft (Rekkof)* The NPA states under: ***"6.1 Comparing the options*** *The Agency prefers Option 1, rulemaking action.* *The associated total cost of 51.8 million Euros (Nominal value: 57.7 million Euros) brought by the proposed rule is considered balanced by the safety benefit of 76.3 million Euros (Nominal value: 183.1 million) of preventing accidents. The net benefit of option 1 is 24.5 million Euros.* *Although there are no documented fatal accidents in the EU caused by the specific severe icing environment, we consider that the safety threat is present with an equivalent probability as established by the FAA and that Certification Specifications must be updated to better protect new aeroplane types.* The above considers visual cues only, which NGA believes is not an option, since no in flight ice detectors exist that are capable of detecting droplet size, and thus Appendix O conditions. Therefore, it is our firm belief that aircraft, and certainly the smaller transport aircraft cannot be designed to sustain the severe icing conditions as given in Appendix O, unless radically new concepts are employed such as but not limited to wing upper surface heating using heat mats up to the wing highlight. To achieve sufficient electrical power and redundancy, it is estimated that a twin engine transport the size of a Fokker 100NG would require two additional 40 KVA IDG generators. This will require major changes to engines and engine gearboxes, quite apart from the additional system cost and weight, the installation of heat mats, etc. In addition, use of electrical devices in close proximity to the wing fuel tanks brings additional certification problems to meet the SFAR88 fuel flammability requirements, further increasing complexity and cost. NGA believes the NPA mentioned costs will not be anywhere near the real costs of the above mentioned electrical solution.
response	*Not accepted*

	There are currently no evidence showing that future CS-25 aeroplanes (especially the larger CS-25 aircraft) will need to have a wing upper surface heating system installed. Neither did the IPHWG identify this requirement. Such requirement would not be generated by the proposed rule.

A. Explanatory Note - V. Regulatory Impact Assessment - 6. Conclusion and preferred option p. 47-48

comment	*71* comment by: *E. Bakker (Fokker Services)* The CS-25 aircraft fleet is divided in three sub-groups (smaller, medium and larger) in the cost analysis of the NPA, the accidents should also have been rated accordingly: • Four accidents in the smaller CS-25 group (3x EMB-120 and 1x Cessna 560), leading to 31 fatalities and 13 minor injuries, • Two accidents in the medium CS-25 group (2x ATR-72), leading to 70 fatalities and 0 minor injuries and • Nil accidents in the larger CS-25 group, leading to nil fatalities and nil minor injuries. Therefore, the effect of the Appendix O conditions on the three groups might also not be the same (a large CS-25 a/c might be less affected by the Appendix O conditions) and cannot be generalized over the three groups. Next to that, the type of aircraft could also have been of influence. 99 Fatalities and 13 minor injuries happened with prop aircraft and 2 fatalities and 0 injuries happened with jet aircraft. Why is that division not made in the analysis i.s.o. the weight division?
response	*Noted* It is accepted that the effect of flying into Appendix O icing conditions may be different depending on the aircraft size and design.

comment	*169* comment by: *Boeing* Attachment #14 **Page: 47 & 48** **Paragraph: V. Regulatory Impact Assessment** **5.4.1.6 Cost Summary** **And** **6. Conclusion and preferred option** **6.1 Comparing the options** See attached file for comments.
response	*Not accepted* See our response to comment #164.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 p. 53

comment	*24* comment by: *Dassault Aviation* Dassault aviation comments on §: Proof of compliance - §25.21(g)(3) (page 53) " If the applicant seeks certification for flight in any portion of the icing conditions of appendix O of this part, each requirement of this subpart, except §§ 25.123(c), 25.143(b)(1) and (2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the appendix O icing conditions for which certification is sought. and Appendix O - Part II(c)(1) (page 73): "Takeoff ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and 122 m (400 feet) above the takeoff surface, assuming accretion starts at liftoff in the icing conditions defined in Part I of this appendix." <u>Comment:</u> The requirements for safe operation in any portion of proposed Appendix O are similar to those currently required for Appendix C, with one exception: compliance with §25.121(a) Climb one engine inoperative - take-off, landing gear extended would be required for Appendix O. Taking into account §25.111(c)(4) - *"the airplane configuration may not be changed, except for gear retraction …… until the airplane is 400 ft above the take-off surface"*, ice accretion which should be considered to show compliance with §25.121(a)(1) should be the one occurring between liftoff and the point at which the landing gear is fully retracted. <u>Requested Change:</u> It is proposed to add in Appendix O - Part II(c) a definition for the Takeoff - landing gear extended ice: "Takeoff - landing gear extended ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and the point at which the landing gear is fully retracted, assuming accretion starts at liftoff in the icing conditions defined in Part I of this appendix."
response	*Not accepted* We have agreed with the comment #129 from FAA proposing adding CS 25.121(a) in the list of exception of CS 25.21(g)(3).

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.21 Proof of compliance p. 53-54

comment	*4* comment by: *Transport Canada Civil Aviation Standards Branch* **<u>CS 25.21(g) – Proof of Compliance –</u>** Transport Canada notes that the proposed EASA NPA 2011-03 wording for CS 25.21(g) is similar to CS 25.1420(a) which makes the new design requirement applicable to all CS 25 aeroplanes.

	As per the EASA NPA 2011-03 – Section 15(a) – Differences Compared to the FAA NPRM -, the CS 25.21(g) proposal would not be harmonized with the proposed FAA NPRM 10-10 wording where an applicability discriminator for take-off weight or reversible flight controls is included. Transport Canada supports the proposed applicability wording for CS 25.21(g) in EASA NPA 2011-03. Refer to specific Transport Canada comments to CS 25.1420(a) – Applicability.
response	*Noted*

comment	*5* comment by: *Transport Canada Civil Aviation Standards Branch* **CS 25.21(g) – Proof of Compliance –** The proposed wording in EASA NPA 2011-03 for CS 25.21(g)(3) and (g)(4) state an exception for compliance to CS 25.251(b) through (e). Transport Canada believes that service experience and other test evidence suggests that exposure to Appendix O icing conditions may result in icing accretions further aft on fuselage, wing and stabilizer surfaces and control surfaces than would normally be obtained in Appendix C conditions. Therefore, existing and past practices and experience justifying no need to consider these paragraphs for Appendix C icing conditions may not be valid for Appendix O. Transport Canada suggests that consideration should be given to retaining CS 25.251(b) through (e) for Appendix O icing condition with a method of compliance to be determined.
response	*Not accepted* The existing CS 25.21(g)(1) exception for CS 25.251(b) through (e) was developed by the Flight Test Harmonisation Working Group (FTHWG), based on a review of all incidents and accidents in icing conditions. The CS 25.21(g)(1) exemptions were determined to be beyond what was necessary to determine an aeroplane's ability to be safely operated in icing conditions. As the in-service review did not limit itself to Appendix C icing conditions, the same lessons learnt can be applied to Appendix O icing conditions. Therefore, we decide not to change the proposed rule.

comment	*70* comment by: *Thales Avionics* The CRD should provide a rationnal as to why Appendix P is excluded of CS 25.21 (g), 25.123 (b) (2) (i), 25.143 (c) et (i), 25.207 (h), 25.253 (c), 25.773 (b) (1) (ii).
response	*Accepted* Please refer to IPHWG report and FAA draft AC 20-147A. The results of FAA aerofoil testing in a mixed phase icing environment indicates that these icing conditions do not appreciably accrete on unheated aircraft wings. Furthermore, the testing showed that exposure to mixed phase environment results in the same or less ice accretion than exposure to supercooled liquid water environment with the same Total Water Content (TWC).

comment | 170 | comment by: Boeing

Page: 53
Paragraph: B(I). Draft Decision amending CS-25
CS 25.21 Proof of compliance

Revise the text with the following considerations:

CS 25.21Proof of compliance

(g) …

"**(1) Paragraphs (g)(3) and (g)(4) of this section apply only to aeroplanes with one or more of the following attributes:**

[Option 1]
(i) Takeoff maximum gross weight is less than 60,000 pounds; or
(ii) The aeroplane is equipped with reversible flight controls.

Or ***[Option 2]***
(i) The aeroplane is equipped with reversible flight controls; or
(ii) The aeroplane is not equipped with a thermal anti-icing wing ice protection system; or
(iii) The aeroplane is not equipped with wing leading-edge high-lift devices (i.e., slats or Krueger flaps).

~~(1)~~ **(2)** Each requirement . . . .

~~(2)~~ **(3)** If the applicant does not seek certification for flight in all icing conditions defined in Appendix O, each requirement of this subpart, except CS 25.105, 25.107, 25.109, 25.111, 25.113, 25.115, 25.121, 25.123, 25.143(b)(1), (b)(2), and (c)(1) **if appropriate**, 25.149, 25.201(c)(2), 25.207(c), ~~and~~ (d), **and e(1)**, and 25.251(b) through (e), must be met . . . .

~~(3)~~ **(4)** If the applicant seeks . . . ."

JUSTIFICATION:

The revisions to proposed CS 25.21(g) reflect those necessary pursuant to the recommended applicability of proposed CS 25.1420, as well as correction of the takeoff requirements as discussed in separate comments.

Regarding the applicability of proposed CS 25.1420, Boeing stands behind the Minority Position contained in Appendix F of the IPHWG Working Group Report. We maintain that application of proposed CS 25.1420 to all CS-25 aeroplanes is unnecessary and unwise. It will have the unintended effect of inhibiting the viability of new "larger" large aeroplane programs due to insurmountable compliance requirements and associated prohibitively high costs and programme risks.

Following years of harmonization effort and opportunity, the lack of harmonization with the FAA's proposed § 25.1420 on such a fundamental and critical issue is unacceptable. Therefore, we prefer our suggested revision option No. 1 to accomplish harmonization.

However, we acknowledge EASA's issues with the 60,000 lb. weight criterion. Therefore, we are alternately proposing option No. 2 for consideration by both EASA and the FAA. Option No. 2 would eliminate the weight discriminator, maintain the reversible controls criterion, and add the additional criteria of thermal anti-icing wing ice protection systems and wing leading-edge high-lift devices. We believe that this combination of design features will result in CS 25.1420 being applied to only to those aeroplanes with similar design features as those that have had accidents and incidents in SLD icing conditions. The result would be similar to EASA's interim CRI philosophy by focusing on aeroplanes with design features of potential concern. We request that EASA and the FAA jointly, and favorably, consider harmonization based on option 2. We note the FAA's statement in their NPRM: *". . . EASA has a project similar to SLD on its rulemaking inventory and our intent is to harmonize these regulations."* (75 FR 37320, 29 June 2010)

It is clear that reversible controls have contributed to accidents in SLD conditions, but no aeroplane with irreversible controls has had an in-flight SLD event. Similarly, no aeroplane with a thermal anti-icing ice protection system and leading-edge high-lift devices has had an SLD event, but some aeroplanes with "de-icing boot" ice protection systems and "hard" leading edges have had events. We submit that reconsideration of these design features as discriminating criteria for the applicability of proposed CS 25.1420 is warranted. We also note that relative to EASA's consideration of accepting similarity and service history as means of compliance, it is these very types of design features that would establish similarity with predecessor models. To accept their value via means of compliance but deny the same in application of the rule is illogical.

The EASA concern that future designs may not result in the same level of exemplary safety ignores the fact that recent models meet far more stringent performance and handling qualities requirements for flight in Appendix C icing conditions, due to recent CS-25 amendments, than the majority of the current larger aeroplane fleet that has accumulated the excellent safety record in icing conditions. Thus, it is prudent and reasonable to assume that any new larger aeroplanes that achieve certification to the latest Appendix C icing requirements, even with novel designs, will have to be at least as safe for operation in all icing conditions as current models.

Current flight operations for the "larger" large aeroplane types are consistent with the "unrestricted" option of proposed CS 25.1420(a)(3). Since that is the way that these aeroplanes have operated safely for decades, the airlines and the flying public expect no less in the future. Certification via this option, as well as for the "approved portion" of option (a)(2), requires extensive knowledge of estimated Appendix O ice shapes very early in the airplane <u>design phase</u> in order to ensure compliant aerodynamic and ice protection system characteristics. This was emphasized in the Minority Position on natural SLD flight testing contained in the IPHWG Working Group Report. Using natural SLD flight testing as a tool during the aeroplane design phase is simply unrealistic.

It is well known that despite lengthy efforts by government research agencies within Europe, Canada, and the U.S., the SLD engineering tools and methods (icing codes and icing tunnels) necessary to reliably determine "operation in Appendix O" ice shapes are not currently available. Furthermore, due to research budget cutbacks, these necessary tools are not likely to become available until long after the proposed regulations take effect. As a result, the

IPHWG produced simplified interim means of compliance during their Phase IV activity (contained in an Appendix to the FAA's draft AC 25-XX). However, due to the FAA's lack of confidence in the currently available engineering tools and methods, simplified means of compliance are proposed to only be applicable to the SLD "detect and exit" certification options of proposed CS 25.1420(a)(1) and (a)(2) for the unapproved portions.

Per the FAA's draft guidance material, certification to operate within Appendix O will require significant flight testing in natural SLD conditions as means of compliance. Thus, manufacturers desiring to certify new models for operation in SLD conditions will face prohibitively high development and certification costs, and in addition will face very high levels of risk. Both are unacceptable from an industry business perspective and may result in the elimination of new product programmes. (For more on the economics, see separate comments on the Regulatory Impact Assessment section.) While we do not believe that it is EASA's intention to force the industry into an "insignificant-change derivatives only" future, we believe that could be the consequence of proposed CS 25.1420.

Another option that manufacturers of large airplanes are forced to strongly consider is to operate new large jets as "detect and exit" aeroplanes. The impact on industry-wide operations of such a drastic change could become severe. Consider, for example, in the case of FZDZ at a major airport – mass diversions, emergency landings, and cancellations. This could create an even more hazardous situation than the icing conditions. As undesirable as the "detect and exit" option is for larger aeroplanes, at this time, we are not certain whether certification for unrestricted operation in SLD conditions will be feasible for the foreseeable future.

response

Partially accepted

The Agency maintains its position explained in NPA 2011-03 and does not exempt aircraft based on a weight criterion.

It is accepted to add CS 25.207(e)(1) in the list of exceptions for aircraft certified in accordance with CS 25.1420(a)(2).

comment

192 comment by: *Bombardier Aerospace*

We propose that the Appendix O requirements of 25.21(g)(3) be limited to those that address relevant safety concerns regarding stability and handling only: 25.143 excepting (b)(1), (b)(2), (c); 25.145; 25.147; 25.207 excepting (c), (d) and (e)(1). When seeking certification for unrestricted operation in Appendix O conditions, the proposed scope of performance requirements in §25.21(g)(4) is appropriate. Where the applicant does not intend to certify the aircraft for unrestricted operation however, the exhaustive minimum requirements of §25.21(g)(3) result in considerable substantiation analysis, development and certification testing that does not directly address the specific safety concern identified with flight in SLD and mixed-phase conditions. This concern is an irrecoverable loss of control of the aircraft caused by ice build-up in front of the control surfaces.

We also find the proposed ice accretion scenarios are elaborate and will unduly penalize aircraft capabilities if Appendix C and Appendix O accretions need to be combined to assess performance against the majority of requirements of

	Subpart B of Part 25. Beyond these performance penalties, the ability to encounter both of these conditions on a single test flight would be highly improbable and thus impractical to demonstrate. In order to address the relevant safety concerns, for unprotected surfaces we propose the deletion of the requirement to combine Appendix C and Appendix O conditions, as Appendix C ice accretions are large enough to confirm the aerodynamic robustness of these surfaces in the presence of icing contamination. For protected surfaces, we propose a requirement to demonstrate that any additional residual ice behind the protected area and in front of reversible flight control surfaces has no impact on performance. Until the development of an accepted analysis method, a quarter round 1-inch ice shape just aft of protected areas would be acceptable for this demonstration. This quarter-round shape is developed from the flight test data requested by the FAA in support of AD-99-19-182.
response	*Partially accepted* We agree with the first part of the comment. CS 25.21(g)(2) (incorrectly referred as (g)(3) in your comment) has been updated by adding CS 25.207(e)(1) in the list of exceptions. We disagree with the second part of the comment. Limiting the analysis to Appendix C and using a quarter round 1-inch ice shape just aft of protected areas is not considered acceptable to demonstrate safe operation or exit from Appendix O icing conditions. Analytical codes are being developed to simulate SLD accretion ice shapes and we expect applicants to use this kind of tool to generate accretion shapes.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.123 En-route flight paths p. 55

comment	*70* ❖ comment by: *Thales Avionics* The CRD should provide a rationnal as to why Appendix P is excluded of CS 25.21 (g), 25.123 (b) (2) (i), 25.143 (c) et (i), 25.207 (h), 25.253 (c), 25.773 (b) (1) (ii).
response	*Accepted* Please refer to the IPHWG report and FAA draft AC 20-147A. The results of FAA aerofoil testing in a mixed phase icing environment indicates that these icing conditions do not appreciably accrete on unheated aircraft wings. Furthermore, the testing showed that exposure to mixed phase environment results in the same or less ice accretion than exposure to supercooled liquid water environment with the same Total Water Content (TWC).

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.207 Stall warning p. 56-57

comment	*70* ❖ comment by: *Thales Avionics* The CRD should provide a rationnal as to why Appendix P is excluded of CS 25.21 (g), 25.123 (b) (2) (i), 25.143 (c) et (i), 25.207 (h), 25.253 (c), 25.773 (b) (1) (ii).

response | *Accepted*

Please refer to the IPHWG report and FAA draft AC 20-147A.

The results of FAA aerofoil testing in a mixed phase icing environment indicates that these icing conditions do not appreciably accrete on unheated aircraft wings. Furthermore, the testing showed that exposure to mixed phase environment results in the same or less ice accretion than exposure to supercooled liquid water environment with the same Total Water Content (TWC).

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.253 High-speed characteristics p. 57

comment | *70* ❖ comment by: *Thales Avionics*

The CRD should provide a rationnal as to why Appendix P is excluded of CS 25.21 (g), 25.123 (b) (2) (i), 25.143 (c) et (i), 25.207 (h), 25.253 (c), 25.773 (b) (1) (ii).

response | *Accepted*

Please refer to the IPHWG report and FAA draft AC 20-147A.

The results of FAA aerofoil testing in a mixed phase icing environment indicates that these icing conditions do not appreciably accrete on unheated aircraft wings. Furthermore the testing showed that exposure to mixed phase environment results in the same or less ice accretion than exposure to supercooled liquid water environment with the same Total Water Content (TWC).

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.773 Pilot compartment view p. 57-58

comment | 6 comment by: *Transport Canada Civil Aviation Standards Branch*

<u>CS 25.773 – Pilot Compartment View -</u>

Transport Canada notes that the proposed wording in EASA NPA 2011-03 for CS 25.773(b)(1)(ii)(C) is "…For aeroplanes certificated in accordance with CS 25.1420(a)(3) and for aeroplanes not subject to CS 25.1420, all icing conditions."

Transport Canada interprets the proposed wording in EASA NPA 2011-03 for CS 25.1420(a) as applying to all CS Part 25 aeroplanes.

Transport Canada requests EASA to provide clarification of the intent of the proposed wording in CS 25.773(b)(ii)(C) as the phrase "and for aeroplanes not subject to CS 25.1420" would not seem to apply where EASA NPA 2011-03 does not have a take-off weight or flight control discriminator in CS 25.21 or 25.1420.

EASA may have other reasons for including this particular phrase, however, this is not immediately clear.

response	*Accepted* This is a mistake that has been corrected: "and for aeroplanes not subject to CS 25.1420" is deleted.

comment	*70* ❖ comment by: *Thales Avionics* The CRD should provide a rationnal as to why Appendix P is excluded of CS 25.21 (g), 25.123 (b) (2) (i), 25.143 (c) et (i), 25.207 (h), 25.253 (c), 25.773 (b) (1) (ii).
response	*Accepted* Please refer to the IPHWG report and FAA draft AC 20-147A. The results of FAA aerofoil testing in a mixed phase icing environment indicates that these icing conditions do not appreciably accrete on unheated aircraft wings. Furthermore, the testing showed that exposure to mixed phase environment results in the same or less ice accretion than exposure to supercooled liquid water environment with the same Total Water Content (TWC).

comment	*100* comment by: *AIRBUS* It is proposed to amend CS 25.773 by revising paragraph (b)(1)(ii) to read as follows: CS 25.773 Pilot compartment view. * * * * * (b) * * * (1) * * * (ii) The icing conditions specified in CS 25.1419 Appendix C ~~and the following icing conditions specified in appendix O~~ of this part, if certification for flight in icing conditions is sought~~:~~ ~~(A) For airplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the airplane is certified to safely exit following detection.~~ ~~(B) For airplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the airplane is certified to safely operate in and the icing conditions that the airplane is certified to safely exit following detection.~~ ~~(C) For airplanes certificated in accordance with CS 25.1420(a)(3) and for airplanes not subject to CS 25.1420, all icing conditions~~. There are no known events that support a safety concern due to windshield icing in SLD conditions aloft. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety. If needed, the EASA can issue special conditions, in accordance with IR 21, to provide adequate safety standards in the unlikely event that [e.g., a future system design is dissimilar enough to warrant concern].

response

Not accepted

The Appendix O icing conditions do not have the same effect than the Appendix C conditions (supercooled drops) in particular on side windows. A specific assessment will be required to justify the absence of openable windows.

We have retained the IPHWG proposal on this subject.

comment

171 comment by: *Boeing*

Page: 57
Paragraph: B(I). Draft Decision amending CS-25
CS 25.773 Pilot compartment view

<u>Revise the text as follows</u>:

"CS 25.773 Pilot compartment view
…
(b) …

(1) …

(ii) The icing conditions specified in CS 25.1419 Appendix C ~~and the following icing conditions specified in Appendix O~~, if certification for flight in icing conditions is requested sought<u>.</u>~~:~~

~~(A) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplanes is certified to safely exit following detection.~~

~~(B) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplanes is certified to safely operate in and the icing conditions that the aeroplanes is certified to safely exit following detection.~~

~~(C) For aeroplanes certificated in accordance with CS 25.1420(a)(3) and for aeroplanes not subject to CS 25.1420, all icing conditions.~~"

<u>JUSTIFICATION</u>: There are no known events that support a safety concern due to windshield icing in SLD conditions aloft. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

Lacking any quantifiable safety benefit (also see separate comments on the RIA), we recommend that EASA not impose unnecessary requirements for consideration of Appendix O conditions, as discussed in separate comments.

response

Not accepted

The Appendix O icing conditions do not have the same effect than the Appendix C conditions (supercooled drops) in particular on side windows. A specific assessment will be required to justify the absence of openable windows.

We have retained the IPHWG proposal on this subject.

comment

186 comment by: *Mitsubishi Aircraft Corporation*

No ground facility is fully adapted for supercooled large drops (SLD) condition. Flights in SLD environment are very limited examples and authorities such as EASA should take the initiative in collecting data and information to be shared for use in type certification activities. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Phase 4 of the ARAC TAG IPHWG report addresses the lack of reliable means for showing compliance to the proposed SLD rulemaking.

response

Not accepted

The Agency will not delay a rulemaking activity aiming at improving or correcting a safety issue based on the non-availability of a fully satisfactory means of compliance. It is expected that industry takes pro-active actions in order to prepare their strategy to show compliance with new proposed rule.

Regarding this rulemaking task, our understanding is that the IPHWG discussed during phase IV (finishing in 2009) about engineering tools and test capabilities.

Some engineering tools and test facilities are available although they have some limitations, in particular for the simulation of freezing rain. Simulation of freezing drizzle appears to be demonstrated.

As long as engineering tools and/or wind tunnel facilities are not able to simulate all Appendix O conditions, it is agreed that flight testing in natural SLD Appendix O conditions would be required, especially when the applicant wishes to certify the aircraft for unrestricted flight in the entire Appendix O.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.929 Propeller de-icing p. 58

comment

14 comment by: *General Electric Company*

What about this proposed requirement do we want changed?

If certification for flight in icing is sought, there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in ~~Appendixces~~ ***Appendix*** C ~~and O~~ on propellers or on accessories where ice accumulation would jeopardize engine performance.

Why is the change justified?

The changes to the proposed rules for engine and engine installations reflect the conclusions of the ARAC Engine Harmonization Working group that no in flight engine events have been recorded in SLD. This is accepted by the working group as a result of rigorous compliance for Appendix C. The proposed rules therefore have no new requirements for engines and engine installations in flight, but do have a new CS 25.1093 condition for ground taxi operations in

SLD.

response *Not accepted*

We refer to FAA Advisory Circular AC 20-73A, Appendix J, which documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions.

Moreover, the Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore, the entire Appendix O has to be retained.

comment *53* comment by: *Pratt & Whitney*

CS 25.929 Propeller de-icing
(a) For aeroplanes intended for use where If certification for flight in icing may be expected is sought, there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in Appendices C ~~**and O**~~ on propellers or on accessories where ice accumulation would jeopardise engine performance.

<u>JUSTIFICATION</u>: The changes to the proposed rules for engine and engine installations reflect the conclusions of the ARAC Engine Harmonization Working group that no in flight engine events have been recorded in SLD. This is accepted by the working group as a result of rigorous compliance for Appendix C. The proposed rules therefore have no new requirements for engines and engine installations in flight, but do have a new CS 25.1093 condition for ground taxi operations in SLD.

response *Not accepted*

We refer to FAA Advisory Circular AC 20-73A, Appendix J, which documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions.

Moreover, the Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore, the entire Appendix O has to be retained.

comment *130* comment by: *Rolls-Royce plc*

response *Noted*

Empty comment.

comment *200* comment by: *Cessna Aircraft Company*

What about this proposal do we want changed?

Amend CS 25.929 as follows:

CS 25.929 Propeller de-icing.

(a) If certification for flight in icing is sought~~,~~ there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in Appendix~~ces~~ C ~~and O~~ on propellers or on accessories where ice accumulation would jeopardise engine performance.

Why is the change justified?

There are no known events that support a safety concern due to propeller icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

response

Not accepted

We refer to FAA Advisory Circular AC 20-73A, Appendix J, which documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR-06/60 Propeller Icing Tunnel Test on a Full-scale Turboprop Engine, dated March 2010, have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions.

Moreover, the Agency considers that the propeller should be treated consistently with what is required for the engine and the air intake; therefore, the entire Appendix O has to be retained.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1093 Air intake system de-icing and anti-icing provisions p. 58-59

comment

15 comment by: *General Electric Company*

What about this proposed requirement do we want changed?

Each engine, with all icing protection systems operating, must:
(1) Operate throughout its flight power range, including the minimum descent idle~~ing~~ ~~speeds~~, in the icing conditions defined in Appendices C, ~~O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following:
Why is the change justified?
There are no known events that support a safety concern due to engine

induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

response *Not accepted*

Idling speed: not accepted, we retain this wording to maintain harmonization with the FAA regulatory text.

Removal of Appendix O: not accepted. The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore, the same icing environment applies and Appendix O is retained for this paragraph.

Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience.

comment *16* comment by: *General Electric Company*

What about this proposed requirement do we want changed?

(ii) Result in unacceptable temporary power or thrust loss or unacceptable engine damage; ~~or~~
~~(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback)~~

Why is the change justified?

(ii) For consistency with FAA regulations add “or thrust” and “unacceptable” damage
(iii) The words “stall, surge, or flameout or loss of engine controllability (for example, rollback)” are redundant to the requirement for no unacceptable loss of power or thrust. The inclusion of “stall, surge, or flameout or loss of engine controllability (for example, rollback)” causes confusion. For example, as written, a rotating stall, which can cause no noticeable impact to engine operation and would only be detectable by special instrumentation could be found unacceptable. Therefore delete (iii).

response *Not accepted*

We maintain harmonization with FAA on this text.

Furthermore, unacceptable loss of power or thrust does not necessarily mean that it is accompanied by a surge or stall; thus, there is no redundancy.

comment *17* comment by: *General Electric Company*

What about this proposed requirement do we want changed?

(2)...........The applicant must document the engine run-up procedure

	(including the maximum time interval between run-ups from idle, run-up power setting, and duration at power) and associated minimum ambient temperature, if any, demonstrated for the maximum time interval, and these conditions must be used in the analysis in establishing the aeroplane operating limitations in accordance with CS 25.1521 Why is the change justified? The condition (i) test point has very little service experience or science to validate that it is appropriate to set a low temperature operational limit in ground fog. At temperatures far below -18°C, it is clear that there is little liquid water, yet the rule as written would require an applicant to test at 0.3g/m3 at any temperature. The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by a critical point analysis. This analysis should also be used to show that at colder temperatures below Table 1, Condition (i) test temperatures, a more critical point does not exist. The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Airplane Flight Manual. LWC decreases rapidly below -18 °C. The FAA Aircraft Icing Handbook supports this as Fig 1-7 shows extremely low water contents below –4°F and no measured LWC below –13°F. Table 3-4 shows the 0.1% probability for LWC between 15 & 25 microns at 0.09 to 0.17 g/m3 at –4°F, and 0.01 to 0.02g/m3 at –22°F.
response	*Accepted*

comment	*18* comment by: *General Electric Company* CS 25.1093 (2), Table 1 What about this proposed requirement do we want changed? Condition (ii) – glaze ice conditions: Change the temperature range to greater than –9 to –1 °C Why is the change justified? Historically, ground icing testing has included the range from –9 °C to –7 °C demonstration of those points has yielded good performance in service. For this reason, applicants who have demonstrated between –9 °C to –7 °C previously should be allowed to continue in that temperature range since there is no evidence that this has not produced good in-service performance. In order to maintain two separate points the lower glaze limit could be stated as "greater than 9 to –1 °C."
response	*Not accepted* We keep the IPHWG table and harmonization with FAA.

comment	*54* comment by: *Pratt & Whitney* Page: 58 Paragraph: B(I). Draft Decision amending CS-25

CS 25.1093 Air intake system de-icing and anti-icing provisions

"CS 25.1093 Air intake system de-icing and anti-icing provisions
…
(b) Turbine engines

Each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent idl~~eing speeds~~, in the icing conditions defined in Appendices C, ~~O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following: . . . ."

[revisions indicated per prior comment]

Concern: An applicant can't comply with the requirements for ice crystal envelope without advisory material allowing certification by similarity analysis in the interim until analytical tools are available.

<u>JUSTIFICATION</u>:
The current state of the art relative to understanding the impact of ice crystal icing conditions on turbine engines is very immature. As a result, there is a critical and sensitive relationship between the newly proposed engine regulations and the corresponding guidance material. Without adequate time to review the revised AC contents and the proposed means of compliance along with the draft regulations, it is extremely difficult to formulate comments on the proposed engine rules. Furthermore, the ARAC committee recognized that there are technology needs not yet addressed in order for an applicant to comply with the mixed phase and ice crystal environment. In order to allow for near term certification to Appendix P, a process of certification by similarity must be provided, as the FAA has done in AC 20-147. The upcoming revisions to the guidance material must provide a similar process in order that the industry can reasonably show compliance until the technology gaps are closed.

response *Not accepted*

Idling speed: not accepted, we retain this wording to maintain harmonization the FAA regulatory text.

Removal of Appendix O: not accepted. The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore, the same icing environment applies and Appendix O is retained for this paragraph.

Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience.

comment *55* comment by: *Pratt & Whitney*

Page: 59
Paragraph:

Table 1- ICING CONDITIONS FOR GROUND TESTS	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration

Condition				
(i) Rime ice condition	-18 to -9°C (0 to 15°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(ii) Glaze ice condition	**~~-7 to -1°C (20 to 0°F)~~ >-9 to -1°C (>15 to 30°F)**	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(iii) Large drop condition	-9 to -1°C (15 to 30°F)	Liquid—0.3 g/m3	100 **-3000** microns **~~(minimum)~~**	By test, analysis or combination of the two.

JUSTIFICATION:
The temperature revisions are suggested to eliminate a gap between glaze and rime ice temperatures. Expanding the upper limits of droplet size ranges will allow flexibility in test demonstrations

response *Not accepted*

We keep the IPHWG table and harmonization with FAA.

comment *101* comment by: *AIRBUS*

It is proposed to amend 25.1093 to read as follows:

"Each engine, with all icing protection systems operating, must:
(1) Operate throughout its flight power range, including ~~the~~ minimum descent idl~~eing speeds~~, in the icing conditions defined in Appendices C~~, O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following:

(i) Adversely affect installed engine operation or cause a sustained loss of power or thrust; or an unacceptable increase in gas path operating temperature; or an airframe/engine incompatibility; or
(ii) Result in unacceptable temporary power <u>or thrust</u> loss or <u>unacceptable</u> engine damage; or
~~(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback).~~
(2) Idle for a minimum of 30 minutes on the ground in the following icing conditions shown in Table 1, unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to takeoff power or thrust. During the idle operation the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the EASA. The applicant must document the engine run-up procedure (including the maximum time interval between run-

ups from idle, run-up power setting, and duration at power) and associated minimum ambient temperature, if any, demonstrated for the maximum time interval, and these conditions must be used in the analysis which establishes~~ing~~ the aeroplane operating limitations in accordance with CS 25.1521."

Table 1- ICING CONDITIONS FOR GROUND TESTS

Condition	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration
(i) Rime ice condition	-18 to -9°C (0 to 15°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(ii) Glaze ice condition	~~-7 to -1°C (20 to 30°F)~~ > -9 to -1°C (> 15 to 0°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(iii) Large drop condition	-9 to -1°C (15 to 30°F)	Liquid—0.3 g/m3	100 - 3000 microns ~~(minimum)~~	By test, analysis or combination of the two.

Re (b)(1) -- There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

Re (b)(1)(iii) It is suggested to remove paragraph (iii) as these affects are already addressed by (i) and (ii). It is recommended to move this additional detail related to the types of installed engine operating instabilities, power loss or controllability events.

If needed, the EASA can issue special conditions, in accordance with IR 21 to provide adequate safety standards in the unlikely event that [e.g., a future system design is dissimilar enough to warrant concern].

Re (b)(2) -- The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis as required by CS-E-780. This analysis should also be used to show that at colder temperatures below the CS25 Table 1, Condition 2 test temperatures, a more critical point does not exist. The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Airplane Flight Manual.

The ground test table points are included in CS 25 but not CS-E. This is inconsistent and the table of engine ground test points (14CFR Part 33 §33.68

	Table 1) proposed by NPRM 10-10 must be added to CS-E Book 1. Otherwise the critical interface between the engine and airframe will not function correctly leading to potential late certification problems or a reduction in safety due to the misalignment of the engine and airframe icing requirements. A modified freezing fog requirement is needed for APUs because the APU does not have a shedding procedure and the statements regarding take-off thrust are obviously not applicable.
response	*Partially accepted* (1): Idling speed: not accepted, we retain this wording to maintain harmonization the FAA regulatory text. Removal of Appendix O: not accepted The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore the same icing environment applies and Appendix O is retained for this paragraph. Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience. (1)(i), (ii) and (iii): partially accepted, "or thrust" is added , for the rest we maintain harmonization with the FAA regulatory text. (2): Accepted Table 1: Changes not accepted. We maintain the IPHWG table and also harmonization with FAA. Re (b)(1): Not accepted: see response above. Re (b)(1)(iii): Not accepted. We keep this text harmonized with FAA. Re (b)(2): Accepted. Ground test table: Accepted. We propose a table in the AMC E-780 proposal. APUs freezing fog requirement: Accepted. We have amended CS 25J1093 consistently with the amended CS 25.1093. Refer to the resulting text.

comment	*102* comment by: *AIRBUS* It is proposed to amend 25.1093(b)(2) to read as follows: "These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to takeoff power or thrust <u>in accordance with the procedures</u>

	<u>defined in the aircraft flight manual."</u> The proposed wording will ensure that the test is performed in accordance with aircraft procedures to provide adequate conservatism. These procedures are defined in collaboration with the engine manufacturer and may be defined on the basis of engine certification or development test results.
response	*Accepted*

comment	*125* comment by: *Mitsubishi Aircraft Corporation* It should be clearly described this regulation is applicable only to engine and essential APU. No ground facility is fully adapted for supercooled large drops (SLD) condition. Flights in SLD environment are very limited examples and authorities such as EASA should take the initiative in collecting data and information to be shared for use in type certification activities. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Phase 4 of the ARAC TAG IPHWG report addresses the lack of reliable means for showing compliance to the proposed SLD rulemaking. Appendix P is based on theoretical considerations, and should be expected to be verified by atmospheric measurement. So appendix P TWC may be overly conservative. Therefore, promulgation of this rule should occur after atmosphere measurements have been made. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Aircraft operation temperature on ground should not be limited when aircraft is tested with the ground icing condition defined in NPA No2011-03 CS 25.1093 table-1
response	*Partially accepted* This paragraph is applicable to powerplant only. Essential APUs are addressed by an amendment to CS 25J1093 similar to the proposed amendment to CS 25.1093. See the resulting text. The Agency will not delay a rulemaking activity aiming at improving or correcting a safety issue based on the non-availability of a means of compliance. It is expected that industry takes pro-active actions in order to prepare their strategy to show compliance with new proposed rule. The proposed Appendix P is based on best available knowledge. The Agency may update it later if it is confirmed by planned research and flight tests that the conditions should be changed. Comment on ground operation temperature limitation: accepted.

comment	*131* comment by: *Rolls-Royce plc*

	Since CS 25.1093(b) is a requirement on the powerplant, particularly the engine, the requirements should be in line with those in CS-E 780. (The effect on airframe/engine compatibility is considered in CS-E 780(e)) Propose that the paragraph is re-written as: Each engine, with all icing protection systems operating, must: (1) Operate throughout its flight power range, including the minimum descent idling speeds, in the icing conditions defined in Appendices C, O and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would *give unacceptable:* *(i) Immediate or ultimate reduction of Engine performance,* *(ii) Increase of Engine operating temperatures,* *(iii) Deterioration of Engine handling characteristics, and* *(iv) Mechanical damage.* *(v) Adverse effects on airframe/engine compatibility.*
response	*Not accepted* We maintain harmonization with FAA on this text.

comment	*132* comment by: *Rolls-Royce plc* **CS 25.1093 Air Intake System de-icing and anti-icing provisions** - The requirements of CS 25.1093 are much broader than de-icing and anti-icing provisions and this should be recognised in the title. Suggest that the paragraph is entitled "Powerplant Icing"
response	*Accepted*

comment	*133* comment by: *Rolls-Royce plc* **CS 25.1093 Table 1** There is a gap in the 'Total air temperature' column where, we believe, the 'Glaze ice condition' should cover the range -9 to -1 degrees C (rather than -7 to -1 degrees C). The current CRI being applied to new engines calls for tests at -9 or below as the basis for ground operation in line with the current temperature range specified in CS-25.
response	*Not accepted* We keep the IPHWG table and harmonization with FAA.

comment	*172* comment by: *Boeing* **Page: 58** **Paragraph: B(I). Draft Decision amending CS-25** **CS 25.1093 Air intake system de-icing and anti-icing provisions** **--** **Revise the text as follows:** "CS 25.1093 Air intake system de-icing and anti-icing provisions …

(b) Turbine engines

Each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent ~~idling speeds~~ **idle**, in the icing conditions defined in Appendices C,~~-O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following:

(i) Adversely affect installed engine operation or cause a sustained loss of power or thrust; or an unacceptable increase in gas path operating temperature; or an airframe/engine incompatibility; or

(ii) Result in unacceptable temporary power **or thrust** loss or **unacceptable** engine damage; or
~~(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback).~~

(2) Idle for a minimum of 30 minutes on the ground in the following icing conditions shown in Table 1, unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to takeoff power or thrust. During the idle operation the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the EASA. The applicant must document the engine run-up procedure (including the maximum time interval between run-ups from idle, run-up power setting, and duration at power) and associated minimum ambient temperature**, if any,** demonstrated for the maximum time interval, and these conditions must be used in **the analysis that** ~~establishing~~ **establishes** the aeroplane operating limitations in accordance with CS 25.1521."

[EASA proposed revisions incorporated]

JUSTIFICATION:

Re (b)(1) -- There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

Lacking any quantifiable safety benefit (also see separate comments on the RIA), we recommend that EASA not impose unnecessary requirements for consideration of Appendix O conditions, as discussed in separate comments.

Re subparagraph (ii) -- For consistency with FAA regulations add "or thrust" and "unacceptable" damage.

Re subparagraph (iii) -- The words "stall, surge, or flameout or loss of engine controllability (for example, rollback)" are redundant to the requirement for no unacceptable loss of power or thrust. The inclusion of "stall, surge, or flameout or loss of engine controllability (for example, rollback)" causes confusion. For example, as written, a rotating stall, which can cause no noticeable impact to engine operation and would only be detectable by special instrumentation could be found unacceptable. Therefore delete subparagraph (iii).

The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Aeroplane Flight Manual.

response

Partially accepted

(b)(1): Idling speed: not accepted, we retain this wording to maintain harmonization the FAA regulatory text.
Removal of Appendix O: not accepted

The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore, the same icing environment applies and Appendix O is retained for this paragraph.

Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience.

(1)(i), (ii) and (iii): partially accepted, "or thrust" is added, for the rest we maintain harmonization with the FAA regulatory text.

(2): Accepted

Re (b)(1): Not accepted: see response above.

Re subparagraph (ii): Partially accepted. "or thrust" is added.

Re subparagraph (iii): Not accepted.

Demonstration of safe operation without temperature limitation: Accepted.

comment

173 comment by: *Boeing*

Page: 58
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1093 Air intake system de-icing and anti-icing provisions

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Revise the text as follows:
"CS 25.1093 Air intake system de-icing and anti-icing provisions
…
(b) Turbine engines

Each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent

~~idling speeds~~ **idle**, in the icing conditions defined in Appendices C, ~~O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following: . . . ."

[revisions indicated per prior comment]

Concern: An applicant cannot comply with the requirements for ice crystal envelope without advisory material allowing certification by similarity analysis in the interim until analytical tools are available.

JUSTIFICATION: The current state of the art relative to understanding the impact of ice crystal icing conditions on turbine engines is very immature. As a result, there is a critical and sensitive relationship between the newly proposed engine regulations and the corresponding guidance material. Without adequate time to review the revised AC contents and the proposed means of compliance along with the draft regulations, it is extremely difficult to formulate comments on the proposed engine rules. Furthermore, the ARAC committee recognized that there are technology needs not yet addressed in order for an applicant to comply with the mixed phase and ice crystal environment. In order to allow for near term certification to Appendix P, a process of certification by similarity must be provided, as the FAA has done in AC 20-147, *"Turbojet, Turboprop, and Turbofan Engine Induction System Icing and Ice Ingestion."* The upcoming revisions to the guidance material must provide a similar process in order that the industry can reasonably show compliance until the technology gaps are closed.

response

Partially accepted

The text changes are not accepted (see our response to your previous comment).

Regarding your suggestion for a possibility of using a similarity analysis, we agree and will propose corresponding AMC material.

comment

174 comment by: *Boeing*

Page: 59
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1093 Air intake system de-icing and anti-icing provisions
Table 1

Revise the Table as follows:

Table 1- ICING CONDITIONS FOR GROUND TESTS				
Condition	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration
(i) Rime ice condition	-18 to -9°C (0 to 15°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.

(ii) Glaze ice condition	~~-7 to -1°C (20 to 0°F)~~ **>-9 to -1°C (>15 to 0°F)**	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(iii) Large drop condition	-9 to -1°C (15 to 30°F)	Liquid—0.3 g/m3	100 **- 3000** microns ~~(minimum)~~	By test, analysis or combination of the two.

JUSTIFICATION:

The temperature revisions are suggested to eliminate a gap between glaze and rime ice temperatures. Expanding the upper limits of droplet size ranges will allow flexibility in test demonstrations.

response *Not accepted*

We keep the IPHWG table and harmonization with FAA.

comment *195* comment by: *Snecma*

Attachment #15

Please see in attached letter 2764-RC : comment n°1 page 2 and comment n°4 page 4 and comment n°6 page 6 and comment n°8 page 8

response *Accepted*

comment *201* comment by: *Cessna Aircraft Company*

What about this proposal do we want changed?

Amend CS 25.1093 as follows:

CS 25.1093 Air intake system de-icing and anti-icing provisions.

* * * * *

Each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent ~~idling speeds~~ idle, in the icing conditions defined in Appendices C~~, O~~ and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, inlet system components or airframe components that would do any of the following:

(i) Adversely affect installed engine operation or cause a sustained loss of power or thrust; or an unacceptable increase in gas path operating

temperature; or an airframe/engine incompatibility; or
(ii) Result in unacceptable temporary power or thrust loss or unacceptable engine damage.; or
(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback).

(2) Idle for a minimum of 30 minutes on the ground in the following icing conditions shown in Table 1, unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to takeoff power or thrust. During the idle operation the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the EASA. The applicant must document the engine run-up procedure (including the maximum time interval between run-ups from idle, run-up power setting, and duration at power) and associated minimum ambient temperature if any demonstrated for the maximum time interval if any, and these conditions must be used in establishing the analysis which establishes the aeroplane operating limitations in accordance with CS 25.1521.

Table 1- ICING CONDITIONS FOR GROUND TESTS

Condition	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration
(i) Rime ice condition	-18 to -9°C (0 to 15°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(ii) Glaze ice condition	-7 >-9° to -1°C (20 >15° to 30°F)	Liquid—0.3 g/m3	15–25 microns	By test, analysis or combination of the two.
(iii) Large drop condition	-9 to -1°C (15 to 30°F)	Liquid—0.3 g/m3	100 – 3000 microns (minimum)	By test, analysis or combination of the two.

Why is the change justified?

Re (b)(1) -- There are no known events that support a safety concern due to engine induction system icing in SLD conditions aloft. In particular, the ARAC EHWG evaluated all of the known icing-related events since 1988 and found no events in SLD conditions aloft. The current rigorous compliance using Appendix C conditions for engines is credited with this result. To maintain this good service history, key aspects of prior successful practices for ice slab ingestion were made part of this rule. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety, and therefore proper operation In the icing conditions of Appendix O should not be required in the rule.

Also regarding (b)(1) changed text to be consistent with proposal for 14CFR 33.68 (a) and (b) and 14CFR 25.1093(b) (reference NPRM 10-10). The wording of the proposed (iii) is redundant, as all the conditions listed there would be addressed by the wording in (i) an/or (ii) and should therefore be removed.

Re (b)(2) -- The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis. This critical point analysis should also be used to show that at temperatures below the Table 1, Condition (i) test temperatures, a more critical point does not exist. The applicant should be permitted to use this analysis to substantiate safe operation of the engine at temperatures below the required test demonstration temperature. If appropriate, no limitation would then be required for the Airplane Flight Manual. Additionally, if the test demonstrates a repeatable build/shed cycle of ice, then no time limitation should be imposed on operation of the engine in freezing fog conditions.
Also see comment #3.

Re Table 1 – The added Table 1 is similar to the tables contained in AC 20-147. Historically, the AC 20-147 table points have been kept relatively consistent since demonstration of those points has yielded good performance in service.
For this reason the original ground fog temperature range should be maintained since applicants who have demonstrated between 15 and 20F previously should be allowed to continue in that temperature range since there is no evidence that this has not produced good in-service performance. In order to maintain two separate points the lower glaze limit could be stated as "greater than 15 to 30F".
The range on the effective droplet diameter for condition (iii) should be changed to add a maximum droplet diameter to match the definition proposed by the FAA for 14CFR 33.68 (reference NPRM 10-10)

response *Partially accepted*

(b)(1): Idling speed: not accepted. We retain this wording to maintain harmonization the FAA regulatory text.

Removal of Appendix O: not accepted

The nacelle should be treated consistently with the engine and, if applicable, the propeller. Therefore, the same icing environment applies and Appendix O is retained for this paragraph.Nevertheless, we will propose provisions in an AMC to take credit from positive in service experience.

(1)(i), (ii) and (iii): partially accepted, "or thrust" is added, for the rest we maintain harmonization the FAA regulatory text.

(2): Accepted

Table 1: Changes not accepted. We maintain the IPHWG table and also harmonization with FAA.

We have been informed that FAA should update FAR 33.68 Table 2, condition 4 by removing the maximum drop diameter.

Re (b)(1): Not accepted: see response above.

Re (b)(2): Accepted.

Re Table 1: Not accepted. Table 1 is maintained harmonized with FAA.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1323 Airspeed indicating system p. 59

comment 7 comment by: *Transport Canada Civil Aviation Standards Branch*

CS 25.1323 – Airspeed Indicating Systems -

Transport Canada notes that the proposed EASA NPA 2011-03 removes the existing wording for CS 25.1323(i) and reserves the space. From this proposed wording, Transport Canada understands that EASA has moved the existing CS 25.1323(i) to the new design requirement - CS 25.1324.

response *Noted*

Correct.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Create a new CS 25.1324 Flight instrument external probes heating systems p. 60

comment 8 comment by: *Transport Canada Civil Aviation Standards Branch*

CS 25.1324 – Flight Instrument External Probe Heating Systems – first comment -

Transport Canada notes that EASA NPA 2011-03 proposes a new design requirement – CS 25.1324 – to address flight instrument external probes where *flight instrument external probes* may include, but are not necessarily limited, to Pitot tubes, Pitot-static tubes, static probes, angle of attack sensors, side-slip vanes, and temperature probes. Transport Canada understands that this proposed design requirement would apply to the airframe locations of such probes / sensors / vanes. Other design standards (anticipated to be similar) would apply to the flight instrument external probes located in the power plant assembly with design standards being applied through CS E.

Transport Canada is aware of recent investigations into engine and air data systems in-service events and an aeroplane accident where air data probes qualified to present standards may not be adequate for all known icing conditions and can lead to system malfunction and possible erroneous information display to the flight crew. Many of these events have occurred in icing conditions at very cold ambient temperatures and higher altitudes. These icing conditions are similar to the icing conditions of the proposed Appendix P of this NPA as compared to the icing conditions of Appendix C or current TSO icing conditions specifications.

Given this recent service experience, Transport Canada acknowledges that EASA has been re-evaluating the icing conditions for qualification of flight instrument external probes.

Transport Canada supports the proposed wording for CS 25.1324 in EASA NPA 2011-03.

response *Noted*

comment *9* comment by: *Transport Canada Civil Aviation Standards Branch*

CS 25.1324 – Flight Instrument External Probe Heating Systems – second comment -

Similar to Transport Canada's comment to CS 25.773, Transport Canada notes that the proposed wording in EASA NPA 2011-03 for CS 25.1324(c) is "…For aeroplanes certificated in accordance with CS 25.1420(a)(3) and for aeroplanes not subject to CS 25.1420, all icing conditions."

Transport Canada interprets the proposed wording in EASA NPA 2011-03 for CS 25.1420(a) as applying to all CS Part 25 aeroplanes.

Transport Canada requests EASA to provide clarification of the intent of the proposed wording in CS 25.1324(c) as the phrase "and for aeroplanes not subject to CS 25.1420" would not seem to apply where EASA NPA 2011-03 does not have a take-off weight or flight control discriminator in CS 25.21 or 25.1420.

EASA may have other reasons for including this particular phrase, however, this is not immediately clear.

response *Accepted*

This was a mistake. It has been corrected.

comment *103* comment by: *AIRBUS*

It is proposed to amend 25.1324 to read as follows:

"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, must be heated or have an equivalent means of preventing malfunction due to icing conditions as defined in Appendices C and P.~~, and the following icing conditions specified in Appendix O:~~
~~(a) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to exit safely following detection;~~
~~(b) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in and the icing conditions that the aeroplane is certified to exit safely following detection;~~
~~(c) For aeroplanes certificated in accordance with CS 25.1420(a)(3) and for aeroplanes not subject to CS 25.1420, all icing conditions.~~
Each flight instrument external probes systems must be designed and installed to operate normally without any malfunction in presence of heavy rain conditions (refer to AMC 25.1324)."

There are no known events that support a safety concern due to angle of attack system icing in SLD conditions aloft. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable insurance of future safety.

If needed, EASA can issue special conditions, in accordance with IR 21 to provide adequate safety standards in the unlikely event that [e.g., a future system design is dissimilar enough to warrant concern].

AOA systems can use different types of technology to provide the aircraft with AOA indication. Both pneumatic and mechanical systems can be used. Mechanical systems with vanes are less sensitive to ice or liquid water ingress. The mechanical installation of such AOA sensor can be a means of compliance.

Flight testing of flush mounted AOA vanes and static ports indicates that they are not sensitive to ice accretion in ice crystal conditions. Testing in supercooled water conditions is, therefore normally, adequate for mechanical AoA probes and a means of compliance based on installation and probe design is adequate to address the ice crystal and mixed phase threat. AoA instruments that use air pressure measurements to determine aircraft AoA may be more sensitive to ice crystal conditions. Guidance material should be developed that includes the above means of compliance.

Considering the good inservice experience and that a flight test will not allow the full range of conditions to be tested due to the difficulty in finding the precise combination of conditions, a flight test in ice crystals, mixed phase, freezing rain or drizzle should not be mandated as it would add little in terms of safety whilst considerably impacting the certification program.
Airbus supports the application of CS25 App. P icing conditions to flight critical air data probes. However, there is no safety case for applying App P to non flight critical sensors. It is necessary to develop an acceptable means of compliance that considers the capabilities of the existing engineering tools (models, icing tunnels etc) and provide guidance on these new requirements. Considering that the currently available laboratories cannot achieve the full range of icing and flight conditions, an exemption may be required or specific scaling and test techniques developed. (Refer also to comments on App P)

response *Not accepted*

Refer to response to comment #93.

comment *127* comment by: *Mitsubishi Aircraft Corporation*

No ground facility is fully adapted for supercooled large drops (SLD) condition. Flights in SLD environment are very limited examples and authorities such as EASA should take the initiative in collecting data and information to be shared for use in type certification activities. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Phase 4 of the ARAC TAG IPHWG report addresses the lack of reliable means for showing compliance to the proposed SLD rulemaking.

Appendix P is based on theoretical considerations, and should be expected to

	be verified by atmospheric measurement. So appendix P TWC may be overly conservative. Therefore, promulgation of this rule should occur after atmosphere measurements have been made. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking.
response	*Not accepted* The Agency will not delay a rulemaking activity aiming at improving or correcting a safety issue based on the non-availability of a means of compliance. It is expected that industry takes pro-active actions in order to prepare their strategy to show compliance with new proposed rule.

comment *175* comment by: *Boeing*

Page: 60
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1324 Flight instrument external probes and heating systems

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Revise the text as follows:

"CS 25.1324 Flight instrument external probes heating systems

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 **if shown to be flight critical**, must be heated or have an equivalent means of preventing malfunction due to icing conditions as defined in Appendices C and P, and the following icing conditions specified in Appendix O:

(a) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to exit safely following detection;

(b) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in and the icing conditions that the aeroplane is certified to exit safely following detection;

(c) For aeroplanes certificated in accordance with CS 25.1420(a)(3) and for aeroplanes not subject to CS 25.1420, all icing conditions.

Each flight instrument external probes systems **shown to be flight critical** must be designed and installed to operate normally without any malfunction in presence of heavy rain conditions (refer to AMC 25.1324). "

[EASA proposed revisions incorporated]

JUSTIFICATION: Boeing does not agree that certain probes, such as temperature sensors, which are not flight critical, should be included in the expanded requirement. The applicant should show the criticality of the measurement, and then apply the regulation as appropriate.

response *Not accepted*

We maintain the specification that all flight instrument external probes must function normally in all icing conditions.

Nevertheless, it is acknowledged that total air temperature probes protection over the full Appendix P conditions may not be possible (it may involve a level of heating power that could degrade the temperature measurement to an unacceptable level). Therefore, we have added a paragraph in the draft AMC 25.1324 recognising that the TAT probe may not be fully protected over a portion of the Appendix P but that the malfunction must not prevent continued safe flight and landing.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1325 Static pressure systems p. 60

comment | *10* comment by: *Transport Canada Civil Aviation Standards Branch*

CS 25.1325 – Static Pressure Systems -

Transport Canada notes the new reference to CS 25.1324 in CS 25.1325.

response | *Noted*

comment | *128* comment by: *Mitsubishi Aircraft Corporation*

No ground facility is fully adapted for supercooled large drops (SLD) condition. Flights in SLD environment are very limited examples and authorities such as EASA should take the initiative in collecting data and information to be shared for use in type certification activities. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Phase 4 of the ARAC TAG IPHWG report addresses the lack of reliable means for showing compliance to the proposed SLD rulemaking.

Appendix P is based on theoretical considerations, and should be expected to be verified by atmospheric measurement. So appendix P TWC may be overly conservative. Therefore, promulgation of this rule should occur after atmosphere measurements have been made. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking.

response | *Not accepted*

The Agency will not delay a rulemaking activity aiming at improving or correcting a safety issue based on the non-availability of a means of compliance. It is expected that industry takes pro-active actions in order to prepare their strategy to show compliance with new proposed rule.

comment | *176* comment by: *Boeing*

Page: 60
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1325 - Static pressure systems

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Revise the text as follows:

"CS 25.1325 Static pressure systems

(b) Each static port must be designed and located so that:

(1) The static pressure system performance is least affected by airflow variation, or by moisture or other foreign matter, and

(2) The correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not changed when the aeroplane is exposed to **the** icing conditions **defined in Appendix C. (See AMC to 25.1323 (i) and 25.1325(b).)** ~~The static pressure system shall comply with CS 25.1324.~~"

JUSTIFICATION:
There are no known events that support a safety concern due to static pressure system icing in SLD conditions aloft. The safety of these systems for flight in Appendix O conditions has already been proven by service history. Continuing to certify future systems to the requirements for Appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in Appendix O conditions, should be acceptable to ensure future safety.

Lacking any quantifiable safety benefit (also see separate comments on the RIA), we recommend that EASA not impose unnecessary requirements for consideration of Appendix O conditions, as discussed in separate comments.

response

Partially accepted

This subject is treated in the AMC we will propose.

Based on the design of the probe, the drop size may not be a significant factor to consider as compared to the other parameters and in particular the Liquid Water Content. The SLD concentrations defined in Appendix O (between 0.2 and 0.5 g/m3) are largely covered by the Appendix C continuous concentrations (between 0.2 and 0.8 g/m3) and the Appendix C intermittent concentrations (between 0.25 and 2.9 g/m3).

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.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1326 Flight instrument external probes heat indication systems	p. 60

comment

11 comment by: *Transport Canada Civil Aviation Standards Branch*

CS 25.1326 – Flight Instrument External Probes Heat Indication Systems -

Transport Canada notes the new reference to flight instrument external probes as per the proposed wording in CS 25.1324.

	Transport Canada notes the wording change to the CS 25.1326(b)(2) to replace the word "inoperative" with "not functioning normally". Transport Canada understands that this wording change proposed in EASA NPA 2011-03 is based on recent service experience including Airworthiness Directive actions from EASA that have identified unsafe conditions where heating systems are malfunctioning, however, not completely inoperative. Transport Canada supports the proposed wording for CS 25.1326 in EASA NPA 2011-03.
response	*Noted*

comment	*68* comment by: *Thales Avionics* CS 25.1326 (a) should be written "(a) The indication provided must incorporate an amber light *<u>or equivalent</u>* that is in clear view of a flight-crew member." as is worded CS 25.1419 (c) CS 25.1326 (b) (2) could be written "The flight instrument external probe heating system is switched 'on' and any flight instrument external probe *<u>does not meet the applicable requirements of CS 25.1324</u>*." as the probe may not function normally but still meet CS 25.1324 requirements.
response	*Partially accepted* CS 25.1326(a): Partially accepted The wording is updated to explain that the alert must conform to Caution alert indications. CS 25.1326(b)(2): Not accepted. The Agency will propose an AMC 25.1326 which will better explain when the alert should be triggered.

comment	*104* comment by: *AIRBUS* The clarification of the agency's interpretation of CS 25.1419(c) is welcome and Airbus supports this monitoring philosophy. It is noted that this level of monitoring is beyond that required by the existing requirement CS 25.1326. Whilst CS 25.1419(c) provides the necessary flexibility it is helpful to have the additional requirement to clearly define requirements for the probe heat monitoring systems. The capability of existing technology and the feasibility of future designs must also be considered. Nuisance alerts shall be avoided as defined by AMC 25.703 in defining an adequate level of monitoring.
response	*Accepted*

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Create a new CS 25.1420 Supercooled large drop icing conditions p. 61

comment	*12* comment by: *Transport Canada Civil Aviation Standards Branch* **<u>CS 25.1420 (a) – Applicability –</u>** Transport Canada notes that the proposed EASA NPA 2011-03 wording for CS 25.1420(a) makes the new design requirement applicable to all CS 25

	aeroplanes. As per the EASA NPA 2011-03 – Section 15(a) – Differences Compared to the FAA NPRM -, the CS 25.1420(a) proposal would not be harmonized with the proposed FAA NPRM 10-10 wording where an applicability discriminator for take-off weight or reversible flight controls is included. Transport Canada notes that the applicability wording for CS 25.1420(a) in EASA NPA 2011-03 is consistent with the original FAA ARAC IPHWG recommendations for 25.1420(a) applicability. EASA notes that a Minority / Majority Position on the applicability of 25.1420 was raised within the FAA ARAC. The Majority Position did not accept the Minority Position that aeroplanes with certain design features should be excluded from the proposed 25.1420 rule and that the proposed 25.1420 rule should apply to all new transport category aeroplane designs. The NPA also states that the Majority Position was supported by Transport Canada at the time. Transport Canada supports the proposed applicability wording for CS 25.1420(a) in EASA NPA 2011-03.
response	*Noted*

comment	*65* ❖ comment by: *Thales Avionics* Regarding C) Similarity analysis: In-service experience can be used for flight instrument external probe for SLD as SLD are not a key driver of the probe design face to Ice Crystal, Mixed phase and supercooled droplet. However, the use of in-service experience should be limited to the cases where the different parameters including the level of water content can be documented.
response	*Partially accepted* Severe ice crystal icing conditions have created in-service events on some probes; therefore, this kind of environment may indeed be the driver for probe anti-icing protection system design. The scope of paragraph C) on page 11 is about compliance with CS 25.1420 which is related to operation with SLD conditions. But the Agency does not intend to require a demonstration based on specific liquid water content values documented from in-service experience.

comment	*115* comment by: *Claudio Mauerhofer* *<u>Proposed requirement 25.1420(a)(1) and (2)</u>* Both options require that "Following detection, the aeroplane must be capable of operating safely while exiting all icing conditions". It is suggested to clarify the rationale behind the "all icing conditions". May an applicant claim that it would be sufficient to demonstrate that the aircraft can safely exit the conditions for which it is not required (for regulatory or commercial reasons) to be approved?
response	*Not accepted*

This is not an approach chosen by the ARAC group nor by FAA and EASA.

After encountering SLD icing conditions that exceed the certified environment, the aeroplane must exit all icing conditions.

If conditions beyond the certified boundaries are encountered and the aeroplane continues flying in whatever icing conditions, there is a risk that the aeroplane contamination by ice accretions will increase and reach a hazardous level. Consequently, the only means to ensure a safe flight continuation and safe landing is to minimize further exposure to icing conditions and in the end fully exit icing conditions.

comment

126 comment by: *Mitsubishi Aircraft Corporation*

Flights in SLD environment are infrequent. Flight test demonstration in supercooled large droplet (SLD) condition to show compliance with proposed amendment seems impractical.

No ground facility is fully adapted for supercooled large drops (SLD) condition. Flights in SLD environment are very limited examples and authorities such as EASA should take the initiative in collecting data and information to be shared for use in type certification activities. In addition, EASA should insure confident means of compliance are available and practical before promulgating rulemaking. Phase 4 of the ARAC TAG IPHWG report addresses the lack of reliable means for showing compliance to the proposed SLD rulemaking.

response

Partially accepted

The applicant may use a combination of several means to show compliance.

comment

177 comment by: *Boeing*

Page: 61
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1420 Supercooled large drop icing conditions
- paragraph (a)

Revise the text with the following considerations:

"CS 25.1420 Supercooled large drop icing conditions

[***Option 1***]
(a) If certification for flight in icing conditions is sought, in addition to the requirements of CS 25.1419, ~~the~~ **an** aeroplane **with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls** must be capable of operating in accordance with sub-paragraphs (a)(1), (a)(2), or (a)(3) of this paragraph."

or

[***Option 2***]
(a) If certification for flight in icing conditions is sought, in addition to the requirements of CS 25.1419, ~~the~~ **an** aeroplane **with reversible flight**

controls, or without thermal wing anti-icing ice protection systems, or without wing leading-edge high-lift devices must be capable of operating in accordance with sub-paragraphs (a)(1), (a)(2), or (a)(3) of this paragraph."

JUSTIFICATION:

Boeing stands behind the Minority Position contained in Appendix F of the IPHWG Working Group Report. We believe that application of proposed CS 25.1420 to all CS-25 aeroplanes is unnecessary and unwise. We believe that it will have the unintended effect of destroying the viability of new "larger" large aeroplane programs due to insurmountable compliance requirements and associated prohibitively high costs and programme risks.

Following years of harmonization effort and opportunity, the lack of harmonization with the FAA's proposed §25.1420 on such a fundamental and critical issue is unacceptable. Therefore, we prefer our suggested revision option No. 1 to accomplish harmonization.

However, we acknowledge EASA's issues with the 60,000 lb. weight criterion. Therefore, we are alternately proposing option No. 2 for consideration by both EASA and the FAA. Option No. 2 would eliminate the weight discriminator, maintain the reversible controls criterion, and add the additional criteria of thermal anti-icing wing ice protection systems and wing leading-edge high-lift devices. We believe that this combination of design features will result in CS 25.1420 being applied to only to those aeroplanes with similar design features as those that have had accidents and incidents in SLD icing conditions. The result would be similar to EASA's interim CRI philosophy by focusing on aeroplanes with design features of potential concern. We request that EASA and the FAA will jointly, and favorably, consider harmonization based on option 2. We note the FAA's statement in their NPRM*: ". . . EASA has a project similar to SLD on its rulemaking inventory and our intent is to harmonize these regulations."* (75 FR 37320, 29 June 2010)

It is clear that reversible controls have contributed to accidents in SLD conditions, but no aeroplane with irreversible controls has had an in-flight SLD event. Similarly, no aeroplane with a thermal anti-icing ice protection system and leading-edge high-lift devices has had an SLD event, but some aeroplanes with "de-icing boot" ice protection systems and "hard" leading edges have had events. We submit that reconsideration of these design features as discriminating criteria for the applicability of proposed CS 25.1420 is warranted. We also note that relative to EASA's consideration of accepting similarity and service history as means of compliance, it is these very types of design features that would establish similarity with predecessor models. To accept their value via means of compliance but deny the same in application of the rule seems illogical.

The EASA concern that future designs may not result in the same level of exemplary safety ignores the fact that recent models meet far more stringent performance and handling qualities requirements for flight in Appendix C icing conditions, due to recent CS-25 amendments, than the majority of the current larger aeroplane fleet that has accumulated the excellent safety record in icing conditions. Thus, it is prudent and reasonable to assume that any new larger aeroplanes that achieve certification to the latest Appendix C icing requirements, even with novel designs, will have to be at least as safe for operation in all icing conditions as current models.

Current flight operations for the "larger" large aeroplane types are consistent with the "unrestricted" option of proposed CS 25.1420(a)(3). Since that is the way that these aeroplanes have operated safely for decades, the airlines and the flying public expect no less in the future. Certification via this option, as well as for the "approved portion" of option (a)(2), requires extensive knowledge of estimated Appendix O ice shapes very early in the airplane design phase in order to ensure compliant aerodynamic and ice protection system characteristics. This was emphasized in the Minority Position on natural SLD flight testing contained in the IPHWG Working Group Report. Using natural SLD flight testing as a tool during the aeroplane design phase is simply unrealistic.

It is well known that despite lengthy efforts by government research agencies within Europe, Canada, and the U.S., the SLD engineering tools and methods (icing codes and icing tunnels) necessary to reliably determine "operation in Appendix O" ice shapes are not currently available. Furthermore, due to research budget cutbacks, these necessary tools are not likely to become available until long after the proposed regulations take effect. As a result, the IPHWG produced simplified interim means of compliance during their Phase IV activity (contained in an Appendix to the FAA's draft AC 25-XX). However, due to the FAA's lack of confidence in the currently available engineering tools and methods, simplified means of compliance are proposed to only be applicable to the SLD "detect and exit" certification options of proposed CS 25.1420(a)(1) and (a)(2) for the unapproved portions.

Per the FAA's draft guidance material, certification to operate within Appendix O will require significant flight testing in natural SLD conditions as means of compliance. Thus, manufacturers desiring to certify new models for operation in SLD conditions will face prohibitively high development and certification costs, and in addition will face very high levels of risk. Both are unacceptable from an industry business perspective and may result in the elimination of new product programmes. (For more on the economics, see separate comments on the Regulatory Impact Assessment section.) While we do not believe that it is EASA's intention to force the industry into an "insignificant-change derivatives only" future, we believe that could be the consequence of proposed CS 25.1420.

Another option that manufacturers of large airplanes are forced to strongly consider is to operate new large jets as "detect and exit" aeroplanes. The impact on industry-wide operations of such a drastic change could become severe. Consider, for example, in the case of FZDZ at a major airport – mass diversions, emergency landings, and cancellations. This could create an even more hazardous situation than the icing conditions. As undesirable as the "detect and exit" option is for larger aeroplanes, at this time, we are not certain whether certification for unrestricted operation in SLD conditions will be feasible for the foreseeable future.

response *Not accepted*

See our response to comment #137.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1521 Powerplant limitations p. 61-62

comment 19 comment by: *General Electric Company*

What about this proposed requirement do we want changed?

(3) Maximum time interval between engine run-ups from idle, run-up power setting, duration at power, and the associated minimum ambient temperature, if any, demonstrated for the maximum time interval, for ground operation in icing conditions, as defined in CS 25.1093(b)(2).

Why is the change justified?

The CS 25-1093 (2) Table 1 condition (i) test point has very little service experience or science to validate that it is appropriate to set a low temperature operational limit in ground fog. At temperatures far below -18°C, it is clear that there is little liquid water, yet the rule as written would require an applicant to test at 0.3g/m3 at any temperature. The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by a critical point analysis. This analysis should also be used to show that at colder temperatures below Table 1, Condition (i) test temperatures, a more critical point does not exist. The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Airplane Flight Manual.
LWC decreases rapidly below -18 °C. The FAA Aircraft Icing Handbook supports this as Fig 1-7 shows extremely low water contents below –4°F and no measured LWC below –13°F. Table 3-4 shows the 0.1% probability for LWC between 15 & 25 microns at 0.09 to 0.17 g/m3 at –4°F, and 0.01 to 0.02g/m3 at –22°F.

response *Accepted*

comment *56* comment by: *Pratt & Whitney*

Page: 61
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1521 Powerplant limitations
- paragraph (c)(3)

"(3) Maximum time interval between engine run-ups from idle, run-up power setting, duration at power, and the associated minimum ambient temperature**, if any,** demonstrated for the maximum time interval, for ground operation in icing conditions, as defined in CS 25.1093(b)(2)."

JUSTIFICATION:
Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1, Condition 1 rime ice condition test temperatures, a more critical point does not exist. If appropriate, no temperature limitation would then be needed in the Airplane Flight Manual. See related comments elsewhere in this document.

response *Accepted*

comment *105* comment by: *AIRBUS*

It is proposed to amend 25.1521 to read as follows:

"(c)…

(3) Maximum time interval between engine run-ups from idle, run-up power setting and duration at power and the associated minimum ambient temperature, If any, ~~demonstrated for~~ the maximum time interval, if any, for ground operation in icing conditions, as defined in CS 25.1093(b)(2)."

The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis. This analysis should also be used to show that at colder temperatures below the CS25.1093(b) Table 1, Condition 2 test temperatures, a more critical point does not exist. The applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration. If appropriate, no limitation would then be required for the Airplane Flight Manual. See also comment on Preamble, paragraph h) Engine and engine installation requirements.

response *Accepted*

comment *178* comment by: *Boeing*

Page: 61
Paragraph: B(I). Draft Decision amending CS-25
CS 25.1521 Powerplant limitations
- paragraph (c)(3)

Revise the text as follows:

"(3) Maximum time interval between engine run-ups from idle, run-up power setting, duration at power, and the associated minimum ambient temperature**, if any,** demonstrated for the maximum time interval, for ground operation in icing conditions, as defined in CS 25.1093(b)(2)."

JUSTIFICATION: Analysis should be allowed to show that at colder temperatures below the CS 25.1093, Table 1, Condition 1 rime ice condition test temperatures, a more critical point does not exist. If appropriate, no temperature limitation would then be needed in the Airplane Flight Manual. See related comments elsewhere in this document.

response *Accepted*

comment *198* comment by: *Snecma*

please see in Snecma letter 2764-RC : comment n°7 page 7. Letter is in comment for rule CS-25.1093.

response *Accepted*

comment *202* comment by: *Cessna Aircraft Company*

What about this proposal do we want changed?

Amend CS 25.1521 as follows:

	CS 25.1521 Powerplant limitations. * * * (c) * * * (3) Maximum time interval between engine run-ups from idle, run-up power setting, and duration at power, ~~and~~ the associated minimum ambient temperature if any ~~demonstrated for,~~ and– the maximum time interval if any, for ground operation in icing conditions, as defined in CS 25.1093(b)(2). ***Why is the change justified?*** The choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis. This critical point analysis should also be used to show that at temperatures below the CS 25.1093(b) Table 1, Condition (i) test temperatures, a more critical point does not exist. The applicant should be permitted to use this analysis to substantiate safe operation of the engine at temperatures below the required test demonstration temperature. If appropriate, no limitation would then be required for the Airplane Flight Manual. Additionally, if the test demonstrates a repeatable build/shed cycle of ice, then no time limitation should be imposed on operation of the engine in freezing fog conditions. Also see Comment #2.
response	*Accepted*

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Amend CS 25.1533 Additional operating limitations	p. 62

comment	*13* comment by: *Transport Canada Civil Aviation Standards Branch* **CS 25.1533 – Additional Operating Limitations –** Transport Canada notes that the proposed wording for 25.1533 addresses the establishment of limitations when encountering certain icing conditions, however, it is not clear as to whether the intended limitation addresses only in-flight icing encounters or whether it addresses the take-off phase of flight as well. For example, when choosing option CS 25.1420(a)(1), Transport Canada requests clarification of the intent of CS 25.1533 wording as to whether the AFM limitation should contain a prohibition against take-off into Appendix O icing conditions. Similarly, when choosing option CS 25.1420(a)(2), the AFM limitation should contain a prohibition against take-off in the portion of Appendix O that is not approved. Transport Canada requests that EASA should address these cases, and suggests that the proposed CS 25.1533 wording should be modified accordingly.
response	*Accepted* We acknowledge that today some operators dispatch their aircraft in icing conditions for which the aircraft is not certified, taking credit from anti-icing fluid hold over time. However, as soon as the aircraft has lifted off, it is not anymore protected by anti-icing fluid. Therefore for aircraft certified vs CS

25.1420(a)(1), take-off in SLD conditions should be forbidden. It is anticipated that applicants will chose the option of CS 25.1420(a)(2) to allow departure in light freezing rain/drizzle as it is done today; in this case the applicant will have to demonstrate safe aircraft performance within the Appendix O portion chosen for certification.

For landing, we understand that this case should be treated like any in flight encounter of SLD conditions. Therefore, the aircraft should be diverted to an alternate airport when landing icing conditions are outside the certified envelope.

We have amended CS 25.1533 to bring clarifications on these aspects.

For aeroplanes certified in accordance with CS 25.1420(a)(1) or (a)(2), an operating limitation must be established to:

1) Prohibit intentional flight, including take-off and landing, into icing conditions defined in Appendix O for which the aeroplane has not been certified to safely operate; and

(2) Require exiting all icing conditions if icing conditions defined in Appendix O are encountered for which the aeroplane has not been certified to safely operate.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Create a new Appendix O - Part I p. 63-70

comment

62 comment by: *Goodrich Sensors and Integrated Systems*

On page 64, Appendix O, Part I (a), "Supercooled Large Droplet Icing Conditions", Freezing Drizzle. The NPA defines a drizzle drop as being 100 to 500 µm in diameter , however the Figure 1 LWC envelope on page 64 lists freezing drizzle environments MVD <40 and MVD >40. By definition MVD <40 is not freezing drizzle, nor are drops with 40<MVD<100. Given the same MVD, temperature, and LWC at altitude exists in both App O and App C, can you clearly define the mass distribution boundary between App O and App C?

response

Not accepted

MVD means Median-volume (mass-median) diameter.

The characterization of the freezing drizzle is made with reference to the maximum drop diameter D_{max} which is between 100 and 500µm.

Dmax and MVD are two different parameters. You can find detailed explanations by referring to the FAA document DOT/FAA/AR-09/10, in particular chapter 3.13.

comment

63 comment by: *Goodrich Sensors and Integrated Systems*

1. On page 67, the NPA identifies new requirements, to include freezing rain environment for installed flight instrument external probes in figures 4 through 7. GSIS would like to understand how the specific values for liquid water content, horizontal extent and mean droplet diameter were

	determined and what the technical justification for these levels is. 2. On page 67, the NPA identifies new requirements, to include freezing rain environment for installed flight instrument external probes in figures 4 through 7. GSIS is not aware of a facility to test the freezing rain requirement of this NPRM. Does EASA plan to provide guidance on methodologies to validate equipment against these requirements in lieu of direct testing?
response	*Noted* Please refer to FAA document DOT/FAA/AR-09/10, in particular chapter 3.13. EASA will publish AMC material providing support on how to show compliance.

comment	*108* comment by: *AIRBUS* Appendix O Part I Paragraph (a) (4) should be amended to read as follows: "Appendix O to CS 25 – Supercooled Large Drop Icing Conditions... Part I – Meteorology (a) Freezing Drizzle . . . (4) Total liquid water content with maximum points of 0.44 g/(m^3) at 0°C and 0.29 g/(m^3) at -25°C for MVD < 40 µm and 0.27 g/(m^3) at 0°C and 0.18 g/(m^3) at -25°C for MVD > 40." Explicitly defining the corner points of the envelope will help remove the ambiguity introduced by the proposed rudimentary plot.
response	*Accepted* We reviewed document DOT/FAA/AR-09/10 which is at the origin of the LWC values provided in Appendix O, and we concluded that the proposed values are corner points values consistent. The corner points have been added on the figure.

comment	*109* comment by: *AIRBUS* Appendix O Part I Paragraph (b) (4) should be amended to read as follows: "Appendix O to CS 25 – Supercooled Large Drop Icing Conditions... Part I – Meteorology (b) Freezing Rain . . . (4) Total liquid water content with maximum points of 0.31 g/(m^3) at 0°C and 0.26 g/(m^3) at -13°C for MVD < 40 µm and 0.26 g/(m^3) at 0°C and 0.21 g/(m^3) at -13°C for MVD > 40." Explicitly defining the corner points of the envelope will help remove the ambiguity introduced by the proposed rudimentary plot.
response	*Accepted*

	We reviewed document DOT/FAA/AR-09/10 which is at the origin of the LWC values provided in Appendix O, and we concluded that the proposed values are corner points values consistent. The corner points have been added on the figure.

comment	*110* comment by: *AIRBUS* Appendix 0 Paragraph (c) should be amended to read as follows: "Part I – Meteorology (c) Horizontal extent. The liquid water content for freezing drizzle and freezing rain conditions for horizontal extents other than the standard 17.4 nautical miles can be determined by the value of the liquid water content determined from Figure 1 or Figure 4, multiplied by the factor provided in Figure 7 <u>which is defied by the following equation:</u> <u>Horizontal extent factor = [insert appropriate equation] (Distance in km).</u>" Explicitly defining the equation will help remove the ambiguity introduced by the proposed rudimentary plot.
response	*Partially accepted* The equation has been added in addition to the figure. The distance is kept in nautical miles for consistency with other figures.

comment	*179* comment by: *Boeing* **Page: 63** **Paragraph: B(I). Draft Decision amending CS-25** **Appendix O, Supercooled large drop icing conditions** **- 1st paragraph** **---------------------------------------** **<u>Revise the text as follows</u>**: "Appendix O consists of two parts. Part I defines Appendix O as a description of supercooled large drop (SLD) icing conditions in which the drop median volume diameter (MVD) is less than or greater than 40 μm, the maximum mean effective drop diameter (MED) of Appendix C continuous maximum (stratiform clouds) icing conditions. For Appendix O, SLD icing conditions consist of freezing drizzle and freezing rain occurring in and/or below stratiform clouds. Part II defines ice accretions used to show compliance with CS-25~~, subpart B, aeroplane performance and handling qualities~~ requirements." **<u>JUSTIFICATION</u>:** The ice accretion scenario definitions contained in Part II of Appendix O would be used to show compliance with more than just the subpart B requirements (e.g., for systems exposure).
response	*Accepted*

comment | 180 comment by: *Boeing*

Page: 63
Paragraph: B(I). Draft Decision amending CS-25
Appendix O, Supercooled large drop icing conditions
- Part I, paragraph (a)

<u>Revise the text as follows</u>:

Part I—Meteorology
* * *
(a) Freezing Drizzle (Conditions with spectra maximum drop diameters from 100 µm to 500 µm):

(1) Pressure altitude range: 0 to 6706 m (22000 feet) MSL.

(2) Maximum vertical extent: 3656 m (12000 feet).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

<u>(4) Total liquid water content with maximum points of 0.44 g/(m^3) at 0°C and 0.29 g/(m^3) at -25°C for MVD < 40 µm and 0.27 g/(m^3) at 0°C and 0.18 g/(m^3) at -25°C for MVD > 40.</u>"

<u>JUSTIFICATION</u>: Explicitly defining the corner points of the envelope will help remove the ambiguity introduced by the proposed rudimentary plot.

response | *Accepted*

We reviewed document DOT/FAA/AR-09/10 which is at the origin of the LWC values provided in Appendix O, and we concluded that the proposed values are corner points values consistent.

The corner points have been added on the figure.

comment | 181 comment by: *Boeing*

Page: 67
Paragraph: B(I). Draft Decision amending CS-25
Appendix O, Supercooled large drop icing conditions
- Part I, paragraph (b)

<u>Revise the text as follows</u>:

"Part I—Meteorology
* * *
(b) Freezing Rain (Conditions with spectra maximum drop diameters greater than 500 µm):

(1) Pressure altitude range: 0 to 3656 m (12000 ft) MSL.

(2) Maximum vertical extent: 2134 m (7000 ft).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

(4) Total liquid water content~~:~~ **with maximum points of 0.31 g/(m^3) at 0°C and 0.26 g/(m^3) at -13°C for MVD < 40 µm and 0.26 g/(m^3) at 0°C and 0.21 g/(m^3) at -13°C for MVD > 40.**"

JUSTIFICATION: Explicitly defining the corner points of the envelope will help remove the ambiguity introduced by the proposed rudimentary plot.

response

Accepted

We reviewed document DOT/FAA/AR-09/10 which is at the origin of the LWC values provided in Appendix O, and we concluded that the proposed values are corner points values consistent.

The corner points have been added on the figure.

comment

182 comment by: *Boeing*

Page: 70
Paragraph: B(I). Draft Decision amending CS-25
Appendix O, Supercooled large drop icing conditions
- Part I, paragraph (c)

Revise the text as follows:

"Part I—Meteorology
* * *
(c) Horizontal extent

The liquid water content for freezing drizzle and freezing rain conditions for horizontal extents other than the standard 32.2 km (17.4 nautical miles) can be determined by the value of the liquid water content determined from Figure 1 or Figure 4, multiplied by the factor provided in Figure 7**, which is defined by the following equation: Horizontal extent factor = 1.329-0.271log10 (Distance in km)**."

JUSTIFICATION: Explicitly defining the corner points of the envelope will help remove the ambiguity introduced by the proposed rudimentary plot.

response

Partially accepted

The equation has been added in addition to the figure. The distance is kept in nautical miles for consistency with other figures.

comment

193 comment by: *American Kestrel Company, LLC*

The extent of this upper left hand corner of this plot is not supported by the

	available meteorological data The LWC is far too high for the low temperature. The justification that has been used as the basis for the values used is flawed and has resulted in an LWC that is at least 4 times too high. This will preclude the implementation of at least one viable system type that would otherwise satisfactorily allow an aircraft to fly in Appendix O conditions. This will also be a critical condition for thermal ice protection system affecting the certification pursued.
response	*Not accepted* A reference to a figure number is missing in your comment. We assume you refer to figure 1, page 64. This figure is identical to the one provided by the IPHWG report. We rely on the expertise of this group concerning the pertinence of the corner points. There was no recorded disagreement or divergence within the Group on this aspect.

comment	*194* comment by: *American Kestrel Company, LLC* The above plot, excerpted from figure 11 pg 32 of Jeck, DTO/FAA/AR-09/10 shows a clear reduction in available LWC at temperatures below -10 deg C. The proposed appendix should be modified to be consistent with meteorological observations. This was missed by the FAA and industry during the comment period for NPRM 10-10.
response	*Not accepted* Again, this figure is identical to the one provided by the IPHWG report. We rely on the expertise of this group concerning the pertinence of the corner points. There was no recorded disagreement or divergence within the Group on this aspect.

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Create a new Appendix O - Part II p. 71-74

comment	*24* ❖ comment by: *Dassault Aviation* Dassault aviation comments on §: Proof of compliance - §25.21(g)(3) (page 53) " If the applicant seeks certification for flight in any portion of the icing conditions of appendix O of this part, each requirement of this subpart, except §§ 25.123(c), 25.143(b)(1) and (2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the appendix O icing conditions for which certification is sought. And Appendix O - Part II(c)(1) (page 73): "Takeoff ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and 122 m (400 feet) above the takeoff surface, assuming accretion starts at liftoff in the icing conditions defined in Part I of this appendix." <u>Comment:</u> The requirements for safe operation in any portion of proposed Appendix O are similar to those currently required for Appendix C, with one exception: compliance with §25.121(a) Climb one engine inoperative - take-off, landing

	gear extended would be required for Appendix O. Taking into account §25.111(c)(4) - *"the airplane configuration may not be changed, except for gear retraction …… until the airplane is 400 ft above the take-off surface"*, ice accretion which should be considered to show compliance with §25.121(a)(1) should be the one occurring between liftoff and the point at which the landing gear is fully retracted. Requested Change: It is proposed to add in Appendix O - Part II(c) a definition for the Takeoff - landing gear extended ice: "Takeoff - landing gear extended ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and the point at which the landing gear is fully retracted, assuming accretion starts at liftoff in the icing conditions defined in Part I of this appendix."
response	*Not accepted* We have agreed with the comment #129 from FAA proposing adding CS 25.121(a) in the list of exception of CS 25.21(g)(3).

comment	*26* ❖ comment by: *Dassault Aviation* Dassault-Aviation comments on : "Consideration about Appendix O, Part II (page 13) and Appendix O - Part II (page 71)" Taking into account the fact that this Part II is very detailed and complex, the Agency is considering the option to move it in Book 2. Comment: The way the appendix is written is complex. Definition of a specific ice accretion is linked to the definition of other ones, with references to other paragraphs and sub-paragraphs of this Part II. Consequently, the text is not enough clear which might lead to misunderstanding. Moreover, the text is more written in the spirit of an AMC than in the one of a rule. So, Dassault considers that moving this Part II in CS25 Book 2 in an AMC could be a good option. In that case, only the generic list of ice accretions to be considered for the various flight phases could be kept in the Appendix O – Part II. Nevertheless, clarification of the presentation is needed whatever the decision to keep this Part II in Appendix O or to move it in CS25 Book 2 in an AMC. Suggested Change It is proposed to move this Part II in CS25 Book 2 in an AMC and to keep in the Appendix O the generic list of ice accretions to be considered. But, whatever the decision to keep this Part II in Appendix O or to move it in CS25 Book 2 in an AMC, it is proposed to clarify the text of this Appendix O Part II by using, as for example, a presentation based on tables.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA.

	We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*66* ❖ comment by: *Thales Avionics* Regarding B) Consideration about Appendix O, Part II Moving Appendix O, Part II to CS-25 Book 2 to become the AMC material seems clearer and easier to use.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*106* comment by: *AIRBUS* This section and Part II of appendix C would be more appropriately placed in the guidance material. The Part II section should be clarified to more clearly define what is required and this section and Part II of Appendix C should be moved to CS25 Book 2 (AMC). The requirements are extremely detailed and it would be more appropriate to include these details in the AMC.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization.

comment	*107* comment by: *AIRBUS* Paragraph (C) (7) reads: *"...Crew activation of the ice protection system is in accordance with a normal operating procedure provided in the Airplane Flight Manual, except that after beginning the takeoff roll, it must be assumed that the crew takes no action to activate the ice protection system until the airplane is at least 400 feet above the takeoff surface...."* This requirement should be deleted. This appears to be a direct cut and paste from the Appendix C regulations. Whilst this is perhaps understandable for Appendix C icing conditions it would seem reasonable to expect the crew to activate the WAIS prior to take-off if there are SLD or severe icing conditions within 400 feet of the runway, whether

	the AFM specifically states that it is required or not.
response	*Not accepted* The Agency does not agree with the proposed justification. If a pilot can decide not to select ice protection system "On" in presence of Appendix C icing conditions, there is no clue that he would act differently in presence of Appendix O icing conditions.

comment	*116* comment by: *Claudio Mauerhofer* *Consideration about Appendix O, Part II (page 13)* We support the proposal of moving Part II of Appendix O to CS-25 Book 2. Generally we wish to remark the need and value of investing adequate resources in the drafting of CS-25 Book 2.
response	*Not accepted* We decide to keep Appendix O Part II in Book 1 and we harmonize with FAA. We also recognize that future rulemaking could be planned to improve the way this Part II is written and possibly re-write it in a simpler and clearer manner, including transferring some elements in the Book 2. For the time being, we retain the IPHWG proposal and follow the FAA decision for harmonization

B. Draft Decision - I Draft Decision amending CS-25 Book 1 - Create a new Appendix P p. 75-77

comment	*2* comment by: *European Cockpit Association* ECA welcomes the proposals made by EASA as the corridors in Appendix P of NPA 2011-03 are a step in the right direction However, as noted by EASA on page 14 there are known icing events outside the proposed certification corridors: *"The proposed Appendix P is identical to the FAA proposed Appendix D to Part 33, which originated from the ARAC recommendations. Based on EASA knowledge of service experiences with Pitot probes, the associated convective cloud ice crystal icing envelope (Figure 1 of Appendix P) would cover an important portion but not all of the occurrences. Indeed, EASA is aware of incidents of temporary erroneous airspeed indication which happened at high altitude with static air temperature (SAT) below the current proposed Appendix P limit of -60°C. One of these events happened at (SAT=-70°C, Altitude=45,000ft). Other events occurred at SAT above-60°C but at altitudes outside the proposed Appendix P, figure 1.* *For this reason, EASA is envisaging an extension of Appendix P, figure 1 envelope to encompass all the known occurrences, with a minimum temperature of -75°C. This extension should also include the current AMC 25.141 Ice crystal conditions envelopes. Any comments on this proposal are welcome."* ECA proposes to enlarge the corridor further to also include the conditions under which those icing events occurred.
response	*Noted*

We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE group 89.

comment

67 ❖ comment by: *Thales Avionics*

The observation of events outside of the envelope in Appendix P figure 1 (particularly at SAT=-70°C, Altitude=45,000ft) make the extension of the envelope to these points mandatory. However, extending the envelope beyond SAT = -70°C should not be considered as not grounded by any observation and because of its unreasonable impact on probe designs, on their installation and of the resulting economic impact.

response

Noted

We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE Group 89.

comment

111 comment by: *AIRBUS*

The current proposal for a future Appendix D to 14 CFR Part 33 uses a relationship between TWC and cloud length that according to the EHWG is based on a re-evaluation of the data provided in Ref 1. A similar evaluation of the same data but including additional information which have not been published in Ref. 1 (for example the exact flight tracks) has lead to a recommendation as put forward in Ref. 3. For very short cloud lengths of the order of 2.6 nm both evaluations lead to a very similar TWC. However, for larger cloud lengths, the new proposed total water content will be bigger than the values suggested in Ref. 3 (cf. Table 3, p. 29+30 of Ref. 2). This is a considerable added conservatism taking into account that that the EHWG acknowledged in Ref. 2 that

- "The new calculation of the EHWG/PPIHWG may be biased by the data collection method [for data in Ref. 1]. A typical type of flight track used in the McNaughtan study is not simply a straight track, but rather includes diversions intended to keep the aircraft near intense storm cores where the regions of higher TWC are found." (Ref. 2, p. 24)
- [the new guidelines] "may represent a conservative distance scale guideline" (Ref. 2, p. 25)
- "A new effort be conducted to collect a database of deep convective cloud measurements using modern instrumentation with accurate TWC measurement capability." (Ref. 2, p. 27)

Moreover, the EHWG considered the new guideline only as being an "interim guidance" (see heading of Ch. 4.6 of Ref. 2).

Using the EHWG event database and referring to the flight distance between TAT sensor anomaly and the engine event one can see that almost half of the engine events occured at a flight distance equal or smaller than 10 nmi from the occurance of the TAT anomaly with a significant portion below 4 nautical miles. We would conclude based on the same facts that short cloud exposures are the most critical. However the new appendix D definition implies that the longest clouds are the most critical for engines and APU' s and adds a factor of 2 to the conservatism of the definitions already defined in EASA CS-E-780 and AMC 25.1419. This is not supported by the in-service experience.

	This is not an issue for protected components as the low water content long duration tests do not represent the critical conditions for such features. Considering the uncertainty in the new rule it is considered inappropriate to add an additional factor of 2 to the icing conditions for long appendix D icing exposures. Ref. 1 refers to "The Analysis of Measurements of Free Ice and Ice/Water Concentrations in the Atmosphere of the Equatorial Zone. Ian I. McNaughtan, B.Sc., Dip. R.T.C., Royal Aircraft Establishment (Farnborough) Technical Note No: Mech. Eng. 283, 1959." Ref. 2 refers to "Task 2 Working Group Report on Supercooled Large Droplet Rulemaking Revision 1 Decemver 2005." Ref. 3 refers to "Flight into Ice Crystal. Aeroplanes and Rotorcraft Joint Airworthiness Committee Paper 733, Leaflet 714Y, August 1958."
response	*Noted*

comment	*113* comment by: *AIRBUS* Attachments #16 #17 Application of Appendix P to air data sensors must be clarified as the phenomenon of ice accretion in ice crystal conditions is different for air data sensors than for engines. The available data indicates that the freezing of sensors occurs at shorter length scales and much higher total water contents than the conditions under which the engine events occur. As an alternative to Figure 2, the attachments provide a possible envelope. Refer to attached document (ATT 1) The figures below could be specifically applied to pitot probes: Refer to attached document (ATT 2) It is recognized that the understanding of the ice crystal and mixed phase environments and the physics of ice crystal effects on engines and probes must be improved and that long running efforts will lead to a detailed characterization of the ice crystal environment in highly convective weather systems later this decade. In the interim however the original standard defined by the ARAC Engine Harmonisation Working Group in 2005 can be improved based upon the data collected since that time. The proposed charts take into account that the Appendix P must be modified before it can be applied to air data sensors because the phenomenon of ice accretion in ice crystal conditions is different for air data sensors than for engines. The figures proposed above are based on the work of the EHWG but rather than use the average value of TWC for a 17.4 nm cloud shorter length scales are applied. The data used to define the 14 CFR Part 33 Appendix D (CS 25 Appendix P) envelope came from engine in-service events in ice crystal conditions and theoretical adiabatic lifting models. However the latest information indicates that the freezing of sensors occurs at shorter length scales and much higher total water contents than the conditions under which

	the engine events occur. Therefore a more appropriate length scale and TWC definition is required for probe icing requirements. For glaciated (ice crystal) conditions it is proposed to use the peak value of TWC computed assuming adiabatic lifting with no application of the horizontal distance TWC reduction factor. The proposed TWC curves are given in **FAA document DOT/FAA/AR-09/13, in § 4.5 figure 23**.and correspond to the theoretcial **max or peak** TWC concentration values that can be encountered in clouds assuming 90% humidity at sea level. Note that the peak values correspond to the 17.4 NM scaled values multiplied by a factor of **1.538.** An alternative means would be to retain the Appendix P figure 2 but define a specific TWC reduction factor characteristic for pitot probes. For mixed phase icing conditions it is proposed to use the standard Appendix C intermittent maximum cloud standard length scale of 2.6 nm. This yields the TWC relationships shown in Figure 3. The Appendix D also provides a TWC correction law (TWC factor), allowing correction of the 17.4 NM typical values for horizontal extensions from 300 NM down to 4.5 NM. From this correction law, the correction factor is about 1.13 for the minimum horizontal extent of 4.5 NM provided by the law. But the correction law does not allow accounting horizontal extensions that are shorter than 4.5 NM. This existing TWC factor curve is therefore inappropriate for pitot probes. It is proposed to extend the glaciated and mixed phase altitude and temperature ranges of Appendix P to the blue dotted lines and violet dotted lines shown in attachment 1. It is noted that the current compliance methods (icing tunnels and simulation models) for air data instruments and engines cannot produce the cold extremes defined by the Appendix P environment and a means of compliance that addresses these test means limitations will be required.
response	*Noted* We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE group 89.
comment	*183* comment by: *Boeing* Attachment #18 **Page: 75-76** **Paragraph: B(I). Draft Decision amending CS-25** **Appendix P, Mixed phase and ice crystal icing envelope (Deep convective clouds)** See attached file for comments.
response	*Noted* We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following

the recommendations from the EUROCAE group 89.

comment

196 comment by: *Snecma*

please see in Snecma letter 2764-RC : comment n°2 page 2 an comment n°3 page 3. Letter is in comment for rule CS-25.1093.

response

Accepted

comment

203 comment by: *Cessna Aircraft Company*

What about this proposal do we want changed?

To reflect new engine power loss and airspeed loss events in ice crystal conditions, Appendix P should be updated. There are four known engine power loss events which fall outside of the proposed Appendix P envelope. The events occurred at the following conditions:

Altitude (ft)	Ambient Temperature (degrees C)
25200	-10
29400	-19
32800	-48
41000	-63

Furthermore, known airspeed loss events in ice crystal weather conditions should be included, such as those documented in, “Interim Report no 2,” Bureau D’Enquetes et D’Analyses pour la securite d’aviation civile (BEA) F-GZCP.

Why is the change justified?

To ensure that the envelope includes the most up-to-date information.

response

Noted

We decide not to extend the Appendix P at this stage. Instead we will propose extreme icing conditions for flight probes in an AMC to CS 25.1324, following the recommendations from the EUROCAE group 89.

V. Amended explanatory note of NPA 2011-03

NPA 2011-03 proposed to update large aeroplanes Certification Specifications (CS-25) for flight in icing conditions. Following the consultation on NPA 2011-03, the Agency analysed the comments received and made some changes to the explanatory note. The revised version is provided below.

1. Background

It has been evidenced that the icing environment used for certification of large aeroplanes and turbine engines needs to be expanded in order to improve the level of safety when operating in icing conditions.

On 31 October 1994, near Roselawn, Indiana-USA, an accident involving an Avions de Transport Régional ATR 72 occurred in icing conditions believed to include freezing drizzle drops. Indeed, the accident investigation led to the conclusion that freezing drizzle conditions created a ridge of ice on the wings' upper surface aft of the de-icing boots and forward of the ailerons. It was further concluded that the ridge of ice resulted in an un-commanded roll of the aeroplane. Freezing drizzle and freezing rain are atmospheric conditions that are outside the existing CS-25 Appendix C icing envelope that is used for certification of large aeroplanes.

Freezing drizzle and freezing rain constitute an icing environment known as Supercooled Large Drops (SLDs).

Following the ATR 72 accident, the National Transportation Safety Board in the USA (NTSB) recommended updating aeroplanes icing conditions specifications. Although some knowledge existed at this date about severe icing conditions, including SLD, it was not possible to immediately update the icing environment in the Certification Specifications, because there was a need to identify in detail the parameters of the relevant environmental envelopes applicable to aircraft operations and to accurately assess the associated safety risk In addition, the methods of compliance by aircraft manufacturers with potential new icing environment requirements had to be investigated (capabilities in terms of engineering tools, ground test facilities, flight tests). This was recognised as a very complex task requiring expertise in different fields. Therefore, an Aviation Rulemaking Advisory Committee (ARAC) was tasked by the Federal Aviation Administration (FAA) in December 1997, through its Ice Protection Harmonization Working Group (IPHWG), to perform the following actions:

- Define an icing environment that includes SLDs;
- Consider the need to define a mixed phase icing environment (supercooled liquid and ice crystals);
- Devise requirements to assess the ability of an aeroplane to either safely operate without restrictions in these conditions or safely operate until it can exit these conditions;
- Study the effects icing requirement changes could have on FAR/JAR 25.773 Pilot compartment view, 25.1323 Airspeed indicating system, and 25.1325 Static pressure systems.
- Consider the need for a regulation on ice protection for angle of attack probes.

Service experience of different engine types installed on CS-25 aircraft has also identified the potential for a multiple engine failure during take-off, after prolonged ground operation in freezing fog. A multiple engine failure during take-off would compromise safe flight and landing.

Moreover, falling and blowing snow is a weather condition, which needs to be considered for the powerplants and essential Auxiliary Power Units (APUs) of transport aeroplanes. Although snow conditions can be encountered on the ground or in flight, there is little evidence that snow can cause adverse effects in flight on turbojet and turbofan engines with traditional Pitot style inlets where protection against icing conditions is provided. However, service history has shown that in-flight snow (and mixed phase) conditions have caused power interruptions on some turbine engines and APUs with inlets that incorporate plenum chambers, reverse flow, or particle separating design features.

The proposed rule was based on the recommendations of the ARAC group. The ARAC IPHWG task 2 report rev A and the task 2 phase IV review (submitted on 29 June 2009) are available on the FAA website .

The Agency also considered the rule proposed by FAA in their Notice of Proposed Rulemaking (NPRM) "Airplane and Engine Certification Requirements in Supercooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions" dated 29 June 2010 (Docket No. FAA-2010-0636; Notice No. 10-10).

2. Existing CS-25 Certification Specifications for operation in icing conditions

CS-25 provides for a set of requirements involving protection systems and aeroplane operation performances.

CS 25.1419 (Ice protection) requires the aeroplane to be able to "safely operate in the continuous maximum and intermittent maximum icing conditions of Appendix C".

Minimum performance and handling qualities, as well as methods to detect airframe icing and to activate and operate ice protection systems, are also required in these icing conditions. These specifications were introduced respectively in CS-25 Amendment 3 (refer to NPA 16/2004 "Flight in icing conditions") and Amendment 7 (refer to NPA 2009 08 "Activation of ice protection system and update of ETSO C16 for electrically heated Pitot and Pitot-static tubes"). They can be found in the following paragraphs of Subpart B: CS 25.21(g) (Proof of compliance), CS 25.103(b)(3) (Stall speed), CS 25.105(a) (Take-off), CS 25.107(h) (Take-off speeds), CS 25.111(c)(5) (Take-off flight path), CS 25.119(b) (Landing climb: all engines operating), CS 25.121(b)(2), (c)(2) and (d)(2) (Climb: one engine inoperative), CS 25.123(b) (En-route flight paths), CS 25.125 (Landing), CS 25.143(Controllability and manoeuvrability – General), CS 25.207 (Stall warning), CS 25.237 (Wind velocities), CS 25.253(c) (High-speed characteristics).

Appendix C to CS-25 provides the atmospheric icing conditions and the ice accretions to be used for showing compliance with the requirements of CS-25 Subpart B "Flight" mentioned above.

The atmospheric conditions are defined by the variables of the cloud liquid water content and horizontal extent, the mean effective diameter of the cloud droplets, the ambient air temperature and the interrelationship of these three variables. The icing environment is also limited in terms of pressure altitude: 0-6700m (0-22,000ft) for the continuous maximum icing conditions (stratiform clouds) and 1000-9500m (3000-31,000ft) for the intermittent maximum icing (cumuliform clouds).

CS 25.1093(b) provides requirements for turbine engines air intake system de-icing and anti-icing.

CS 25.1093(b)(1) requires turbine engine safe operation throughout Appendix C icing conditions.

CS 25.1093(b)(2) defines test conditions in order to demonstrate the safe operation of the powerplant systems in freezing fog conditions at idle on ground.

CS 25J1093 provides requirements for APU air intake system icing protection. CS 25J1093(a) is applicable to non-essential APUs, CS 25J1093(b) to essential APUs.

3. Existing operational regulation in the European Union for flight in icing conditions

Commission Regulation (EC) No 859/2008 of 20 August 2008 provides in its Annex III common technical requirements and administrative procedures to commercial air transportation by aeroplanes.

According to OPS 1.675, the operator shall not operate an aeroplane in expected or actual icing conditions unless the aeroplane is certificated and equipped to operate in icing conditions. For night operations, the aeroplane must also be equipped with a means to illuminate or detect the formation of ice.

In addition, this regulation requires protection of the airspeed indicating system in the following cases:

For day VFR operations, OPS 1.650 requires each airspeed indicating system being equipped with a heated Pitot tube or equivalent means for preventing malfunction due to either condensation or icing for: aeroplanes with a maximum certificated take-off mass in excess of 5,700 kg or having a maximum approved passenger seating configuration of more than 9; aeroplanes first issued with an individual certificate of airworthiness on or after 1 April 1999.

For IFR or night operations, OPS 1.652 requires an airspeed indicating system with heated Pitot tube or equivalent means for preventing malfunctioning due to either condensation or icing including a warning indication of Pitot heater failure. The Pitot heater failure warning indication requirement does not apply to those aeroplanes with a maximum approved passenger seating configuration of nine or less or a maximum certificated take-off mass of 5,700 kg or less and issued with an individual Certificate of Airworthiness prior to 1 April 1998.

4. JAA, FAA and EASA actions taken to minimise the safety risk from severe icing conditions

Following the ATR 72 accident in 1994, measures were taken to minimise the potential hazard associated with certain aeroplanes operating in severe icing conditions.

Several Airworthiness Directives (AD) have been issued to require certain aeroplanes to exit severe icing conditions when visual cues indicate that these conditions exceed the capabilities of the ice protection equipment. These ADs are applicable to aeroplanes equipped with unpowered roll controls and pneumatic de-icing boots.

JAA issued interim policy INT/POL/25/11 "Severe Icing Conditions" (dated 1 October 1998) and FAA produced a generic issue paper "Roll control in Supercooled Large Droplet conditions". These policies have been applied to certify new aeroplanes equipped with unpowered roll controls and pneumatic de-icing boots, because service experience revealed issues on these types of aircraft (like the ATR 72). EASA would also use a CRI (Certification Review Item) providing Special Conditions for new certification projects based on JAA INT/POL/25/11. The intent is to ensure protection against loss of control by providing for means of detection and exiting from freezing drizzle and freezing rain conditions. However, they are not intended to certify an aeroplane for unrestricted flight in Supercooled Large Drops or any other conditions which are outside of the Appendix C icing envelope.

5. Discussion of the CS-25 rule change

a. General

It is decided to amend CS-25 to better protect large aeroplanes certificated for flight in icing conditions. The new icing environment includes Supercooled Large Drops, Mixed Phase, and Ice Crystals. We also update the requirements for turbine engine air intake system protection (updated freezing fog conditions and new falling and blowing snow conditions) and APU air intake system protection (the specification for essential APU air intake is similar to the one applicable to engine air intake) . In connection with this proposal, an amendment of CS-E to update turbine engine Certification Specifications was proposed through NPA 2011-04.

The Agency considered and analysed the IPHWG recommendations, the FAA NPRM "Airplane and Engine Certification Requirements in Supercooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions" dated 29 June 2010 (Docket No. FAA-2010-0636; Notice No. 10-10), and all the lessons from in-service large aeroplanes.

b. Review of accidents and incidents lessons

The IPHWG reviewed icing events involving large aeroplanes and found accidents and incidents that are believed to have occurred in icing conditions that are not addressed by the current regulations. Therefore these icing conditions must be considered for introduction in the Certification Specifications for large aeroplanes.

These icing conditions resulted in flight crews losing control of their aircraft and, in some cases, engine power loss. The IPHWG events review found hull losses and fatalities associated with SLD conditions for some smaller-sized large aeroplanes, but not for ice crystal and mixed phase conditions. The proposed rule would provide a SLD environment in an Appendix O to CS-25.

However, there have been a number of engine power loss events reports during the last two decades, which occurred in presence of ice crystals and mixed phase. Some of them involved multi-engine power loss. Although the events did not result in accidents, they are considered as a serious safety threat.

The incident history also indicates that flight crews have experienced temporary loss of or erroneous airspeed indications in severe icing conditions (in areas of deep convection). Airspeed indications on large aeroplanes are derived from the difference between two air pressures—the total pressure, as measured by a Pitot tube mounted somewhere on the fuselage, and the ambient or static pressure, as measured by a static port. The static port may be flush mounted on the aeroplane fuselage or co-located on the Pitot tube. When the static and Pitot systems are co-located, the configuration is referred to as a Pitot-static tube. Static ports are not prone to collecting ice crystals, either because of their flush mounted locations or their overall shape. Due to the way Pitot or Pitot-static tubes are usually mounted, they are prone to collecting ice crystals. Encountering high concentrations of ice crystals may lead to blocked Pitot or Pitot-static tubes because the energy necessary to melt the ice crystals can exceed the tube heating system capability, or the water formed by the melting process is not completely evacuated and it can re-freeze downstream inside the tube. Pitot or Pitot-static tube blockage can lead to errors in measuring airspeed.

The IPHWG did not identify any events due to ice accumulations on probes that are used to measure angle of attack, or other angle of attack sensors. However, the IPHWG determined there are angle of attack probe designs that are susceptible to mixed phase conditions.

Moreover, events of malfunctioning and/or damage to temperature probes have also been reported to EASA and attributed to severe adverse environment encounters.

The proposed rule would therefore require any flight instrument external probe to operate normally in a new ice crystal and mixed phase environment (proposed Appendix P of CS-25).

Some incidents have evidenced that Pitot probes heating system abnormal operating must be better monitored and indicated to the flight crews. Indeed, some failures of the heating resistance (such as an out-of-tolerance resistance) could not be detected. The existing CS-25 provisions thus need to be clarified and updated.

In addition, service history has shown that in flight snow (and mixed phase) conditions have caused power interruptions on some turbine engines and APUs with inlets that incorporate plenum chambers, reverse flow, or particle separating design features.

Finally, service experience of different engine types has identified the potential for a multiple engine failure during take-off, after prolonged ground operation in freezing fog. A multiple engine failure during take-off would compromise safe flight and landing. Recent events have occurred at both Northern European and North American airports. In one event, the damage to the engines was not detected until a number of flights later when one engine surged in cruise requiring the throttle to be retarded to idle for the remainder of the flight. Subsequent examination identified mechanical damage to the compressors of both engines. The damage was identified to have occurred during take-off after operation at idle on the ground in freezing fog conditions below −10°C for a period greater than one hour. Ice accreted on the engine static structure and subsequent acceleration to take-off caused the ice to shed, which resulted in damage to the compressor.

c. EASA certification interim measures

Related to the SLD environment, Certification Review Items (Special Conditions) based on JAA interim policy INT/POL/25/11 "Severe Icing Conditions" (dated 01 October 1998) could be used by EASA if a relevant application was received (for aeroplanes equipped with unpowered roll controls and pneumatic de-icing boots). (Note: since the EASA creation in 2003, no application was received).

Related to Mixed Phase and Ice Crystals environment, the Agency also issued a generic CRI (Interpretative Material) entitled "Flight Instrument External Probes – Qualification in Icing Conditions". Flight instrument external probes (including, but not necessarily limited to Pitot probes, alpha vanes, side slip vanes and temperature probes) are requested to be evaluated against specified icing conditions including supercooled droplets, ice crystals, mixed phase, and rain droplets. It has been introduced to certification projects by JAA since 2001. More recently, for the reasons explained before, the Agency has decided to strengthen the Interpretative Material and to develop a Special Condition which will be applicable to all new applications since 31 January 2010.

Concerning turbine engines, another CRI has been created to clarify that "Pitot" type engine intakes need to be assessed against ice crystal conditions mentioned in AMC E.780. The CRI makes clear that the existing AMC E.780 statement that this type of intake is not susceptible to ice crystal is no longer acceptable.

Freezing fog: a generic CRI is used in order to avoid any unsafe conditions resulting from prolonged exposure to freezing fog beyond the conditions demonstrated during compliance demonstration to CS-25. The conditions defined in current CS 25.1093(b)(2), in terms of time and temperature, if any, are considered as limitations necessary for the safe operation in freezing fog, as per CS 25.1501, and they must be available to the crew in the AFM. Meanwhile, the applicant may demonstrate capability beyond the conditions of CS 25.1093(b)(2).

Falling and blowing snow: a generic CRI is used for analysis of falling and blowing snow on turbine engine and APUs. For turbojet and turbofan engines with traditional Pitot (straight duct) type inlets, icing conditions are generally regarded as a more critical case than falling and blowing snow. For these types of inlet, compliance with the icing requirements will be accepted in lieu of any specific snow testing or analysis. For non-Pitot inlet types, demonstration of compliance with the falling and blowing snow ground conditions should be conducted by tests and/or analysis. The CRI then provides the test conditions to be used by the applicant.

d. The Supercooled Large Drop (SLD) icing conditions: new Appendix O

It is decided to create CS-25 Appendix O which provides a new SLD icing environment to be used for certification of Large Aeroplanes, in addition to the existing CS-25 Appendix C icing environment. The Appendix O is structured in two parts like the existing Appendix C.

The first part specifies the SLD icing conditions and the second part defines the ice accretions to be considered, based on the conditions provided in the first part.

A) Appendix O, Part I – The SLD Standard Environment

The proposed Appendix O specifies the SLD conditions to be used for certification of Large Aeroplanes. It was developed by the ARAC IPHWG, which included meteorologists and icing research specialists from industry, FAA/FAA Tech Center, Meteorological Services of Canada, National Aeronautics and Space Administration (NASA), and Transport Canada/Transport Development Center. The IPHWG collected and analysed airborne measurements of pertinent SLD variables, developed an engineering standard to be used in aircraft certification, and recommended that standard to the FAA.

Appendix O Part I provides standards for SLD conditions as two specific environments: freezing drizzle and freezing rain. The freezing drizzle and freezing rain environments are further divided into categories in which the drop median volume diameters are either less than or greater than 40 microns. Appendix O consists of measured data that was divided into drop distributions within these four icing categorizations. These distributions were averaged to produce the representative distributions for each category.

The distributions of drop sizes are defined as part of Appendix O. The distributions are included because they are necessary to capture the bimodal nature of the SLD environment. That is, there tends to be one mass concentration in smaller drop sizes and a second in larger drop sizes. Both the larger and smaller drops contribute to the total mass of water that impinges on aeroplane components, the drop impingement, icing limits, and the ice build-up shape.

Appendix O also provides a liquid water content scale factor that is used to adjust the liquid water content for freezing drizzle and freezing rain. The scale factor is based on the liquid water contents of continuous freezing drizzle and freezing rain conditions decreasing with increasing horizontal extents.

Note: Figure 7 of Appendix O Part I ("Horizontal Extent") is slightly different compared to the one published in the IPHWG report. FAA published an updated curve in their NPRM based on information from the specialist (Environment Canada) author of the curve provided to the IPHWG. We use also this new curve in our proposal.

B) Appendix O, Part II – Ice Accretions

The ice accretion definitions in the Appendix O Part II are similar to those currently required for flight in Appendix C icing conditions. The Appendix O Part II(a) contains information regarding which ice shape definitions must be used relative to the CS 25.1420(a) certification options.

The Appendix O Part II(b) defines the ice accretions to be used by applicants certifying to CS 25.1420(a)(1) or (a)(2) for detecting and exiting any portion of Appendix O in which the aeroplane is not certified to operate.

The Appendix O Part II(c) defines the ice accretions to be used by applicants certifying to proposed CS 25.1420(a)(2) or (a)(3) for any portion of Appendix O in which the aeroplane is certified to operate.

The Appendix O Part II(d) defines the ice accretion in Appendix O conditions before the airframe ice protection system is activated and is performing its intended function to reduce or eliminate ice accretions on protected surfaces ("pre-activation ice"). This ice accretion is to be used in showing compliance with the controllability and stall warning margin requirements of CS 25.143(j) and CS 25.207(h), respectively, that apply before the airframe ice protection system has been activated and is performing its intended function.

Even if the aeroplane is certified to operate only in a portion of the Appendix O icing conditions, or in none of the Appendix O icing conditions, the ice accretion used to show compliance with CS 25.143(j) and CS 25.207(h) must consider all Appendix O icing conditions (indeed, the initial entry into icing conditions may be into Appendix O icing conditions in which the aeroplane is not certified to operate).

To reduce the number of ice accretions needed to show compliance, the Appendix O Part II(e) allows the option of using an ice accretion defined for one flight phase for any other flight phase if it is shown to be more critical than the ice accretion defined for that other flight phase.

e. The new requirements in SLD icing conditions

A) General

The new CS 25.1420 adds safety requirements that must be met in SLD icing conditions for large aeroplanes to be certified for flight in icing conditions. This change requires evaluating the operation of these aeroplanes in the SLD icing environment; developing a means to differentiate between different SLD icing conditions, if necessary; and developing procedures to exit all icing conditions, if necessary. The rule requires consideration of the SLD icing conditions (freezing drizzle and freezing rain) defined in the proposed new CS-25 Appendix O, part I, in addition to the existing CS-25 Appendix C icing conditions. The Appendix O was developed by the ARAC IPHWG, which included meteorologists and icing research specialists from industry, FAA/FAA Tech Center, Meteorological Services Canada, National Aeronautics and Space Administration (NASA), and Transport Canada/Transport Development Center. The IPHWG collected and analysed airborne measurements of pertinent SLD variables and developed an engineering standard to be used in aircraft certification. Appendix O includes drop sizes larger than those considered by the current icing Appendix C. These larger drops impinge and freeze farther aft on aeroplane surfaces than the drops defined in Appendix C and may affect the aeroplane's performance, handling qualities, flutter characteristics, and engine and systems operations. The Appendix O icing conditions may affect the design of aeroplane ice protection systems.

The Appendix O SLD icing conditions are those in which the aeroplane must be able to either safely exit following the detection of any or specifically identified Appendix O icing conditions, or safely operate without restrictions. Specifically, the CS 25.1420 allows three options:

- Detect Appendix O conditions and then operate safely while exiting all icing conditions (CS 25.1420(a)(1)).
- Safely operate in a selected portion of Appendix O conditions, detect when the aeroplane is operating in conditions that exceed the selected portion, and then operate safely while exiting all icing conditions (CS 25.1420(a)(2)).
- Operate safely in all of the Appendix O conditions (CS 25.1420(a)(3)).

B) Analysis and tests requirements

To establish that an aeroplane could operate safely in the proposed Appendix O conditions described above, the CS 25.1420(b) would require both analysis and one test, or more as found necessary, to establish that the ice protection for the various components of the aeroplane is adequate. The majority of the IPHWG acknowledged the difficulties in flight testing in natural SLD icing conditions; for this reason, CS 25.1420(b) considers flight testing in natural Appendix O conditions as one of the available methods to support the required analysis.

During the certification process, the applicant demonstrates compliance with the rule using a combination of analyses and test(s). The applicant's means of compliance consists of analyses and the amount and types of testing it finds necessary to demonstrate compliance with the regulation. The applicant chooses to use one or more of the tests identified in paragraphs CS 25.1420(b)(1) through (b)(5). Although the applicant may choose the means of compliance, it is ultimately the EASA that determines whether the applicant has performed sufficient test(s) and analyses to substantiate compliance with the rule. Similarly, the words ''as necessary,'' which appear in CS 25.1420(b)(3) and (b)(5), would result in the applicant choosing the means of compliance that is needed to support the analysis, but the EASA would make a finding whether the means of compliance is acceptable.

C) Similarity analysis

If an applicant has adequate data, based on extensive experience from its own CS-25 aircraft in-service fleet, a similarity analysis may be used in lieu of the analysis and tests required by CS 25.1420(b). Although SLD icing conditions are hazardous, accidents and incidents involving this type of meteorological condition mainly concern certain types of large aeroplanes; events essentially involved aeroplanes with a maximum take-off weight less than 27000 kg (60000 lbs), reversible flight controls, de-icing protection systems (e.g. de-icing boots as opposed to thermal anti-icing systems). Many currently certified large aeroplanes have been proven by their field service experience to be safe to operate in these conditions.

New large aeroplanes designs, similar to those of which have proven safe operation in SLD icing conditions, would be allowed to show compliance by comparative analysis. This comparison would only be allowed with aeroplane types held by the same applicant. This possibility has been incorporated in the AMC material that is proposed by the Agency through a separate new NPA.

D) Ice protection system activation and operation

For an aeroplane certified to operate in at least a portion of the proposed Appendix O icing conditions, the CS 25.1420(c) extends the requirements of CS 25.1419(e), (f), (g), and (h) to include activation and operation of airframe ice protection systems in the Appendix O icing conditions for which the aeroplane is certified. The CS 25.1420(c) does not apply to aeroplanes certified to CS 25.1420(a)(1), since CS 25.1420(a)(1) requires a method to identify Appendix O icing conditions and safely exit all icing conditions.

f. Performance and Handling Qualities

A) Description of the requirements

The existing CS 25.21(g)(1) requires that the performance and handling qualities requirements of CS-25 Subpart B, with certain exceptions, be met in Appendix C icing conditions. The proposed CS 25.21(g)(2) would identify the performance and handling qualities requirements that must be met to ensure that an aeroplane certified to either the proposed CS 25.1420(a)(1) or (a)(2) could safely exit icing if the icing conditions of proposed Appendix O, for which certification is not sought, are encountered. An aeroplane certified to proposed CS 25.1420(a)(1) would not be approved to take off in proposed Appendix O icing conditions and would only need to be able to detect and safely exit those icing conditions encountered en route. An aeroplane certified to proposed CS 25.1420(a)(2) might not be approved to take off in some or all of the proposed Appendix O conditions, depending upon the applicant's selected portion. In cases where there is a portion of the Appendix O conditions for which certification is not sought, such aeroplane likewise would only need to be able to detect and safely exit the unapproved conditions encountered en route.

Therefore, it is proposed that, in addition to the exceptions identified in the existing CS 25.21(g)(1), such an aeroplane would not need to meet certain requirements for Appendix O icing conditions.

With two exceptions, for an aeroplane certified under proposed CS 25.1420(a)(1) or (a)(2), the same handling qualities requirements that must currently be met for flight in Appendix C icing conditions are proposed during the detection and safe exit from the Appendix O icing conditions for which certification is not sought. The exceptions are CS 25.143(c)(1), which addresses controllability following engine failure during take-off at V2 and CS 25.207(e)(1), which addresses stall warning requirements with take-off ice accretions. Compliance with those rules would not be necessary for an aeroplane certified under proposed CS 25.1420(a)(1) or not certifying for take-off under proposed CS 25.1420(a)(2), since the aeroplane would not be approved for take-off in Appendix O icing conditions. No justification for a relaxation of other handling qualities requirements could be identified.

The requirements for safe operation in all or any portion of proposed Appendix O icing conditions under proposed CS 25.21(g)(3) are similar to those currently required for Appendix C icing conditions. The list of CS 25 Subpart B requirements that currently do not have to be met for flight in Appendix C icing conditions would not have to be met in proposed Appendix O icing conditions. For continued operation in Appendix O icing conditions, there should effectively be no degradation in handling qualities from the minimum standards established by CS-25 Subpart B specifications, and any degradation in performance should be no greater than that allowed by the rules for Appendix C icing conditions.

B) Consideration about Appendix O, Part II

The Agency is considering an option of moving Part II of Appendix O to CS-25 Book 2. This would then become the AMC material used to show compliance with CS-25 Subpart B using the meteorological data in Part I of Appendix O.

This consideration comes from our assessment of Part II which appears to be relatively detailed and complex. Usually, rules are written at higher level and the possible detailed means of compliance are provided in an AMC. This could also provide more flexibility in the process of showing compliance when interpretation of the requirements is complex and subject to discussions or different views between the parties.

We therefore invite stakeholders to provide their comments about this option. If decided, the same change could be applied to Part I of Appendix C.

g. Component requirements

In certification programmes, both the aeroplane as a whole and its individual components are evaluated for flight in icing conditions. There are several rules in CS-25 that contain icing related requirements for specific components. It is proposed to revise those rules to ensure the aeroplane can safely operate in the new icing conditions established in this proposed rule.

CS 25.1419 requires that an aeroplane be able to safely operate in all of the conditions specified in Appendix C, whereas the proposed CS 25.1420 would not require an aeroplane to safely operate in all of the Appendix O icing conditions. Proposed CS 25.1420(a)(1) and (a)(2) only require an aeroplane to be capable of safely exiting icing conditions after encountering an Appendix O icing condition for which that aeroplane will not be certified. The existing rules for pilot compartment view, airspeed indication system, and static pressure system contain requirements for operation in icing conditions.

CS 25.773(b)(1)(ii), for pilot compartment view, would be revised to add requirements for operation in Appendix O icing conditions.

A new paragraph CS 25.1324 Flight Instrument External Probes Heating Systems would be created to require each flight instrument external probe system to be heated, or have an equivalent means of preventing malfunction, in the icing conditions specified in Appendix C, Appendix O, in the ice crystals and mixed phase conditions of Appendix P, and the rain conditions that will be provided in an AMC to CS 25.1324.

Flight instrument external probes include but are not limited to Pitot tubes, Pitot-static tubes, static probes, angle of attack sensors, side slip vanes, and temperature probes.

The proposed Appendix P is identical to the FAA proposed Appendix D to Part 33, which originated from the ARAC recommendations. Based on EASA knowledge of service experiences with Pitot probes, the associated convective cloud ice crystal icing envelope (Figure 1 of Appendix P) would cover an important portion but not all of the occurrences. Indeed, EASA is aware of incidents of temporary erroneous airspeed indication which happened at high altitude with static air temperature (SAT) below the current proposed Appendix P limit of -60°C. One of these events happened at (SAT=-70°C, Altitude=45,000ft). Other events occurred at SAT above -60°C but at altitudes outside the proposed Appendix P, figure 1.

For this reason, EASA has envisaged an extension of Appendix P environment. However, after discussing this possibility with FAA and industry stakeholders, it appears that we need first to complete the on-going research activities that will collect and analyse information from flight test in areas of deep convection, in order to gather knowledge on ice crystal and mixed phase icing environment. In the meantime, the Agency will propose, in its AMC material for flight instrument external probes, more severe glaciated icing conditions using higher TWC values (e.g. peak values instead of the 17.4 NM values).

In addition, we propose to revise the existing CS 25.1326 Pitot heat indication systems. The objective is to explicitly cover abnormal functioning of the heating system, since incidents evidenced that some failures of the Pitot probe heating resistance may not be detected by the low current detection system. This is considered as a clarification since CS 25.1419(c) already requires that “Caution information, such as an amber caution light or equivalent, must be provided to alert the flight crew when the anti-ice or de-ice system is not functioning normally”. Consistently with the creation of the new CS 25.1324, paragraph CS 25.1326 would be modified to extend the scope of the requirement to all Flight Instrument External Probes including, but not necessarily limited to Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes, and temperature probes.

In the proposed revision to pilot compartment view requirements and in the proposed new requirements for flight instrument external probes, an aeroplane certified in accordance with CS 25.1420(a)(1) or (a)(2) would not be required to be evaluated for all of Appendix O. For aeroplanes certified in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to safely exit following detection must be considered. For aeroplanes certified in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in, and to safely exit following detection, must be considered. For aeroplanes certified in accordance with CS 25.1420(a)(3), all icing conditions must be considered. Aeroplanes not certified for flight in icing need not consider Appendix O.

The engine air intake system icing paragraph CS 25.1093, the APU air intake system icing paragraph CS 25J1093 and the propeller de-icing paragraph CS 25.929 contain requirements for operation in icing conditions. As a conservative approach to ensure safe operation of an aeroplane in an inadvertent encounter with icing, the existing CS 25.1093 contains requirements for operation in icing conditions, even for an aeroplane that is not approved for flight in icing. Since proposed Appendix O defines icing conditions that also may be inadvertently encountered, CS 25.1093 would be revised to reference Appendix O in its entirety. The same applies to APU air intake. This would maintain the conservative approach for these paragraphs. CS 25.929 (propeller de-icing) would also be revised to reference Appendix O in its entirety. The proposed revision to CS 25.929 also clarifies the meaning of the words ''for aeroplanes intended for use where icing may be expected.'' The intent has been for the rule to be applicable to aeroplanes certified for flight in icing.

CS 25.929 and CS 25.1323 generically reference icing instead of specifically mentioning Appendix C. Historically, the icing conditions specified in Appendix C have been applied to these rules. For clarity, CS 25.929 is revised to specifically reference Appendix C and Appendix O. CS 25.1323 will reference CS 25.1324 which provides the icing conditions to be considered for all flight instrument external probes; similarly, the same reference is added to CS 25.1325 for static probes (and sub-paragraphs to CS 25.1325(b) are created for clarity).

The proposed revisions to icing regulations for pilot compartment view, propellers, engine air intake system icing protection, flight instrument external probe systems would be applicable to all large aeroplanes to ensure safe operation during operations in icing conditions.

The proposed revisions to CS 25.903 would retain the existing regulations and add new sub-paragraphs to be consistent with the proposed CS-E changes in CS-E 780 (please refer to NPA 2011-04). These revisions would allow for approving new aircraft type certification programmes with engines certified to earlier amendment levels. The proposed revisions would make it clear that the proposed CS-E changes would not be retroactively imposed on an already type-certified engine design, unless service history indicated that an unsafe condition was present.

h. Engine and engine installation requirements

The proposed revisions to CS 25.1093 and to CS-E (please refer to NPA 2011-04) would change the icing environmental requirements used to evaluate engine protection and operation in icing conditions. The reason for these changes is that the incident history of some aeroplanes has shown that the current icing environmental requirements are inadequate. The effect of the change would be to require an evaluation of safe operation in the revised icing environment.

The proposed revision to CS 25.1093 and CS 25J1093, applicable to engines and APUs air intake systems, restructures Paragraph (b) and adds a new table providing freezing fog conditions to be used for engine and APU ground test. In-service events over the recent past years have shown that those conditions may be exceeded in service, as aircraft may remain on the ground for longer than 30 minutes while taxiing or waiting for de-icing procedure. Environmental conditions may also be more severe than the temperature range defined in CS 25.1093(b)(2). Service history has also shown that in flight snow (and mixed phase) conditions have caused power interruptions on some turbine engines and APUs with inlets that incorporate plenum chambers, reverse flow, or particle separating design features. The proposed rules would require engines, engine installations and APUs to operate safely throughout the SLD conditions defined in the proposed new Appendix O, the newly defined mixed phase and ice crystal conditions defined in the proposed Appendix P, and in falling and blowing snow.

The proposed Appendix P was developed by the ARAC Engine Harmonization Working Group and the Power Plant Installation Harmonization Working Group, which included meteorologists and icing research specialists from industry, FAA/FAA Tech Center, Meteorological Services of

Canada, National Aeronautics and Space Administration (NASA), and Transport Canada/Transport Development Center. It has been recommended as a new Appendix D to FAR Part 33. For more details on the development of this Appendix, please refer to FAA report DOT/FAA/AR–09/13 Technical Compendium from Meetings of the Engine Harmonization Working Group, March 2009.

Based on EASA experience, there is at least one engine event which occurred outside the proposed Appendix P, figure 1 envelope (at approximately Altitude=42,000ft and SAT=-65°C). Therefore, as explained above when reviewing Pitot probes incidents, the EASA has considered the extension of Appendix P, figure 1 to encompass all the events. However, after discussing this possibility with FAA and industry stakeholders, it appears that we need first to complete the on-going research activities that will collect and analyse information from flight test in areas of deep convection, in order to gather knowledge on ice crystal and mixed phase icing environment.

A new sub-paragraph to CS 25.1521 is proposed to require an additional operating limitation for turbine engine installations during ground operation in icing conditions defined in CS 25.1093(b)(2). That operating limitation would address the maximum time interval between any engine run-ups from idle and the minimum ambient temperature associated with that run-up interval. This limitation is necessary since currently we do not have any specific requirements for run-up procedures for engine ground operation in icing conditions. The engine run-up procedure, including the maximum time interval between run-ups from idle, run-up power setting, duration at power, and the minimum ambient temperature, if any, demonstrated for that run-up interval proposed in CS 25.1521, would be included in the Aeroplane Flight Manual in accordance with existing CS 25.1581(a)(1) and CS 25.1583(b)(1). The engine run-up procedure from ground idle to a moderate power or thrust setting is necessary to shed ice build-up on the fan blades before the quantity of ice reaches a level that could adversely affect engine operation if ice is shed into the engine. The proposed revision to CS 25.1521 would not require additional testing. The ice shedding demonstration may be included as part of the CS-E 780 engine icing testing.

i. Additional operating limitations

A new CS 25.1533 sub-paragraph (c) is proposed to establish a requirement for an operating limitation applicable to aeroplanes that are certified in accordance with proposed CS 25.1420(a)(1) or (a)(2). Operation would be prohibited into icing conditions defined in Appendix O for which the aeroplane has not been certified to safely operate (including take-off and landing). Furthermore, the flight crews of these aeroplanes would be required to exit all icing conditions if they encounter Appendix O icing conditions in which the aeroplane has not been certified to safely operate.

6. Differences compared to the FAA NPRM

The proposed CS-25 rules entail several differences compared to the FAA proposal in their NPRM "Airplane and Engine Certification Requirements in Supercooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions" dated 29 June 2010 (Docket No. FAA-2010-0636; Notice No. 10-10). The main differences are described below:

a. The applicability of the FAA proposed § 25.21(g) and §25.1420 (Supercooled Large Droplet (SLD) icing conditions) to a certain category of aeroplanes

The FAA proposed the exclusion of aeroplanes with certain attributes (aeroplanes with a maximum take-off weight (MTOW) less than 60,000 lbs or with reversible flight controls) from the §25.1420 rule requiring the evaluation of the aeroplane in the SLD conditions of the proposed Appendix O. This exclusion is not supported by EASA. Indeed, SLD large drops impinge and freeze farther aft on aeroplane surfaces than the drops defined in the current Appendix C and this may affect the aeroplane's performance, handling qualities on all type of aeroplane.

EASA reviewed the IPHWG Task 2 Report Rev A dated December 2005, which provides explanation on the "minority position" proposition for this exclusion. The main argument put forward by the "minority position" is that safety record of the class of aeroplanes proposed for exclusion support that the current airworthiness requirements of FAR Part 25/CS-25 for flight in icing certification have proven to be sufficient to provide the desired level of safety.

It is agreed that many aeroplanes have been flying safely in SLD conditions for decades.

It is also recognised that existing large aeroplanes designs are less sensitive to lifting surfaces contamination than aeroplanes designs not covered by the proposed exclusion, but we cannot assume that the design will not change on future aeroplanes and that past service experience will remain applicable. The proposed Certification Specifications will be in application for the next decades, and it is difficult today to predict design evolutions.

EASA agrees with the IPHWG "majority position" (ALPA, CAA/UK, FAA/FAA Tech Center, Meteorological Services of Canada, NASA, SAAB, Transport Canada/Transport Development Center) in the Appendix F of the IPHWG task 2 report rev A, "Response to exclusion from §25.1420 for aeroplane with certain design features".

Moreover, new on-going large aeroplane projects already tend to use different anti-icing systems compared to previous usual systems: either based on electrical power architectures or they use engine bleed air anti-icing systems in a different way (e.g. running wet instead of fully evaporative). This, combined with different aeroplane aerodynamic characteristics, makes it difficult to anticipate the aeroplane behaviour when flying in the Appendix O environment.

Operational experiences in SLD indicate that CS-25 Appendix C icing conditions standards are no longer sufficient and that the icing conditions standards of CS-25 should be expanded to include SLD, mixed-phase, and ice crystal icing envelope without any exclusion of aeroplane class.

EASA therefore proposes a CS 25.1420 rule applicable to all CS-25 large aeroplanes.

b. The mixed phase and ice crystals environment proposed by FAA for Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

The conditions of FAA proposed environment (Table 1 of §25.1323) are already included in the current EASA AMC 25.1419. EASA has been using the proposed conditions for many years and got strong indications, based on recent in-service data, that the proposed Appendix D to FAR Part 33 does better cover the existing environment.

As recognised by FAA on page 37318 of the NPRM, the FAA proposed Table 1 of §25.1323 would not address some known events of airspeed indicating system malfunctions. EASA proposes to use the mixed phase and ice crystal environment provided in FAA Appendix D to FAR Part 33. These conditions are proposed as a new Appendix P to CS-25.

In addition, again based on in-service experience, EASA fully supports the inclusion of a new requirement to cover heavy rain conditions, as suggested by FAA on page 37318 of their NPRM. The EASA proposed rule includes the requirement for operation in heavy rain conditions (a description of the conditions will be proposed in the AMC material).

c. The applicability of the FAA proposed mixed phase and ice crystals which is limited to Pitot tubes and Angle of Attack sensors (§25.1323 and §25.1324).

As explained above, EASA has been using the FAA proposed conditions for many years and got strong indications that the proposed FAR Part 33 Appendix D does better cover the existing environment, which is applicable to any external probe fitted on an aeroplane. Consistently, EASA has recently issued a generic CRI "Flight Instrument External Probes – Qualification in Icing Conditions" which will be used on all new type certificate applications made after 31 January 2010.

Therefore we propose to have a specific requirement for Flight Instrument External Probes (new CS 25.1324) including, but not necessarily limited to, Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes, and temperature probes.

d. Flight instrument external probes heat indication system

Some incidents evidenced that some failures of the Pitot probe heating resistance may not be seen by the low current detection system on aircraft. In some conditions, an out of tolerance resistance, failing to provide a proper Pitot probe de-icing could not be detected. EASA thus proposes to address failures, such as found in Pitot probes that may not be seen by the low current detection system on aircraft, by modifying the existing CS 25.1326 "Pitot heat indication systems" to explicitly cover abnormal functioning of the heating system. This is considered as a clarification since CS 25.1419 (c) already requires that "Caution information, such as an amber caution light or equivalent, must be provided to alert the flight crew when the anti-ice or de-ice system is not functioning normally". CS 25.1326 is also proposed to be modified to extend the scope of the requirement to all Flight Instrument External Probes including, but not necessarily limited to Pitot tubes, Pitot-static tubes and static probes, angle of attack sensors, side slip vanes, and temperature probes.

This change has not been proposed by FAA.

e. Figures 1 and 4 of the proposed Appendix O

FAA proposed curves that are different compared to the IPHWG report.

After discussion with FAA, it seems that these figures should not have been changed (mistake). Therefore, the EASA keeps the IPHWG report curves.

7. Alternatives to rulemaking

Two alternatives to rulemaking were considered by the IPHWG group. They were not retained for the reasons explained below.

a. Alternative 1: Terminal Area Radar and Sensors

This alternative would be based on the use of terminal area radar and ground-based sensors to identify areas of icing conditions including SLD. Once SLD areas would be detected and characterised, the information could be communicated to flight crews which would be able to avoid these areas. This could be an alternative to requiring certification for safe operation in SLD conditions. Equipment for detecting and characterising icing conditions in holding areas is being developed. However, this equipment would have limited coverage area.

For areas not covered by terminal area radar and ground-based sensors, airborne radars and sensors are being developed that would identify SLD conditions in sufficient time for avoidance. However, these ground-based and airborne systems are not mature enough to provide sufficient protection for all flight operations affected by SLD.

Even if the equipment was mature, rulemaking would still be necessary to establish safety margins for inadvertent flight into such conditions and to provide an option for applicants to substantiate that the aeroplane is capable of safe operation in SLD conditions.

b. Alternative 2: Icing Diagnostic and Predictive Weather Tools

Another alternative would be the use of icing diagnostic and predictive weather tools to avoid SLD rather than certify an aeroplane to operate in SLD conditions. Tools have been developed that can provide information on icing and SLD potential, but may not report all occurrences of SLD. These experimental tools are available on the Internet and can be used to provide flight planning information guidance for avoidance of SLD conditions.

However, rulemaking would still be necessary to establish safety margins for inadvertent flight into such conditions and to provide an option for applicants to substantiate that the aeroplane is capable of safe operation in SLD conditions.

VI CS-25 Book 1 resulting text

BOOK 1

SUBPART B - FLIGHT

Amend CS 25.21 as follows:

CS 25.21 Proof of compliance

…

(g) …

(1) Each requirement of this subpart, except CS 25.121(a), 25.123(c), 25.143(b)(1) and (b)(2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the icing conditions specified in Appendix C. CS 25.207(c) and (d) must be met in the landing configuration in the icing conditions specified in Appendix C but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II of Appendix C, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.

(2) If the applicant does not seek certification for flight in all icing conditions defined in Appendix O, each requirement of this subpart, except CS 25.105, 25.107, 25.109, 25.111, 25.113, 25.115, 25.121, 25.123, 25.143(b)(1), (b)(2), and (c)(1), 25.149, 25.201(c)(2), 25.207(c), (d) and (e)(1), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is not sought in order to allow a safe exit from those conditions. Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.

(3) If the applicant seeks certification for flight in any portion of the icing conditions of Appendix O, each requirement of this subpart, except paragraphs CS 25.121(a), 25.123(c), 25.143(b)(1) and (2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is sought. CS 25.207(c) and (d) must be met in the landing configuration in the icing conditions specified in Appendix O for which certification is sought but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.

(~~2~~4) No changes in the load distribution limits of CS 25.23, the weight limits of CS 25.25 (except where limited by performance requirements of this subpart), and the centre of gravity limits of CS 25.27, from those for non-icing conditions, are allowed for flight in icing conditions or with ice accretion.

Amend CS 25.105 as follows:

CS 25.105 Take-off

(a) …

(2) In icing conditions, if in the configuration used to show compliance with ~~of~~ CS 25.121(b), and with the most critical of the "Take-off Ice" accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g):

…

Amend CS 25.111 as follows:

CS 25.111 Take-off path

…

(c) …

(5) …

(i) With the most critical of the "Take-off Ice" accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), from a height of 11 m (35 ft) above the take-off surface up to the point where the aeroplane is 122 m (400 ft) above the take-off surface; and

(ii) With the most critical of the "Final Take-off Ice" accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), from the point where the aeroplane is 122 m (400 ft) above the take-off surface to the end of the take-off path.

…

Amend CS 25.119 as follows:

CS 25.119 Landing climb: all-engines-operating

…

(b) In icing conditions with the most critical of the "Landing Ice" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g), and with a climb speed of V_{REF} determined in accordance with CS 25.125(b)(2)(ii).

Amend CS 25.121 as follows:

CS 25.121 Climb: one-engine-inoperative

…

(b) …

(2) …

(ii) In icing conditions with the most critical of the "Take-off Ice" accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), if in the configuration used to show compliance with ~~of~~ CS 25.121(b) with ~~the~~this "Take-off Ice" accretion:

…

(c) …

(2) …

(ii) In icing conditions with the most critical of the "Final Take-off Ice" accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), if in the configuration used to show compliance with ~~of~~ CS 25.121(b) with the "Take-off Ice" accretion used to show compliance with CS 25.111(c)(5)(i):

…

(d) …

(2) …

(ii) In icing conditions with the most critical of the "Approach Ice" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g). The climb speed selected for non-icing conditions may be used if the climb speed for icing conditions, computed in accordance with sub-paragraph (d)(1)(iii) of this paragraph, does not exceed that for non-icing conditions by more than the greater of 5.6 km/h (3 knots) CAS or 3%.

…

Amend CS 25.123 as follows:

CS 25.123 En-route flight paths

(b) …

(2) In icing conditions with the most critical of the "En-route Ice" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g), if:

…

Amend CS 25.125 as follows:

CS 25.125 Landing

(a) …

(2) In icing conditions with the most critical of the "Landing Ice" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g), if V_{REF} for icing conditions exceeds V_{REF} for non-icing conditions by more than 9.3 km/h (5 knots) CAS at the maximum landing weight.

(b) …

(2) …

(ii) …

(B) 1.23 V_{SR0} with the most critical of the "Landing Ice" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g), if that speed exceeds VREF selected for non-icing conditions by more than 9.3 km/h (5 knots) CAS; and

(C) A speed that provides the manoeuvring capability specified in CS 25.143(h) with the most critical of the "Llanding iIce" accretion(s) defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g).

…

Amend CS 25.143 as follows:

CS 25.143 Controllability and manoeuvrability - General

(c) The aeroplane must be shown to be safely controllable and manoeuvrable with the most critical of the ice accretion(s) appropriate to the phase of flight as defined in Appendixces C and O, as applicable, in accordance with CS 25.21(g), and with the critical engine inoperative and its propeller (if applicable) in the minimum drag position:

…

(i) …

(1) Controllability must be demonstrated with the most critical of the ice accretion(s) for the particular phase of flight as defined in ~~described in~~ Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g) ~~that is most critical for the particular flight phase~~.

…

(j) For flight in icing conditions before the ice protection system has been activated and is performing its intended function, it must be demonstrated in flight with the most critical of the ice accretion(s) defined in Appendix C, part II(e), and Appendix O, part II(d), as applicable, in accordance with CS 25.21(g), that:

…

Amend CS 25.207 *Stall warning* as follows:

CS 25.207 Stall warning

…

(b) The warning must be furnished either through the inherent aerodynamic qualities of the aeroplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself. If a warning device is used, it must provide a warning in each of the aeroplane configurations prescribed in sub-paragraph (a) of this paragraph at the speed prescribed in subparagraphs (c) and (d) of this paragraph. Except for ~~showing compliance with~~ the stall warning ~~margin~~ prescribed in subparagraph (h)(3)(ii) of this paragraph, the stall warning for flight in icing conditions must be provided by the same means as the stall warning for flight in non-icing conditions. (See AMC 25.207(b).)

…

(e) …

(1) The ~~more~~ most critical of the take-off ice and final take-off ice accretions defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), for each configuration used in the take-off phase of flight;

(2) The most critical of the en route ice accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), for the en route configuration;

(3) The most critical of the holding ice accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), for the holding configuration(s);

(4) The most critical of the approach ice accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), for the approach configuration(s); and

(5) The most critical of the landing ice accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), for the landing and go-around configuration(s).

…

(h) The following stall warning margin is required ~~F~~for flight in icing conditions before the ice protection system has been activated and is performing its intended function. Compliance must be shown using the most critical of~~, with~~ the ice accretion(s) defined in Appendix C, part II(e), and Appendix O, part II(d), as applicable, in accordance with CS 25.21(g). T~~t~~he stall warning margin in straight and turning flight must be sufficient to allow the pilot to prevent stalling without encountering any adverse flight characteristics when:

…

Amend CS 25.237 as follows:

CS 25.237 Wind velocities

(a) …

(3) …

(ii) Icing conditions with the most critical of the landing ice accretion(s) defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g).

Amend CS 25.253 as follows:

CS 25.253 High-speed characteristics

…

(c) *Maximum speed for stability characteristics in icing conditions*. The maximum speed for stability characteristics with the most critical of the ice accretions defined in Appendi~~x~~ces C and O, as applicable, in accordance with CS 25.21(g), at which the requirements of CS 25.143(g), 25.147(e), 25.175(b)(1), 25.177(a) through (c), and 25.181 must be met, is the lower of:

…

SUBPART D – DESIGN AND CONSTRUCTION

Amend CS 25.773 as follows:

CS 25.773 Pilot compartment view

…

(b) …

(1) …

(ii) The icing conditions specified in ~~CS 25.1419~~Appendix C and the following icing conditions specified in Appendix O, if certification for flight in icing conditions is ~~requested~~ sought:

(A) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplanes is certified to safely exit following detection.

(B) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplanes is certified to safely operate in and the icing conditions that the aeroplanes is certified to safely exit following detection.

(C) For aeroplanes certificated in accordance with CS 25.1420(a)(3), all icing conditions.

(see AMC 25.773(b)(1)(ii))

(4) …

(ii) An encounter with severe hail, birds, or insects.

(see AMC 25.773(b)(4))

SUBPART E - POWERPLANT

Amend CS 25.903 as follows:

CS 25.903 Engines

(a) …

(3) Any engine not certificated to CS–E must be shown to comply with CS–E 780 or be shown to have an ice accumulation service history in similar installation locations which has not resulted in any unsafe conditions.

…

Amend CS 25.929 as follows:

CS 25.929 Propeller de-icing

(a) ~~For aeroplanes intended for use where~~ If certification for flight in icing conditions ~~may be expected~~ is sought, there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in Appendices C and O on propellers or on accessories where ice accumulation would jeopardise engine performance.

(see AMC 25.929(a))

…

Amend CS 25.1093 as follows:

CS 25.1093 ~~Air intake system de-icing and anti-icing provisions~~Powerplant Icing

…

(b) Turbine engines

~~(1) Each turbine engine must operate throughout the flight power range of the engine (including idling), without the accumulation of ice on the engine, inlet system components, or airframe components that would adversely affect engine operation or cause a serious loss of power or thrust (see AMC 25.1093 (b).) –~~

~~(i) Under the icing conditions specified in Appendix C.~~

~~(ii) Reserved~~

~~(2) Each engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between –9º and –1ºC (15º and 30ºF) and has a liquid water content not less than 0·3 grams per cubic metre in the form of drops having a mean effective diameter not less than 20 microns, followed by a momentary operation at take-off power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting.~~

Each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent idling speeds, in the icing conditions defined in Appendices C, O and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the engine, air intake system components or airframe components that would do any of the following:

(i) Adversely affect installed engine operation or cause a sustained loss of power or thrust; or an unacceptable increase in gas path operating temperature; or an airframe/engine incompatibility; or

(ii) Result in unacceptable temporary power or thrust loss or engine damage; or

(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback).

(2) Idle for a minimum of 30 minutes on the ground in the following icing conditions shown in Table 1, unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to take-off power or thrust, in accordance with the procedures defined in the aircraft flight manual. During the idle operation the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Agency. The applicant must document the engine run-up procedure (including the maximum time interval between run-ups from idle, run-up power setting, and duration at power), the associated minimum ambient temperature, if any, and the maximum time interval. These conditions must be used in the analysis that establishes the aeroplane operating limitations in accordance with CS 25.1521.

Table 1- ICING CONDITIONS FOR GROUND TESTS

Condition	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration
(i) Rime ice condition	-18 to -9°C (0 to 15°F)	Liquid—0.3 g/m^3	15–25 microns	By test, analysis or combination of the two.
(ii) Glaze ice condition	-7 to -1°C (20 to 30°F)	Liquid—0.3 g/m^3	15–25 microns	By test, analysis or combination of the two.
(iii) Large drop condition	-9 to -1°C (15 to 30°F)	Liquid—0.3 g/m^3	100 microns (minimum)	By test, analysis or combination of the two.

SUBPART F - EQUIPMENT

Amend CS 25.1323 as follows:

CS 25.1323 Airspeed indicating system

…

(i) ~~Each system must have a heated pitot tube or an equivalent means of preventing malfunction due to icing. (See AMC to 25.1323 (i) and 25.1325(b).)~~ Reserved

…

Create a new CS 25.1324 as follows:

CS 25.1324 Flight instrument external probes heating systems

(see AMC 25.1324)

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, must be heated or have an equivalent means of preventing malfunction due to icing conditions as defined in Appendices C and P, and the following icing conditions specified in Appendix O:

(a) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to exit safely following detection;

(b) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in and the icing conditions that the aeroplane is certified to exit safely following detection;

(c) For aeroplanes certificated in accordance with CS 25.1420(a)(3), all icing conditions.

Each flight instrument external probes systems must be designed and installed to operate normally without any malfunction in presence of heavy rain conditions (refer to AMC 25.1324).

Amend CS 25.1325 as follows:

CS 25.1325 Static pressure systems

(b) Each static port must be designed and located ~~in such manner~~ so that:

(1) The static pressure system performance is least affected by airflow variation, or by moisture or other foreign matter, and

(2) ~~that t~~The correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not changed when the aeroplane is exposed to ~~the continuous and intermittent maximum~~ icing conditions ~~defined in Appendix C. (See AMC to 25.1323 (i) and 25.1325(b).)~~ The static pressure system shall comply with CS 25.1324.

Amend CS 25.1326 as follows:

CS 25.1326 Flight instrument external probes ~~Pitot~~ heat ~~indication~~ alerting systems

(see AMC 25.1326)

If a flight instrument external probe ~~pitot~~ heating system is installed, an ~~indication~~ alerting system must be provided to ~~indicate~~ alert~~to~~ the flight crew when ~~that~~ the flight instrument external probe ~~pitot~~ heating system is not operating or not functioning normally. The ~~indication~~ alerting system must comply with the following requirements:

(a) The ~~indication~~ alert provided must ~~incorporate~~ conform to the ~~an amber light that is in clear view of a flight-crew member~~ Caution alert indications.

(b) The ~~indication~~ alert provided must be ~~designed to alert the flight crew~~ triggered if either of the following conditions exists:

(1) The flight instrument external probe ~~pitot~~ heating system is switched 'off'.

(2) The flight instrument external probe ~~pitot~~ heating system is switched 'on' and any flight instrument external probe ~~pitot tube~~ heating element is not functioning normally ~~inoperative~~.

Amend CS 25.1403 as follows:

CS 25.1403 Wing ice detection lights

(see AMC 25.1403)

…

Create a new CS 25.1420 as follows:

CS 25.1420 Supercooled large drop icing conditions

(see AMC 25.1420)

(a) If certification for flight in icing conditions is sought, in addition to the requirements of CS 25.1419, the aeroplane must be capable of operating in accordance with sub-paragraphs (a)(1), (a)(2), or (a)(3) of this paragraph.

(1) Operating safely after encountering the icing conditions defined in Appendix O:

(i) The aeroplane must have a means to detect that it is operating in Appendix O icing conditions; and

(ii) Following detection of Appendix O icing conditions, the aeroplane must be capable of operating safely while exiting all icing conditions.

(2) Operating safely in a portion of the icing conditions defined in Appendix O as selected by the applicant.

(i) The aeroplane must have a means to detect that it is operating in conditions that exceed the selected portion of Appendix O icing conditions; and

(ii) Following detection, the aeroplane must be capable of operating safely while exiting all icing conditions.

(3) Operating safely in the icing conditions defined in Appendix O.

(b) To establish that the aeroplane can operate safely as required in sub-paragraph (a) of this paragraph, an applicant must show through analysis that the ice protection for the various components of the aeroplane is adequate, taking into account the various aeroplane operational configurations. To verify the analysis, one, or more as found necessary, of the following methods must be used:

(1) Laboratory dry air or simulated icing tests, or a combination of both, of the components or models of the components.

(2) Laboratory dry air or simulated icing tests, or a combination of both, of models of the aeroplane.

(3) Flight tests of the aeroplane or its components in simulated icing conditions, measured as necessary to support the analysis.

(4) Flight tests of the aeroplane with simulated ice shapes.

(5) Flight tests of the aeroplane in natural icing conditions, measured as necessary to support the analysis.

(c) For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O of this paragraph in which the aeroplane is certified to operate.

SUBPART G – OPERATING LIMITATIONS AND INFORMATION

Amend CS 25.1521 as follows:

CS 25.1521 Powerplant limitations

…

(c)…

(3) Maximum time interval between engine run-ups from idle, run-up power setting, duration at power, and the associated minimum ambient temperature, if any, demonstrated for the maximum time interval, for ground operation in icing conditions, as defined in CS 25.1093(b)(2).

(~~3~~4) Any other parameter for which a limitation has been established as part of the engine type certificate except that a limitation need not be established for a parameter that cannot be exceeded during normal operation due to the design of the installation or to another established limitation.

Amend CS 25.1533 as follows:

CS 25.1533 Additional operating limitations

…

(c) For aeroplanes certified in accordance with CS 25.1420(a)(1) or (a)(2), an operating limitation must be established to:

(1) Prohibit intentional flight, including take-off and landing, into icing conditions defined in Appendix O for which the aeroplane has not been certified to safely operate; and

(2) Require exiting all icing conditions if icing conditions defined in Appendix O are encountered for which the aeroplane has not been certified to safely operate.

Amend CS 25J1093(a) as follows:

CS 25J1093 Air intake system icing protection

(a) Each non-essential APU air intake system, including any screen if used, which does not comply with CS 25J1093(b) will be restricted to use in non-icing conditions, unless it can be shown that the APU complete with air intake system, if subjected to the icing conditions defined in Appendices C, O and P, will not affect the safe operation of the aeroplane.

Replace CS 25J1093(b) by the following text:

CS 25J1093 Air intake system icing protection

(a)…

(b) For essential APUs:

Each essential APU, with all icing protection systems operating, and screen if used, must:

(1) Operate throughout its flight power range in the icing conditions defined in Appendices C, O and P, and in falling and blowing snow within the limitations established for the aeroplane for such operation, without the accumulation of ice on the APU, air intake system components or airframe components that would do any of the following:

(i) Adversely affect installed APU operation or cause a sustained loss of power; or an unacceptable increase in gas path operating temperature; or an airframe/APU incompatibility; or

(ii) Result in unacceptable temporary power loss or APU damage; or

(iii) Cause a stall, surge, or flameout or loss of APU controllability (for example, rollback).

(2) Operate for a minimum of 30 minutes on the ground in the icing conditions shown in Table 1 of CS 25.1093(b)(2), unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available icing protection (if applicable) at its critical condition, without adverse effect. The applicant must document the APU minimum ambient temperature demonstrated, if any, and establish the aeroplane operating limitations.

APPENDICES

APPENDIX C

Amend Appendix C, Part II as follows:

Part II - Airframe Ice Accretions ~~for Showing Compliance with Subpart B~~

(a) *Ice accretions - General*

…

(1) Take-off Ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, occurring between ~~lift-off~~ the end of the take-off distance and 122 m (400 ft) above the take-off surface, assuming accretion starts at ~~lift-off~~ the end of the take-off distance in the take-off maximum icing conditions of Part I, paragraph (c) of this Appendix.

(2) Final Take-off Ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, between 122 m (400 ft) and either 457 m (1500 ft) above the take-off surface, or the height at which the transition from the ~~takeoff~~take-off to the en route configuration is completed and VFTO is reached, whichever is higher. Ice accretion is assumed to start at ~~liftoff~~ the end of the take-off distance in the take-off maximum icing conditions of Part I, paragraph (c) of this Appendix.

…

(d) …

(2) The ice accretion starts at ~~lift-off~~ the end of the take-off distance;

…

Create a new Appendix O as follows:

Appendix O

Supercooled Large Drop icing conditions

Appendix O consists of two parts. Part I defines Appendix O as a description of supercooled large drop (SLD) icing conditions in which the drop median volume diameter (MVD) is less than or greater than 40 µm, the maximum mean effective drop diameter (MED) of Appendix C continuous maximum (stratiform clouds) icing conditions. For Appendix O, SLD icing conditions consist of freezing drizzle and freezing rain occurring in and/or below stratiform clouds. Part II defines ice accretions used to show compliance with CS-25 specifications.

Part I—Meteorology

Appendix O icing conditions are defined by the parameters of altitude, vertical and horizontal extent, temperature, liquid water content, and water mass distribution as a function of drop diameter distribution.

(a) Freezing Drizzle (Conditions with spectra maximum drop diameters from 100 µm to 500 µm):

(1) Pressure altitude range: 0 to 6706 m (22000 feet) MSL.

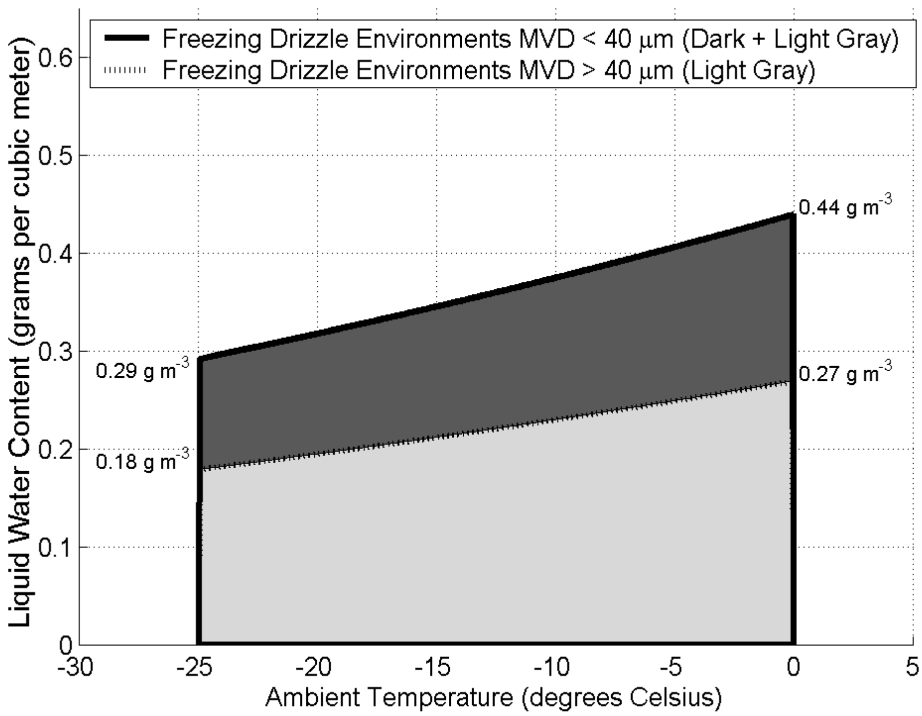
(2) Maximum vertical extent: 3656 m (12000 feet).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

(4) Total liquid water content:

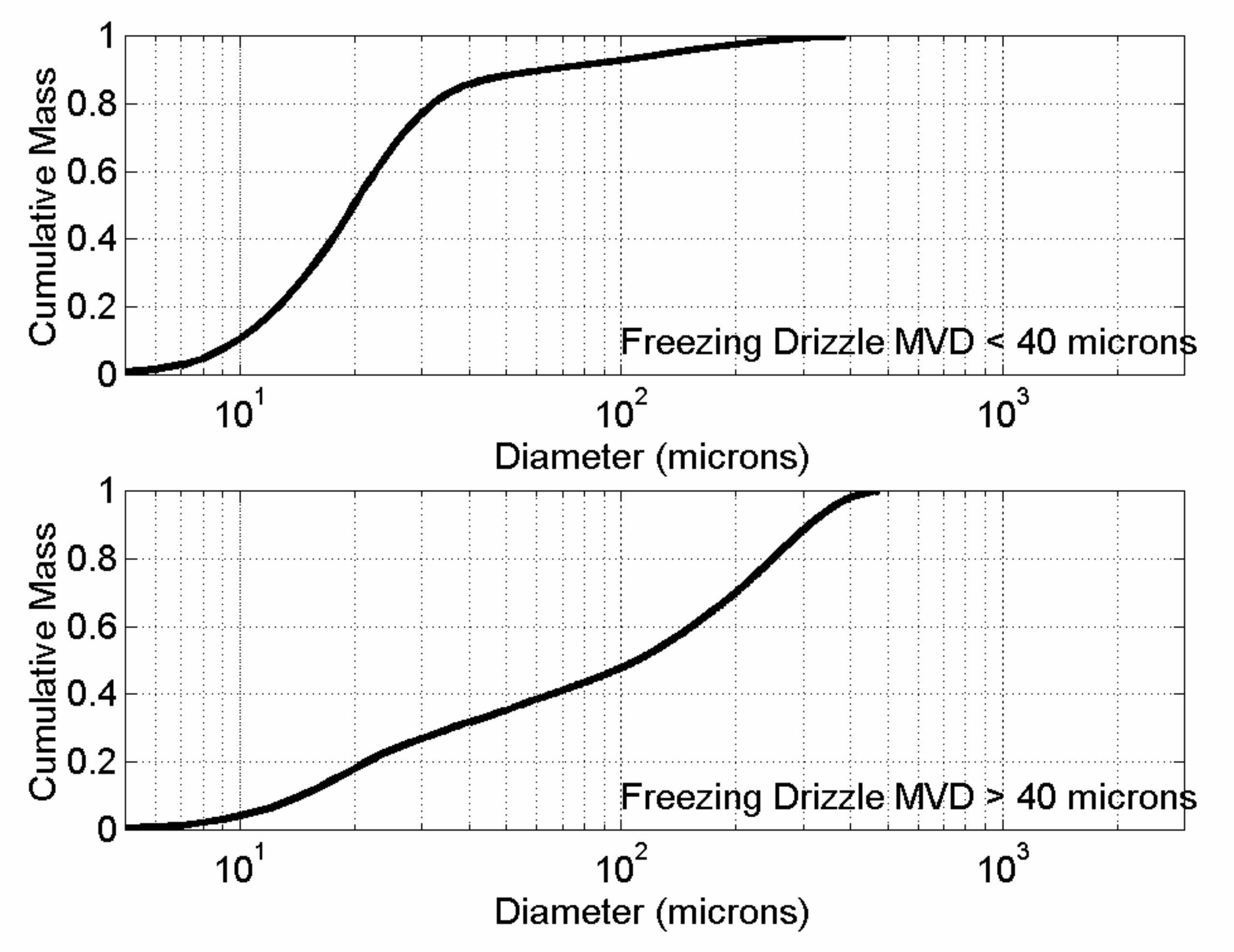
Note: Liquid water content (LWC) in grams per cubic meter (g/m3) based on horizontal extent standard distance of 32.2 km (17.4 nautical miles).

Figure 1 –Appendix O, Freezing Drizzle, Liquid Water Content



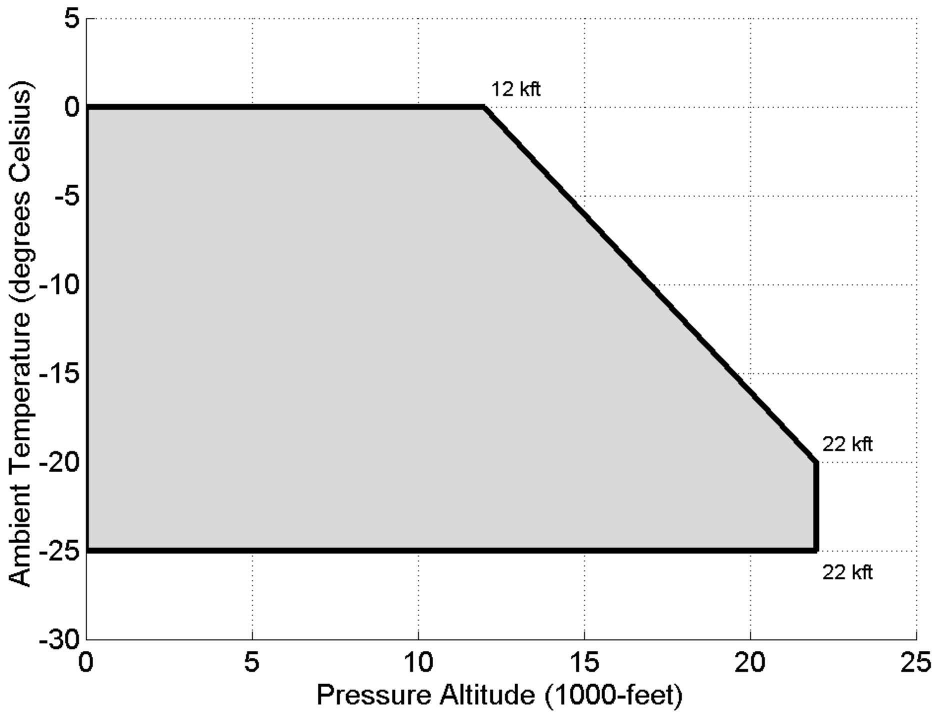
(5) Drop diameter distribution:

Figure 2 – Appendix O, Freezing Drizzle, Drop Diameter Distribution



(6) Altitude and temperature envelope:

Figure 3 – Appendix O, Freezing Drizzle, Altitude and Temperature



(b) Freezing Rain (Conditions with spectra maximum drop diameters greater than 500 µm):

(1) Pressure altitude range: 0 to 3656 m (12000 ft) MSL.

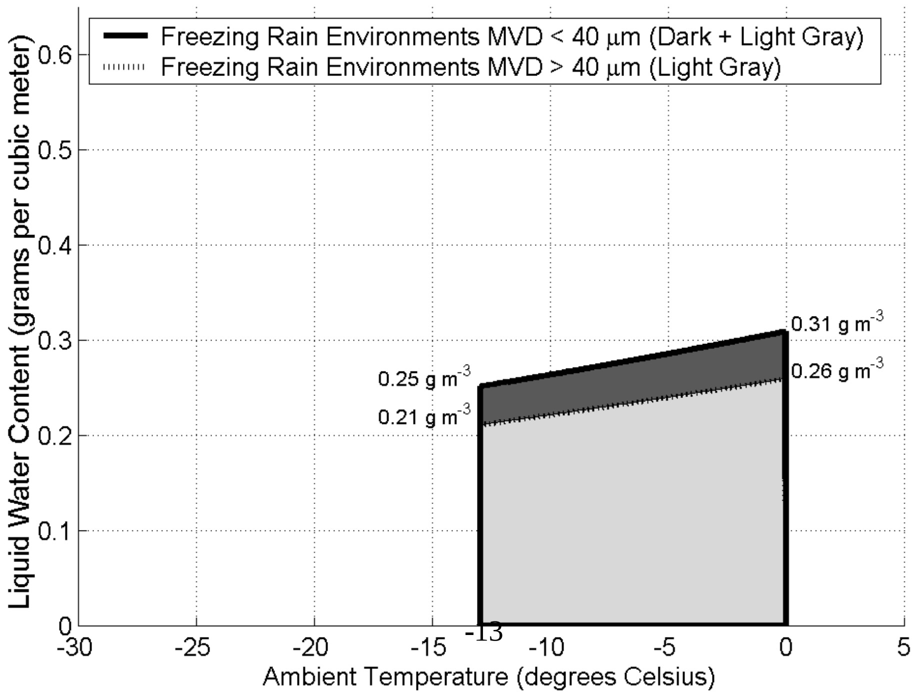
(2) Maximum vertical extent: 2134 m (7000 ft).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

(4) Total liquid water content:

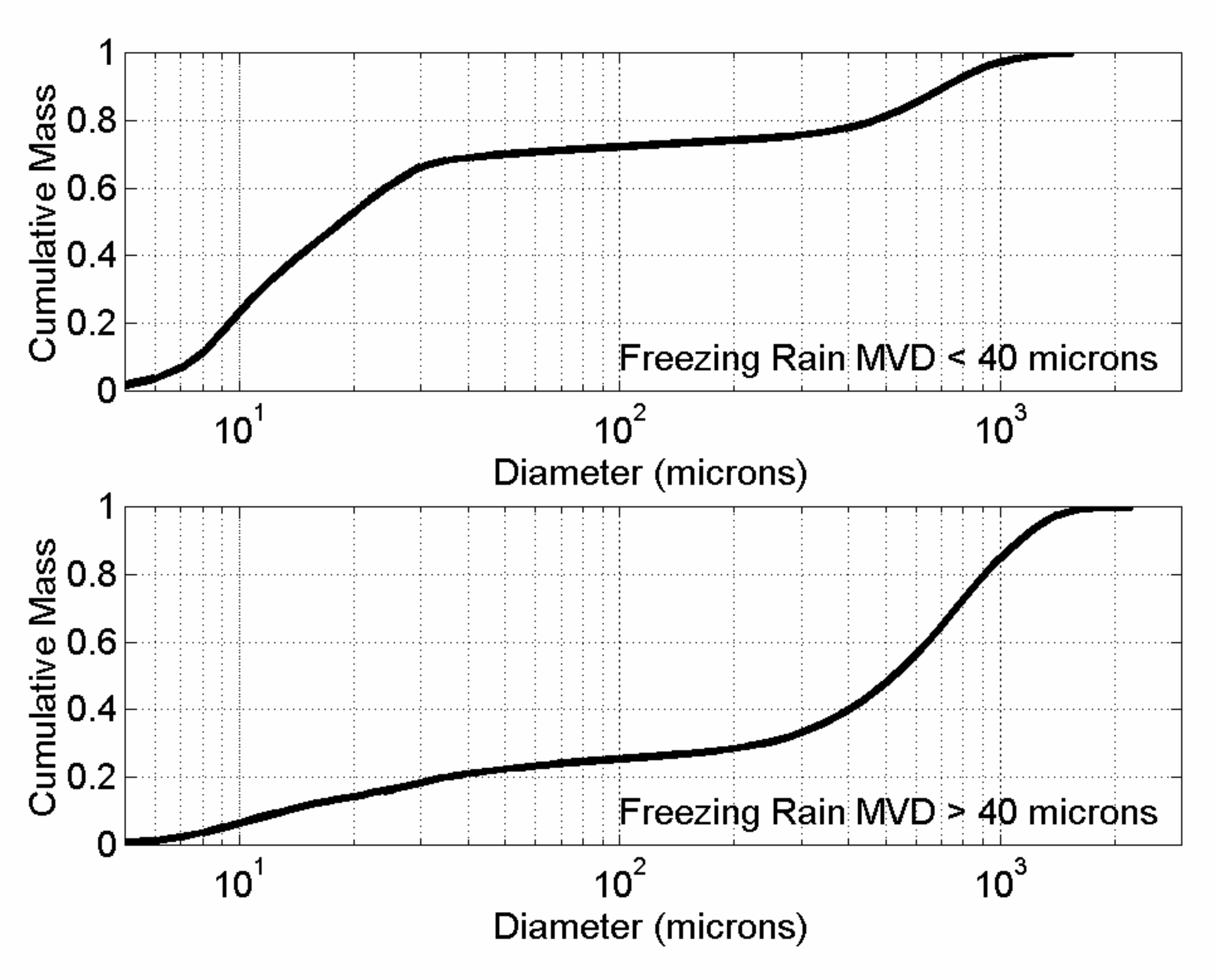
Note: LWC in grams per cubic meter (g/m3) based on horizontal extent standard distance of 32.2 km (17.4 nautical miles).

Figure 4 – Appendix O, Freezing Rain, Liquid Water Content



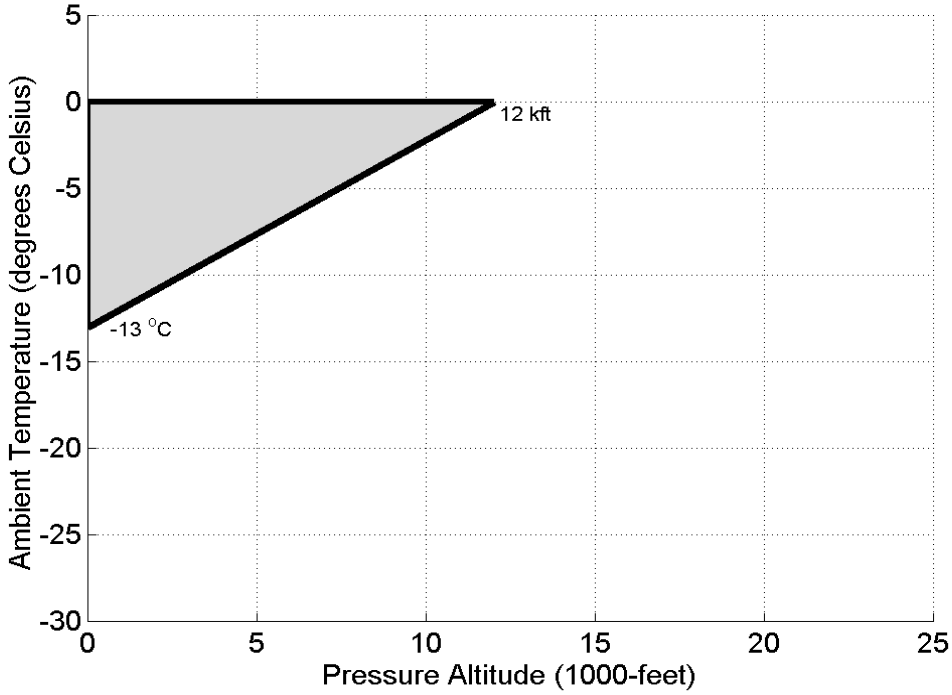
(5) Drop diameter distribution:

Figure 5 – Appendix O, Freezing Rain, Drop Diameter Distribution



(6) Altitude and temperature envelope:

Figure 6 – Appendix O, Freezing Rain, Altitude and Temperature



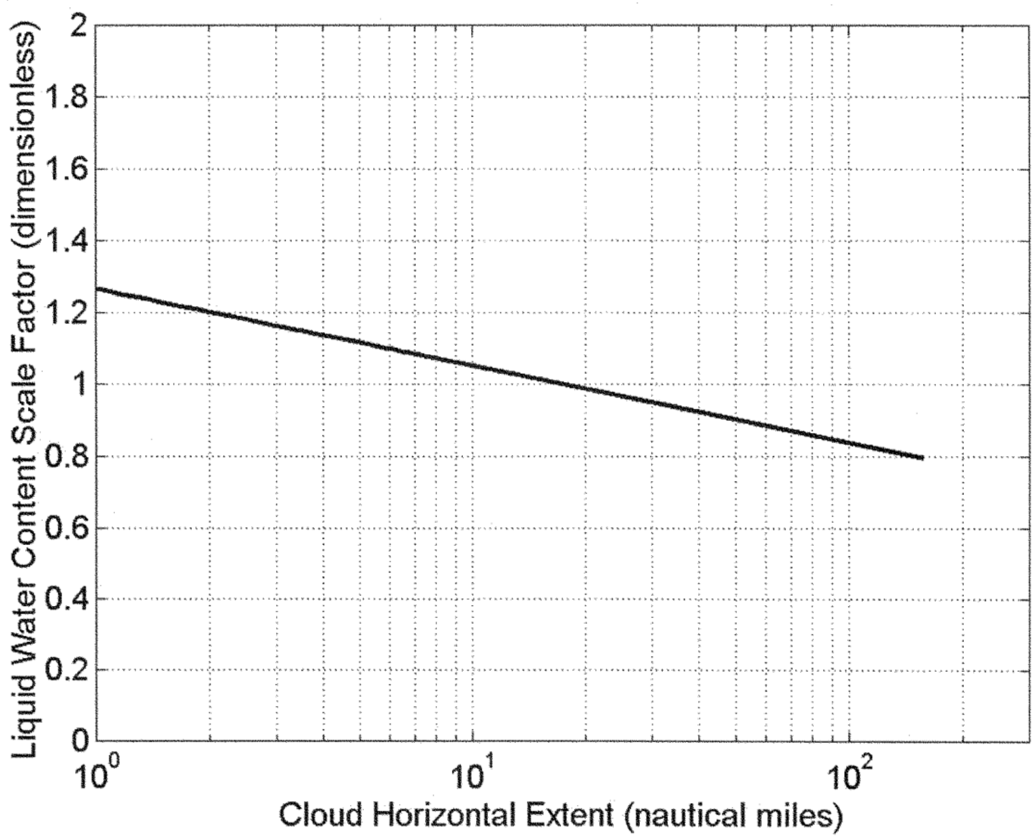
(c) Horizontal extent

The liquid water content for freezing drizzle and freezing rain conditions for horizontal extents other than the standard 32.2 km (17.4 nautical miles) can be determined by the value of the liquid water content determined from Figure 1 or Figure 4, multiplied by the factor provided in Figure 7, which is defined by the following equation:

$S = 1.266 - 0.213 \log_{10}(H)$

Where S = Liquid Water Content Scale Factor (dimensionless) and H = horizontal extent in nautical miles

Figure 7 – Appendix O, Horizontal Extent, Freezing Drizzle and Freezing Rain



Part II—Airframe ice accretions

(a) General.

The most critical ice accretion in terms of aeroplane performance and handling qualities for each flight phase must be used to show compliance with the applicable aeroplane performance and handling qualities requirements for icing conditions contained in Subpart B. Applicants must demonstrate that the full range of atmospheric icing conditions specified in part I of this appendix have been considered, including drop diameter distributions, liquid water content, and temperature appropriate to the flight conditions (for example, configuration, speed, angle-of-attack, and altitude).

(1) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accretions for each flight phase are defined in part II, paragraph (b) of this appendix.

(2) For an aeroplane certified in accordance with CS 25.1420(a)(2), the most critical ice accretion for each flight phase defined in part II, paragraphs (b) and (c) of this appendix, must be used. For the ice accretions defined in part II, paragraph (c) of this appendix, only the portion of part I of this appendix in which the aeroplane is capable of operating safely must be considered.

(3) For an aeroplane certified in accordance with CS 25.1420(a)(3), the ice accretions for each flight phase are defined in part II, paragraph (c) of this appendix.

(b) Ice accretions for aeroplanes certified in accordance with CS 25.1420(a)(1) or (a)(2).

(1) En-route ice is the en-route ice as defined by part II, paragraph (c)(3), of this appendix, for an aeroplane certified in accordance with CS 25.1420(a)(2), or defined by part II, paragraph (a)(3), of Appendix C, for an aeroplane certified in accordance with CS 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II paragraph (b)(5) of this appendix; and

(ii) The ice accumulated during the transit of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(2) Holding ice is the holding ice defined by part II, paragraph (c)(4), of this appendix, for an aeroplane certified in accordance with CS 25.1420(a)(2), or defined by part II, paragraph (a)(4) of Appendix C, for an aeroplane certified in accordance with CS 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II, paragraph (b)(5) of this appendix; and

(ii) The ice accumulated during the transit of one cloud with a 32.2 km (17.4 nautical miles) horizontal extent in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(iii) Except the total exposure to holding ice conditions does not need to exceed 45 minutes

(3) Approach ice is the more critical of the holding ice defined by part II, paragraph (b)(2) of this appendix, or the ice calculated in the applicable paragraph (b)(3)(i) or (ii) of part II of this appendix:

(i) For an aeroplane certified in accordance with CS 25.1420(a)(2), the ice accumulated during descent from the maximum vertical extent of the icing conditions defined in part I of this appendix to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during the transit at 610 m (2 000 feet) above the landing surface of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accumulated during descent from the maximum vertical extent of the maximum continuous icing conditions defined in part I of Appendix C to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during the transit at 610 m (2 000 feet) above the landing surface of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(4) Landing ice is the more critical of the holding ice as defined by part II, paragraph (b)(2) of this appendix, or the ice calculated in the applicable paragraph (b)(4)(i) or (ii) of part II of this appendix:

(i) For an aeroplane certified in accordance with CS 25.1420(a)(2), the ice accretion defined by part II, paragraph (c)(5)(i) of this appendix, plus a descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration in the icing conditions defined in part I of this appendix, plus:

(A) Pre-detection ice, as defined in part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during an exit manoeuvre, beginning with the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface through one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accumulated in the maximum continuous icing conditions defined in Appendix C, during a descent from the maximum vertical extent of the icing conditions defined in Appendix C, to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 610 m (2 000 feet) above the landing surface, plus a descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration, plus:

(A) Pre-detection ice, as described by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during an exit manoeuvre, beginning with the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface through one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(5) Pre-detection ice is the ice accretion before detection of Appendix O conditions that require exiting per CS 25.1420(a)(1) and (a)(2). It is the pre-existing ice accretion that may exist from operating in icing conditions in which the aeroplane is approved to operate prior to encountering the icing conditions requiring an exit, plus the ice accumulated during the time needed to detect the icing conditions, followed by two minutes of further ice accumulation to take into account the time for the flight crew to take action to exit the icing conditions, including coordination with air traffic control.

(i) For an aeroplane certified in accordance with CS 25.1420(a)(1), the pre-existing ice accretion must be based on the icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(2), the pre-existing ice accretion must be based on the more critical of the icing conditions defined in Appendix C, or the icing conditions defined in part I of this appendix in which the aeroplane is capable of safely operating.

(c) Ice accretions for aeroplanes certified in accordance with CS 25.1420(a)(2) or CS 25.1420(a)(3).

For an aeroplane certified in accordance with CS 25.1420(a)(2), only the portion of the icing conditions of part I of this appendix in which the aeroplane is capable of operating safely must be considered.

(1) Take-off ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, occurring between the end of the take-off distance and 122 m (400 feet) above the take-off surface, assuming accretion starts at the end of the take-off distance in the take-off maximum icing conditions defined in part I of this appendix.

(2) Final take-off ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, between 122 m (400 feet) and either 457 m (1 500 feet) above the take-off surface, or the height at which the transition from the take-off to the en-route configuration is completed and V_{FTO} is reached, whichever is higher. Ice accretion is assumed to start at lift-off the end of the take-off distance in the icing conditions defined in part I of this appendix.

(3) En-route ice is the most critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, during the en-route flight phase in the icing conditions defined in part I of this appendix.

(4) Holding ice is the most critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from 45 minutes of flight within a cloud with a 32.2 km (17.4 nautical miles) horizontal extent in the icing conditions defined in part I of this appendix, during the holding phase of flight.

(5) Approach ice is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accumulated in the icing conditions defined in part I of this appendix during a descent from the maximum vertical extent of the icing conditions defined in part I of this appendix, to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 610 m (2 000 feet) above the landing surface; or

(ii) Holding ice as defined by part II, paragraph (c)(4) of this appendix.

(6) Landing ice is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accretion defined by part II, paragraph (c)(5)(i), of this appendix, plus ice accumulated in the icing conditions defined in part I of this appendix during a descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration, followed by a go-around at the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface to 610 m (2 000 feet) above the landing surface, flying for 15 minutes at 610 m (2 000 feet) above the landing surface in the approach configuration, and a descent to the landing surface (touchdown) in the landing configuration; or

(ii) Holding ice as defined by part II paragraph (c)(4) of this appendix.

(7) For both unprotected and protected parts, the ice accretion for the take-off phase must be determined for the icing conditions defined in part I of this appendix, using the following assumptions:

(i) The airfoils, control surfaces, and, if applicable, propellers are free from frost, snow, or ice at the start of takeoff;

(ii) The ice accretion begins at lift-off;

(iii) The critical ratio of thrust/power-to-weight;

(iv) Failure of the critical engine occurs at V_{EF}; and

(v) Crew activation of the ice protection system is in accordance with a normal operating procedure provided in the Aeroplane Flight Manual, except that after beginning the take-off roll, it must be assumed that the crew takes no action to activate the ice protection system until the aeroplane is at least 122 m (400 feet) above the take-off surface.

(d) The ice accretion before the ice protection system has been activated and is performing its intended function is the critical ice accretion formed on the unprotected and normally protected surfaces before activation and effective operation of the ice protection system in the icing conditions defined in part I of this appendix. This ice accretion only applies in showing compliance to CS 25.143(j) and 25.207(h).

(e) In order to reduce the number of ice accretions to be considered when demonstrating compliance with the requirements of CS 25.21(g), any of the ice accretions defined in this appendix may be used for any other flight phase if it is shown to be more critical than the specific ice accretion defined for that flight phase. Configuration differences and their effects on ice accretions must be taken into account.

(f) The ice accretion that has the most adverse effect on handling qualities may be used for aeroplane performance tests provided any difference in performance is conservatively taken into account.

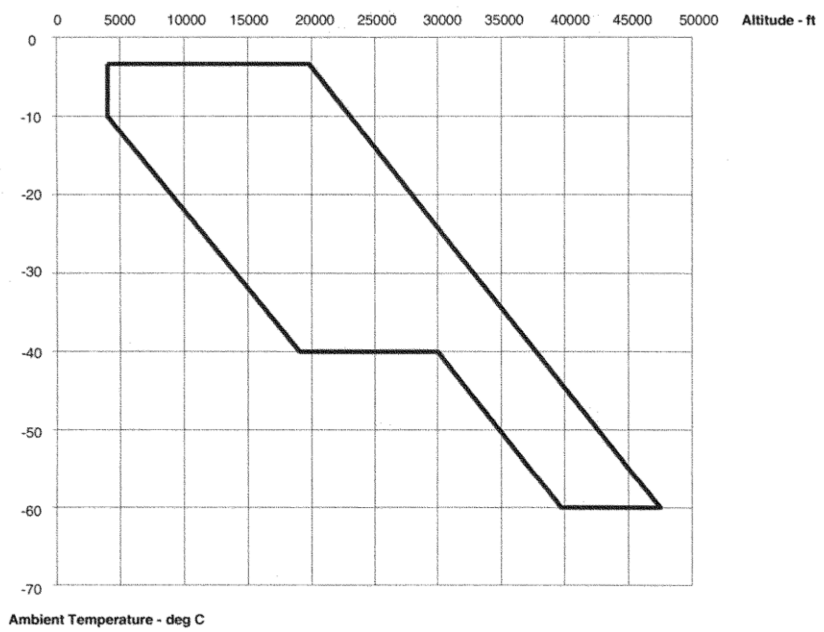
Create a new Appendix P as follows:

Appendix P

Mixed phase and ice crystal icing envelope (Deep convective clouds)

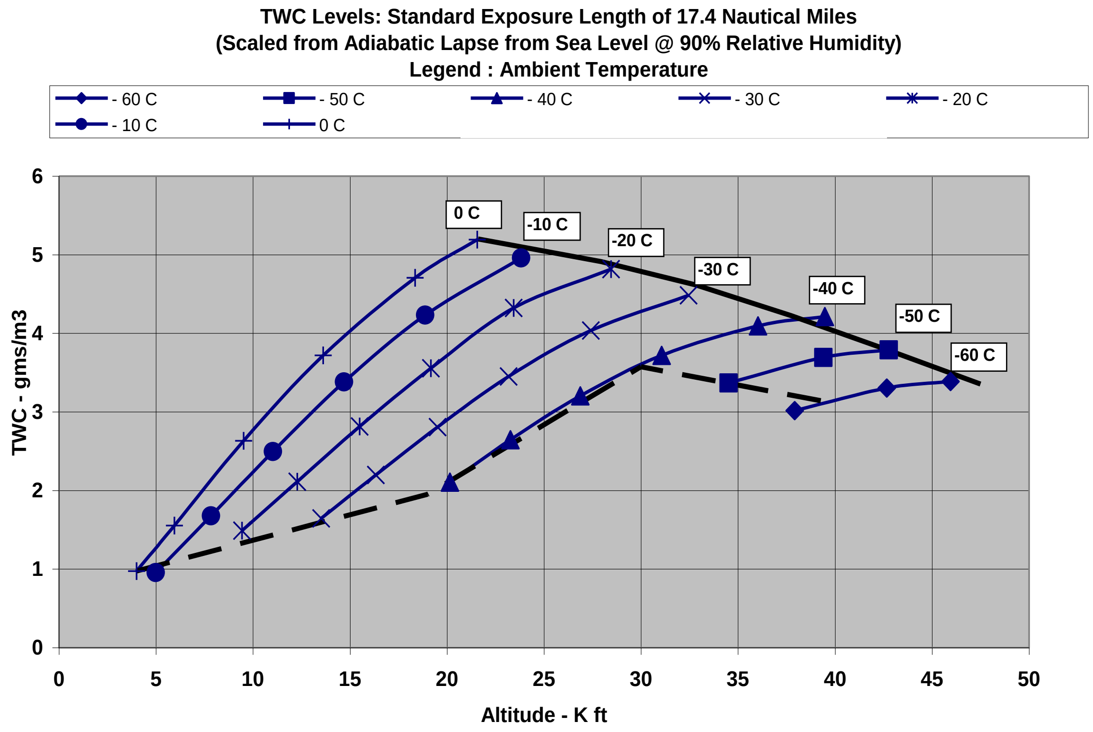
The ice crystal icing envelope is depicted in Figure 1 below.

Figure 1 – Convective cloud ice crystal envelope



Within the envelope, total water content (TWC) in g/m^3 has been determined based upon the adiabatic lapse defined by the convective rise of 90 % relative humidity air from sea level to higher altitudes and scaled by a factor of 0.65 to a standard cloud length of 32.2 km (17.4 nautical miles). Figure 2 displays TWC for this distance over a range of ambient temperature within the boundaries of the ice crystal envelope specified in Figure 1.

Figure 2 – Total Water Content



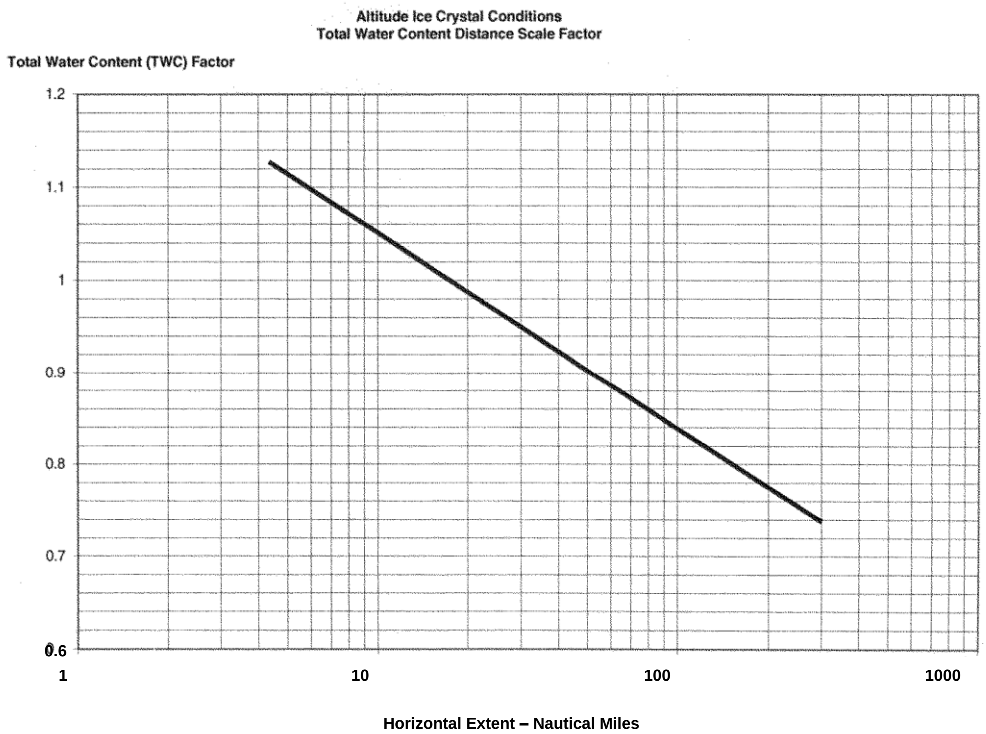
Ice crystal size median mass dimension (MMD) range is 50–200 microns (equivalent spherical size) based upon measurements near convective storm cores. The TWC can be treated as completely glaciated (ice crystal) except as noted in the Table 1.

Table 1 – Supercooled Liquid Portion of TWC

Temperature range – deg C	Horizontal cloud length	LWC – g/m^3
0 to -20	≤92.6 km (50 nautical miles)	≤1.0
0 to -20	Indefinite	≤0.5
< -20		0

The TWC levels displayed in Figure 2 represent TWC values for a standard exposure distance (horizontal cloud length) of 32.2 km (17.4 nautical miles) that must be adjusted with length of icing exposure.

Figure 3 – Exposure Length Influence on TWC



Appendix A - Attachments

L390-11-1530 Comments 1093 EASA.pdf
Attachment #1 to comment #50

Comments for NPA2011-03 PWC.pdf
Attachment #2 to comment #64

FAA comments on EASA NPA 2011-03.pdf
Attachment #3 to comment #129

GCH - 0087-2011.pdf
Attachment #4 to comment #185

Icing Flight Tests of the Lockheed P2V (figuren en plaatjes).pdf
Attachment #5 to comment #205

Icing Flight Tests of the Lockheed P2V(tekst).pdf
Attachment #6 to comment #205

AIAA-10478-987.pdf
Attachment #7 to comment #187

NPA-cmt-21.pdf
Attachment #8 to comment #155

NPA-cmt-27.pdf
Attachment #9 to comment #161

NPA-cmt-29.pdf
Attachment #10 to comment #163

NPA-cmt-30.pdf
Attachment #11 to comment #164

NPA-cmt-34-C.pdf
Attachment #12 to comment #168

NPA-cmt-34-B.pdf
Attachment #13 to comment #168

NPA-cmt-35.pdf
Attachment #14 to comment #169

2764-RC-Snecma comments on NPA Icing.pdf
Attachment #15 to comment #195

ATT 2.pdf
Attachment #16 to comment #113

ATT 1.pdf
Attachment #17 to comment #113

NPA-cmt-49.pdf
Attachment #18 to comment #183