COMMENT RESPONSE DOCUMENT

EASA CRD of Special Condition SC-F25.1419-01 "Aeroplane Ice Protection System operation above the ~~maximum altitude of~~ CS-25 Appendix C Intermittent Maximum icing altitude ~~envelopes~~"

[Published on 02 July 2019 and officially closed for comments on 30 September 2019]

List of abbreviations

AAs	Aviation Authorities
AMC	Acceptable Means of Compliance
AIA	Aerospace Industries Association (US)
ASD	Aerospace & Defence Association – Association of Europe
CM	Continuous maximum
IM	Intermittent maximum
IPS	Ice Protection System
MOC	Mean of Compliance
SC	Special Condition
SLD	Supercooled Large Droplet (CS 25 Appendix O)
S/W	Software

Note to readers.

To allow readers to also see the detailed changes in the Special Conditions as consequences of the accepted or partially accepted comments, this document has been created. When a commenter suggests and EASA accepts a word change in the Special Conditions text, the following formalism has been used to show the changes[1]:

(a) Deleted text is marked with ~~strikethrough~~.

(b) New or amended text is highlighted in grey.

(c) An ellipsis (…) indicates that the remaining text is unchanged in front of or following the reflected amendment.

[1] Changes into the final text may originate from the commenters or stem from the restricted scope of the Special conditions as referred in Explanatory Note 1.

In cases where the Special Condition (included the “Statement of Issue” section also referred later as “Preamble”) underwent major changes or complete re-draft, commenter(s) will be notified, and no specific details provided in this CRD. In such case, the proposed changes from commenter will be indicated as acknowledged or noted.

Explanatory Note 1

Many commenters stated that the EASA proposed ice envelope[2] above CS-25 Appendix C altitudes was too severe (nevertheless, most of them do not object the existence of icing conditions above Appendix C) and was not based on scientific evidence. In addition, they were not in favour allowing each applicant to propose its own icing environment as an alternative solution. With reference to these comments, aerospace industry interests were voiced by AIA/ASD association during several meetings with EASA and AAs representatives and they presented on 22.02.2022 a final position for an icing scenario valid above current CS-25 Appendix C IM altitude, which was derived from their own flying fleet database. Based on such proposal and in agreement with AIA/ASD Association representatives, EASA considered that the Special Condition scope should be restricted to address implementation of “optimised” IPS above Appendix C IM icing envelope only (see the changes of the SC title and changes implemented into “Statement of issue” section of the final SC text). Details of the proposed icing scenario are presented in the Annex 1 of the associated MOC to the Special Condition text.
Many commenters also highlighted that a rulemaking task should be performed. EASA regularly review special conditions for amendment of the CS-25 through rulemaking tasks.

Explanatory Note 2

With the reference to the compliance strategy denoted as option b) Direct Demonstration in the associated MOC[2] to the published Special Condition during the several meetings with AIA/ASD Association representatives it came out that it was difficult at that stage to converge into a single proposal on the guidance material to demonstrate that aircraft was still safe with the ice shapes, if any, accreted during the exposure to the proposed icing scenario above Appendix C IM icing altitude (see Explanatory Note 1). It was agreed that industry could develop a proposal and provide it to EASA for discussion in a future step. Nevertheless, the concept of combination of flight phases has been removed from the associated MOC text. It has to be noted that the option b) / Direct demonstration, does not require flight tests in natural icing conditions above the Appendix C IM icing envelope.

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[2] EASA complemented the Special Condition with some Acceptable Means of Compliance (AMC) to provide guidance how to comply with the requirement. Icing conditions envelope above current Appendix C altitudes were proposed in the first instance. Although the text of the Special Condition stated that the attached AMC were only published for awareness and not subject to public consultation, EASA eventually considered relevant and applicable all the comments received on the AMC text and provides feedback in this CRD.
When the SC has been eventually published as “final”, this guidance material has been renamed as “associated MOC” to the Special Condition without any change of the meaning. As far as the present CRD is concerned the 2 terms “AMC” and “MOC” can be exchanged without any different meaning.

Commenter 1: TCCA

Comment # 1

Comment 1
Identification of Issue.-Paragraph 1,page 2.

Comment summary
The text…” (figure 1-21) also” is quite confusing…”

Suggested resolution
We suggest to change the text to read: …”Figure 1-21 also”

EASA response: Accepted

Based also on other comments received, the reference to this picture as far as the reference to the suspected severe ice encounters above 31000 feet has been removed from the SC preamble.

Commenter 1: TCCA

Comment # 2

Comment 2
Identification of Issue. Page 1.

Suggested resolution
We suggest to add Amendment levels for CS 25.1419, CS 25.1093(b) and CS-25 Appendix C to make it clearer for the reader.

EASA response: Accepted

EASA agrees with TCCA comments; the CS 25 amendment level applicable to the aircraft TC (at the time the final SC text will be published), where the SC first was applicable, has been included in the final published SC text.

Commenter 1: TCCA

Comment # 3

Comment 3
Acceptable Means of…/modulated IPS). Page 4

Comment Summary
Both terms “aeroplane” and “aircraft” are used.

Comment resolution
We suggest to use only the term “aeroplane” throughout this SCA “

EASA response: Accepted

SC text changed to replace any occurrence of term “*aircraft*” with “*aeroplane*”.

Commenter 1: TCCA

Comment # 4

Comment 4
Identification of the issue. Page 1, paragraph 3.
Comment Summary
It is stated that the IM icing condition extends to 30000 feet. While in fact, it can extend to 31000 feet.

Suggested resolution
We suggest EASA to amend the text to read “31000 feet” for IM icing conditions per CS-25 Appendix C Figure 5

EASA response: Accepted

SC text changed to replace the max current IM icing envelope from *30000* to *31000* feet.

Commenter 1: TCCA

Comment # 5

<u>**Comment 5**</u>
General

<u>**Comment Summary**</u>
There is no reference as to what the basic engine should be certified to, in order for the engine bleed system performance to be suitable for the aeroplane to operate outside the Appendix C envelope

<u>**Suggested resolution**</u>
We suggest to include reference CS-E 780 as applicable to the basic engine certification.

EASA response: Not accepted.

The current SC does not address the engine certification when it includes its own ice protection system according to CS E-780. Therefore, there is no need to refer to any specific engine related certification paragraph.

Commenter 1: TCCA

Comment # 6

<u>**Comment 6**</u>
Compliance Strategy/Option a): Direct Demonstration, page 5.

<u>**Comment Summary**</u>
It is not clear what is meant by “essential equipment”

<u>**Suggested resolution**</u>
We suggest EASA to provide definition or clarification for “essential equipment”

EASA response: Accepted

Essential is a definition/attribute in CS 25 verbiage and denotes equipment that contributes to hazardous or catastrophic system failure conditions. A footnote has been included in the final SC text.

Commenter 1: TCCA

Comment # 7

Comment 7
General

Comment Summary
Aeroplane IPS operation (whether the IPS is optimized/modulated, or even inhibited) above the maximum altitudes of CS-25 Appendix C icing envelope should be assessed under CS-25.1309 as part of this SC Acceptable Means of Compliance.

Suggested resolution
We suggest compliance to CS-25.1309 part of this SC

EASA response: Not accepted.

The SC text is only focusing on the Ice Protection System performance above Appendix C IM altitude, whether it is optimised or modulated according to the altitude It is not intended to cover general CS 25 requirements which shall anyway be complied with considering the applicable certification basis.

Commenter 1: TCCA

Comment # 8

Comment 8
General

Comment summary
Typically a SC is product and applicant specific. Why is this a generic SC for CS-25 aeroplanes? Is this SC applicable to new type certificates, amended type certificates and supplemental type certificates (STC)?

Suggested resolution
We suggest EASA to clarify SC for applicability if required.

EASA response: Partially accepted.

The applicability of the special condition has been clearly specified in the SC preamble. This special condition has been first raised in the frame of a specific project, but it can be applicable for all projects (new, amended, or supplemental type certificates) falling in the applicability of the special condition.

Commenter 1: TCCA

Comment # 9

Comment 9
General

Comment Summary
Attach Figure(s) of the new icing conditions at altitudes above the maximum altitude of the Appendix C icing envelopes

Suggested resolution
We suggest to add exemplary Figure(s) to show the extended envelopes.

EASA response: Accepted

The interim proposed icing scenario is presented in the Annex 1 of the associated MOC to Special Conditions text.

SeeExplanatory Note 1.

Commenter 1: TCCA

Comment # 10

Comment 10
General

Comment summary
The IPS components and software (if software is part of the IPS) must be shown to be qualified or suitable to meet their intended function under foreseeable operating conditions above the Appendix C envelope limits.

Suggested resolution
We suggest EASA to add wording that will relate this comment to CS-25.1301/25.1309 compliance

EASA response: Not accepted.

EASA agrees with TCCA that the IPS components and embedded S/W should be adequately qualified also above Appendix C, but the objective of this SC is to focus on the IPS performance above Appendix C IM icing altitude. The qualification aspects are considered as already part of CS 25. Therefore, EASA will not make any amendments to SC text to highlight that environmental qualification of the concerned equipment shall be extended to cover the additional operational envelope. See also answer to comment #7.

Commenter 1: TCCA

Comment # 11

Comment 11
Paragraph (Special Condition) page 4

Comment summary
It is understood that the reason for introducing the SC was initiated by novel features “optimised” IPS systems. However, it is not clear why these special conditions are restricted to this type of system (“If an Ice protection System (IPS) is optimised/modulated, or even inhibited…”).

Under the wording of these Special Conditions, if a new IPS design is not optimised/modulated or inhibited at higher altitudes, but simply happens to be inadequate at altitudes beyond appendix C, it would not fall within the boundary of the Special Condition. How would this new system be evaluated?

Suggested resolution
We suggest EASA expands the applicability clause of the Special Conditions (“If an Ice protection System (IPS) is optimised/modulated, or even inhibited…”) to address other types of new IPS systems and make it more encompassing

EASA response: Not accepted.

The demonstration of capability of a “traditional On/Off” IPS (not optimised) above Appendix C IM icing envelope has not been historically requested and it is not put into question with the present Special Condition. As stated into the “Identification of Issue” section: “*Decades of safe in-service history of in-flight icing operation with aeroplane whose IPS thermal power was only naturally reduced (phased out) by engine bleed flow availability with altitude (i.e., due to natural reduction of global engine inlet mass flow with altitude) prove the robustness of such IPS design. It will be referred hereafter as “traditional On/Off IPS”. In such a case, and on the basis of the past good in-service experience, it is assumed that an aeroplane equipped with “traditional On/Off IPS” operated in the full flight aeroplane envelope can be certified using the Appendix C envelopes, and that no further assessment is required for the part of the flight envelope which is beyond the Appendix C IM altitude.*”

The special condition is only applicable to IPSs which are voluntary optimised or phased out (i.e., a novel design) at altitudes above Appendix C IM icing threshold and requests a demonstration that above current Appendix C IM icing envelope such system can still function as intended.

Commenter 1: TCCA

Comment # 12

Comment 12
"Compliance Strategy/Option a): direct demonstration. Page 5.

Comment summary
We observed a typo in this title "Compliance strategy/Option a) direct demonstration"

Suggested resolution
We suggest EASA to remove "…Option a) direct demonstration" …and replace it with "…Option b) direct demonstration …"

EASA response: Accepted

EASA acknowledge the typo in the published pdf text. Final text is amended as proposed by the commenter.

Commenter 1: TCCA

Comment # 13

Comment 13

Paragraph 4, page 2

Comment summary

EASA states in the proposed SC that, where the "traditional On/Off IPS" on an aeroplane shows good service history, the result would be only a need to be certified using the Appendix C envelopes and that no further assessment is required for the part of the approved flight envelope which is beyond Appendix C. Transport Canada acknowledges that some aeroplane designs with "traditional On/Off IPS" that are currently in service may have good service history – in other words - no in-service events of icing outside the Appendix C envelopes have been reported and are documented. However, this does not necessarily mean that the "traditional On/Off IPS" on all aeroplanes – existing aeroplanes and new aeroplanes with "traditional On/Off IPS" would result in the same service history. Transport Canada understands that the EASA proposed SC is expected to be applicable to new aeroplane, or new derivative aeroplane, designs rather than applicable to currently certified aeroplane designs – essentially not retro-actively applied. From the application of current SC's or SCA's on this subject by the Authorities, Transport Canada understands that some aeroplanes, even with the "traditional On/Off IPS", may be challenged to have adequate IPS performance at altitudes above Appendix C maximum altitudes if icing conditions are encountered. Therefore, simply providing a discriminator that good service history allows no further assessment of a new, or derivative, aeroplane design with "traditional On/Off IPS" where that aeroplane design might be comparable to an existing aeroplane design does not seem to meet the intent of the SC which is to provide a minimum design standard for aeroplane IPS operation throughout the approved flight envelope.

Suggested resolution

Transport Canada would recommend that EASA consider that new aeroplane, or new derivative aeroplane, designs with "traditional On/Off IPS" would still have to be evaluated to the proposed SC standards.

EASA response: Not accepted.

This comment is very similar to the comment #11 of the same commenter. The SC text focuses on unusual IPS designs and it is issued according to Commission Regulation (EU) No 748/2012 as last amended, Annex I, also known as "Part-21", Subpart B, 21.B.75(a)(1). Traditional On/Off IPS are by essence not unusual and are exempted by further assessment above current Appendix C IM icing envelope.

Changing the aircraft icing certification envelope for all IPSs shall be done in the context of standard rulemaking exercise with proper characterization of the icing conditions. The scope of this SC is limited to unusual design features, and it is based on limited available data to expand the Appendix C IM icing envelope above the current altitude.

Commenter 1: TCCA

Comment # 14

Comment 14

Paragraph 5-6, page 2.

Comment summary

EASA identifies the IPS design which provides for “optimization” of the bleed air flow to the IPS such that at some altitudes including up to the maximum approved flight envelope, the performance of the IPS may not be adequate to protect the aeroplane against an icing conditions encounter. As a result, some means of IPS and aeroplane evaluation along with potential limitations must be developed.

Suggested resolution

Transport Canada supports the EASA objective that these “optimized” IPS – whether thermal / bleed air or other systems – need to be evaluated for adequate performance throughout the approved flight envelope or appropriate limitations are proposed.

EASA response: Noted

EASA acknowledges TCCA support on the subject.

Commenter 1: TCCA

Comment # 15

Comment 15

Atmospheric Icing Condition, page 5

Comment summary

EASA identifies the conservative assumptions for CM and IM conditions that the liquid water content (LWC) used for the evaluation of the aeroplane IPS performance would be that LWC for the coldest temperature in the respective Appendix C envelopes with an LWC reducing to 0 gm/m^3 at -40ºC. However, EASA does not expand upon how that temperature of -40ºC is to be arrived at versus altitude. For example, is that temperature equivalent to an altitude only for a standard day condition? Is it required that the temperature be considered for extreme temperature environments – such as hot day conditions – which would result in -40ºC occurring at significantly higher altitudes. Transport Canada would expect that the aeroplane design, and its unique IPS, would cater for not only the approved flight envelope when considering standard day conditions but also for the expected extremes in air temperatures for the foreseeable operation of the aeroplane at those altitudes exceeding Appendix C altitudes and up to and including the maximum approved flight altitude. That said, Transport Canada acknowledges that the typical definition of icing conditions includes temperature and visible moisture criteria and it is commonly agreed that, at ambient air temperatures colder than -40ºC SAT in the natural atmosphere, the water is not present in a liquid state and is all solid state. Thus, liquid water icing conditions in the natural atmosphere are typically not assessed at temperatures colder.

Suggested resolution

Transport Canada would request clarification from EASA as to how the temperature extreme condition would need to be accounted for in this proposed SC.

EASA response: Accepted

EASA agrees with the TCCA considerations about the extreme values of the temperature profiles in not “standard day” conditions. Through discussion with industry representatives, as highlighted in the Explanatory Note 1, the interim proposed icing scenario above Appendix C IM limit, as illustrated in the Annex 1 of the associated MOC to SC text, includes and justifies the assumed max temperature deviation from those in the standard atmosphere, which are considered relevant for the current SC applicability.

Commenter 2: Dassault-Aviation

Comment # 16

With reference to the proposed text:

Page 1: "Although the intent of CS 25.1419 and CS 25.1093(b) is for the aeroplane to safely operate in icing conditions, the specifications limit the icing conditions to CM and IM icing conditions as specified in CS-25 Appendix C. CM and IM icing conditions are currently limited to a maximum of 22000 feet, with a possible extension to 30000 feet for IM icing conditions. Icing conditions may exist above current Appendix C icing envelopes, albeit they are currently not precisely characterised. Although one can postulate that they are less severe in nature compared to Appendix C conditions owing to the Liquid Water Content (LWC) general trend with temperature, it cannot be completely ruled out that icing conditions above Appendix C may definitely exist."

DA Comment:

Recent MFTC studies and presentation explained that ice conditions do exist above appendix C but they do not pose any safety concern due to their light nature.

In a normal rulemaking process, there is a cost vs. safety benefit performed to consolidate the proposal. In the current case, such analysis has not been performed.

New text proposal:

None

EASA response: Not accepted.

This Special Condition is raised since an applicant has proposed a type design which includes unusual features in the way a function is implemented compared with similar past projects. This is the case of an aeroplane with an optimised (with altitude) IPS compared to a traditional On/Off system, which has been demonstrated to be safe also above Appendix C IM altitude without further verification. The process to raise a special condition is not directly comparable to a standard rulemaking procedure. EASA regularly review special conditions for amendment of the CS through rulemaking tasks.

Commenter 2: Dassault-Aviation

Comment # 17

With reference to the proposed text:

Page 2: "Compared with the here-above referred "traditional On/Off" IPS design where the limitation of thermal power is only (mainly) driven by the air bleed availability from the engine with altitude without performing any further air bleed optimisation, these latter designs represent globally a novel or unusual design when compared to the existing flying fleet. […]"

Page 3: "In order to address such unusual IPS design and to ensure that the aeroplane is able to safely operate in icing conditions in the entire aeroplane flight envelope, according to the Annex I of Commission Regulation (EU) No 748/2012 , also known as "Part-21", Subpart A, 21.A.16B(a)(1), there is a need to raise a Special Condition (SC): "The product has novel or unusual design features relative to the design practices on which the applicable airworthiness code is based"."

DA Comment:

A design that modulate IPS with altitude above appendix C is not novel and already certified on Falcon aircraft. The Falcon 7X (in service since 12 years) presents the same wing anti-ice power decrease with altitude and complete shut off at an altitude above FL400.

The CRI should be limited to real unusual features such as design that switch off power just above appendix C limits.

New text proposal:

Compared with the here-above referred "traditional On/Off" IPS design where the limitation of thermal power is only (mainly) driven by the air bleed availability from the engine with altitude without performing any further air bleed optimisation, designs that inhibit thermal IPS above appendix C represent globally a novel or unusual design when compared to the existing flying fleet. […]

EASA response: Not accepted.

EASA could not agree to limit an "unusual" design to IPS with complete inhibition above certain altitude. EASA stated in many instances that the reduction of anti-icing flow can be such that protection is not anymore assured above certain altitude because the anti-icing flow sent to the protected surface can be very marginal. The claimed in-service experience logged on the F7X fleet might be not enough to consider such a design as conventional for all the aircraft types. In such a case, a comparative analysis, as proposed also in the associated MOC material, could be the way forward to justify that the new type design does not behave worse compared to past Dassault designs, which incorporates similar IPS features.

Commenter 2: Dassault-Aviation

Comment # 18

With reference to the proposed text:

page 4: "The SC text is complemented by acceptable means of compliance (AMC) in order to indicate how to demonstrate compliance with the SC."

[…]

page 5: "The associated Means of Compliance is published for awareness only and is not subject to public consultation."

DA Comment:

The current CS25 specifies icing conditions in the appendices C, O and P that are part of CS-25 Book 1 (specifications).

In the proposed SC, the ice conditions above appendix C are not specified and proposed as an AMC. This is not consistent with the current ice regulation.

Moreover, the proposed acceptable means of compliance are mentioned “for awareness” and not subject to public consultation. For icing conditions, this is again not consistent with the development of previous ice regulation where the ice conditions have been discussed by the scientists community. In addition, the content of the compliance strategy (comparative analysis or direct demonstration) should be opened to comments in order to give opportunity to get concurrence on acceptable means of compliance.

DA suggests the EASA to take account of comments on the AMC part.

New text proposal:

None

EASA response: Partially accepted.

EASA has also provided response to all the comments received on the MOC (formerly referred as AMC material when the SC was published for open consultation) associated to the Special Conditions (see the present CRD).

The proposed icing scenario above Appendix C IM (see Explanatory Note 1) is included as Annex 1 of the associated MOC to Special Condition text.

Commenter 2: Dassault-Aviation

Comment # 19

With reference to the proposed text:

Page 4: "When an aeroplane is operated with such IPS logic, it could not be able to demonstrate safe operation in icing conditions within its entire flight envelope."

DA Comment:

The sentence is not consistent with the rest of the CRI. Per definition of Appendix C icing conditions, there is no ice below -40°C and consequently the substantiation is not extended to the whole flight envelope but to area where ice can exist. Proposal to precise with "extended app C icing conditions".

New text proposal:

When an aeroplane is operated with such IPS logic, it could not be able to demonstrate safe operation in extended app C icing conditions within its entire altitude envelope above -40°C.

EASA response: Partially accepted.

EASA agrees with commenter' concerns but will not retain exactly the proposed text and rather amends the introductory wording of the AMC material as follows:

"When an aeroplane is operated (….) safe operation in icing conditions above Appendix C IM altitude ~~within its entire flight envelope~~, at any altitude within its flight envelope where icing conditions may exist."

Based on the *interim* icing scenario proposal above Appendix C IM altitude, as clarified in the Explanatory Note 1, the ice accretion evaluation is requested only up to altitude where icing conditions may exist (see Annex 1 of the associated MOC to the Special Condition).

Commenter 2: Dassault-Aviation

Comment # 20

With reference to the proposed text:

Page 5: “Compliance Strategy/Option a): Comparative Analysis

For new aeroplane design having comparable handling qualities and performance in both dry air and Appendix C icing conditions to previous certified product, the applicant may demonstrate compliance with the Special Condition by means of a comparative analysis …”

DA Comment:

Using "comparable handling qualities and performance" in appendix C to justify aircraft behaviour above appendix C is questionable. On the other hand, current rules do not require assessment of handling qualities and performance at high altitude and high speed.

The comparative analysis should be limited to an IPS design comparative analysis.

New text proposal:

The applicant may demonstrate compliance with the Special Condition by means of a comparative analysis between the proposed “optimised” IPS above the altitude of Appendix C icing envelopes and a previously approved design, supported by safe flight-in-icing in-service history in the entire certified aeroplane operating envelope.

The analysis should demonstrate that the new IPS provides comparable performance as the reference one within the respective aeroplane operational envelopes. The applicant might claim that although the IPS thermal flow is optimised above Appendix C altitudes, it still provides sufficient ice protection and remains comparable to former IPS design in a reference fleet.

Both aeroplane operational envelopes and the kind of operation of the IPS should be comparable.

EASA response: Partially accepted.

The updated text is now referring to comparable handling qualities and performance margins.

Reference to comparable performance and handling qualities margins between “iced” and clean configuration permits to take benefit of past in-service experience of the reference type compared with the new type design.

EASA started from a similar concept to develop the comparative analysis methodology to demonstrate compliance with Appendix O (SLD) icing envelop.

EASA assumes that 2 aircraft having similar handling qualities and performance margins while operating in Appendix C icing conditions compared to dry air ones, the same will be valid above Appendix C IM icing altitude, by considering that icing conditions are even lighter there. Only in such cases the comparative analysis on IPS system aspect is applicable, otherwise nothing may be said about the aerodynamic behaviour in icing conditions above Appendix C IM altitude. In other words, the aerodynamic behaviour similarity is a key pre-condition for the applicability of the comparative analysis.

EASA has slightly modified the introductory wording of the Option a) to better clarify the pre-condition for the applicability of the comparative analysis as it follows:

(..)

Compliance Strategy/Option** Error! Reference source not found.**): Comparative Analysis

For a new aeroplane with an “optimised” IPS design having in Appendix C icing conditions comparable handling qualities and performance margins to a previous certified aeroplane ~~in both dry air and Appendix C icing conditions to previous certified product~~, the applicant may demonstrate compliance with the Special Condition by means of a comparative analysis between the proposed “optimised” IPS above ~~the altitude of~~ Appendix C *IM icing ~~envelopes~~ altitude and a previously approved design, supported by safe flight-in-icing in-service history in the entire certified aeroplane operating envelope (..)*

Commenter 2: Dassault-Aviation

Comment # 20bis

With reference to the proposed text:

Page 5: “Compliance Strategy/Option a): Comparative Analysis

[...] The applicant might claim that although the IPS thermal flow is optimised above Appendix C altitudes, it still provides sufficient ice protection and remains comparable to former IPS design in a reference fleet.

DA Comment:

Even with on/off design, there is no evidence that the system provide sufficient ice protection. The approach is just to substantiate that there is no regression of the new design compared to a design that has no in service incidents/accidents. Proposal to remove “provides sufficient ice protection”.

New text proposal:

The applicant might claim that although the IPS thermal flow is optimised above Appendix C altitudes, it still remains comparable to former IPS design in a reference fleet.

EASA response: Partially accepted.

If a reference fleet has demonstrated good in-service experience, it does mean that the protection above Appendix C IM altitude is sufficient for this fleet, and also for the ‘optimised’ design if comparable in terms of ice protection to this reference fleet.

The comparative analysis should be based on comparing the capability of the proposed IPS to sufficiently protect the aircraft above Appendix C IM icing envelope. The comparison is not limited to the anti-icing mass flow schedule provided by a traditional On/Off system but may take as “reference” a former IPS with similar “optimised” anti-icing flow schedule characteristics installed in a flying fleet aeroplane model with good in-service experience.

EASA agree to remove the text as indicated by the commenter and propose to integrate the text as follows:

Modified text: *“(…) it ~~still provides sufficient ice protection and~~ remains comparable in term of ice protection to former IPS design in ~~a~~ the reference fleet (…)”*.

Commenter 2: Dassault-Aviation

Comment # 21

With reference to the proposed text:

Page 6: “The applicant should propose and substantiate the icing conditions and scenarios that should be considered.

[...]

In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: ..."

DA Comment:

Letting an applicant the freedom to define icing conditions may lead to different and inhomogeneous icing conditions. This would lead to different playfield and potential unfair conditions depending on the data an applicant could have or could access to.

The icing conditions above appendix C proposed by the EASA do not rely on any studies. Moreover, the EASA explains at the beginning of the proposed SC that “they are currently not precisely characterized”.

In the framework of the MFTC, a preliminary analysis has shown that the proposed EASA conditions are unrealistic and over conservative.

Icing conditions above appendix C should be determined by a study and agreed by the scientific community before imposed to aircraft projects.

DA recalls that icing conditions defined in the appendix C (or the new conditions of appendix O) needed years of discussion to converge and it is not possible to conduct these studies in the framework of a given project.

New text proposal:

None

EASA response: Accepted

See Explanatory Note 1. An interim icing scenario above current Appendix C IM icing envelope has been proposed by AIA/ASD Association and included in the Annex 1 of the associated MOC to SC text.

Commenter 2: Dassault-Aviation

Comment # 22

With reference to the proposed text:

Page 6 : “Compliance Strategy/Option b): Direct Demonstration

Operational scenario to compute the relevant airframe ice accretion.

The basic assumption is that the aircraft may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas.

To show that the airplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate “en-route” ice shapes accordingly:

1. Operations in icing conditions above 22,000 feet in CM icing conditions

a) The critical ice accretion that would be already on the airplane after a climb through a single 17.4 nm CM cloud within the appendix C, i.e., below 22,000 ft.

b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aircraft cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aircraft operational restriction, in order to maximise the ice accretion mass.

2. Operations in icing conditions above 30,000 feet in IM icing conditions

a) The critical ice accretion that would be already on the airplane after a climb through a single 2.6 nm IM cloud within the appendix C, i.e., below 30,000 ft.

b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aircraft operational restriction.”

DA Comment:

1) Any additional evaluation should be restricted to protected parts and should not be considered to be contiguous and sequential with other ice accretion scenarios.

EASA proposal contradicts current certification expectations for evaluations at high altitude. The proposed AMC requires the determination of ice at lower altitude on both protected and unprotected parts which is then kept beyond the upper altitudes of the icing appendices for evaluation with additional ice accretion.

These scenarios are in conflict with CS 25 Book 2 AMC 25.21(g) §5.2.1.2:

“… It is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the highest altitudes specified in Appendix C and Appendix O to CS-25).”

Independent of potential ice accretion beyond the ceiling of the existing ice appendices, there is no existing expectation to assess critical ice shapes on both unprotected and protected parts derived from lower altitudes up to the maximum cruise operating altitude.

2) EASA is additionally requested to remove the ‘en route’ reference from the proposed AMC since ‘en route’ ice is explicitly defined in Appendix C Part II(a)(3) as being the ice accreted “during the en-route phase” to be used to show compliance with CS 25.123 requirements; CS25.123 is En route flight paths which is associated with an engine failure; it is therefore not compatible with the proposed AMC for CM and IM scenarios.

<u>New text proposal:</u>

Operational scenario to compute the relevant airframe ice accretion.

To show that the airplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate ice shapes accordingly:

1. Operations in icing conditions above 22,000 feet in CM icing conditions

an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude …

2. Operations in icing conditions above 30,000 feet in IM icing conditions

an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude …”

EASA response: Partially accepted.

After the receipt of the AIA/ASD final position letter dated 22.02.2022, the text of the associated MOC material, as far as the proposed Option b) was concerned, has been largely revised.

The former operational icing scenario <u>with combination of flight phases below and above Appendix C IM altitude has been removed</u>. The reference to “en-route” ice shape has also been removed.

See <u>Explanatory Note 1</u> and Annex 1 of the associated MOC to SC as for the proposed icing scenario above Appendix C IM envelope.

According to the

<u>Explanatory Note 2</u>, the performance & handling characteristics to be demonstrated with the possible resulting ice shapes on both protected and unprotected parts due to the exposure to the proposed icing scenario above Appendix C IM envelope only is not yet established in the associated MOC material.

Commenter 2: Dassault-Aviation

Comment # 23

With reference to the proposed text:

page 7 :"b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximise the ice accretion mass."

DA Comment:

Figure 3 of Appendix C defines the Liquid Water Content Factor vs. Cloud Horizontal Distance. By specifically referencing figure 3 and the cloud horizontal distance, it should be clarified that the corresponding Liquid Water Content Factor may also be used.

New text proposal:

b) The critical ice accretion … The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm *along with the corresponding liquid water Content factor* should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximise the ice accretion mass

EASA response: Noted

See Explanatory Note 1 and Annex 1 of the associated MOC to SC as for the new proposed icing scenario above Appendix C IM altitude.

See

Explanatory Note 2. EASA has completely removed the reference to the previous icing scenario in the associated MOC material of the SC text. The commenter' proposed text change is not applicable anymore. See also reply to Comment #22.

Commenter 2: Dassault-Aviation

Comment # 24

With reference to the proposed text:

page 7: “b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.”

DA Comment:

Figure 6 of Appendix C defines the Liquid Water Content Factor vs. Cloud Horizontal Distance. By specifically referencing figure 3 and the cloud horizontal distance, it should be clarified that the corresponding Liquid Water Content Factor may also be used.

New text proposal:

b) The critical ice accretion ... The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm *along with the corresponding liquid water content factor* should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.

EASA response: Noted

See EASA reply to comment #23.

Commenter 3: Bombardier

Comment # 25

COMMENT #1 of 3			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page:1 Paragraph: 5,6		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** "CS 25.1419 requires applicants seeking certification for flight in icing conditions to demonstrate that the aeroplane is able to safely operate within the CS-25 Appendix C Continuous Maximum (CM) and Intermittent Maximum (IM) icing environment. CS 25.1093(b) requires the power-plant installation being able to properly function in icing conditions of Appendix C as well. Although the intent of CS 25.1419 and CS 25.1093(b) is for the aeroplane to safely operate in icing conditions, the specifications limit the icing conditions to CM and IM icing conditions as specified in CS-25 Appendix C. CM and IM icing conditions are currently limited to a maximum of 22000 feet, with a possible extension to 30000 feet for IM icing conditions. Icing conditions may exist above current Appendix C icing envelopes, albeit they are currently not precisely characterised. Although one can postulate that they are less severe in nature compared to Appendix C conditions owing to the Liquid Water Content (LWC) general trend with temperature, it cannot be completely ruled out that icing conditions above Appendix C may definitely exist." **<u>REQUESTED CHANGE</u>:** "CS 25.1419 requires applicants seeking certification for flight in icing conditions to demonstrate that the aeroplane is able to safely operate within the CS-25 Appendix C Continuous Maximum (CM) and Intermittent Maximum (IM) icing environment. CS 25.1093(b) requires the power-plant installation being able to properly function in icing conditions of Appendix C as well. Although the intent of CS 25.1419 and CS 25.1093(b) is for the aeroplane to safely operate in icing conditions, the specifications limit the icing conditions to CM and IM icing conditions as specified in CS-25 Appendix C. CM and IM icing conditions are currently limited to a maximum of 22000 feet, with a possible extension to 30000 feet for IM icing conditions. Icing conditions may exist above current Appendix C icing envelopes, albeit they are currently not precisely characterised. **~~Although one can postulate that they are less severe in nature compared to Appendix C conditions owing to the Liquid Water Content (LWC) general trend with temperature, it cannot be completely ruled out that icing conditions above Appendix C may definitely exist.~~**"		

Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** BA has participated in formulating and supports all comments provided as a common response by AIA/ASD to EASA SC-F25.1419-01, including the offer to propose CM and IM conditions by 31 March 2020. In addition, BA provides supplementary comments. BA believes that high altitude cloud encounters at typical cruise conditions are not conducive to significant ice accumulation. In the context of high altitude operating characteristics, it is believed that any potential small ice shapes will not affect the safe operation of the airplane.

EASA response: Not accepted.

It is not understood the proposed removal of the text. It is a common understanding that atmosphere icing does not stop at Appendix C IM icing threshold, and this is endorsed by AIA/ASD final position letter.

Based on the AIA/ASD proposal, according to the <u>Explanatory Note 1</u>, EASA has slightly revised the SC preamble text, now stating:

“..*icing conditions above Appendix C IM icing altitude may definitely exist*.”

Commenter 3: Bombardier

Comment # 26

COMMENT #2 OF 3			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 4 Paragraph: Footnote [1]		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “[1] In case of SC, the associated Interpretative Material and/or Acceptable Means of Compliance may be published for awareness only and they are not subject to public consultation.” **REQUESTED CHANGE:** ~~“[1] In case of SC, the associated Interpretative Material and/or Acceptable Means of Compliance may be published for awareness only and they are not subject to public consultation.”~~		
Why is your suggested change justified?	**JUSTIFICATION:** In Footnote [1], it is stated that the interpretative material and/or Acceptable Means of Compliance (AMC) may be published for awareness only and they are not subject to public consultation. Since the text of the SC is a single paragraph, it appears that the substance of the rules and requirements are provided in the AMC. Therefore, BA believes that the requirements expressed in the AMC should be subjected to a formal rulemaking process, and consequently would be open to public consultation.		

EASA response: Accepted

EASA has replied to any comment received on AMC material attached to Special Condition proposed text.

Commenter 3: Bombardier

Comment # 26bis

COMMENT #3 OF 3			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 2 Paragraph: 1 (Continued from page 1 paragraph 6)		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters. Finally, hot-day conditions are not addressed in the current CS 25 Appendix C..."		
What is your concern and what do you want changed in this paragraph?	**REQUESTED CHANGE:** "… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. ~~**Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters.**~~ Finally, hot-day conditions are not addressed in the current CS 25 Appendix C…"		
Why is your suggested change justified?	**JUSTIFICATION:** BA acknowledges that EASA considers that atmospheric icing conditions may exist beyond Appendix C. In an effort to evaluate the real-world propensity for icing conditions exceeding Appendix C, BA has conducted a survey of recent research describing cloud measurement campaigns and other data, detailed in Supplement A of this document. Based on the information currently available it is believed that the existence of non-trace icing above 30,000 ft is extremely rare, expected to exist transiently in the central convective core of developing thunderstorm cells. High altitude encounters in convective clouds will be extremely short in duration, measured in seconds (not minutes). It is believed that glaciation, once initiated, will mitigate the extent and severity of Supercooled Liquid Water (SLW) such that encounters above 35,000 ft will be limited to ice crystals. Therefore, BA believes that extending Appendix C icing conditions as proposed in the SC is not justified by the meteorological data compiled by the industry (more than Supplement A). Therefore, if icing conditions above Appendix C need to be defined, the compiled data should be used in a formal harmonized rulemaking process.		

EASA response: Accepted

The text in the "Identification of Issue" has been largely re-worded referring to more data available from recent research/studies. See Explanatory Note 1 and Annex 1 of the associated MOC to SC text about AIA/ASD industry association proposed interim icing scenario above Appendix C IM altitude.

Commenter 4: Pratt & Whithney

Comment # 27

Pratt & Whitney Canada (P&WC) and Pratt & Whitney (P&W) have participated in the Industry review of the EASA’s Special Condition SC-F25.1419-01 related to the icing conditions above current Appendix C envelope, and supports the consensus position that has been documented and submitted to the EASA by the Aerospace Industries Association (AIA) on behalf of the Industry.

EASA response: Noted

EASA has agreed to consider the consensus position sent by AIA/ASD on 22 February 2022; refer to Explanatory Note 1.

Please refer next to EASA reply to AIA/ASD comments.

Commenter 4: Pratt & Whithney

Comment # 28

EASA’s proposed Appendix C extension is not based on meteorological data. It is recommended to review modern meteorological icing data if there is a need to extend the Appendix C envelope, e.g. Ref. [2][3] proposed an envelope extension based on modern data. In the case that modern icing data is insufficient then a characterization of supercooled icing conditions at altitudes higher than current appendix C envelope would be required.

EASA response: *(Please indicate if EASA agrees, partially agrees, or disagrees).* Noted

EASA has agreed to consider the consensus position sent by AIA/ASD on 22 February 2022; refer to Explanatory Note 1.

[3] 2/ Jeck, R. K., *Advances in the Characterization of Super-cooled Clouds for Aircraft Icing Applications*, FAA report, DOT/FAA/AR-07/4, November 2008
3/ Pfeifer, G. D., and Maier, G. P., *Engineering Summary of PowerPlant Icing Technical Data, FAA report*, FAA-RD-77-76, July 1977
4/ Aircraft Icing Handbook Volume 1 of 3, FAA report, DOT/FAA/CT-88/8-1, March 1991
5/ Curry, J. A., and Liu, G., *Assessment of Aircraft Icing Potential Using Satellite Data*, Journal of Applied Meteorology, June 1992.

Commenter 4: Pratt & Whithney

Comment # 29

High altitude icing events (37,000ft and 39,000ft) reported in EASA’s Special Condition requires more investigation before implying that these events were related to supercooled icing conditions. There is a high probability that these icing events were due to the aircraft flying in ice crystal conditions. The Appendix D/P ice crystal envelope already defines the scenario of encountering high altitude icing conditions.

EASA response: Accepted

EASA has removed in the “Statement of Issue” section the reference to these two uncertain events at altitude above 37000 feet.

Commenter 4: Pratt & Whithney

Comment # 30

Several icing references such as Ref. [2], [3], [4], and [5][3] state that the supercooled liquid water icing conditions above 25,000ft have a very low probability of occurrence and if existent the LWC level is very low, i.e. it would not constitute an icing threat. Based on the available data, there is no flight test data to support the existence of these low supercooled LWCs over large horizontal extents.

EASA response: Partially accepted.

EASA has agreed to consider the consensus position sent by AIA/ASD on 22 February 2022; refer to Explanatory Note 1**.**

Commenter 4: Pratt & Whithney

Comment # 31

Low LWC and cold temperatures corresponding to icing conditions at altitudes higher than current appendix C envelope cannot be created in today’s icing wind tunnel facilities mainly because of the difficulty in controlling the spray nozzle stability.

EASA response: Noted

As explained in
Explanatory Note 2, compliance methodology according to option b) Direct Compliance is not addressed into the MOC material associated to the SC text. Nevertheless, it is not expected at this stage that generation of ice shape in the icing wind tunnel is necessary as a result to exposure to the interim scenario provided in the Annex 1 of the MOC.

Commenter 4: Pratt & Whithney

Comment # 32

Harmonization between EASA & FAA is highly recommended if there is a need to extend the current Appendix C envelope.

EASA response: Accepted/Noted

EASA is obviously in favour of rules harmonization among Authorities to reduce the burden of validation activities. In this spirit, EASA has reviewed with the highest consideration the comments/remarks received from other Airworthiness Authorities.

Commenter 4: Pratt & Whithney

Comment # 33

Clarification is required to confirm that the Special Condition is only intended for airframe and nacelle ice protection systems, i.e. it is not intended to apply to probes and engine certification.

EASA response: Noted.

This SC primarily addresses the airframe and nacelle IPS because those systems are recently ‘optimised’ with altitude, which is not today the case of the probes, whether they are installed on the airframe or in the engine. Whether a similar optimization logic can be implemented on engine specific icing protection, this is not covered by the current paper.

Commenter 4: Pratt & Whithney

Comment # 34

It is also recommended to address the Special Condition through a formal harmonized rulemaking process, taking into account all of the available industry data and with the advisory participation of specialists in meteorology.

EASA response: Accepted

Although there was not literally a rulemaking process, the proposed icing scenario, as clarified in the Explanatory Note 1, derived from a process where all the stakeholders participated to get to a consensus position.

Commenter 5: General Electric

Comment # 35

Dear Mr. Stefano Fico et al:

General Electric appreciates the opportunity to comment on the Special Condition EASA SC-F25.1419-01, “Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes.” GE participated in developing comments to this Special Condition with the Aerospace Industries Association (AIA) and the AeroSpace and Defence Industries Association of Europe (ASD) and agrees with all of them.

EASA response: *Noted*

Commenter 6: AIA

Comment # 36

Dear Mr. Stefano Fico:

Representatives of the Aerospace Industries Association (AIA) and AeroSpace and Defence Industries Association of Europe (ASD), appreciate the opportunity to review and provide comments on the subject Special Condition. While the individual representatives may submit specific and/or additional comments separately, a collective set of high priority comments were organized which AIA/ASD believe to represent a consensus from the industry that should be considered.

The recommendation is to address this Special Condition through formal harmonized rulemaking with industry advisory committee participation, in order to develop appropriate regulation(s) and guidance material. Due to the complex nature of the issue, requiring inputs from a range of disciplines, including meteorologists, a rigorous rulemaking process is considered to be the most appropriate means to address the topic. Given the low probability and light nature of high altitude supercooled liquid water icing (SLW) conditions the return of experience from the in-service fleet could also provide invaluable data. The rulemaking would allow the requirements and guidance to be based on the best available data rather than excessively conservative assumptions, and establish harmonized certification expectations for the applicants.

During the June 2019 SAE International Icing Conference in Minneapolis, EASA advised that as part of the EPAS process, icing rulemaking had been identified as one of the Best Intervention Strategies to address the inflight icing risk. The identified task is called “Icing Certification Requirements Clarifications & Simplification” and could be a suitable task to address the high altitude SLW icing topic. Rulemaking could be further supported by standardization activities through SAE, EUROCAE or another appropriate group.

AIA/ASD also acknowledge the EASA desire to address the subject designs and as such would recommend that those specific designs continue to be addressed via Interpretative Material Certification Review Item (CRI) until formal rulemaking is completed. The primary reason to utilize an IM CRI rather than the Special Condition is to avoid publication of a generic Special Condition and AMC material, which the AIA/ASD representatives believe has not been adequately developed (e.g. an appropriate representation of the icing environment to ensure consistency with other flight in icing Subpart standards) to clearly achieve the desired safety objective; these concerns are communicated specifically in the Enclosure. Launching a formal harmonized rulemaking committee would allow the requirements to be based on industry and regulatory flight test data in order to ensure the continued safety of aircraft designs, as well as avoiding unintended consequences due to changing mission requirements. The available data should be carefully analyzed and interpreted prior to establishing defined requirements. AIA/ASD recommends removal of the AMC from the Special Condition until rulemaking activities evaluate the data regarding environmental effects. Furthermore, the enclosed comments are considered to be applicable to the Special Condition as it is proposed by EASA or relevant to guide and advise applicant/project-specific discussions under the context of an Interpretative Material CRI as proposed by AIA/ASD.

Since there are no current performance requirements for IPS outside of the current Appendix C, the level of protection that the existing fleet provides is unknown, and it is an assumption that a full level of protection is provided by legacy IPS. Whilst the architecture and operation of a new system might be novel, it does not follow and has not been shown that the performance of the system is also novel. The EASA statements about the design and performance of existing “traditional” systems are based on assumptions about the design and operation of the existing systems.

The EASA special condition preamble implies that the researchers that developed Appendix C made no attempts to extrapolate beyond the limitations of the flight test data. In fact, the standard was developed based on analysis, flight test and scientific judgement grounded in meteorological theory. The research flights with altitude limited aircraft operating in specific

regions were augmented by tests with high altitude interceptor aircraft and commercial flights. This data combined with adiabatic lifting theory, probability analyses and the understanding of cloud physics and meteorology led to the envelopes defined in Appendix C. The researchers explicitly recorded the flight test data limitations and address them through analysis and judgement. The researchers purposefully limited Continuous Maximum (CM) icing conditions to 22,000 ft. maximum altitude and did not extrapolate Intermittent Maximum (IM) conditions beyond 30,000 ft. More contemporary reports such as DOT/FAA/CT-88/8-1 Vol. 1 Section 1.2.1.1 have since reaffirmed that, for continuous maximum stratiform type clouds, only ice crystals are present above 22,000 ft. AIA/ASD propose to provide proposals for both the CM and IM conditions by 31 March 2020. It is noted that developing definitions of icing scenarios and demonstrations, including addressing limitations, direct compliance, and similarity, are other important tasks; however, it is unlikely that the proposed timeframe would allow a thorough assessment of these items. Therefore, it is recommended that these tasks be included in the workscope for a formal harmonized rulemaking committee. AIA/ASD notes that the proposals for the CM and IM conditions could be an interim solution whilst awaiting the launch of a rulemaking committee. The comments included in this letter are informed by research performed by the AIA/ASD representatives and the MFTC (Manufacturer's Flight Test Council). This research reviewed a range of meteorological reports, reviewed in-service experience and feedback, studied the science related to SLW aloft and applied a proprietary meteorological database. The research also reviewed the unintended consequences that overly conservative requirements (and interpretation) could have or has already had on the design and certification of commercial aircraft. These unintended consequences either have already or will in the future manifest as oversized engines, ice protection systems, non-optimal bleed port selections, overly conservative stall protection and, likely, delayed certification due to overly constrained flight tests campaigns. Whilst the AIA/ASD agrees that high altitude supercooled icing should be addressed, it is important that it is addressed in a way that is commensurate with the safety risk and is based on the available data. AIA/ASD is aware that the MFTC is submitting additional comments regarding the EASA SC. The MFTC will be providing comments from the perspective of flight test specialists, whereas the AIA/ASD representatives will be providing comments from the perspective of airframers and engine manufacturers. Again, we thank you for the opportunity to provide inputs to this document and trust that you will consider our comments and recommended actions.
EASA response: Noted EASA appreciates the comments received on that matter which have triggered almost 2-years period of "open discussion" between Industry association representatives and AAs; several follow-up meetings were held which eventually led to a final position letter dated 22.02.2022; therein, an interim icing scenario above Appendix C IM icing altitude has been proposed and accepted by EASA. This proposal has been included as Annex 1 of the associated MOC to SC text. Refer to Explanatory Note 1. See specific reply to each comment.

Commenter 6: AIA

Comment # 37

COMMENT #1 of 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page:1 Paragraph: 6		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters. Finally, hot-day conditions are not addressed in the current CS 25 Appendix C...” **<u>REQUESTED CHANGE</u>:** “… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. **~~Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters.~~** Finally, hot-day conditions are not addressed in the current CS 25 Appendix C…”		
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Additional data regarding supercooled liquid droplet icing conditions that may exist over tropic and equatorial warm ocean waters would be valuable, especially for a harmonized rulemaking committee. However, some data already exists, such as published reports from the HAIC-HIWC flight campaigns. While the HAIC-HIWC flight campaigns were focused on ice crystal icing (ICI) conditions, the Reference states that “There were no mixed phase zones colder than -35°C”. This could be used to substantiate the fact that SLW is rarely found outside of the strongest convective cores at these low temperatures. (Reference 1). **<u>REFERENCES:</u>** 1. Strapp, J.W., Schwarzenboeck, A., Bedka, K., Bond, T., et al., “An Assessment of Cloud Total Water Content and Particle Size from Flight Test Campaign Measurements in High Ice Water Content, Mixed Phase/Ice Crystal Icing Conditions: Primary In-Situ Measurements,” FAA Rep. DOT/FAA/TC-18/1, 2019, in review and publication process.		

EASA response: Accepted

This is similar to comment # 26bis proposed by another commenter.

See EASA reply to comment # 26bis.

Commenter 6: AIA

Comment # 38

COMMENT #2 OF 14			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 2 Paragraph: 1 (Continued from page 1 paragraph 6)		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “… Furthermore, the same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; the occurrence at 37000 feet was reported as ‘severe’. (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington). The report also states (§ 1.3.3) that ‘…an Ice Protection System designed to meet Appendix C icing environment will probably have no difficulties when icing is encountered at high altitude.’”		

	What is your concern and what do you want changed in this paragraph?	**REQUESTED CHANGE:** "~~**Furthermore, t**~~…The same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; ~~**the occurrence at 37000 feet was reported as 'severe'**~~ **these encounters are in conflict with the -40°C temperature accepted as the lower limit for supercooled water to persist in an air mass and, due to the lack of information surrounding these individual events, would not be used to substantiate very high altitude icing significantly beyond the current explicit upper altitude limit associated with the IM icing envelope.** (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington). **The report also states (§ 1.3.3) that '…an Ice Protection System designed to meet Appendix C icing environment will probably have no difficulties when icing is encountered at high altitude.' It affirms as well, that, from the data presented, it may be seen that icing encounters above 24,000 ft. (7315 meters) are rare, as are icing encounters below -22 F (-30 °C). It does appear that the temperature range of the icing envelopes could be increased by about 10 F at the higher altitudes.** **With two exceptions (ref: ADS-4 reference 3-38), the high-altitude icing encounters are reported as 'light' icing; this is in agreement with previous data showing reduced LWC with lower temperature. The two exception data points are found at temperatures well below -40 F (-40 °C); however, the notation with the data (reference 3-38) states that the temperatures were probably measured in dry air after the icing encounter. (Temperature in clouds may be several degrees warmer than the adjacent air.) Existence of water in supercooled droplet form at temperatures below -40 F (-40 °C) is very unlikely.** **It is also acknowledged that the report states (§ 1.3.3) that 'Based on the data available, it appears that high-altitude icing is infrequent and when encountered is not likely to be of a severe nature."**
	Why is your suggested change justified?	**JUSTIFICATION:** EASA acknowledges that the original icing envelopes for Continuous Maximum and Intermittent Maximum, while recognized to constitute an engineering standard, were developed using data acquired from aircraft with limited altitude capability. However, the referenced FAA Technical report ADS-4, Figure 1-21 includes encounters derived from B-52, KC-135 and 707 type aircraft, all with service ceilings in excess of 40,000 feet (i.e., exceeding the plot scale) which corroborate the appropriateness of the corresponding certification icing envelope upper altitudes. The only two appreciable deviations correspond to reported encounters of icing at approximately 37,000 and 39,000 feet; both of which are exceedingly below the accepted -40°C temperature accepted as the lower limit for supercooled water to persist in an air mass. These events occurred at -51°C and -54°C respectively. In fact, the ADS-4 report goes on to state these encounters "were probably measured in dry air after the icing encounter" which further raises doubt about their validity. AIA/ASD speculate that the reported events were due to ice crystal icing, rather than SLW icing. The ice crystal icing phenomenon was not well understood at the time of the letter from Mr. Rock. Pilot reports have indicated that a common flight deck effect due to ICI is the appearance of liquid water on the windscreen, which is caused by melting ice crystals on the heated windscreen. In addition, the recommendation is to add the rest of the text from ADS-4 §1.3.3 "High altitude icing data" to provide context for the proposed text.

EASA response: Partially accepted.

Comment is similar to Comment #29, #64, #83.

EASA has deleted in the “Statement of Issue” section of the final SC text the reference to these two events included in the FAA Technical report ADS-4, considered uncertain. See also EASA reply to comment #29. The comment is considered “partially accepted” since EASA does not literally implement the proposed text.

Refer to Explanatory Note 1.

Commenter 6: AIA

Comment # 39

COMMENT #3 OF 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 2 Paragraph: 7		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “Compared with the here-above referred “traditional On/Off” IPS design where the limitation of thermal power is only (mainly) driven by the air bleed availability from the engine with altitude without performing any further air bleed optimization, these latter designs represent globally a novel or unusual design when compared to the existing flying fleet.” **REQUESTED CHANGE:** “~~**Compared with the here-above referred “traditional On/Off” IPS design where the limitation of thermal power is only (mainly) driven by the air bleed availability from the engine with altitude without performing any further air bleed optimization, these latter designs represent globally a novel or unusual design when compared to the existing flying fleet**~~.”		

	Why is your suggested change justified?	**JUSTIFICATION:** AIA/ASD respectfully disagrees that the airflow in the “traditional On/Off” IPS design is mainly governed by the engine’s ability to provide bleed airflow. There are some aircraft, for example, where the airflow is driven by the gage pressure setting of the wing anti-ice valve. AIA/ASD respectfully disagrees as well with this conclusion being drawn from this statement in subsequent paragraphs. While it is true to state that some modulated or optimized IPS do represent new design approaches, the implication of using the terminology “novel or unusual” is that such a design approach changes the behavior of a system in a fashion that requires specific attention. Such a conclusion is implied in the second paragraph of page 3, namely: “*Such modulated IPS may be unable to maintain the protected surface temperatures above zero at altitudes above the Appendix C envelope limits, and, particularly, at low temperatures, ice could accrete on the protected surface.”* There is an unstated assumption that a “Traditional On/Off” IPS will be able to “maintain the protected surface temperatures above zero…” The need for the Special Condition depends upon this unstated assumption that the performance levels of “traditional On/Off” IPS are superior to what might be provided in an “optimized” IPS. AIA/ASD respectfully suggests that there may be existing “traditional On/Off” IPS designs which provide degraded high altitude performance of a similar level to that provided by “optimized” IPS, and have demonstrated safe service history.

EASA response: Partially accepted.

Commenter assumes that EASA means that traditional “On/Off” IPS(s) provides full protection, which is not the genuine intention of the proposed text; nevertheless, traditional IPS without a voluntary specific regulation (reduction) logic with altitude (above Appendix C IM envelope), as proposed by new designs, have demonstrated good in-service experience.

EASA means that modulated or optimized IPS are considered as novel or unusual design compared to the “traditional On/Off” IPS design, although it is recognised that those latter may also not be able to maintain the protected surface temperatures above 0 °C at altitudes above the Appendix C IM icing envelope altitude. The compliance strategy option a) in the associated AMC material permits the use of the comparative analysis to assess modulated or optimized IPS.

Text is updated as follow:

“*Compared with the here-above referred “traditional On/Off” IPS design where the limitation of thermal power is only (mainly) determined ~~driven~~ by the…*

(…)

At altitudes above the Appendix C IM icing envelope, and particularly at low ambient temperatures, such modulated IPS may be unable to maintain the protected surface at temperature below which, unacceptable amount of ice might accrete on the protected surface.

(…)

~~Such modulated IPS may be unable to maintain the protected surface temperatures above zero at altitudes above the Appendix C envelope limits, and, particularly, at low temperatures, ice could accrete on the protected surface.~~

(…)

Commenter 6: AIA

Comment # 40

COMMENT # 4 OF 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 3 Paragraph: 2		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES:</u>** “Such modulated IPS may be unable to maintain the protected surface temperatures above zero at altitudes above the Appendix C envelope limits, and, particularly, at low temperatures, ice could accrete on the protected surface.” **<u>REQUESTED CHANGE:</u>** “Such modulated IPS may be unable to maintain the protected surface temperatures above zero at altitudes above the Appendix C envelope limits~~**, and, particularly, at low temperatures, ice could accrete on the protected surface**~~.”		
Why is your suggested change justified?	**JUSTIFICATION:** AIA/ASD disagrees with the statement that “ice could accrete on the protected surface”. The low atmospheric LWC coupled with a high airspeed would promote sublimation and erosion at the surface; it is not believed that ice accretions would remain on the surface. CS 25.253 (high speed characteristics) only requires icing to be considered up to 300 knots CAS.		

EASA response: Partially accepted.

The final text of this part of the Preamble has been modified based on previous comment #39.

Although EASA understands the commenter’ rationale, nevertheless it may happen that, although not penalising the aircraft performance, some ice might accrete on the protected surface in such conditions. Such conditions may occur at speed less than 300 knots, for example.

EASA proposes to change “could” with “might”; the sentence in the final SC text will read as proposed in comment #39.

Commenter 6: AIA

Comment # 41

COMMENT #5 of 14			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 4 Paragraph: 1		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES**: If an ice protection system (IPS) is optimised/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes, the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope. **REQUESTED CHANGE**: If an ice protection system (IPS) ~~is optimized/modulated, or even inhibited,~~ implements control logic that reduces, cuts-off, or even inhibits the thermal ice protection system, other than being naturally reduced by engine bleed air flow availability with altitude, above the maximum altitude of Appendix C icing envelopes; **the airplane must be able to safely operate** in icing conditions encountered at any altitude~~s of~~ **within** the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope. The applicant shall follow one of the following 3 options: 1. The applicant demonstrates safe operation in icing conditions at all altitudes up to its operational ceiling; then the certified icing envelope is equivalent to the aeroplane flight envelope, and no AFM limitation is required. 2. The applicant does not demonstrate safe operation in icing conditions at altitudes above the maximum altitude of the Appendix C icing envelopes; then the certified icing envelopes are those indicated in the CS-25 Appendix C only; and an AFM limitation is introduced to prevent aeroplane operation in icing conditions above the maximum altitude of Appendix C icing envelopes. 3. The applicant demonstrates safe operation in icing conditions up to a certain altitude between the maximum altitude of Appendix C icing envelopes and its operational ceiling; then the certified icing envelope is the Appendix C icing envelopes extended up to the demonstrated altitude, and an AFM limitation is introduced to prevent aeroplane operation in icing conditions at altitudes above the demonstrated altitude and up to the aeroplane service ceiling. The applicant shall propose and substantiate the icing conditions that should be considered for high altitude supercooled liquid water icing conditions, although it is acknowledged that CM cannot exist above 22,000 ft. due to the cloud type, and no supercooled liquid water icing conditions can exist below -40°C.		

An agency of the European Union

Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Respectfully, several phrases and topics of this brief, but significant paragraph has resulted in extended discussions and disharmonized interpretations of the regulation. After many discussions, this appears to be an incomplete requirement as initially written in the proposed Special Condition. The phrase "…Optimized/Modulated…" is ambiguous and additional clarification is required. It is unclear if pneumatic regulating valves, which are common practice in the industry, would fall under the category of "modulated". In addition, the use of such a valve or even designing the system to the appropriate levels to deliver adequate ice protection would be considered by some applicants to be "optimized". The intent of the proposed Special Condition appears to be directed at more extreme reduction of IPS capabilities, and therefore additional systems definitions are required. The proposed Special Condition text lacks a definition of icing conditions outside of Appendix C, and the only guidance is found in the relevant AMC. Unlike the currently defined icing envelopes of Appendix C, Appendix O and Appendix P, the undefined conditions proposed by the SC make it appear that that the rulemaking is inappropriately accomplished by guidance material. The applicant should propose and define what "safely operate" means, and which respective icing condition(s) will be considered. The expectation is a proposal based on the available research, utilizing analyses which also may include atmospheric physics, or an appropriate alternative. The requested change to the proposed Special Condition is inspired by CS25.1420, where the options for certification are explicitly outlined. The three options for safe operation in icing conditions outside of Appendix C are required for showing compliance, and therefore should be included in the rule text. While the aforementioned proposal offers an alternative approach, it is the position of AIA/ASD that a formal harmonized rulemaking with appropriate industry support would be the preferred method by which to consider any requirements for the atmospheric characterization of high altitude SLW. It is generally accepted and widely reported that SLW does not occur at temperatures below -40°C. FAA document DOA/FAA/CT 88/8-1 reported that stratiform clouds above 22,000 ft. only consisted of ice crystals.

EASA response: Partially accepted.

Commenter proposes to clearly define in the Special Conditions text the definition of "modulated/optimised". EASA agree with this proposal, but EASA included a clear explanation on the introductory wording of the Special Conditions. Therefore, if the proposed wording is clearer for the commenter, no opposition to these changes. In addition, commenter proposes to move the possible options from the AMC material into the Special Conditions to resemble the CS 25.1420 approach. EASA agrees on this respect.

As far as the AIA/ASD proposed icing scenario, seeExplanatory Note 1, since it is an interim solution, it is proposed to be appended as an Annex to the associated MOC of the SC text.

The final SC text is modified in this way as partly proposed by the commenter; indeed, it includes all the other changes proposed by other commenters and implemented in the final text:

Special Condition SC-F25.1419-01 on Aeroplane Ice Protection System operation above the ~~maximum altitudes of~~ CS-25 Appendix C IM icing ~~envelopes~~ altitude.

(…)

If an ice protection system (IPS) ~~is optimised/modulated, or even inhibited,~~ implements control logic that reduces, cuts-off, or even inhibits the power/energy supplied to any protected surfaces with increasing altitude in icing conditions above the ~~maximum altitude of~~ Appendix C IM icing ~~envelope~~ altitude, ~~the applicant shall demonstrate that~~ the aeroplane must ~~can~~ be able to safely operate in icing conditions encountered at any altitude~~s of the~~ within the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes above a certified icing envelope.

The applicant has to follow one of the following options:

~~The aeroplane must be capable of operating in accordance with sub-paragraphs (1) or (2) or (3)~~

(1) The ~~applicant~~ aeroplane is capable ~~demonstrates~~ to safely operate ~~operation~~ in icing conditions above Appendix C IM envelope at any altitude ~~at all altitudes up to its operational ceiling~~ within its flight envelope where icing conditions may exist; then the certified icing envelope is the aeroplane flight envelope, and no AFM limitation is required.

(2) The ~~applicant~~ aeroplane ~~does~~ is not capable to ~~demonstrate~~ safely operate ~~operation~~ in icing conditions ~~at altitudes~~ above the ~~maximum altitude of the~~ Appendix C IM icing altitude~~s~~; ~~then the certified icing envelopes are those indicated in the CS-25 Appendix C only; and~~ an AFM limitation is introduced to prevent aeroplane operation in icing conditions above the ~~maximum altitude of~~ Appendix C IM icing ~~envelopes~~ altitude.

(3) The ~~applicant~~ aeroplane ~~demonstrates~~ is capable to safely operate ~~operation~~ in icing conditions up to a certain altitude between the ~~maximum altitude of~~ Appendix C IM icing ~~envelopes~~ maximum altitude and its operational ceiling; ~~then the certified icing envelope is the Appendix C icing envelopes extended up to the demonstrated altitude; and~~ an AFM limitation is introduced to prevent aeroplane operation in icing conditions above the demonstrated altitude and up to its ceiling.

Commenter 6: AIA

Comment # 42

COMMENT #6 OF 14			
Type of comment (check one)	*Non-Concur X*	*Substantive*	*Editorial*
Affected paragraph and page number	Page: 4 Paragraph: 2		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "The associated Means of Compliance is published for awareness only and is not subject to public consultation." **REQUESTED CHANGE:** ~~**"The associated Means of Compliance is published for awareness only and is not subject to public consultation."**~~		
Why is your suggested change justified?	**JUSTIFICATION:** The AMC requirements go beyond those included in the text of the actual special condition. The AMC is therefore part of the rulemaking and as such, it is subject to public comments.		

EASA response: Accepted

EASA has provided answers to comments to the MOC associated (former AMC material) to Special Conditions in this document as well. The same commenter asked to remove the AMC text at all (see comment #45).

Commenter 6: AIA

Comment # 43

COMMENT #7 OF 14			
Type of comment (check one)	*Non-Concur X*	*Substantive*	*Editorial*
Affected paragraph and page number	Page: 4 Paragraph: 3		

What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES:</u>** “…When an aeroplane is operated with such IPS logic, it could not be able to demonstrate safe operation in icing conditions within its entire flight envelope. In such a case the applicant should define the certified icing envelope where the aircraft operation in icing condition is unrestricted.” **<u>REQUESTED CHANGE:</u>** Delete Text. **~~“When an aeroplane is operated with such IPS logic, it could not be able to demonstrate safe operation in icing conditions within its entire flight envelope. In such a case the applicant should define the certified icing envelope where the aircraft operation in icing condition is unrestricted.”~~**
Why is your suggested change justified?	**<u>JUSTIFICATION:</u>** An aircraft with an “optimized” bleed or IPS will probably be able to demonstrate safe flight in icing conditions above the Appendix C limits. The use of “could not” here is ambiguous and if this paragraph is retained should be replaced **by the word “may not**”. As the available data indicates that SLW icing at high altitude is rare and light in nature it is quite likely that an aircraft with an optimized bleed or IPS could indeed demonstrate safe operations in SLW icing conditions above the Appendix C limits.

EASA response: Partially accepted.

Text will be retained and changed as proposed by the commenter to read as follows:

“(…) When an aeroplane is operated with such IPS logic, it ~~could~~ may not be able to demonstrate safe operation in icing conditions (…)”

Commenter 6: AIA

Comment # 45

COMMENT #8 OF 14			
Non-Concur X	***Substantive***	***Editorial***	

Affected paragraph and page number	Page: 4 through 6 Paragraph: *2 through End*
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “The associated Means of Compliance is published for awareness only and is not subject to public consultation.” **<u>REQUESTED CHANGE</u>:**

	Delete entire AMC from publication: ~~**"The associated Means of Compliance is published for awareness only and is not subject to public consultation... 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction."**~~
Why is your suggested change justified?	**<u>JUSTIFICATION:</u>** The primary suggestion is to remove the AMC material and convert the Special Condition to Interpretive Material CRI. Note that comments 10 and 11 suggest improvements to the AMC text and have been provided to address the case where EASA elects to retain the AMC material. In effect, the suggestion will result in a certification approach similar to the way ETOPS is addressed where each applicant proposes missions and icing conditions relevant to their aircraft platform. The goal is to have a starting position for applicants while awaiting deliberations from the proposed formal harmonized rulemaking committee. The primary reason to withhold publication of the AMC material is that the Group believes the proposed AMC has not been adequately developed (e.g., appropriate representation of the icing environment, ensure consistency with other flight in icing Subpart standards) to clearly achieve the desired safety objective. The assessment from the industry is that any definition or characterization of high altitude SLW conditions, and any determination of acceptable means of compliance should be conducted via a formal harmonized rulemaking process with industry advisory committee participation. Launching a formal harmonized rulemaking committee would allow the requirements to be based on industry and FAA flight test data in order to ensure the continued safety of aircraft designs, as well as avoid unintended consequences due to changing mission requirements. The available data should be carefully analyzed and interpreted prior to establishing defined requirements.
Why is your suggested change justified?	**<u>JUSTIFICATION: *(continued)*</u>** Any characterization of high altitude SLW conditions proposed in the SC must be based on experimental characterization of icing conditions rather than extrapolation based on atmospheric lapse rates or similar. Given that the current Appendix C envelope is intended to be representative of a 99th percentile cloud which could be found within the envelope limits, any proposed changes should be based on a similar statistical analysis of available data within the expanded envelope in order to avoid driving unnecessary conservatism. Moreover, it is believed that the special condition and AMC might represent unintended impact to engine manufacturers: • If the Appendix C envelopes are expanded to encompass what has been proposed in the SC, an engine manufacturer will have to demonstrate compliance within said envelopes regardless of whether or not a modulated ice protection system is installed on a customer airframe. • Modern turbofan engines may include ice protection systems internal to the engine hardware as well as changes to engine control schedules. These systems and control schedules are typically disabled at altitudes above the Appendix C to CS-25 envelopes where they are not required.

		• If the icing threat exists at altitudes higher than Appendix C to CS-25, the applicant would need to update the critical point analysis to include the updated Appendix C to CS-25 envelope. Since engine operation at power levels which can sustain level flight need to show capability for indefinite operation, this evaluation at higher altitudes could not be limited to passage through a single cloud. • The Appendix C icing envelope expansion in the SC is incongruent with the current LWC limit in Appendix P/D mixed phase conditions. Namely, the expansion argues that LWC is possible at the altitudes in question and below -20 ºC, where Appendix P/D defines zero liquid content. While the body of available literature concerning high altitude/low temperature icing indicates that mixed phase conditions with appreciable liquid content are physically possible at temperatures down to the homogeneous freezing threshold of water (approximately -38 ºC), there are no known reports of isolated liquid water at such temperatures outside of laboratory experiments. This implies that the presence of high altitude/low temperature liquid water should be treated in a mixed phase context, and as such potential impact to engine certification under Appendix P/D conditions should be considered when driving any requirement that might set a precedent with respect to the former. For example, the inclusion of liquid water between -20 ºC and -40 ºC in a mixed phase engine icing analysis could cause a meaningful shift of predicted accretion risk zones, and could drive additional certification effort and cost on the part of an engine manufacturer. As such, a data-driven basis must be provided for the probability of the existence of liquid water at the temperatures below -20ºC, and for the likelihood of encountering such temperatures at altitudes over current Appendix C limits. Clearly an unintended consequence of this change to engine manufacturers is additional analysis and/or test points in a regulatory icing envelope where no evidence of engine events have occurred. The group therefore recommends the formal harmonized rulemaking process with industry participation, or other comparable avenue, for a data driven basis for the characterization of high altitude SLW conditions. This will ensure future regulations and requirements are in alignment with all current aviation regulations, while minimizing the environmental impacts of future airplanes.

EASA response: Not accepted.

This comment has to be also read in combination with the comment #41 of the same commenter.

EASA keeps the AMC but agreed to move some text from the associated MOC (former AMC) to Special Condition, except the AIA/ASD proposed icing scenario above Appendix C IM icing altitude, which remains an Annex to the MOC. See the Explanatory Note 1.

The associated MOC is reduced and more general in the scope; now it only proposes option a) – comparative analysis - and option b) – direct compliance - to comply with SC intent. Assessment of combination of flight phases has been removed as well as any related icing scenarios. As far as option b) is concerned, see Explanatory Note 2. The present SC does not intend to address engine icing certification.

Commenter 6: AIA

Comment # 46

COMMENT #9 OF 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: 5		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimized/modulated or even inhibited IPS above the Appendix C icing envelopes, is still safe. For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane unprotected and protected parts. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment.” **REQUESTED CHANGE** “Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimized/modulated or even inhibited IPS above the Appendix C icing envelopes, is still safe. ~~**For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane unprotected and protected parts. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment.**~~”		
Why is your suggested change justified?	**JUSTIFICATION:** AIA/ASD respectfully notes that the description of the necessary evaluations to ensure safe operation is inconsistent with the current expectations for CS 25.21(g) and 25.1419, which do not require assessment of handling qualities and performance at high altitude and high speed for either protected or unprotected surfaces. If a flight test at high altitudes and high speeds with ice shapes is required, then this would be a severe burden on industry which is unjustified by safe service history. Moreover, demonstration of potential effects of ice release on engines and essential equipment is already performed in natural icing at low altitude. Further demonstration at high-altitude would be unnecessary as any realistic ice accumulations would be significantly smaller. It would also be impractical due to the extreme difficulty in finding high-altitude SLW icing conditions.		

EASA response: Partially accepted.

This comment is similar to comment #22, comment #57 and comment #81. See reply to comment #22.

Explanatory Note 2 provides additional information as how to proceed to agree on the compliance demonstration according to option b) of the associated MOC material. At the present, the final MOC material does not provide any further information about this aspect, although it restates that a demonstration is requested. It is slightly modified and reads as follows:

(..) For the evaluation of safe operation, the applicant should assess the degradation of ~~aeroplane~~ performance and handling qualities created by the potential ice accretion on the aeroplane unprotected and protected parts. Furthermore, the applicant should assess the impact ~~effect~~ of the sudden release of ~~the~~ ice accretions from aircraft surfaces on the engines and essential equipment (…).

Commenter 6: AIA

Comment # 47

COMMENT #10 OF 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: 6		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "The applicant should propose and substantiate the icing conditions and scenarios that should be considered. In the absence of any proposal, the following icing conditions and operational scenarios may be considered. Atmospheric icing Conditions In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature. - The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C." **REQUESTED CHANGE:**		

	“The applicant should propose and substantiate the icing conditions and scenarios that should be considered. ~~**In the absence of any proposal, the following icing conditions and operational scenarios may be considered.**~~ ~~**Atmospheric icing Conditions**~~ ~~**In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken:**~~ ~~**- The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature.**~~ ~~**- The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C.”**~~
Why is your suggested change justified?	**JUSTIFICATION:** While service experience does not indicate that this SC is necessary, it is acknowledged that the intent of the SC is to address design implementations that may utilize the explicit boundaries of the existing certification icing envelopes to modify an ice protection system’s operation. However, the proposed AMC icing conditions, while not considered open for public comment, may undermine the intent of the SC. The proposed AMC icing conditions are exceedingly conservative and may drive substantially different applicant proposals resulting in an unintended disharmony in certification expectations within the industry. Consistent application of the proposed AMC icing conditions within this SC would retain harmonization, however the exceedingly conservative nature of the proposed AMC raises legitimate concerns that the net result of this SC could be an unintended decrease in the level of safety (e.g., design change to address an unrealistic condition resulting in the unintended sub-optimization for other conditions), unsubstantiated economic burden, and/or unspecified adverse environmental effects. Specific examples of adverse environmental effects can include decreased fuel economy resulting from maintaining higher airflows and pressures from the engine bleed system to accommodate a higher altitude ceiling for icing conditions. This would result in increased CO_2 emissions, which does not align with the European Aviation Environmental Report 2019 (ISBN 978-92-9210-214-2) which lists greenhouse gas emission reduction targets (page 26), nor the implementation of new CO_2 and engine PM standards that become applicable as of 1 January 2020 (page 29). In addition, engine endurance issues may become apparent as a result of increased bleed pressure and airflow requirements, and a different design may drive increased engine weight and increased design complexity to accommodate the additional pneumatic requirements for a very rare occurrence. Some aircraft operating their IPS above the current Appendix C altitudes may cause the aircraft to descend and lead to fewer options for flight crew to avoid icing and other weather threats. Other unintended design consequences also relate to requiring additional bleed capability for pneumatic icing; this may result in reduced margins for cabin pressurization requirements and cabin environmental controls, as well as reduced capability for cargo fire protection.

Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC.

-

EASA response: Accepted

EASA eventually removed the initially proposed icing scenarios based on the proposal received from AIA/ASD on 22/02/2022. See Explanatory Note 1.

Commenter 6: AIA

Comment # 48

COMMENT #11 OF 14			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page 5 Paragraph 7		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES:</u>** “The applicant should propose and substantiate the icing conditions and scenarios that should be considered. In the absence of any proposal, the following icing conditions and operational scenarios may be considered. <u>Atmospheric icing Conditions</u> In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature.		

		- The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C." **REQUESTED CHANGE:** ~~"~~The applicant should propose and substantiate the icing conditions and scenarios that should be considered. ~~**In the absence of any proposal, the following icing conditions and operational scenarios may be considered.**~~ ~~**Atmospheric icing Conditions**~~ ~~**In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken:**~~ ~~**- The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature.**~~ ~~**- The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C."**~~
	Why is your suggested change justified?	**JUSTIFICATION:** It is proposed that both the altitude expansion and the methodology used for such an expansion of the CS 25 Appendix C envelope are excessively conservative. The altitude limitations of the aircraft which gathered the data in the NACA TN which provided the basis for CS 25 Appendix C were recognized and addressed by the researchers who prepared that documentation. Analytical efforts and a year of operations of fast jets with far greater altitude capability were used to address this limitation; the IM conditions at FL310 are extrapolations based on these tests and scientific assessments of the ensemble of data, theory, and analysis. SLW cannot physically exist below -40°C (References 1 – 5). Typical cruise altitudes for aircraft of FL300 and above still have low probabilities of entrained SLW in the atmosphere. Atmospheric physics as well as in-service data support a lack of SLW icing risk at the service ceiling of aircraft, and often well below the service ceiling. An example of an aircraft-observed sounding is shown below in Figure 1; it is an example of how meteorologists correlate atmospheric temperature and altitude.

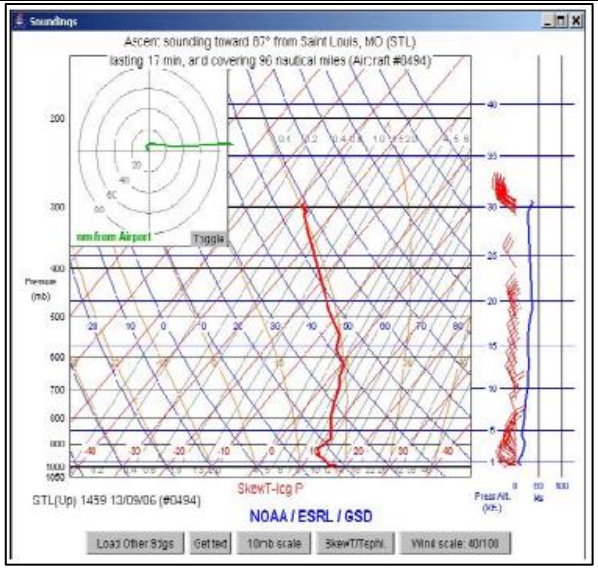

Figure 1: Aircraft-Observed Sounding

Figure 2 represents the 99th percentile temperatures globally at FL340. This is another example of correlating atmospheric temperature and altitude to establish probability of icing threats to aircraft.

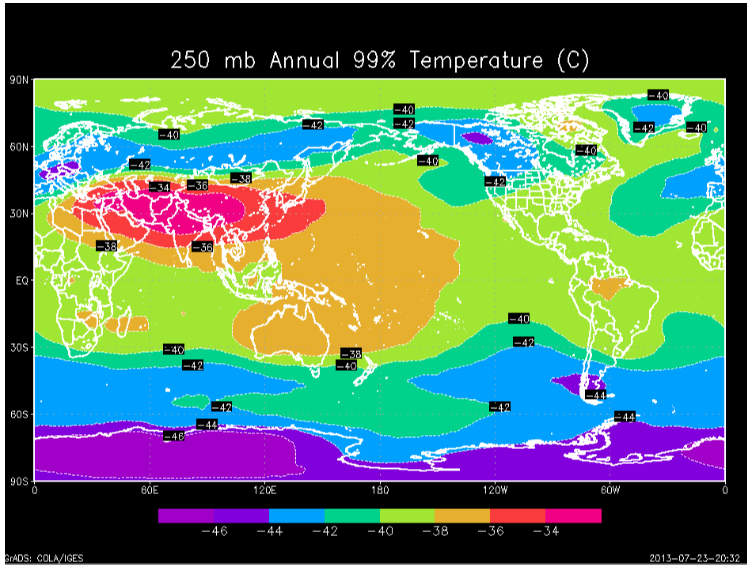

Figure 2: 99th Percentile Temperatures Globally at FL340

In addition, References 6 and 7 are intended to document existing flight campaigns which explored thunderstorm cores at high altitudes. These campaigns showed that while significant amounts of SLW in intense updrafts could be found at -38C, any colder temperatures were ice crystals.
By using the lower temperature limits described in the references, it is possible to utilize global temperature distributions (Figure 2), which are fairly well established, to infer upper limits to the icing envelope. These tools, along with the historical probability of icing and knowledge of global route distribution, make it possible to globally study the various icing threats.

REFERENCES:

1. https://www.pnas.org/content/99/25/15873.short
2. https://journals.ametsoc.org/doi/abs/10.1175/1520-0469(1990)047%3C1056%3AFNRODS%3E2.0.CO%3B2
3. https://journals.ametsoc.org/doi/abs/10.1175/1520-0469(1988)045%3C1357:HNRFHS%3E2.0.CO%3B2
4. https://digital.library.unt.edu/ark:/67531/metadc53560/
5. https://journals.ametsoc.org/doi/full/10.1175/JAS-3360.1#
6. https://journals.ametsoc.org/doi/full/10.1175/JAM2403.1
7. https://www.researchgate.net/publication/12477834_Deep_convconvec_clouds_with_sustained_supercooled_liquid_water_dowd_to_-_375_C

-

EASA response: Accepted

See Explanatory Note 1 and answer to comment #47.

Commenter 6: AIA

Comment # 49

COMMENT #12 OF 14			
Type of comment (check one)	***Non-Concur X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 6 Paragraph: 2		
What is your concern and	**THE PROPOSED TEXT STATES:**		

what do you want changed in this paragraph?	"The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas. To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate 'en route' ice shapes accordingly:" 1. <u>Operations in icing conditions above 22,000 feet in CM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft. b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass. 2. <u>Operations in icing conditions above 30,000 feet in IM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft. b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction."
What is your concern and what do you want changed in this paragraph?	**<u>REQUESTED CHANGE</u>:** *Note: for convenience, a consolidated Requested Change is included below which incorporates requested changes corresponding to Comment #12-14 Justifications.* "~~**The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas.**~~ ~~**To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, t**~~The applicant should consider the following operational scenarios to define the appropriate ~~**'en route'**~~ ice shapes accordingly:"
	1. <u>Operations in icing conditions above 22,000 feet in CM icing conditions</u> ~~**a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft.**~~ b) ~~**The critical ice accretion from step a) plus**~~ an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm **<u>along with the corresponding liquid water content factor</u>** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass.

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		2. <u>Operations in icing conditions above 30,000 feet in IM icing conditions</u> ~~**a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft.**~~ b) ~~**The critical ice accretion from step a) plus**~~ an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm **<u>along with the corresponding liquid water content factor</u>** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.”
	Why is your suggested change justified?	**<u>JUSTIFICATION:</u>** The referenced EASA assumption and subsequent AMC contradicts current certification expectations for evaluations at high altitude. Specifically, the proposed AMC requires the determination of ice at lower altitude on both protected <u>and</u> unprotected parts which is then carried beyond the upper altitudes of the icing appendices for evaluation with yet additional ice accretion. Independent of potential ice accretion beyond the ceiling of the existing ice appendices, there is no existing expectation to assess critical ice shapes on both unprotected and protected parts derived from lower altitudes up to the maximum cruise operating altitude. These scenarios are in conflict with CS 25 Book 2 paragraph 5.2.1.2 and represent an unreasonable and significant regulatory extrapolation: “It is not necessary to repeat an extensive performance and flight characteristics test program on an aeroplane with ice accretion … It is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the highest altitudes specified in Appendix C and Appendix O to CS-25).” – CS 25 para 5.2.1.2 Any additional assessment deemed necessary in accordance with the applicability of this SC should be restricted to protected parts and should not be considered to be contiguous and sequential with other ice accretion scenarios. Furthermore, the proposed combination of sequential icing encounters is inconsistent with current practice as the relevant operational scenarios defined in Appendix C Part II do not require multiple icing encounters.

EASA response: Accepted

EASA has removed all the part of the associated MOC in relation with the combination of flight phases in icing conditions and related icing scenarios in line with current approach for flight in Appendix C in CM and IM icing envelopes.

See

Explanatory Note <u>2</u> as far as the option b) of the associated MOC material is concerned. Reference to “*en-route*” ice has been obviously removed as well.
This intends to answer in addition also comment #50 & #51 thereafter.

Commenter 6: AIA

Comment # 50

COMMENT #13 OF 14			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 6 Paragraph: 5		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES:</u>** "The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas. To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate 'en route' ice shapes accordingly:" 1. <u>Operations in icing conditions above 22,000 feet in CM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft. b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass. 2. <u>Operations in icing conditions above 30,000 feet in IM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft. b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction." **<u>REQUESTED CHANGE</u>:** *Note: for convenience, a consolidated Requested Change is included below which incorporates requested changes corresponding to Comment #12-14 Justifications.*		

	“~~**The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas.**~~ ~~**To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, t**~~The applicant should consider the following operational scenarios to define the appropriate ~~**‘en route’**~~ ice shapes accordingly:” 1. Operations in icing conditions above 22,000 feet in CM icing conditions ~~**c) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft.**~~ ~~**The critical ice accretion from step a) plus**~~ an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading d) to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm **along with the corresponding liquid water content factor** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass. 2. Operations in icing conditions above 30,000 feet in IM icing conditions ~~**c) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft.**~~ d) ~~**The critical ice accretion from step a) plus**~~ an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm **along with the corresponding liquid water content factor** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.”
Why is your suggested change justified?	**JUSTIFICATION:** EASA is requested to remove the ‘en route’ nomenclature from the proposed AMC since ‘en route’ ice is explicitly defined in Appendix C Part II(a)(3) as the ice “during the en-route phase.” Furthermore, the only en route phase identified for Subpart B compliance is defined in CS 25.123 En route flight paths which is associated with an engine failure and is therefore not compatible with the proposed AMC for CM and IM scenarios.

EASA response: Accepted

See answer to comment #49.

Commenter 6: AIA

Comment # 51

COMMENT #14 OF 14			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 6 Paragraph: 5		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas. To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate ‘en route’ ice shapes accordingly:” 1. <u>Operations in icing conditions above 22,000 feet in CM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft. b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass. 2. <u>Operations in icing conditions above 30,000 feet in IM icing conditions</u> a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft. b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.” **<u>REQUESTED CHANGE</u>:** *Note: for convenience, a consolidated Requested Change is included below which incorporates requested changes corresponding to Comment #12-14 Justifications.*		

	"~~**The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas.**~~ ~~**To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, t**~~**T**he applicant should consider the following operational scenarios to define the appropriate ~~**'en route'**~~ ice shapes accordingly:" 1. Operations in icing conditions above 22,000 feet in CM icing conditions ~~**e) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft.**~~ f) ~~**The critical ice accretion from step a) plus**~~ an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm **along with the corresponding liquid water content factor** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximize the ice accretion mass. 2. Operations in icing conditions above 30,000 feet in IM icing conditions ~~**e) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft.**~~ f) ~~**The critical ice accretion from step a) plus**~~ an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm **along with the corresponding liquid water content factor** should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction."
Why is your suggested change justified?	**JUSTIFICATION:** Figure 3 of Appendix C defines the Liquid Water Content Factor as a function of Cloud Horizontal Distance. By specifically referencing Figure 3 and the cloud horizontal distance, it should be clarified that the corresponding Liquid Water Content Factor may also be used.

EASA response: Accepted

See reply to comment #49 & #50.

Commenter 7: Textron Aviation Inc.

Comment # 52

Dear Mr. Fico:

Textron Aviation Inc. (TXTAV) appreciates the opportunity to provide comments on the reference 1[4] consultation paper with proposed special conditions for ice protection system operation at high altitudes.

TXTAV is the type certificate holder of Cessna and Beechcraft aircraft certified under FAA Part 25/JAR 25 and EASA CS 25, many of which have been in operation with altitudes up to 51,000 ft for almost fifty years. As such, the consultation directly affects TXTAV current and future products, including the pending EASA validation of the Cessna Model 700 which has been issued CRI D-10 on the topic.

TXTAV has participated in discussions of the proposed Special Condition with the rest of industry via the Manufacturer's Flight Test Committee (MFTC) and the AIA Working Group sponsored by the Engine Icing Working Group (EIWG) and concurs with comments provided by both of those organizations. The following additional comments reflect TXTAV positions.

TXTAV strongly agrees with the AIA Group recommendation to address this Special Condition through formal harmonized rulemaking with industry advisory committee participation, in order to develop appropriate regulation(s) and guidance material. Due to the complex nature of the issue, requiring inputs from a range of disciplines, including meteorologists, a rigorous rulemaking process is considered to be the most appropriate means to address the topic.

Experience shows that the probability of encountering supercooled liquid water above 30,000 feet is very low and that the nature of this icing is typically very light. Data collected from the in-service fleet could be invaluable in better characterizing this environment. The rulemaking would allow the requirements and guidance to be based on the best available data including that from the in-service fleet, rather than arbitrary extrapolations. Rulemaking would also serve to establish harmonized certification expectations for the applicants.

TXTAV believes the proposed Special Condition and Acceptable Means of Compliance as written are incomplete and inadequate for their intended purpose.

Among the concerns are that the phrase "Optimized/Modulated" is ambiguous and additional clarification is required. It is unclear if pneumatic regulating valves, which are common practice in the industry, would fall under the category of "modulated". In addition, the use of such a valve or even

[4] 1. Product Certification Consultation with respect to:
SC-F25.1419-01 Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes
2. FAA Advisory Circular 20-73A, "Aircraft Ice Protection."
3. DOT/FAA/AR-07/4, "Advances in the Characterization of Super-cooled Clouds for Aircraft Icing Applications", November 2008.
4. DOT/FAA/AR-05/24, "An Inferred European Climatology of Icing Condition, Including Supercooled Large Droplets." June 2005.
5. Bernstein et al., "An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part I: Canada and the Continental United States," Feb 2007.
6. Bernstein and Le Bot, "An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part II: Europe, Asia, and the Globe," Mar 2009.

designing the system to deliver adequate bleed air flow would be considered by some to be “optimized”. The intent of the proposed Special Conditions appears to be directed at more extreme reductions of IPS capabilities and therefore a definition of affected systems in question is required.
In addition, the proposed Special Condition text lacks a definition of icing conditions to be considered above the Appendix C envelope; the only guidance is found in the relevant AMC. The Special Condition should define the icing conditions to be considered, otherwise it appears that the rulemaking is inappropriately accomplished by guidance material.
In support of these concerns, TXTAV offers the following supporting information related to the proposed SC and AMC:

- Lack of technical data supporting altitude definitions
- Environmental Effects
- Practicality of AFM Limitation to Prohibit High Altitude Flight in Icing
- Compliance Concerns
- Safety Benefit not Quantified

Lack of Technical Data Supporting Altitude Definitions

Application of Appendix C Data to High Altitudes

While the altitude limits of the Appendix C icing data collection cited in the “Identification of Issue” portion of the special condition is acknowledged, the lack of data in the high-altitude environment does not definitively provide evidence to support that it exists up to the maximum aircraft altitude (which can be as high as 51,000 ft), and the validity of extrapolating the Appendix C data to the high-altitude environments.
FAA Advisory Circular 20-73A (reference 2)[4] advises that “Appendix C icing conditions are envelopes of maximum-severity that occur in winter stratiform and cumulus clouds”. The proposed special conditions provide no technical data that supports direct extrapolation of these wintertime stratus and cumuliform conditions to hot-day, high altitude icing conditions.
As a public domain indicator of stratiform cloud altitude limits, the FAA has released a technical report (reference 3)[4] that provides an indicator of the scarcity of high altitude stratiform conditions (layer clouds) in Figure 27 of the report as reproduced below. The report states that the original Appendix C was defined with 3,000 nm of data, and the presented plot contains 22,900 nm of data. As such, even with a greatly expanded database, there are only two indications of stratiform clouds above 22,000 ft and a clear reduction in probability with increasing altitudes.

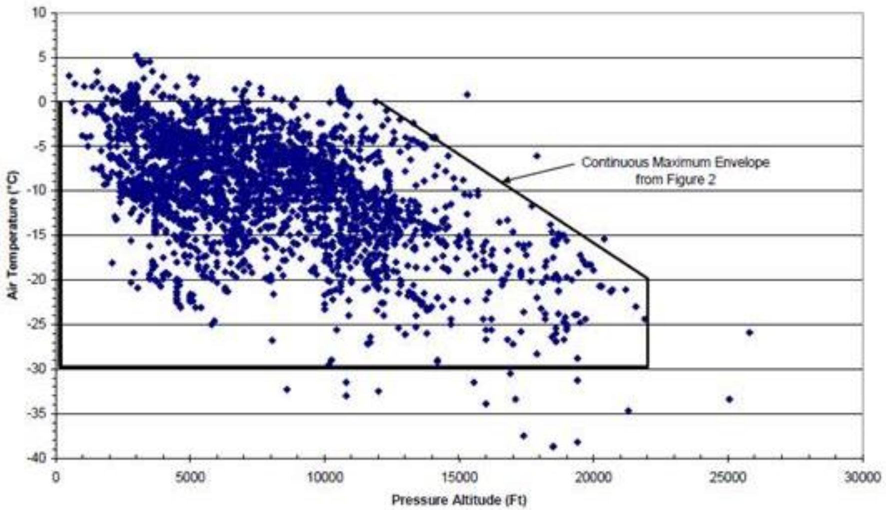

Figure 27. Observed Icing Events in Layer Clouds (22,900 nmi contributing)

Figure 1 - Reference DOT/FAA/AR-07/4 (Figure 27)

It is agreed that cumuliform clouds can lift supercooled liquid to higher altitudes than stratiform clouds, but the time required for this lifting increases the probability that the liquid water will freeze into ice crystals. Similarly, there is no data to support altitude limits to the maximum operation altitudes, particularly for aircraft certified up to 51,000 ft, as it is generally accepted that there is no liquid water present at temperatures below -40°C which corresponds to an altitude of approximately 28,000 ft on a standard day.

This same technical report then analyzed the overall altitude dependence of supercooled liquid water content (SLWC) regardless of horizontal extent and determined that the maximum expected SLWCs are altitude dependent. The data showed no icing encounters greater than FL260 (Figures 41 and 43 in Reference 3) for 23,000 nm of supercooled layer clouds and 5,000 nm of supercooled convective clouds, therefore the water content encountered at altitudes above Appendix C is likely to be significantly less than the proposed extrapolated values from Appendix C.

Inferred Icing Data Review

Between 2006 and 2008, three climatological surveys (references 4-6) were published which utilized up to fourteen years of atmospheric soundings and surface observations with a specially tailored version of the “Current Icing Product” algorithm to infer icing conditions across the globe. These studies produced a set of charts providing the probability of encountering icing conditions at a given altitude throughout the year.

The overall trends provided by the climatological survey plots are strongly supported by the data gathered and results of reference 3, especially when the survey results are compared to Figures 41 and 43 of reference 3. Per the climatological survey results, the highest probability of encountering icing conditions is between 10,000 ft and 20,000 ft. Above 20,000 ft, the probability of encountering icing at any time of the year very rapidly decreases to zero. This pattern holds true across the globe except for some regions of Southeast Asia. Here, the local geography pushes the higher probability icing encounters up to altitudes between 20,000 ft and 30,000 ft with probabilities decreasing rapidly at the higher altitudes.

NASA ASRS Review

The Aviation Safety Reporting System (administered by NASA) provides additional insight into aircraft events that do not result in incidents or accidents. The database is publicly available and searchable at https://asrs.arc.nasa.gov/. The database was searched using the search terms below:

- Weather was icing
- Flight Phase was Climb, Cruise, or Descent

This search generated 1,117 reports which were then manually filtered to remove piston and turboprop aircraft and events that occurred at altitudes below FL300. The data in the remaining 55 reports were then reviewed to determine whether icing conditions existed (temperature and moisture) and if there were indications of actual ice accumulation within the report. The distinction is that the reports without evidence of accumulation were potentially ice crystal conditions which do not produce accumulations on the airframe. Reports classified as "icing conditions" were those with evidence of temperature and moisture but with no accumulations noted. Reports classified as "accumulation indicated" where those with any language suggesting accumulations (rime ice, ice on wiper blade, windshield, etc.) and were viewed as an indicator of supercooled water being present in the cloud.
These data were then mapped against the reported altitude of occurrence to determine the distribution of potential icing reports at high altitudes, Figure 2. While the trend suggests that the probability of icing decreases with increasing altitude, it should be noted that most reports were on aircraft with ceilings at FL410 which limits the available data at higher flight levels.

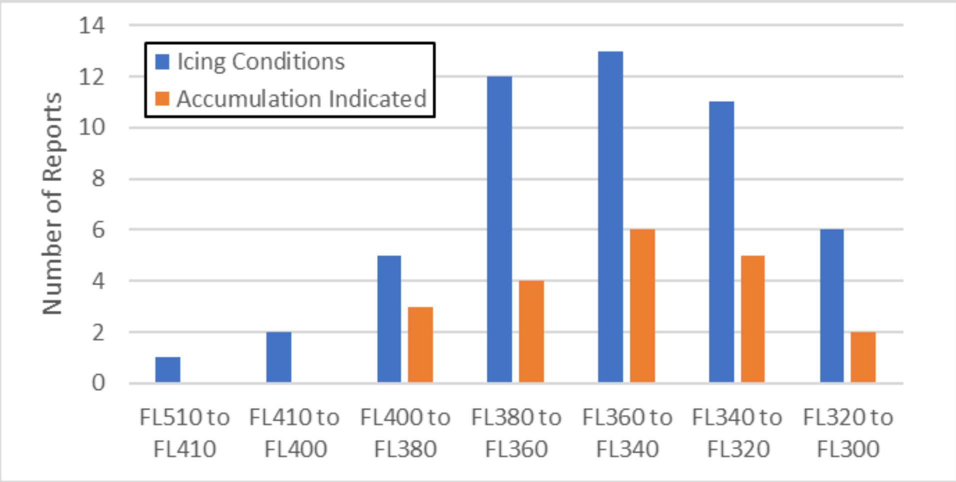

Figure 2 - Distribution of Icing Indications

Many of the reports had a common theme of flights attempting to avoid thunderstorms with tops at or above their flight level. Some of the thunderstorms were described as embedded which would make visual avoidance challenging. Many of the narratives contained reports of severe turbulence, and some reports of airspeed or TAT sensor anomalies likely associated with an ice crystal environment.
While there were some crew comments that could be interpreted as ice accumulation up to 40,000 ft there were no indications of loss of control or a safety event. Given the vast number of ASRS reports and the low number of reports including icing encounters suggests icing at high altitudes is a very low probability event, typically associated with convective/cumuliform avoidance. Additionally, there were no indications of high altitude stratiform supercooled water conditions.

<u>Ice Accumulation Effect - Stratiform vs. Cumuliform</u>

Extrapolating stratiform conditions to high altitudes can produce accumulations on unprotected surfaces that are five to ten times the accumulations for cumuliform conditions. As a result, the stratiform conditions would be the most penalizing in terms of leading-edge accumulations. This can be illustrated simply with SAE AIR1168/4 methods as shown in the table below. As such, a data-driven altitude limit for stratiform conditions would provide a large benefit as compared to assuming the aircraft maximum altitude which can extend to 51,000 ft.

$$\boldsymbol{Potential\ Accumulation = 0.38 * \cancel{KTAS} * LWC * Local\ Collection\ Efficiency * \frac{Hz\ Extent_{NM}}{\cancel{KTAS}}}$$

Equation based on SAE AIR1168/4 methods. Resulting units are lbm/ft², with LWC units of g/m³ and horizontal extent in NM.

Table 1 - Potential Accumulation Comparison

Conditions	Stratiform	Stratiform	Cumuliform	Cumuliform
SAT	-30°C	-30°C	-40°C	-40°C
Drop Size	15μm	15μm	15μm	15μm
Extent	17.4nm	310nm	2.6nm	5.21nm
LWC	0.200 g/m^3	0.040 g/m^3	0.245 g/m^3	0.208 g/m^3
Potential Accumulation	1.32 lbm/ft^2	4.71 lbm/ft^2	0.24 lbm/ft^2	0.41 lbm/ft^2

Note: Local collection efficiency assumed as one for comparison purposes

For an aircraft designed with engine bleed air limits that require prohibiting system operation, the calculated large accumulation of ice associated with the stratiform clouds on a normally protected wing leading edge could result in accumulations that produce performance and handling deteriorations. Service experience does not indicate such deteriorations have occurred and demonstrates the excessive conservatism of the extrapolation of Appendix C to higher altitudes.
Due to the excessive conservatism of the proposed icing conditions, and the current lack of supporting data to define more realistic icing conditions above Appendix C, TXTAV recommends this Special Condition be addressed through formal harmonized rulemaking with industry advisory committee participation.

Environmental Effects

The growing movement towards reducing aircraft emissions drives aircraft designs towards smaller, more efficient engines that typically do not have the bleed air capacity of past designs. This factor is in addition to the naturally reducing engine inlet mass flows as a function of altitude as discussed in the proposed special condition. Smaller scale aircraft are commonly certified to altitudes up to 51,000 ft where the ambient pressure is less than 1/10 the sea level value which greatly reduces bleed flow availability. Requiring sufficient anti-ice bleed air flows to protect the airframe throughout the icing conditions defined in the proposed AMC could place an excessive bleed air requirement on the engine design. It also unnecessarily penalizes this class of aircraft as one of the significant benefits of certifying to high operational altitudes is the ability to climb above most weather/icing conditions.

The proposed special conditions define requirements that could increase bleed flow requirements thus increasing engine size, adding weight and reducing fuel efficiency at maximum aircraft altitudes which is in conflict with both industry’s and EASA’s high-level objective of reducing aircraft emissions on future designs. Implementation of SC-F25.1419-01 would therefore have a negative environmental impact.

Practicality of AFM Limitation to Prohibit High Altitude Flight in Icing

In lieu of showing safe operation in icing conditions above Appendix C with an optimized or inhibited IPS, SC-F25.1419-01 provides the option of introducing an AFM limitation to prevent operations in these icing conditions. However, this option is problematic for use in service.

The United States’ National Weather Service does not provide icing forecasts above 30,000 ft. If the planned cruising altitude for the flight is above 30,000 ft, the pilot would be unable to determine the need to plan a route around any known or forecast icing possibly putting the pilot in violation of the AFM limitation. In lieu of forecast icing, the standard guidance provided for known icing is visible moisture and outside air temperatures below +10°C. Therefore, to comply with the AFM limitation, the pilot would be forced to request deviations around any visible moisture where the aircraft’s IPS may be optimized or inhibited. This in turn would place an undue burden on both the pilot and air traffic controllers as the outside air temperature would always be below +10°C above 20,000 ft. Additionally, in a letter from the FAA Chief Council to AOPA, the FAA stated that it “does not necessarily consider the mere presence of clouds (which may only contain ice crystals) or other forms of visible moisture at or below freezing to be conducive to the formation of ice or to constitute known icing conditions.” It is also conceivable that such an AFM limitation may have a detrimental effect on overall safety if a pilot has to descend into more severe icing to avoid any possibility of flying into icing at higher altitudes.

While not a safety issue, a further side effect of an AFM limitation prohibiting flight in icing is a customer perception effect. A newly certified aircraft with such a limitation will be viewed as less safe as compared an older certification basis aircraft without such high-altitude limitations. Given the rigor of recent icing certifications based later amendment rules, this is a misleading indication of the safety of the aircraft.

Compliance Concerns

For an applicant that elects the compliance option “direct demonstration”, the proposed AMC to the SC contains insufficient information to determine what tests are necessary to demonstrate that the aeroplane can safely operate in icing conditions at the specified altitudes and is in conflict with existing AMC 25.21(g) material.

The proposed AMC says that the applicant should "assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion" but does not provide any guidance for selection of specific flight test evaluations as AMC 25.21(g) does for operations in Appendix C and O conditions. Nor are any criteria defined that identify an acceptable level of degradation.

Throughout the description of the acceptable flight test program outlined in AMC 25.21(g) Paragraph 6 there is an assumption that the "holding ice" accretion is critical. As such, very few handling qualities tests are normally flown with any artificial ice shapes other than "holding." Depending on the IPS operational procedures selected by the applicant above Appendix C, ice may accrete on normally protected surfaces which may invalidate the typical assumption that holding ice shapes result in conservative handling qualities tests. Guidance should be developed to assist the applicant in determining which Subpart B requirements may need to be demonstrated as part of a high-altitude icing flight test program.

AMC 25-21(g) states "it is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the highest altitudes specified in Appendix C and Appendix O to CS-25)." The proposed SC contradicts this by requiring that the "the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope."

The combination of vague and conflicting AMC guidance material creates unacceptable uncertainty for the applicant regarding the specific standards to which an aeroplane will be evaluated. TXTAV believes that this guidance is best developed by authority and industry flight test subject matter experts as part of a formal rulemaking group.

The SC also does not provide any alleviation from the requirements of 25.1419(b) which requires, in part, that the aircraft be tested "in measured natural atmospheric icing conditions." Such a demonstration would have to be performed at ISA + 16.3°C or warmer to remain above -40°C, below which it is universally agreed that liquid water does not exist. A flight test campaign required to find natural icing conditions above Appendix C at or above -40°C and near the aircraft's operational ceiling to match the atmospheric icing assumptions provided in the SC would result in an excessive amount of time, effort, and cost and possibly force flight testing near or within thunderstorms. The AMC should clarify means of compliance to 25.1419(b) for icing conditions outside of Appendix C.

Safety Benefit not Quantified

TXTAV acknowledges EASA's desire to address designs which could limit ice protection system functionality above Appendix C. Such icing encounters are rare and likely not severe, and there are no indications that any unsafe conditions exist today. It is therefore unclear what safety benefit would be gained by the publication of an interim Special Condition.

In addition to the lack of a clear safety benefit, it is evident by the previous discussion items, this special condition has the potential to unduly penalize aircraft with maximum certified ceilings above Appendix C, by either prohibiting flight into icing at altitudes above Appendix C or by driven less efficient aircraft designs in the form of larger engines or over designed ice protection systems.

Recommendations:

In summary, TXTAV re-iterates the position that this proposed special condition should be addressed through formal, harmonized rulemaking with industry advisory committee participation. This rulemaking should include:

- Quantifying the expected safety benefit
- Defining an upper altitude limit above which it can be assumed that icing is highly improbable and, if encountered, would not impact operational safety.
- Defining the reduction in liquid water content with increasing altitude.

- Developing standardized compliance methods for flight test and sub-part B and estimating the associated cost of compliance.
- Estimating the environmental impact of requiring ice protection system operation in the proposed icing conditions considering the potential increased fuel burn, increased engine weight, and increased engine size resulting in increased drag.

In addition to these recommendations, additional comments on the proposed Special Condition are attached to this letter. TXTAV appreciates the opportunity to provide comments on this topic. For questions or comments please contact Dan Ochs by e-mail at dochs@txtav.com or by phone at 1-316-517-6967

EASA response: Noted

Majority of the considerations in the TXTAV preamble letter are basically already answered within this CRD, since already highlighted by other commenters.

See Explanatory Note 1

Explanatory Note 2 and specific EASA position to here-below specific remarks.

Regarding the practicality of an AFM limitation to prohibit high altitude flight in icing, the comment is acknowledged, but considering the light nature of the high-altitude icing scenario proposed in Annex 1 of the associated MOC to SC, it is EASA opinion that the applicant should be able to demonstrate compliance with sub-paragraphs (1) of the SC, therefore without any AFM limitation. If it's not possible for the applicant to demonstrate compliance with sub-paragraphs (1) of the SC, then the applicant may propose a specific definition of the icing conditions including a minimum OAT of -40°C (or corresponding TAT), which should then significantly reduce the number of icing condition encounters above the certified envelope.

Commenter 7: Textron Aviation Inc.

Comment # 53

Page/Paragraph	Comment	Suggested Change
Page 4 Acceptable Means of Compliance….	"An aeroplane IPS is considered optimised/modulated wherever a bleed 'optimization' logic is implemented at engine or aeroplane level..." "Bleed optimized logic" is too specific. An airplane could have an electro-thermal protection system that reduces current draw with increasing altitude to avoid exceeding horsepower extraction limits. Parallel concept to "bleed optimization"	An aeroplane IPS is considered optimised/modulated wherever logic is implemented to reduce the power/energy supplied to any protected leading edge with increasing altitude.

EASA response: Partially accepted.

EASA has slightly modified the introductory wording of the associated MOC text. It has been removed the reference to the engine bleed as unique source of IPS anti-icing energy, to make it more general. Related changes following other commenters' proposal has been also included.

Text is amended as follows:

(...)

An aeroplane IPS is considered optimised/modulated wherever an ~~bleed~~ 'optimization' logic is implemented at engine or aeroplane level. When an aeroplane is operated with such IPS logic, it ~~could~~ may not be able to demonstrate safe operation in icing conditions above Appendix C IM altitude ~~within its entire flight envelope~~, at any altitude within its flight envelope where icing conditions may exist..(...)

The "Preamble" also clarifies that the SC is to be intended general in the scope.

Commenter 7: Textron Aviation Inc.

Comment # 54

Page/Paragraph	Comment	Suggested Change
Page 4 If a limitation is proposed at 22000ft….	If a limitation is proposed at 22000 feet, no further demonstration is required from the applicant; Request the intent of "a limitation" be more specific. Airplane operational limit or a system limit?	If the airplane maximum altitude is limited to operation at or below 22000 feet, no further demonstration is required from the applicant;

EASA response: Noted

Final SC text has reduced its scope; the intent is to address IPS optimised above Appendix C IM altitude only. See Explanatory Note 1 on this respect. The commented part is removed from associated MOC material, due to change into the general objective of the SC.

Commenter 7: Textron Aviation Inc.

Comment # 55

Page/Paragraph	Comment	Suggested Change
Page 4 If a limitation is proposed between 22000ft….	If a limitation is proposed between 22000 and 30000 feet, the capability to safely operate in CM icing conditions has to be demonstrated up to the proposed altitude limit accordingly. Request the intent of "a limitation" be more specific. Airplane operational limit or a system limit?	If the airplane maximum altitude is limited to operation between 22000 and 30000 feet, the capability to safely operate in CM icing conditions has to be demonstrated up to the proposed altitude limit accordingly.

***EASA response*:** Noted

See reply to comment #54.

Commenter 7: Textron Aviation Inc.

Comment # 56

Page/Paragraph	**Comment**	**Suggested Change**
Page 5 Compliance Strategy/Option a): Direct Demonstration	Typographical note, this should be Option b not Option a.	Change “Compliance Strategy/Option a): Direct Demonstration” to Compliance Strategy/Option b): Direct Demonstration

EASA response: Accepted

It has been changed as proposed by commenter. See reply to comment #12 from commenter #1.

Commenter 7: Textron Aviation Inc.

Comment # 57

Page/Paragraph	Comment	Suggested Change
Page 5 Compliance Strategy/Option a): Direct Demonstration	The paragraph starts with "Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimised/modulated or even inhibited IPS above the Appendix C icing envelopes altitude, is still safe." It is not clear what Direct Demonstration means. Does this mean a natural icing encounter above 30000 ft should be demonstrated? Which would be a parallel requirement to 14CFR 25.1419b/EASA CS 25.1419b, and 14CFR 25.1420(b)(5)/EASA CS 25.1420(b)(5). Does the natural icing encounter have to be at the maximum altitude of the airplane? This would create the maximum true airspeed. Does it mean predicted ice shapes should be flown? Would the ice shapes have to be flown at the maximum airplane operating altitude?	Need clarification on the acceptable means of compliance. Is the same level of compliance demonstration expected for icing above 30,000ft expected as compliance in FAA App C and FAA App O? If natural icing encounters are expected or required to show compliance above 30,000 ft then EASA must provide guidance on how to locate these icing conditions. Current weather predicting icing models do not predict icing above 30,000 ft. A natural icing campaign looking for these conditions for a new model could take weeks or months. That amount of wasted fuel could be considered detrimental to the environment.

EASA response: Accepted

This is a comment similar to comment #22, comment #46 and comment #81. See EASA reply to comment #46. Refer to Explanatory Note 2.

Commenter 7: Textron Aviation Inc.

Comment # 58

Page/Paragraph	Comment	Suggested Change
Page 5 - The CM icing conditions at 22,000 feet……	“The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40 °C and the absence of liquid phase below that temperature.” This paragraph arbitrarily extends the CM liquid water contents within Appendix C up to the maximum operating altitude of the airplane. No data or justification is provided for assuming these water contents remain valid for all altitudes. This paragraph arbitrarily reduces the minimum temperature in Appendix C from -30C down to -40C without any data to justify these water contents. Nor does the Special Condition justify that the cloud extents provided in Appendix C Figure 3 remain valid at these reduced temperatures.	These paragraphs should be changed to contain meteorologically justified liquid water content versus altitude charts, similar to Appendix C and FAA Appendix O. An arbitrary icing definition will drive an overly complex system design or airplane design that has not been shown to be a safety concern.

EASA response: Accepted

Refer to Explanatory Note 1.

Commenter 7: Textron Aviation Inc.

Comment # 59

Page/Paragraph	Comment	Suggested Change
Page 6 1. Operations in icing conditions above 22,000 feet in CM icing conditions	310nm should be selected if…… This sentence should be modified to clarify that the 310nm cloud extent should be selected at the corresponding reduced liquid water content provided in Appendix C Figure 3.	A cloud extent of 310 nm should be selected, at the reduced water content defined in Appendix C Figure 3, if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximise the ice accretion mass.

EASA response: Noted

See reply to comment #23. The comment is not anymore relevant since the commented text has been removed from SC final text.

Commenter 7: Textron Aviation Inc.

Comment # 60

Page/Paragraph	Comment	Suggested Change
Page 6 2. Operations in icing conditions above 30,000 feet in IM icing conditions	5.21 nm should be selected if…… This sentence should be modified to clarify that the 5.21 nm cloud extent should be selected at the corresponding reduced liquid water content provided in Appendix C Figure 6	A cloud extent of 5.21 nm should be selected, at the reduced water content defined in Appendix C Figure 6, if the IPS is inhibited on purpose without any aeroplane operational restriction.

EASA response: Noted

See reply to comment #24. The comment is not anymore relevant since the relevant text has been removed from the SC final text.

Commenter 8: Boeing

Comment # 61

Dear Mr. Stefano Fico:

The Boeing Company appreciates the opportunity to review and provide comments on the subject special condition. We have reviewed this document and developed comments.

Our enclosed comments contain the details of our concerns, suggested revisions, and recommendations for following activity to address the subject of this special condition. We would like to note that Boeing provided contributions to the industry efforts to consolidate feedback to EASA through the Aerospace Industries Association (AIA) as well as the Manufacturers Flight Test Council (MFTC), and endorses these comments. As such, some of the enclosed comments will appear duplicative.

Again, we thank you for the opportunity to provide input to this special condition and trust that you will consider our comments, perhaps revising the special condition in the Dockets.

EASA response: Noted

Commenter 8: Boeing

Comment # 62

COMMENT #1 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** **X**	***Editorial***
Affected paragraph and page number	Page: 1 Paragraph: IDENTIFICATION OF ISSUE, Para 3		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES**: “Icing conditions may exist above current Appendix C icing envelopes, albeit they are currently not precisely characterized Although one can postulate that they are less severe in nature compared to Appendix C conditions owing to the Liquid Water Content (LWC) general trend with temperature, it cannot be completely ruled out that icing conditions above Appendix C may definitely exist.”		

	REQUESTED CHANGE: “Icing conditions may exist above current Appendix C icing envelopes, albeit they are currently not precisely characterized Although one can postulate that they are less severe in nature compared to Appendix C conditions owing to the Liquid Water Content (LWC) general trend with temperature, it cannot be completely ruled out that icing conditions above Appendix C may definitely exist. The probability of encountering icing conditions at altitudes above the current appendix C icing envelope shall be defined as less than 1%.
Why is your suggested change justified?	**JUSTIFICATION:** The existing appendix is defined by EASA guidance material to represent the 99th percentile of supercooled liquid water conditions found in the environment. Therefore the probability of icing encounters outside of appendix C is less than 1% of all icing encounters.

EASA response: Not accepted.

The current Appendix C probability is in relation to the conditions actually characterised and cannot be extrapolated to altitude which were not the object of the investigation. Appendix C states that more severe icing conditions than those currently plotted have a probability of 1% but at the considered altitudes. Without additional information, EASA cannot define a probability above the current icing envelope, however from the materials presented by Industry, EASA agrees that the probability of encountering icing conditions at altitudes above the current appendix C IM icing envelope is quite low. No text change is implemented in the preamble of the SC final text

Commenter 8: Boeing

Comment # 63

COMMENT #2 of 19

Type of comment (check one)	***Non-Concur***	***Substantive*** **X**	***Editorial***
Affected paragraph and page number	Page:1 Paragraph: IDENTIFICATION OF ISSUE, Para 4		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters. Finally, hot-day conditions are not addressed in the current CS 25 Appendix C...” **<u>REQUESTED CHANGE</u>:** “… As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. **~~Secondly, there is no available data~~ on icing conditions that may exist over tropic and equatorial warm oceanic waters.** Finally, hot-day conditions are not addressed in the current CS 25 Appendix C…”		
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Additional data regarding supercooled liquid droplet icing conditions that may exist over tropic and equatorial warm ocean waters would be valuable, especially for a harmonized rulemaking committee. However, some data already exists, such as published reports from the HAIC-HIWC flight campaigns. While the HAIC-HIWC flight campaigns were focused on ice crystal icing (ICI) conditions, the Reference states that “There were no mixed phase zones colder than -35°C”. This could be used to substantiate the fact that Supercooled Liquid Water (SLW) is rarely found outside of the strongest convective cores at these low temperatures. (Reference 1). **REFERENCES:**		

	1. Strapp, J.W., Schwarzenboeck, A., Bedka, K., Bond, T., et al., “An Assessment of Cloud Total Water Content and Particle Size from Flight Test Campaign Measurements in High Ice Water Content, Mixed Phase/Ice Crystal Icing Conditions: Primary In-Situ Measurements,” FAA Rep. DOT/FAA/TC-18/1, 2019, in review and publication process.

EASA response: Accepted

See EASA reply to comment #26bis.

Commenter 8: Boeing

Comment # 64

COMMENT #3 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 2 Paragraph: IDENTIFICATION OF ISSUE, Para 1		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “… Furthermore, the same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; the occurrence at 37000 feet was reported as ‘severe’. (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington). The report also states (§ 1.3.3) that ‘…an Ice Protection System designed to meet Appendix C icing environment will probably have no difficulties when icing is encountered at high altitude.’” **<u>REQUESTED CHANGE</u>:**		

	“~~Furthermore, t~~…The same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; ~~the occurrence at~~ 37000 feet was reported as ‘severe’ these encounters are in conflict with the -40°C temperature accepted as the lower limit for supercooled water to persist in an air mass and, due to the lack of information surrounding these individual events, would not be used to substantiate very high altitude icing significantly beyond the current explicit upper altitude limit associated with the IM icing envelope. (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington). The report also states (§ 1.3.3) that ‘…an Ice Protection System designed to meet Appendix C icing environment will probably have no difficulties when icing is encountered at high altitude.’ It affirms as well, that, from the data presented, it may be seen that icing encounters above 24,000 ft. (7315 meters) are rare, as are icing encounters below -22 F (-30 °C). It does appear that the temperature range of the icing envelopes could be increased by about 10 F at the higher altitudes. With two exceptions (ref: ADS-4 reference 3-38), the high-altitude icing encounters are reported as ‘light’ icing; this is in agreement with previous data showing reduced LWC with lower temperature. The two exception data points are found at temperatures well below -40 F (-40 °C); however, the notation with the data (reference 3-38) states that the temperatures were probably measured in dry air after the icing encounter. (Temperature in clouds may be several degrees warmer than the adjacent air.) Existence of water in supercooled droplet form at temperatures below -40 F (-40 °C) is very unlikely. It is also acknowledged that the report states (§ 1.3.3) that ‘Based on the data available, it appears that high-altitude icing is infrequent and when encountered is not likely to be of a severe nature.”	
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** EASA acknowledges that the original icing envelopes for Continuous Maximum and Intermittent Maximum, while recognized to constitute an engineering standard, were developed using data acquired from aircraft with limited altitude capability. However, the referenced FAA Technical report ADS-4, Figure 1-21 includes encounters derived from B-52, KC-135 and 707 type aircraft, all with service ceilings in excess of 40,000 feet (i.e., exceeding the plot scale) which corroborate the appropriateness of the corresponding certification icing envelope upper altitudes. The only two appreciable deviations correspond to reported encounters of icing at approximately 37,000 and 39,000 feet; both of which are exceedingly below the accepted -40°C temperature accepted as the lower limit for supercooled water to persist in an air mass. These events occurred at -51°C and -54°C respectively. In fact, the ADS-4 report goes on to state these encounters “were probably measured in dry air after the icing encounter” which further raises doubt about their validity. Boeing speculates that the reported events were due to ice crystal icing, rather than SLW icing. The ice crystal icing phenomenon	

	was not well understood at the time of the letter from Mr. Rock. Pilot reports have indicated that a common flight deck effect due to ICI is the appearance of liquid water on the windscreen, which is caused by melting ice crystals on the heated windscreen. In addition, the recommendation is to add the rest of the text from ADS-4 §1.3.3 "High altitude icing data" to provide context for the proposed text.

EASA response: Accepted

See reply to comment #29, #38. The text quoted above in Comment #64 has been deleted from the Preamble of the SC.

Commenter 8: Boeing

Comment # 65

COMMENT #4 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 2 Paragraph: IDENTIFICATION OF ISSUE, Para 4		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** In such a case, and on the basis of the past good in-service experience, it is assumed that an aeroplane equipped with "traditional On/Off IPS" operated in the full flight aeroplane envelope can be certified using the Appendix C envelope, and that no further assessment is required for the part of the flight envelope which is beyond the Appendix C. **<u>REQUESTED CHANGE</u>:**		

	In such a case, and on the basis of the past good in-service experience, it is assumed that an aeroplane equipped with “traditional On/Off IPS” operated in the full flight aeroplane envelope can be certified using the Appendix C envelope, and that no further assessment is required for the part of the flight envelope which is beyond the Appendix C. For this scenario, the aeroplane IPS is defined as either an airframe or engine inlet thermal IPS with air flow and/or heat regulation dependent on a number of parameters including but not limited to aeroplane altitude, bleed air supply temperature and pressure, or outside air temperature.
Why is your suggested change justified?	**JUSTIFICATION**: Clarification is required. Based on past experience, we interpret this to be applicable to thermal anti-ice systems for airframe and engines only.

EASA response: Not accepted.

EASA understands the intent of the commenter but does not consider the proposed changes are necessary.

Traditional On/Off IPS are defined in the context of this SC in opposition to an “optimised” IPS above Appendix C IM icing envelope. Modulated IPS, with air flow and/or heat regulation, assessed within Appendix C icing envelopes are out of the scope of this SC. A system modulated in Appendix C conditions can be certified above Appendix C IM limit, provided there is no voluntary power decrease from that established within Appendix C. However, as clarified in the amended SC preamble, in case of optimised IPS between 22kft and 31kft, the text of the SC should be adapted and the icing conditions between 22kft and 31kft, to be considered for certification, should be discussed between Industry and Authorities. Additionally, as further specified in the SC preamble, the content of the SC and associated MOC is not exclusive to thermal IPS.

Commenter 8: Boeing

Comment # 66

COMMENT #5 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive***	***Editorial*** ***X***

Affected paragraph and page number	Page:3 Paragraph: IDENTIFICATION OF ISSUE, Para 2
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** Such modulated IPS may be unable to maintain the protected surface temperatures above zero at altitudes above the Appendix C envelope limits, and, particularly, at low temperatures, ice could accrete on the protected surface. **<u>REQUESTED CHANGE</u>:** Such modulated IPS may be unable to maintain the protected surface temperatures above *0°C* ~~zero~~ at altitudes above the Appendix C envelope limits, and, particularly, at low *ambient* temperatures, ice could accrete on the protected surface.
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Comments provided for clarification only.

EASA response: Noted

This part of the Preamble text has been modified to be more generic according to comment #39.

Commenter 8: Boeing

Comment # 67

COMMENT #6 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***

Affected paragraph and page number	Page: 4 Paragraph: Special Condition on Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “If an ice protection system (IPS) is optimized/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes, the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope.” **REQUESTED CHANGE:** “If an ice protection system (IPS) is optimized/modulated, or even inhibited, *in icing conditions* above the maximum altitude of Appendix C icing envelopes, the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope.”
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** The proposed applicability of this SC related to an IPS that is "optimised/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes" appears problematic since even systems categorized as 'traditional On/Off' may be inhibited while not operating in sensed icing conditions and subsequently be interpreted as having been ‘optimised/modulated’. The proposed literal SC language implies such a design would require additional substantiation when in fact for this type of system the preamble discussion clearly indicates "no further assessment is required for the part of the flight envelope which is beyond the Appendix C." The Boeing recommendation clarifies that no further substantiation is required when a traditional On/Off system is only inhibited when not in icing conditions.

EASA response: Accepted

The SC final text will read as follows, as EASA also retained other text changes proposals (see comment #68, #69 from same commenter), affecting the same sentence.

(…) If an ice protection system (IPS) ~~is optimised/modulated, or even inhibited,~~ implements control logic that reduces, cuts-off, or even inhibits the power/energy supplied to any protected surfaces with increasing altitude in icing conditions above the ~~maximum altitude of~~ Appendix C IM icing ~~envelope~~ altitude, (…)

Commenter 8: Boeing

Comment # 68

COMMENT #7 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** **X**	***Editorial***
Affected paragraph and page number	Page: 4 *Paragraph:* Special Condition on Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “If an ice protection system (IPS) is optimized/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes, the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope.” **REQUESTED CHANGE:** “If an ice protection system (IPS) is optimized/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes, **~~the applicant~~ shall demonstrate that the aeroplane can safely operate** the airplane must be able to safely operate in icing conditions encountered at any altitudes~~s of~~ within the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope.”		

Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** The requirement form of the rule shall not prescribe an MOC, and the word ‘demonstrate’ may carry a general interpretation for flight test. It is recommended that the requirement language be updated to be consistent with CS 25.1419 and avoid implying a specific MOC.

EASA response: Noted

See EASA reply to comment #69, which requests deeper changes to the wording.

Commenter 8: Boeing

Comment # 69

COMMENT #8 of 19			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 4 Paragraph: Special Condition on Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** If an ice protection system (IPS) is optimised/modulated, or even inhibited, above the maximum altitude of Appendix C icing envelopes, the applicant shall demonstrate that the aeroplane can safely operate in icing conditions encountered at any altitudes of the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope. **REQUESTED CHANGE:**		

	If an ice protection system (IPS) is optimized/modulated, or even inhibited, implements control logic that reduces, cuts-off, or even inhibits the thermal ice protection system, other than being naturally reduced by engine bleed air flow availability with altitude, above the maximum altitude of Appendix C icing envelopes; then the airplane must be able to safely operate in icing conditions encountered at any altitudes of altitudes within the operational flight envelope, or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope. The applicant shall follow one of the following 3 options: 1. The applicant shows safe operation in icing conditions at all altitudes above the Appendix C icing envelope up to its operational ceiling; then the certified icing envelope is equivalent to the aeroplane flight envelope, and no AFM limitation is required. 2. The applicant does not show safe operation in icing conditions at altitudes above the maximum altitude of the Appendix C icing envelopes; then the certified icing envelopes are those indicated in the CS-25 Appendix C only; and an AFM limitation is introduced to prevent aeroplane operation in icing conditions above the maximum altitude of the Appendix C icing envelopes. 3. The applicant shows safe operation in icing conditions up to a certain altitude between the maximum altitude of the Appendix C icing envelopes and its operational ceiling; then the certified icing envelope is extended up to the shown altitude; and an AFM limitation is introduced to prevent aeroplane operation in icing conditions at altitudes above the shown altitude and up to the airplane operational ceiling. The applicant shall propose and substantiate the icing conditions that should be considered for high altitude supercooled liquid water icing conditions, although it is acknowledged that CM cannot exist above 22,000 ft. due to the cloud type, and no supercooled liquid water icing conditions can exist below - 40°C.
Why is your suggested change justified?	**JUSTIFICATION:** This appears to be an incomplete requirement as initially written in the proposed Special Condition. The phrase"…Optimized/Modulated…" is ambiguous and the proposed verbiage addresses the specific system characteristics such that the system would be considered an optimized/modulated system.

	The proposed Special Condition text lacks a definition of icing conditions outside of Appendix C, and the only guidance is found in the relevant AMC. Unlike the currently defined icing envelopes of Appendix C, Appendix O and Appendix P; the undefined conditions proposed by the SC make it appear that the rulemaking is inappropriately accomplished by guidance material. The applicant should propose and define what "safely operate" means and which respective icing conditions will be considered. The expectation is a proposal based on the available research, utilizing analysis which may also include atmospheric physics or an appropriate alternative. The requested change to the proposed Special Condition is inspired by CS25.1420, where the options for certification are explicitly outlined. The three options for safe operation in icing conditions outside of Appendix C are required for showing compliance, and therefore should be included in the rule text. While the aforementioned proposal offers an alternative approach, it is the position of Boeing that a formal harmonized rulemaking with appropriate industry support would be the preferred method by which to consider any requirements for the atmospheric characterization of high altitude supercooled liquid water.

EASA response: Partially accepted.

The comment as implemented in the final text (see also reply to comment #41) includes all other changes as result of concurrent comments from other commenters. That is the reason why the comment is only considered as “partially accepted”.

An interim icing scenario above Appendix C IM altitude is defined in the Annex 1 of the associated MOC to SC text. See further Explanatory Note 1.

Commenter 8: Boeing

Comment # 70

COMMENT #9 of 19			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 4 Paragraph: Acceptable Means of Compliance to SC to demonstrate safe operation above the maximum altitudes of the Appendix C icing envelopes with an optimised/modulated IPS, Para 1		

What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** "The associated Means of Compliance is published for awareness only and is not subject to public consultation." **<u>REQUESTED CHANGE</u>:** "The associated Means of Compliance is published for awareness only and ~~is not subject to public consultation."~~
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** The AMC requirements go beyond that included in the text of the actual special condition, Boeing considers that this AMC is therefore part of the rulemaking, and is thus subject to public comments. Thus, this statement needs to be removed from the Special Condition. Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC. While Boeing's service experience does not indicate that this SC is necessary, Boeing acknowledges the intent of the SC to address design implementations that may utilize the explicit boundaries of the existing certification icing envelopes to modify an ice protection system's operation. However, Boeing's position is that the proposed AMC icing conditions, while not considered open for public comment, may undermine the intent of the SC. It is the Boeing position that the proposed AMC icing conditions are exceedingly conservative and may drive substantially different applicant proposals resulting in an unintended disharmony in certification expectations within the industry. Consistent application of the proposed AMC icing conditions within this SC would retain harmonization, however the exceedingly conservative nature of the proposed AMC raises legitimate concerns that the net result of this SC could be an unintended decrease in the level of safety (e.g., design change to address an unrealistic condition resulting in the unintended sub optimization for other conditions), unsubstantiated economic burden, and/or unspecified adverse environmental effects. Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC.

EASA response: Accepted

See reply to comment #42.

Commenter 8: Boeing

Comment #71

COMMENT #10 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive***	***Editorial*** **X**
Affected paragraph and page number	Page: 4 Paragraph: Acceptable Means of Compliance to SC to demonstrate safe operation above the maximum altitudes of the Appendix C icing envelopes with an optimised/modulated IPS, Para 2		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** An aeroplane IPS is considered optimised/modulated wherever a bleed ‘optimization’ logic is implemented at engine or aeroplane level. When an aeroplane is operated with such IPS logic, it could not be able to demonstrate safe operation in icing conditions within its entire flight envelope. In such a case the applicant should define the certified icing envelope where the aircraft operation in icing condition is unrestricted. **REQUESTED CHANGE:** An aeroplane IPS is considered optimised/modulated wherever a bleed ‘optimization’ logic is implemented at engine or aeroplane level. When an aeroplane is operated with such IPS logic, it ~~could~~ may not be able to demonstrate safe operation in icing conditions within its entire flight envelope. In such a case the applicant should define the certified icing envelope where the aircraft operation in icing condition is unrestricted.		
Why is your suggested change justified?	**JUSTIFICATION:** Requested grammatical clarification for readability.		

EASA response: Accepted

Text of the special conditions will be changed reflecting the suggested editorial changes. See also answers to comment #43

New text will read as follows:

(…) it ~~could~~ may not be (…)

Commenter 8: Boeing

Comment # 72

COMMENT #11 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page:5 Paragraph: Compliance Strategy/Option a): Comparative Analysis, Para 1		

What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** For new aeroplane design having comparable handling qualities and performance in both dry air and Appendix C icing conditions to previous certified product, the applicant may demonstrate compliance with the Special Condition by means of a comparative analysis between the proposed "optimised" IPS above the altitude of Appendix C icing envelopes and a previously approved design, supported by safe flight-in-icing in-service history in the entire certified aeroplane operating envelope. **<u>REQUESTED CHANGE</u>:** For new aeroplane design having comparable handling qualities and performance in both dry air and Appendix C icing conditions to previous certified product, the applicant may demonstrate compliance with the Special Condition by means of a comparative analysis between the proposed "optimised" IPS above the altitude of Appendix C icing envelopes and a previously approved design, supported by safe flight-in-icing in-service history in the entire certified aeroplane operating envelope. If the previous design, whether traditional or optimized, was approved for operation in Appendix C, and has an in-service history of at least 2 million flights with no incidents or accidents in icing conditions, then the proposed optimized IPS may be approved by comparison of acceptable similar margins and design features relative to the previous design."
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Clarification is required. Based on the published guidance in AMC 25.1420, it seems reasonable to define comparative analysis in the same way in this SC. Using the same logic, it is reasonable if the previously approved design, whether traditional or optimized, has at least 2 million flights with no incidents or accidents in icing conditions, then statistically it will have encountered icing conditions above 30K', and therefore can be compared for similar margins and design features as allowed by AMC 25.1420.

EASA response: Not Accepted

Two million flights criterion for the adoption of the comparative analysis to demonstrate the adequacy of a IPS design to the icing conditions above Appendix C IM icing envelope is not deemed appropriate and commensurate to this aim. The "two-million flights" criterion was established in the framework of use of comparative analysis for compliance with Appendix O (Supercooled Large Droplets) and was based on the fact that flying fleet would have reached sufficient exposure to Appendix O environment.

The Appendix O is deemed more severe compared to the concerned threat due to exposure to high-altitude icing conditions and the kind of demonstration to assure safe flight in such last conditions should be in proportion more limited. Therefore, there will be no change in the SC final text.

Commenter 8: Boeing

Comment # 73

COMMENT #12 of 19			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page 5 Paragraph Compliance Strategy/Option a): Direct Demonstration, para 2		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** "The applicant should propose and substantiate the icing conditions and scenarios that should be considered. In the absence of any proposal, the following icing conditions and operational scenarios may be considered. Atmospheric icing Conditions In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken:		

		- The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature. - The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C.” **REQUESTED CHANGE:** **“**The applicant should propose and substantiate the icing conditions and scenarios that should be considered. ~~In the absence of any proposal, the~~ following icing conditions and operational scenarios may be considered. Atmospheric icing Conditions In the lack of empirical data to precisely characterise the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - ~~The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature.~~ - ~~The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C.”~~	

JUSTIFICATION:

It is proposed that both the altitude expansion and the methodology used for such an expansion of the CS 25 Appendix C envelope are excessively conservative.

The altitude limitations of the aircraft which gathered the data in the NACA TN which provided the basis for CS 25 Appendix C were recognized and addressed by the researchers who prepared that documentation. Analytical efforts and a year of operations of fast jets with far greater altitude capability were used to address this limitation; the IM conditions at FL310 are extrapolations based on these tests and scientific assessments of the ensemble of data, theory, and analysis.

SLW cannot physically exist below -40°C (References 1 – 5). Typical cruise altitudes for aircraft of FL300 and above still have low probabilities of entrained SLW in the atmosphere. Atmospheric physics as well as in-service data support a lack of SLW icing risk at the service ceiling of aircraft, and often well below the service ceiling.

An example of an aircraft-observed sounding is shown below in Figure 1; it is an example of how meteorologists correlate atmospheric temperature and altitude.

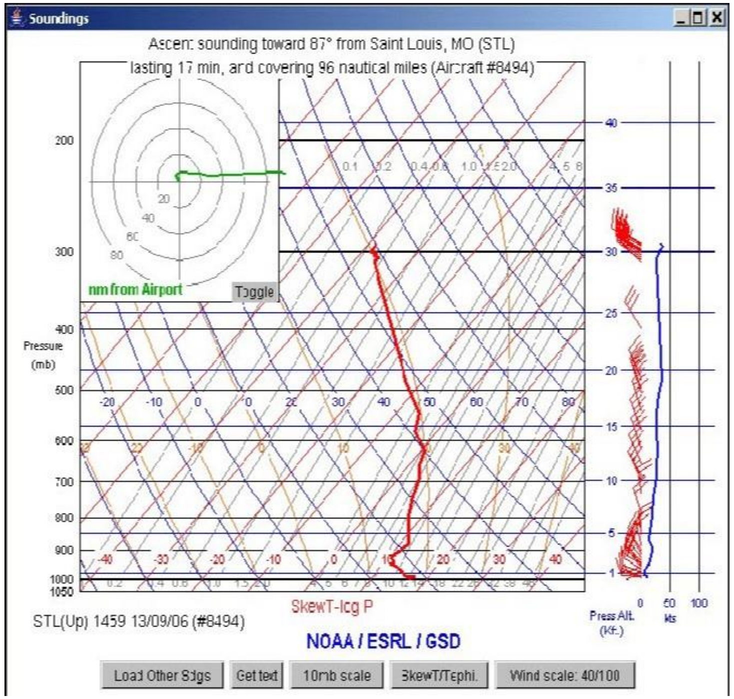

Figure 1: Aircraft-Observed Sounding

Figure 2 represents the 99th percentile temperatures globally at FL340. This

- is another example of correlating atmospheric temperature and altitude to establish probability of icing threats to aircraft.

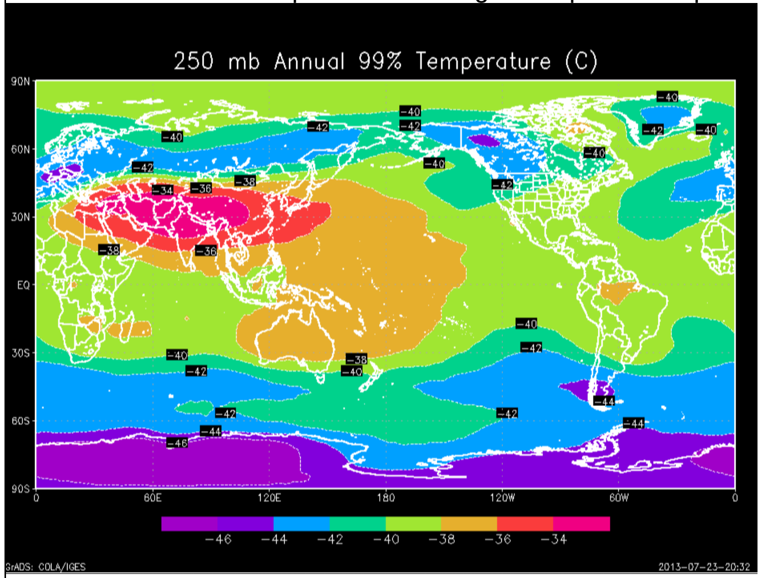

Figure 2: 99th Percentile Temperatures Globally at FL340

In addition, References 6 and 7 are intended to document existing flight campaigns which explored thunderstorm cores at high altitudes. These campaigns showed that while significant amounts of SLW in intense updrafts could be found at -38C, any colder temperatures were ice crystals.

By using the lower temperature limits described in the references, it is possible to utilize global temperature distributions (Figure 2), which are fairly well established, to infer upper limits to the icing envelope. These tools, along with the historical probability of icing and knowledge of global route distribution, make it possible to globally study the various icing threats.

References:

1. https://www.pnas.org/content/99/25/15873.short
2. https://journals.ametsoc.org/doi/abs/10.1175/1520- 0469(1990)047%3C1056%3AFNRODS%3E2.0.CO%3B2
3. https://journals.ametsoc.org/doi/abs/10.1175/1520- 0469(1988)045%3C1357:HNRFHS%3E2.0.CO%3B2
4. https://digital.library.unt.edu/ark:/67531/metadc53560/

5. https://journals.ametsoc.org/doi/full/10.1175/JAS-3360.1#
6. https://journals.ametsoc.org/doi/full/10.1175/JAM2403.1
7. https://www.researchgate.net/publication/12477834_Deep_convectiv e_clouds_with_sustained_supercooled_liquid_water_down_to_-_375_C

EASA response: Accepted

See EASA reply to comment #48. Refer to Explanatory Note 1.

Commenter 8: Boeing

Comment # 74

COMMENT #13 of 19			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: Compliance Strategy/Option a): Direct Demonstration, Para 1		
What is your concern and what do you want changed in this	**<u>THE PROPOSED TEXT STATES</u>:** “For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane unprotected and protected parts.” **REQUESTED CHANGE:**		

paragraph?	“For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane ~~**unprotected and**~~ protected parts.”
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Reference to unprotected parts should be removed since this SC is not relevant to unprotected parts.

EASA response: Not accepted.

In principle, both protected and unprotected aircraft parts shall be assessed against the new proposed icing scenario as introduced by the Explanatory Note 1. As far as option b): Direct demonstration is concerned (see AMC material), refer to Explanatory Note 2.

Commenter 8: Boeing

Comment # 75

COMMENT #14 of 19			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: Compliance Strategy/Option a): Direct Demonstration, Para 1		

What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimised/modulated or even inhibited IPS above the Appendix C icing envelopes altitude, is still safe. For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane unprotected and protected parts. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment. **REQUESTED CHANGE:** “Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimised/modulated or even inhibited IPS above the Appendix C icing envelopes altitude, is still safe. For the evaluation of safe operation, the applicant should assess the degradation of **~~aeroplane~~ performance and** handling qualities created by the potential ice accretion on aeroplane **~~unprotected and~~** protected parts. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment.

Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Boeing notes that one of the most influential factors in determining the operational altitude ceiling for transport category aircraft is the buffet performance regulated by CS 25.251. Boeing further notes that CS 25.251(b) through (e) are not required to be met in icing conditions per CS 25.21(g). It should be acknowledged that the initial buffet boundary performance in accordance with CS 25.251(e) may be dependent on portions of the wing that are either protected and/or unprotected which is determined without the consideration of ice. There are also no indications (e.g., reports of early buffet onset) that would indicate an in service safety issue stemming from high altitude ice on either unprotected or protected airframe surfaces. Determination of the operational altitude ceiling with ice accretions following the AMC could result in an unsubstantiated economic burden and/or unspecified adverse environmental effects. Formal rulemaking with industry participation is recommended to facilitate a technical forum to develop the appropriate requirements to be used in meeting the intent of the proposed SC. Boeing would recommend the continued flight standards philosophy of utilizing non-icing performance to determine high altitude operational performance.

EASA response: Not accepted.

EASA understands that commenter wants to remove “performance” aspect from the assessment of aircraft safe flight. EASA disagrees at this stage to change the text as proposed, since decision to determine the compliance methodology for option b) is postponed. Refer to Explanatory Note 2.

Commenter 8: Boeing

Comment # 76

COMMENT #15 of 19			
Type of comment (check one)	*Non-Concur* **X**	*Substantive*	*Editorial*
Affected paragraph and page number	Page: 5 Paragraph: Atmospheric icing Conditions, Para 1		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40 °C and the absence of liquid phase below that temperature. - The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C. ” **REQUESTED CHANGE:** ~~“In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken:~~ ~~- The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40 °C and the absence of liquid phase below that temperature.~~ ~~- The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C.“~~		
Why is your suggested change justified?	**JUSTIFICATION:** While Boeing’s service experience does not indicate that this SC is necessary, Boeing acknowledges the intent of the SC to address design implementations that may utilize the explicit boundaries of the existing certification icing envelopes to modify an ice protection system’s operation. However, Boeing’s position is that the proposed AMC icing conditions, while not considered open for public comment, may undermine the intent of the SC. It is the Boeing position that the proposed AMC icing conditions are exceedingly conservative and may drive substantially different applicant proposals resulting in an unintended disharmony in certification expectations within the industry. Consistent application of the proposed AMC icing conditions within this SC would retain harmonization, however the exceedingly conservative nature of the proposed AMC raises legitimate		

	concerns that the net result of this SC could be an unintended decrease in the level of safety (e.g., design change to address an unrealistic condition resulting in the unintended sub optimization for other conditions), unsubstantiated economic burden, and/or unspecified adverse environmental effects. Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC.

EASA response: Accepted

See Explanatory Note 1.

Commenter 8: Boeing

Comment # 77

COMMENT #16 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 6 *Paragraph:* Operational scenario to compute the relevant airframe ice accretion		
	THE PROPOSED TEXT STATES:		

	What is your concern and what do you want changed in this paragraph?	“The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas …the applicant should consider the following operational scenarios to define the appropriate ‘en route’ ice shapes accordingly: 1. Operations in icing conditions above 22,000 feet in CM icing conditions a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft. b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude … 2. Operations in icing conditions above 30,000 feet in IM icing conditions a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft. b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude …” **REQUESTED CHANGE:**	

	"**The basic assumption is that the aeroplane may be flying within the Appendix C conditions and may already have some ice accretion on unprotected areas and/or runback ice beyond protected areas** …the applicant should consider the following operational scenarios to define the appropriate **'en route'** ice shapes accordingly: 1. Operations in icing conditions above 22,000 feet in CM icing conditions **a) The critical ice accretion that would be already on the aeroplane after a climb through a single 17.4 nm CM cloud within the Appendix C, i.e., below 22,000 ft.** **b) The critical ice accretion from step a) plus** an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude … 2. Operations in icing conditions above 30,000 feet in IM icing conditions **a) The critical ice accretion that would be already on the aeroplane after a climb through a single 2.6 nm IM cloud within the Appendix C, i.e., below 30,000 ft.** **c) The critical ice accretion from step a) plus** an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude …"

Why is your suggested change justified?	**JUSTIFICATION:** Any additional assessment deemed necessary in accordance with the applicability of this SC should be restricted to protected parts and should not be considered to be contiguous and sequential with other ice accretion scenarios. The referenced EASA assumption and subsequent AMC contradicts current certification expectations for evaluations at high altitude. Specifically, the proposed AMC requires the determination of ice at lower altitude on both protected and unprotected parts which is then carried beyond the upper altitudes of the icing appendices for evaluation with yet additional ice accretion. These scenarios are in conflict with CS 25 Book 2 paragraph 5.2.1.2 and represent an unreasonable and significant regulatory extrapolation: "It is not necessary to repeat an extensive performance and flight characteristics test programme on an aeroplane with ice accretion … It is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the highest altitudes specified in Appendix C and Appendix O to CS-25)." – CS 25 para 5.2.1.2 Independent of potential ice accretion beyond the ceiling of the existing ice appendices, there is no existing expectation to assess critical ice shapes on both unprotected and protected parts derived from lower altitudes up to the maximum cruise operating altitude. Boeing additionally requests removal of the 'en route' nomenclature from the proposed AMC since 'en route' ice is explicitly defined in Appendix C Part II(a)(3) as the ice "during the en-route phase." Furthermore, the only en route phase identified for Subpart B compliance is defined in CS 25.123 En route flight paths which is associated with an engine failure and is therefore not compatible with the proposed AMC for CM and IM scenarios.

EASA response: Partially accepted.

See EASA reply to comment #49. Refer also to Explanatory Note 2.

As far as protected and unprotected area is concerned, refer to EASA reply to comment #74 earlier; combination of flight phases has been also removed from the associated MOC to SC final text.

Commenter 8: Boeing

Comment # 78

COMMENT #17 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** **X**	***Editorial***
Affected paragraph and page number	Page: 6 Paragraph: Operational scenario to compute the relevant airframe ice accretion, Para 2		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate 'en route' ice shapes accordingly: …" **REQUESTED CHANGE:** "To show that the aeroplane can safely operate in CM icing conditions at altitudes above 22,000 feet and in IM icing conditions at altitudes above 30,000 feet, the applicant should consider the following operational scenarios to define the appropriate **~~'en route'~~** ice shapes accordingly: …"		
Why is your suggested change justified?	**JUSTIFICATION:** Boeing requests removal of the 'en route' nomenclature from the proposed AMC since 'en route' ice is explicitly defined in Appendix C Part II(a)(3) as the ice "during the en-route phase." Furthermore, the only en route phase identified for Subpart B compliance is defined in CS 25.123 En route flight paths which is associated with an engine failure and is therefore not compatible with the proposed AMC for CM and IM scenarios.		

EASA response: Accepted

See reply to comment #77. Reference to "*en-route*" ice has been removed from the associated MOC to SC in relation with option b).

Commenter 8: Boeing

Comment # 79

COMMENT #18 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** **X**	***Editorial***
Affected paragraph and page number	Page: 6 *Paragraph:* Operational scenario to compute the relevant airframe ice accretion, Para 1.b)		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximise the ice accretion mass. **REQUESTED CHANGE:** b) The critical ice accretion from step a) plus an exposure to one CM cloud in cruise at altitudes between 22,000 feet and the maximum aeroplane cruise operating altitude. The applicant will define the cloud distance as per figure 3 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 310 nm along with the corresponding liquid water Horizontal extent factor should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction, in order to maximise the ice accretion mass		

Why is your suggested change justified?	**JUSTIFICATION:** Figure 3 of Appendix C defines the Liquid Water Content Factor vs. Cloud Horizontal Distance. By specifically referencing figure 3 and the cloud horizontal distance, it should be clarified that the corresponding Liquid Water Concentration Factor may also be used.

EASA response: Noted.

EASA has completely removed the reference to the icing scenario in the associated MOC to the final SC text. The commenter’ proposed text change is not applicable anymore. See also EASA reply to comment #23.

Commenter 8: Boeing

Comment # 80

COMMENT #19 of 19			
Type of comment (check one)	***Non-Concur***	***Substantive*** ***X***	***Editorial***
Affected paragraph and page number	Page: 6 *Paragraph:* Operational scenario to compute the relevant airframe ice accretion, Para 2.b)		

What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction. **<u>REQUESTED CHANGE</u>:** b) The critical ice accretion from step a) plus an exposure to one IM cloud in cruise at altitudes between 30,000 feet and the maximum cruise operating altitude. The applicant will define the cloud distance as per figure 6 of Appendix C and leading to the maximum runback ice accretion behind the ice protected area(s) (if any). 5.21 nm along with the corresponding liquid water Horizontal extent factor should be selected if the IPS is inhibited on purpose without any aeroplane operational restriction.
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Figure 6 of Appendix C defines the Liquid Water Content Factor vs. Cloud Horizontal Distance. By specifically referencing figure 3 and the cloud horizontal distance, it should be clarified that the corresponding Liquid Water Concentration Factor may also be used.

EASA response: Noted

EASA has completely removed the reference to the icing scenario in the associated MOC to the final SC text. The commenter’ proposed text change is not applicable anymore. See EASA reply to comment #24.

Commenter 9: MFTC

Comment # 81

Subject: Comments to EASA SC-F25.1419-01, “Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes”

References:

1. Product Certification Consultation with respect to: SC-F25.1419-01, “Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes.”
2. CS-25 Amendment 22, “Certification Specification and Acceptable Means of Compliance for Large Aeroplanes.”
3. DOT/FAA/AR-07/4, “Advances in the Characterization of Supercooled Clouds for Aircraft Icing Applications,” November 2008.
4. DOT/FAA/AR-05/24, “An Inferred European Climatology of Icing Condition, Including Supercooled Large Droplets.” June 2005.
5. Bernstein et al., “An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part I: Canada and the Continental United States,” Feb 2007.
6. Bernstein and Le Bot, “An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part II: Europe, Asia, and the Globe,” Mar 2009.
7. US Standard Atmosphere, 1976 NASA report NASA-TM-X-74335, NOAA-S/T-76-1562 https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19770009539.pdf
8. Andrew J. Heymsfield et al, “Homogeneous Ice Nucleation in Subtropical and Tropical Convection and Its Influence on Cirrus Anvil Microphysics,” Journal of Atmospheric Sciences, January 2005
9. Letter from FAA Chief Council to AOPA concerning known icing conditions dated Jan 16, 2009. https://www.faa.gov/about/office_org/headquarters_offices/agc/practice_areas/regulations/interpretations/data/interps/2009/bell%20-%20(2009)%20legal%20interpretation.pdf
10. Rosenfield, D. “Aircraft Microphysical Documentation from Cloud Base to Anvils of Hailstorm Feeder Clouds in Argentina” Journal of Applied Meteorology and Climatology, Sept 2006.

Enclosure 1: Icing Pilot Reports (PIREPS) as a Function of Altitude
Enclosure 2: Detailed Comments Relative to Proposed AMC
Dear Mr. Stefano Fico et al:

The Manufacturers Flight Test Council (hereafter referred to as the MFTC) is a consortium of manufacturers that flight test and certify to 14 CFR Part 25 and CS-25 transport airplane standards. Comprised of Flight Test Department Heads from several international companies, our main focus is on flight test safety, risk reduction, and the sharing of best flight test practices. Each of the signatories to this letter has individually been presented with a version of the proposed Special Condition SC-F25.1419-01 as a CRI on a recent certification program. The MFTC appreciates the opportunity to review and provide comments on the subject Special Condition. While the individual representatives assembled within the MFTC may submit specific and/or

additional comments separately, we have collectively prepared a set of high priority comments that the MFTC believes to represent a consensus from the industry.
The MFTC’s comments on the SC-F25.1419-01 special condition are primarily related to the showing of compliance based on a direct demonstration, the practicality of an AFM limitation to prohibit flight into icing above forecast icing, and a comprehensive analysis to understand and quantify the risk exposure to icing at flight levels above FL 300. It is understood that the associated Acceptable Means of Compliance were published for awareness only and not for public consultation. However, there are requirements in the AMC that go beyond those included in the text of the actual special condition and the MFTC respectfully requests that EASA also consider the enclosed comments related to the AMC.
The MFTC Group is aware that the AIA (Aerospace Industries Association) is submitting additional comments regarding the EASA SC; the comments from the AIA Group are focused on the perspective of airframe and engine manufacturers, whereas the MFTC group is focused on the issues stated above.
For applicants, historical and current compliance strategy to CS25.1419 and CS25.1093 consists of:

- Performing natural icing flight tests in representative portions of the CS25 Appendix C (App C) icing envelope.
- Using the data acquired by the flight test to verify the Ice Protection System (IPS) analysis, with potential recalibration of the Ice Protection models to demonstrate safe operation throughout the App C icing envelope.

If the direct demonstration compliance strategy (option b) of SC-F25.1419-01 requires specific natural icing flight tests above FL300, then this would constitute a substantial change to the compliance strategy.

The MFTC is concerned that the Special Condition’s requirement to show safe operation in icing conditions at all altitudes up to the operational ceiling will result in increased flight test risk and greatly extended flight test campaigns, especially if required to show safe flight in natural icing conditions. Depending on the design of an aircraft’s IPS, the definitions of airframe ice accretion provided by the Special Condition can result in artificial ice shapes ranging from simple sandpaper shapes to grown shapes simulating up to a quarter inch of ice accumulation. With no upper altitude limit to the proposed atmospheric icing conditions, the airplane must then be shown to safely operate with these artificial shapes attached to the airplane up to the maximum certified ceiling. Historically, the vast majority of artificial ice shape testing has occurred below 18,000 ft. At these lower altitudes, there is excess aircraft performance and the handling qualities are well defined. The flight test risk of losing an engine due to ingesting an artificial ice shape always exists, and at these lower altitudes the subsequent loss of performance or depressurization due to bleed loss would not result in a hazardous situation.
Testing artificial ice shapes at high altitudes increases the risk of an ice shape departing the aircraft. This would result in the aircraft being at high altitude and high airspeed with an asymmetric ice shape configuration which would significantly increase flight test risk. If testing to show safe operation includes high altitude stalls, then additional risks are added to the flight test campaign. This is coupled with the lift degradation already due to high altitude operations as well as unknown Mach effects which will further degrade lift. The end result is an increased risk of a high-altitude departure and a single or all engine flameout due to high angles of attack at high altitudes while demonstrating a contaminated airframe condition that has not been shown to exist.
An additional concern with the direct demonstration approach is that SC-F25.1419-01 does not provide any alleviation from the requirements of 25.1419(b) which requires, in part, that the aircraft be tested “in measured natural atmospheric icing conditions.” The flight test campaign required to find natural icing conditions above Appendix C at or above -40°C and near the aircraft’s operational ceiling to match the atmospheric icing assumptions provided in SC-F25.1419-01 would result in an excessive amount of time, effort, and cost, and would force flight testing near or within thunderstorms.

An analysis of the data presented in References 3-6 show that the vast majority of icing occurs between 5,000 and 15,000 ft, with the maximum reported icing event occurring at 26,000. This includes data collected from over 28,000 nmi of flight data gathered under FAA sponsorship. An additional analysis of PIREP data gathered from Jan 1 2018 to Jan 1 2019 in US airspace further supports this data, showing the vast majority of pilot reported icing occurring between 1,000 ft and 30,000 ft - with no icing reported above 36,000 ft. Figure 1 on page 7 illustrates a complete year of data, while Figure 2 on page 7 illustrates the Summer months only, where the majority of the icing reports are between 14,000 ft and 30,000 ft.

Indeed, additional atmospheric modeling shows that the only place to find high-altitude supercooled water is in the updrafts of strong thunderstorms. This is documented in literature and in observations from the HIWC-HAIC campaigns. There are two reasons: First, as the atmosphere approaches -40°C, nucleation rates rapidly increase and thus only the most potent updrafts can transport water in large quantity, from the lower levels of the atmosphere to the upper levels, fast enough to avoid freezing. Secondly, with the atmosphere itself cooling with increasing height, only the increasingly violent cores have enough latent heat release to warm themselves to above -40°C levels.

Intentional penetrations of a high-end thunderstorm core would result in excessive risk to flight test aircraft, none of which are related to icing. Such an icing hunt would require plunging straight into the strongest portion of the updraft, encountering strong shear due to vertical winds as the aircraft enters and exits. At maneuvering speed, occasional stalling on updraft entry and very possible negative G upon exiting would be expected. Violent updrafts in combination with supercooled water is also the recipe for hail, sometimes large. While large hail is less certain than turbulence, it is possible that damaging hail could lurk nearby at any time. High speed updrafts and fall rates would make radar-hail avoidance difficult. Lightning, though less likely at such high altitudes, cannot be ruled out.

One specific report of a research flight through the structure of a severe convective storm is detailed in Reference 10. This report states in part that:

> "The Learjet stalled but control was regained immediately by a couplet of nose-down–nose-up maneuvers that scrambled all that was not tied down in the airplane cabin. The exit from the turbulent convective tower came suddenly at *t* = 70 462 and was associated with a strong momentary negative-gravity force ("G force"). Once again, all of the loose items hit the aircraft ceiling."
>
> "Similar stalls occurred several times at the 9–10-km level while penetrating the most vigorous clouds."
>
> "Even with this flight precaution, the aircraft still encountered small hailstones and large graupel in the tops of the severe convective elements on 7 February 2000. These ice particles broke the DMT LWC hot-wire".

While SC-F25.1419-01 allows for an AFM limitation prohibiting flight in icing conditions above the maximum altitude of Appendix C icing envelopes, the MFTC finds this option problematic for use in service. The United States' National Weather Service does not provide icing forecasts above 30,000 ft. If the planned cruising altitude for the flight is above 30,000 ft, the pilot would be unable to determine the need to plan a route around any known or forecast icing, possibly putting the pilot in violation of the AFM limitation. In lieu of forecast icing, the standard guidance provided for known icing is visible moisture and either outside or total air temperatures below +10°C, depending on the AFM. Therefore, to comply with the AFM limitation, the pilot would be forced to request deviations around any visible moisture where the aircraft's IPS may be optimized or inhibited. This in turn would place an undue burden on both the pilot and air traffic controllers as the outside air temperature would always be below +10°C above 20,000 ft. Additionally, in a letter from the FAA Chief Council to AOPA (Reference 9), the FAA stated that it "does not necessarily consider the mere presence of clouds (which may only contain ice crystals) or other forms of visible moisture at or below freezing to be conducive to the formation of ice or to constitute known icing conditions." It is also conceivable that such an AFM limitation may have a detrimental effect on overall safety if a pilot must descend into more severe icing to avoid any possibility of flying into icing at higher altitudes.

While not a safety issue, a further side effect of an AFM limitation prohibiting high altitude flight in icing is customer perception. A newly certified aircraft with such a limitation will be viewed as less safe as compared with an older certification basis aircraft without such high-altitude limitations. Given the rigor of recent icing certifications with later amendment rules, this is a misleading indication of the safety of the aircraft.

Based on these concerns and those defined below, the MFTC believes SC F25.1419-01 will introduce unnecessary risk and increase the time and cost of a flight test campaign to show compliance to the proposed special condition without providing an increase in safety. The MFTC also does not believe that an AFM limitation prohibiting operation in icing conditions above the maximum altitude of Appendix C icing envelopes is feasible.

Even though service experience does not indicate that this SC is necessary, it is acknowledged that the intent of the SC is to address design implementations that may utilize the explicit boundaries of the existing certification icing envelopes to modify an ice protection system's operation. However, the proposed AMC icing conditions, while not considered open for public comment, may undermine the intent of the SC. The proposed AMC icing conditions are very conservative and may drive substantially different applicant proposals resulting in an unintended disharmony in certification expectations within the industry. Consistent application of the proposed AMC icing conditions within this SC would retain harmonization, however the very conservative nature of the proposed AMC raises legitimate concerns that the net result of this SC could be an unintended decrease in the level of safety (e.g., design change to address an unrealistic condition resulting in the unintended sub optimization for other conditions), unsubstantiated economic burden, and/or unspecified adverse environmental effects.

The MFTC respectfully requests that the subject of this Special Condition be addressed through formal harmonized rulemaking, with industry advisory committee participation, in order to develop appropriate regulation(s) and guidance material. Given the subject matter, the advisory committee should solicit additional support from the aviation meteorological community and other industry groups to develop standardized methods for showing compliance via analysis and flight test. The MFTC does not favor publication of a generic Special Condition and AMC material which has not been adequately developed (e.g., appropriate representation of the icing environment, consistent with other flight in icing Subpart standards) to clearly achieve the desired safety objective; these concerns are communicated specifically in the Enclosure. Furthermore, the enclosed comments are considered to be applicable to the Special Condition as it is proposed by EASA and also relevant to guide and advise applicant/project-specific discussions under the context of an Interpretative Material CRI as proposed by the MFTC.

It is the recommendation of the MFTC that implementation of this Special Condition be paused and submitted to a formal rulemaking body such as an EASA RMT or the Flight Test Harmonization Working Group (FAA ARAC).

Once again, we thank you for the opportunity to provide inputs to the proposed Special Condition and trust that you will consider our comments and recommendation for moving forward on this subject.

Regards,

MFTC Representatives

Enclosure 1: Icing Pilot Reports (PIREPS) as a Function of Altitude

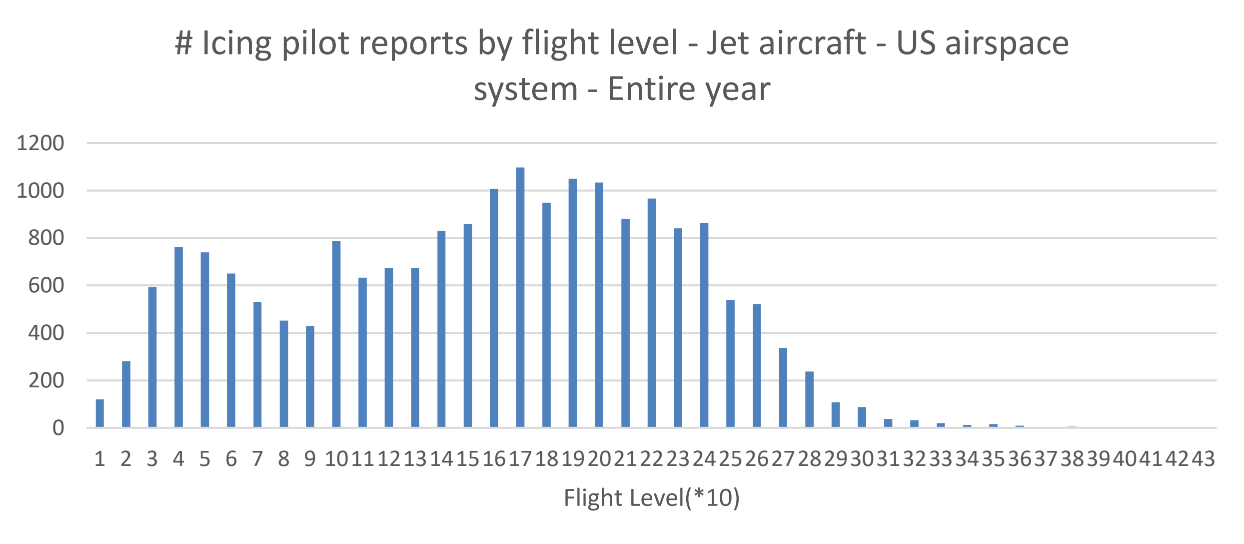

Figure 1: Icing PIREPS versus Altitude for an entire year

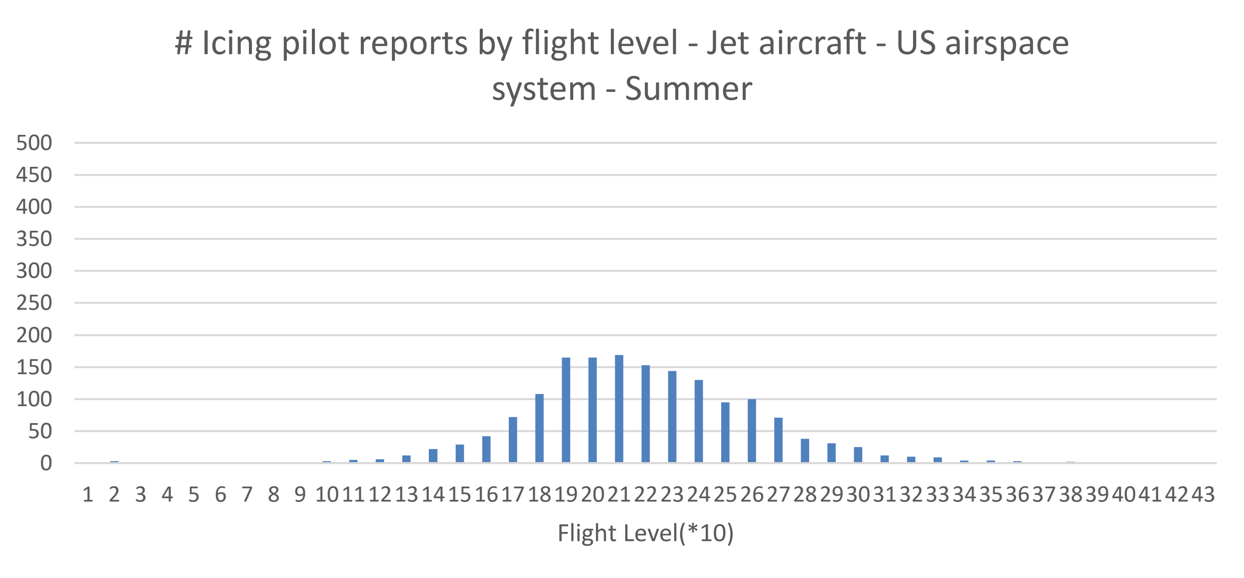

Figure 2: Icing PIREPS during Summer Season only

EASA response: Noted

Responses are provided to the detailed comments that follow. The raised concerns in the cover letter have been already answered/addressed in previous replies to other comments.

Commenter 9: MFTC

Comment # 82

Enclosure 2: Detailed Comments Relative to Proposed AMC

RE: EASA Special Condition, *Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes* (Doc. No. SC-F25.1419-01)

COMMENT #1 of 4			
Type of comment (check one)	***Non-Concur*** *X*	***Substantive***	***Editorial***
Affected paragraph and page number	Page:1 Paragraph: 6		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters. Finally, hot-day conditions are not addressed in the current CS 25 Appendix C.” **<u>REQUESTED CHANGE</u>:** As a matter of fact, it was developed based on data from the continental US atmospheric conditions and the available knowledge on aviation environment that existed at that time. ~~Secondly, there is no available data on icing conditions that may exist over tropic and equatorial warm oceanic waters.~~ Finally, hot-day conditions are not addressed in the current CS 25 Appendix C.		

Why is your suggested change justified?	**JUSTIFICATION:** Additional data regarding super-cooled liquid droplet icing conditions that may exist over tropic and equatorial warm ocean waters would be valuable, especially for a harmonized rulemaking committee. However, some data already exists, such as published reports from the HAIC-HIWC flight campaigns. While The HAIC-HIWC flight campaigns were focused on ICI conditions, the conclusions per Reference 12 state that “There were no mixed phase zones colder than -35°C.” This could be used to substantiate the fact that SLW is rarely found outside of the strongest convective cores at these low temperatures. (References 11,12,13). One of the references below is a direct result of a flight test campaign. There is a wealth of flight test data from campaigns flown by the manufacturers represented in the MFTC that would become accessible through a harmonized rulemaking committee. REFERENCES: 11. Dezitter, F., Grandin, A., Brenguier, J.L., Hervy, F. et al.,“HAIC-High Altitude Ice Crystals,” in Proceedings of the 5th AIAA Atmospheric and Space Environments Conference,2013, doi:10.2514/6.2013-2674. 12. Strapp, J.W., Schwarzenboeck, A., Bedka, K., Bond, T., et al.,“An Assessment of Cloud Total Water Content and Particle Size from Flight Test Campaign Measurements in High Ice Water Content, Mixed Phase/Ice Crystal Icing Conditions: Primary In-Situ Measurements,” FAA Rep. DOT/FAA/TC-18/1, 2019, in review and publication process. 13. Alice Grandin, Jean-Michel Merle, Marc Weber, John Strapp, Alain Protat, Patrick King, “AIRBUS Flight Tests in High Total Water Content Regions”. 6th AIAA Atmospheric and Space Environments Conference. https://doi.org/10.2514/6.2014-2753

EASA response: Accepted

See reply to comment #26bis.

Commenter 9: MFTC

Comment # 83

Enclosure 2: Detailed Comments Relative to Proposed AMC

RE: EASA Special Condition, *Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes* (Doc. No. SC-F25.1419-01)

COMMENT #2 of 4			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***

Affected paragraph and page number	Page: 1 Paragraph: 6
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "Furthermore, the same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; the occurrence at 37000 feet was reported as 'severe'. (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington)." **REQUESTED CHANGE:** "~~**Furthermore,** t~~***T***he same picture (figure 1-21) also includes two reported icing encounters above 30000 feet (supposed to be the higher altitude for the IM icing envelope), at 37000 and 39000 feet, respectively; ~~the occurrence at 37000 feet was reported as 'severe'~~ ***these encounters are in conflict with the -40°C temperature accepted as the lower limit for supercooled water to persist in an air mass and, due to the lack of information surrounding these individual events, should not be used to substantiate very high altitude icing significantly beyond the current explicit upper altitude limit associated with the IM icing envelope.*** (Letter No. 6-7731-69, dated April 29, 1963, from E. A. Rock, Staff Engineer, the Boeing Company, Renton Washington)."
Why is your suggested change justified?	**JUSTIFICATION:** EASA acknowledges that the original icing envelopes for Continuous Maximum and Intermittent Maximum, while recognized to constitute an engineering standard, were developed using data acquired from aircraft with limited altitude capability. However, the referenced FAA Technical report ADS-4 Figure 1-21 includes encounters derived from B-52, KC-135 and 707 type aircraft, all with service ceilings in excess of 40,000 feet (i.e., exceeding the plot scale) which corroborate the appropriateness of the corresponding certification icing envelope upper altitudes. The only two appreciable deviations correspond to reported encounters of icing at approximately 37,000 at -62°F (-52°C) and 39,000 feet at -65°F (-54°C); both of which are significantly below the accepted -40°C temperature accepted as the lower limit for super-cooled water to persist in an air mass. In fact, the ADS-4 report goes on to state these encounters "were probably measured in dry air after the icing encounter" which further raises doubt about their validity.

EASA response: Accepted

See reply to comment #29, #38, #64. The reference to these events has been removed from the "Statement of Issue" section.

Commenter 9: MFTC

Comment # 84

Enclosure 2: Detailed Comments Relative to Proposed AMC
RE: EASA Special Condition, *Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes* (Doc. No. SC-F25.1419-01)

COMMENT #3 of 4			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: 7		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40 °C and the absence of liquid phase below that temperature The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C. **<u>REQUESTED CHANGE</u>:** ~~In the lack of~~***Prior to a thorough study of*** empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, ***and until superseded by formal harmonized rulemaking, applicants may propose a characterization. Alternatively applicants may use the following:***~~, the following conservative assumptions are taken:~~ - ~~The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40 °C and the absence of liquid phase below that temperature~~ - ***There is no additional threat of CM above 22,000 ft that is not adequately addressed by the IM definition in App C.***		

	- The IM icing conditions at 30,000 feet are extended up to ~~the maximum operating aeroplane~~ ***37,000 ft altitude with the linear extent of icing diminishing linearly from 2.6 nm at 30,000 ft to 0 nm at 37,000 ft (conservatively assuming LWC remains constant above FL300).***~~, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C.~~ ***To show that the aeroplane can safely operate in these conditions an analysis should be performed to determine if the amount of ice accreted in this region would result in triggering the ice detection system. If so, the resulting shapes should be compared to the pre-activation ice shapes with respect to the requirements of CS25.207(h). This is not expected to be flown in natural icing conditions as the probability of finding such conditions is extremely low.***
Why is your suggested change justified?	The MFTC does not believe that the continuous maximum icing environment needs to be evaluated above the altitudes presented in the Appendix C icing envelope. CM icing is a result of stratiform clouds which have low mixing energy and therefore a limited vertical extent. Additionally, DOT/FAA/CT-88/8-1 states that “high level stratiform clouds (above 20,000 ft) are composed of ice crystals which do not contribute to airframe icing...” As already stated in the special condition, “it is commonly agreed that below -40°C, air cannot hold any moisture.” Thus, there is no liquid water content below an outside air temperature of -40°C and therefore, there can be no airframe icing. The proposed IM icing scenario is based on this fact and the fact that the probability of encountering icing above 30,000 ft is extremely low and would therefore require a cruise condition with a steady, long exposure to increase that probability. The proposed IM envelope also assumes that an airplane would not be expected to fly below its minimum operational airspeed (either climb or normal cruise). 37,000 ft was chosen as the upper altitude limit because at 37,000 ft, -40°C is equivalent to ISA+16°C. Per the NASA report on the US Standard Atmosphere (Reference 7), the maximum “normally” expected temperature above 30,000 ft is ISA + 15°C. While the updrafts associated with vigorous tropical convection can pull supercooled liquid water to higher altitudes, a study presented by Heymsfield, et al. in the Journal of Atmospheric Sciences (Reference 8) showed that below -35°C, the liquid water would homogenously freeze in the updraft region and then be fully glaciated in the downdraft region. It should also be noted that at temperatures between −35°C and −40°C, there is abundant research showing that cloud droplets of diameter several microns or larger will freeze spontaneously. This proposed set of icing conditions would allow for the continued use of CS 25.1419, Appendix C, and AMC 25-21(g) to show compliance with safe operations for flight into known icing while addressing the scenario presented by the Special Condition in which an Ice Protection System may be inhibited or optimized above Appendix C. This proposal also reinforces that it is not necessary, nor expected, that the airplane be flown in natural icing conditions above those of Appendix C.

EASA response: Partially accepted.

See Explanatory Note 1 about the proposed icing scenario above Appendix C IM icing altitude.

The Note also explains that based on such proposal and in agreement with AIA/ASD Association representatives, EASA considered that the Special Condition scope should be restricted to address implementation of "optimised" IPS above Appendix C IM envelope only.

On this respect EASA does not agree, in general, that "*there is no additional threat of CM above 22,000 ft that is not adequately addressed by the IM definition in App C*" for 'optimised system'. This statement would be valid only when applicant would propose a standard On/Off IPS as intended by SC preamble. For optimised system below 31kft, the text of this SC should be revised and the icing conditions between 22kft and 31kft, to be considered for certification, should be discussed between Industry and Authorities (see the changes implemented into "Statement of issue" section of the SC final text).

Commenter 9: MFTC

Comment # 85

Enclosure 2: Detailed Comments Relative to Proposed AMC

RE: EASA Special Condition, *Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes* (Doc. No. SC-F25.1419-01)

COMMENT #4 of 4			
Type of comment (check one)			
Affected paragraph and page number	Page: 4 *Paragraph: 2* Acceptable Means of Compliance to SC to demonstrate safe operation above the maximum altitudes of the Appendix C icing envelopes with an optimised/modulated IPS.		
What is your concern and what do you want changed in this paragraph?	**The proposed text states:** 1. The applicant demonstrates safe operation in icing conditions at all altitudes up to its operational ceiling; then the certified icing envelope is the aeroplane flight envelope, and no AFM limitation is required. **REQUESTED CHANGE:** *1.* The applicant demonstrates safe operation in icing conditions ~~at all altitudes up to its operational ceiling; then the certified icing envelope is the aeroplane flight envelope~~ ***that may exist above the App C envelope, including defining the limits***		

	of those possible conditions, and no AFM limitation is required. **Flight testing in natural ice outside App C conditions is not expected.**
Why is your suggested change justified?	**<u>JUSTIFICATION:</u>** The MFTC appreciates the inclusion of a direct demonstration as it would be the only means of compliance available for a newly designed aircraft or new OEM. The concern is SC-F25.1419-01 does not expand on what defines safe operation nor does it consider the unique flight test hazards incurred with a direct demonstration. The MFTC is also concerned with the conflicting guidance created by the introduction of SC-F25.1419-01. Certification for flight into icing is guided by AMC 25-21(g) which provides an “acceptable means for showing compliance with the requirements related to performance and handling characteristics of large Aeroplanes as affected by flight in icing conditions.” AMC 25-21(g) 5.2.1.2 then proceeds to state “it is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the highest altitudes specified in Appendix C and Appendix O to CS-25).” SC-F25.1419-01 contradicts this by requiring that the “applicant demonstrate safe operation in icing conditions at all altitudes up to [the aircraft’s] operational ceiling” and then is mute on what flight tests should be conducted to show safe operation. This conflicting guidance now opens the question of what subset of Part 25 Subpart B requirements must be demonstrated to show safe operation; the answer to which could vary greatly based on the individual certification authority’s view on what should or should not be required. The proposed text seeks to redefine the direct demonstration option to focus back on showing safe operating in the Appendix C icing conditions with the acknowledgement that there may be some very limited icing above the Appendix C envelope that would need to be analyzed per comment 3. It also seeks to specifically state that flight in natural icing conditions outside those listed in Appendix C should not be necessary to show compliance with this special condition due to the more detailed concerns listed in the letter above.

EASA response: Partially accepted.

EASA does agree to partially modify the final text in line with the new SC objective as introduced in the <u>Explanatory Note 1</u>. In addition, it is clearly stated that the demonstration is limited to such altitude where icing conditions may exist.

(…)

(1) The ~~applicant~~ aeroplane is capable ~~demonstrates~~ to safely operate ~~operation~~ in icing conditions above Appendix C IM envelope at any altitude ~~at all altitudes up to its operational ceiling~~ within its flight envelope where icing conditions may exist; then the certified icing envelope is the aeroplane flight envelope, and no AFM limitation is required.

(2) .....

(..)

See also similar comment #19, albeit on other part of SC text (AMC material).

As already stated, the compliance methodology through the direct demonstration (option b in the AMC to SC) is addressed in the Explanatory Note 2. As of today, there is no AMC material addressing this aspect yet.

Commenter 10: Collins Aerospace

Comment # 86

Dear Mr. Fico,

Collins Aerospace respectfully submits the enclosed comments regarding EASA SC-F25.1419-01, "Aeroplane Ice Protection System operation above the maximum altitudes of CS-25 Appendix C icing envelopes". In addition to these comments, Collins Aerospace has also participated in and endorses the comments being provided through the Aerospace Industries Association (AIA), organized under the Engine Icing Working Group (EIWG).

Best Regards,
Brian Matheis

EASA response: Noted.

Commenter 10: Collins Aerospace

Comment # 87

COMMENT #1 of 5

Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page:5 Paragraph: 7		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** "Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimized/modulated or even inhibited IPS above the Appendix C icing envelopes altitude, is still safe. For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane unprotected and protected parts. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment." **<u>REQUESTED CHANGE</u>:** "Applicants may seek for direct demonstration to validate that the aeroplane, while operated with an optimized/modulated or even inhibited IPS above the Appendix C icing envelopes altitude, is still safe. For the evaluation of safe operation, the applicant should assess the degradation of aeroplane performance and handling qualities created by the potential ice accretion on aeroplane ~~unprotected and~~ protected parts with <u>optimized IPS</u>. Furthermore, the applicant should assess the effect of sudden release of the ice accretions on the engines and essential equipment."		
Why is your suggested change justified?	**<u>JUSTIFICATION</u>:** Unprotected surfaces and components (e.g. Ram Air Turbines, certain engine components, unheated probes, etc.) are not actively optimized based on altitude. Similar to EASA's argument for "traditional On/Off IPS" that have been certified to Appendix C, it should be assumed that unprotected surfaces and components that have been certified to Appendix C require no further assessment. This is further backed up by past historical excellent in-service experience.		

EASA response: Partially accepted.

This comment is similar to comments #22 and #74.

The here-mentioned unprotected components (e.g., Ram Air Turbines, certain engine components, unheated probes, etc.) are not concerned/affected by this SC. The SC text is clear on this respect since the concerned surfaces are only associated to an optimised IPS.

The "unprotected surfaces" in the SC text identifies those belonging to wing/empennage/nacelle,….

On this respect, in principle, both protected (which are normally protected in Appendix C icing conditions) and unprotected aircraft parts shall be assessed against the new proposed icing scenario, introduced in the Annex 1 of the associated MOC to SC text.

As far as <u>option b): Direct demonstration</u> is concerned, specific methodology to comply with is not yet included in the AMC text. Refer to

<u>Explanatory Note 2</u>.

Commenter 10: Collins Aerospace

Comment # 88

COMMENT #2 of 5			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page: 5 Paragraph: 6		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: …” **REQUESTED CHANGE:** Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC.		
Why is your suggested change justified?	**JUSTIFICATION:** Current and planned Collins nacelle anti-ice (NAI) ice protection systems (IPS) contain design features to restrict the flow at altitudes above Appendix C. The goal was to optimize these NAI IPS by reducing engine bleed flow demands, which has three primary benefits: 1. Increases engine efficiency, and therefore fuel burn 2. Increases engine compressor endurance by reducing compressor pressures and temperatures when the system is activated at altitude 3. Reduces nacelle structural temperatures during inadvertent activation in dry air conditions at high altitude The proposed EASA SC, in conjunction with customer requirements have the potential of negatively impacting these enumerated benefits. The critical point analysis could potentially change as a result of the extension of the Appendix C icing conditions up to the aircraft ceiling, even though these icing conditions may be extremely remote with little to no supporting atmospheric evidence. The acknowledged lack of empirical data or appreciable safety benefit may result in overly conservative design elements. Specifically, nacelle components may need to be redesigned to withstand the higher temperatures associated with inadvertent dry air anti-ice system activation at higher altitudes. Updated designs would likely add weight to the nacelle, which in turn reduces overall aircraft performance. By very conservatively extending the		

	Appendix C icing envelopes, the EASA SC has the potential to reduce the optimization of NAI IPS while increasing system complexity, and weight.

EASA response: Accepted

Refer toExplanatory Note 1.

Commenter 10: Collins Aerospace

Comment # 89

COMMENT #3 OF 5			
Type of comment (check one)	***Non-Concur*** ***X***	***Substantive***	***Editorial***
Affected paragraph and page number	Page 5 *Paragraph 10*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** “The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m^3 at -40°C and the absence of liquid phase below that temperature.” **REQUESTED CHANGE:** Given the facility limitations outlined in the Justification section, what Means of Compliance demonstration will be accepted by EASA in this region?		
Why is your suggested change justified?	**JUSTIFICATION:** Extending the CM conditions down to -40°C could create a significant challenge in demonstrating compliance. Current practice for testing IM conditions to the extended -40°C envelope typically involves adjusting to a warmer temperature in order to avoid issues with		

	droplet freeze-out and ensure a quality test. The current CM envelope already presents challenges to icing tunnels to try and reach the maximum LWC of 0.04 g/m³ at -30 °C and 40 μm. The extension of the Appendix C icing envelope would further exacerbate this problem. Water contents this low are difficult to create and also present issues for controlling the stability and uniformity of the icing cloud. If testing of extremely low LWC’s at temps near -40°C are required, this could result in significant investment in icing tunnel capability and/or calibration with no clear safety benefit as well as lack of harmonization among industry facilities.

EASA response: Noted.

Refer to Explanatory Note 1. In particular, the scope of the SC has been limited to IPS optimised above Appendix C IM altitude only.

The commented text has been removed from SC final text. The “Statement of Issue” section has been amended on this respect to reflect the changed approach.

Commenter 10: Collins Aerospace

Comment # 90

COMMENT #4 OF 5			
Type of comment (check one)	***Non-Concur*** X	***Substantive***	***Editorial***
Affected paragraph and page number	Page 5 *Paragraph 10*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES**: “The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m³ at -40°C and the absence of liquid phase below that temperature.” **REQUESTED CHANGE**: Collins recommends that the extension of Appendix C conditions to higher altitudes be addressed via formal rulemaking with advisory participation from the industry to define appropriate minimum and maximum LWC’s for Appendix C.		
Why is your suggested change justified?	**JUSTIFICATION**:		

	The extension of the CM conditions down to -40°C and a maximum LWC of 0.0 g/m³ presents a significant detectability challenge. The maximum LWC per the proposed Appendix C is below the minimum LWC detection threshold of 0.05 g/m³ (maximum non-detectable LWC) specified by the recently approved SAE AS5498A for a wide range of conditions, which may begin to stretch the limits of certain ice detection technologies. Assuming the flight crew can spot these high altitude, low-LWC clouds is not necessarily a safe assumption either. As discussed in SAE 2019-01-1932, these low LWC clouds are not easily observed. A cloud with a LWC = 0.01 g/m³ and MVD = 50 µm would have a visibility that exceeds the current Visual Flight Rule (VFR) requirement. Thus, the flight crew would assume that they are not in a cloud. Taking into account typical collection efficiencies for the wing / nacelle as well as sublimation rates, a fair portion of these low LWC conditions would build up less than 0.3 mm of ice (AS5498A detection threshold) within 45 minutes. Since there is no flight test data to support the existence of these low LWCs over large horizontal extents, it’s not clear if the proposed changes to Appendix C can be supported.

EASA response: Accepted

Refer to Explanatory Note 1

Commenter 10: Collins Aerospace

Comment # 91

COMMENT #5 OF 5			
Type of comment (check one)	*Non-Concur* X	*Substantive*	*Editorial*
Affected paragraph and page number	Page 5 *Paragraph 6*		
What is your concern and what do you want changed in this paragraph?	**<u>THE PROPOSED TEXT STATES</u>:** “In the lack of empirical data to precisely characterize the icing atmosphere standard over 22,000 feet for CM conditions and over 30,000 feet for IM conditions, the following conservative assumptions are taken: - The CM icing conditions at 22,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS-25 Appendix C, Figure 1 reducing linearly to 0 g/m3 at -40°C and the absence of liquid phase below that temperature. - The IM icing conditions at 30,000 feet are extended up to the maximum operating aeroplane altitude, by assuming the liquid water content for the coldest temperature shown in CS 25 Appendix C, Figure 4 and the absence of liquid phase below -40°C” **<u>REQUESTED CHANGE</u>:**		

	Formal rulemaking with industry participation is recommended to facilitate a technical forum to share and develop the appropriate icing conditions to be used in meeting the intent of the proposed SC.
Why is your suggested change justified?	**JUSTIFICATION**: Collins has been involved in several R&D projects involving hypersonic aircraft that may operate at significantly higher altitudes than typical Part 25 aircraft. According to the proposed EASA SC, Collins will have to assess icing conditions up to these aircraft’s flight ceiling, even though there is little to no data suggesting super-cooled liquid water exists at these extreme altitudes. Therefore, designing IPS at these altitudes and environmental conditions is considered unreasonable and inefficient. While the true impact to these designs is unknown, the proposed EASA SC would likely result in an overdesigned IPS with no clear safety benefit.

EASA response: Accepted

Refer to Explanatory Note 1.

Commenter 11: ANAC

Comment # 92

Dear Mr. Fico,

ANAC would like to provide the following comments regarding the proposed Special Condition SC-F25.1419-01 in consultation period on the EASA website.

ANAC understands EASA safety concern expressed in the proposed Special Condition. ANAC issued in 2009 a similar special condition applied to one Brazilian project. This project inhibits the anti-ice above certain altitudes (https://www.anac.gov.br/assuntos/legislacao/legislacao-1/boletim-de-pessoal/2009/48s/ce-sc-ndeg-23-007). At that time, however, ANAC focused on the particular project and did not envision the same characteristic applicable to several different projects.

ANAC understands that EASA is working with similar characteristics in different projects, i.e. inhibition or “optimization” of anti-ice outside Appendix C envelope. ANAC agrees with EASA’s initiative to provide a level playing field for different products. Nevertheless, ANAC believes that the Special Condition may not be the best approach. The topic requires a through discussion involving all stakeholders since there are several contentious points as listed below:

- What is the expected ice accretion? A great challenge is the lack of significant organized data about icing outside Appendix C. The Special Condition references data which is several decades old. The first step in this topic should be a review of more recent research and manufactures' data.
- Once the ice accretion is defined, what is the exposure risk?
- It is necessary to clearly define what would be an "optimized/modulated" IPS for Special condition applicability.

ANAC recommends EASA to task a group of specialists to discuss the topic with the support of other airworthiness agencies. ANAC, EASA, FAA, and TCCA have been discussing with the aircraft manufactures novel airworthiness topics under FAA ARAC and its working groups such as the Flight Test Harmonization Working Group. ANAC believes this approach is the best for contentious topics as this one.

EASA response: Noted.

EASA target was to address a specific aircraft design at the time of SC publication. EASA has tried to clarify which system may be concerned and which system might be not, knowing that a clear separation was not so obvious. The "statement of Issue" and the SC final text itself has been modified to address such issue.

Eventually, the proposed icing conditions are derived from manufacturers' data. EASA involved all the stakeholders during more than 2-years discussion and reached consensus on aspects like the icing environment above Appendix C IM icing envelope (see Explanatory Note 1).

The

Explanatory Note 2 provides clarification about the subjects where consensus could not be reached in a reasonable timeframe and therefore postponed to a future co-ordinated task.

Commenter 12: Embraer

Comment # 93

Comment #	01
Section, proposed requirement/acceptable means of compliance/guidance material, page	SC-F25.1419-01 page 4.
Comment	The associated Means of Compliance is published for awareness only, not being subject to public consultation. This associated Means of Compliance should be put through the normal process of public consultation as information from other sources (such as equipment manufacturers, aircraft operators, universities and technical entities such as SAE, ESDU, NASA, etc.) may be useful in the discussion.
Rationale	Embraer considers that the Acceptable Means of Compliance also should be opened for public consultation, as there are significant information included, that can not be considered apart from the Special Condition. Thus, EMBRAER suggests EASA that the Acceptable Means of Compliance also should be opened for public consultation
Suggestion	Embraer suggests to change the text as according below: From: The associated Means of Compliance is published for awareness only and is not subject to public consultation. To: The associated Means of Compliance is published not for awareness only and is subject to public consultation.

EASA response: Accepted

EASA has replied to any comment received on the AMC material attached to Special Condition proposed text. This resulted into completely new content and structure of the AMC text attached to the SC final text. See also specific replies to comment #97.

Commenter 12: Embraer

Comment # 94

Comment #	**02**
Section, proposed requirement/AMC/GM, page	SC-F25.1419-01 page 4.
Comment	Embraer suggests to change the text of the SC concerning the AFM information as presented below:
Rationale	Due to the expected low frequency of this phenomena (icing conditions at altitudes beyond a certified icing envelope), Embraer believes an AFM limitation is an unnecessary burden on the operation and training of flight crews, as they may have to memorize a limitation they may never be exposed to. Other means should be used (ex. a CAS message or an aural alert) to inform the crew of icing conditions and/or the operation of the IPS at optimized conditions.
Suggestion	From: "...or an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope." To: "If such demonstration is not carried out and the airplane features alerts to inform the crew that the IPS is inhibited or non-operational, the AFM must present procedures to guide pilots to leave and avoid icing conditions. If the airplane does not feature such alert, then an AFM limitation shall be introduced to prohibit operations in icing conditions at altitudes beyond a certified icing envelope.

EASA response: Partially accepted.

See answer to comment #52; the applicant may propose a specific AFM limitation for icing condition encounters above the certified envelope.

Commenter 12: Embraer

Comment # 95

Comment #	**03**
Section, proposed requirement/AMC/GM, page	SC-F25.1419-01 page 2.
Comment	The Identification of the Issue topic mentions reports of two events of icing encounter above 30,000ft. These two events are too few events on which to base the proposed Special condition, and the corresponding means of compliance, due to the following reasons. 1 – At the time of the encounters, pilots used to report icing encounters when they perceived water on the windshields. There is no precise indication whether these two encounters refer to liquid water (which is not expected to occur at these altitudes, as has been established by thermodynamic analyses over the years) or to ice crystals melting whilst hitting the windshield (a phenomenon that was not well understood at that time). Current knowledge of icing conditions in the atmosphere (characteristics, altitudes and temperatures where they occur) indicates that the second scenario is more likely to have occurred. In this case, it is unlike that ice has accreted on the airplane. 2 – Ice detection probe technology was rather primitive compared to present day standards, which further corroborates the point that reports of icing encounters relied mostly, if not entirely, on pilots’ perception of water on the windshield. 3 - Icing encounter does not mean ice accumulation, as the liquid water content is small (or nil), as stated in the Special Condition, at the altitudes and temperatures of concern (reference FAA document DOT/FAA/AR-98/76). 4 – The special condition does not present any evidence (or substantiation) that, in the remote event when ice accumulates on the airplane above 30,000ft, this ice would be detrimental to aircraft operation (performance, handling) to the point of posing any danger or unsafe condition. There is no further fleet event to substantiate this concern.
Rationale	Not Applicable
Suggestion	Not Applicable

EASA response: Accepted

See reply to comment #29, #38, #64. The text in the Preamble has been changed accordingly.

Commenter 12: Embraer

Comment # 96

Comment #	**04**
Section, proposed requirement/AMC/GM, page	SC-F25.1419-01 page 2.
Comment	Extrapolation of data from Appendix C of CS-25: The plain extrapolation of icing conditions of App. C of CS-25 is arbitrary as it is not based on evidence - it may be overly conservative. As such, a more detailed investigation on these conditions must be performed before the criteria is established.
Rationale	Not Applicable
Suggestion	Not Applicable

EASA response: Accepted

This is a recurrent comment. SeeExplanatory Note 1.

Commenter 12: Embraer

Comment # 97

Additional Embraer comments applicable to the Acceptable Means of Compliance - SC-F25.1419-01

Considering the fact that EASA did not open the Acceptable Means of Compliance for public consultation, Embraer would like to share their comments with EASA apart from the process of the public consultation in order to obtain some additional clarifications from EASA.

Embraer comment ≠1: Page 5/6 - Compliance strategies
The Means of Compliance determines that only two demonstration strategies are accepted: analysis based on previously certified designs and direct demonstration. For an applicant designing the first IPS with modulated-bleed characteristics, there is no previously certified designs on which to base the compliance. Direct demonstration, be it by means of simulated/artificial ice shapes or flights into natural icing conditions pose an increased burden on the applicant. Flying with simulated ice shapes at higher altitudes increase test risk as these may depart the airframe, being ingested by the engines (possibly leading to their failure) or causing an asymmetrical flight condition at high speed and altitude.
As significant improvements have been obtained over the years in icing wind tunnels and numerical methods, a third strategy based on these engineering tools (and their correlation with flight data) should be considered acceptable as well.

Embraer comment ≠2: Page 6/6 - Operational scenario
The proposed operational scenario assumes that ice is accumulated (unprotected areas, runback) at lower altitudes (within appendix C icing envelopes), remains on the aircraft as it climb to higher altitudes, and that more ice is accumulated at higher altitudes. This scenario is unrealistic as it considers that:
1 – The IPS is not working properly within the appendix C icing envelope (if it were working properly, as per certification requirements, there should be no ice accretion).
2 – The accreted ice does not shed from the airplane during the climb.
3 – The applicant should consider the combination/juxtaposition of two icing types on the airframe, which violates conditions set forth in the appendix C, that establish that only the most critical ice forms need to be considered for each flight phase.

Embraer comment ≠3: Page 6/6 - "Selecting 310 NM for CM envelope or 5.21 NM for IM is arbitrary and seems to be extremely conservative. Indeed this is more severe than previous criteria adopted in past programs by other certification authorities. EMBRAER considers that a reasonable criteria could only be established based on scientific or empirical evidence."

Embraer comment ≠4: Page 4/6 - Missing in the Acceptable Means of Compliance, that should be the "escape in safe conditions" option.

Embraer comment ≠5: Page 5/6 - Will It be required minimum flight cycles or flight hours to use the comparative analysis approach like did in the AMC 25.1420?

Embraer comment ≠6: This special condition is similar to other documents already issued by EASA and FAA for programs starting from the EMB-505 and onwards.

In the "Acceptable Means of Compliance to SC to demonstrate safe operation above the maximum altitudes of the Appendix C icing envelopes with and optimized/modulated IPS" section, consider that the icing protection system will not be limited only by altitude, but rather a combination of altitude and outside air temperature. For example: An airplane may be able to operate its IPS at 35,000 feet and temperatures of -30°C and below, but may not operate the IPS at the same altitude with temperatures above -30°C. Different altitudes will have different temperatures at which the IPS can safely operate.

In the "Atmospheric icing Conditions" section, consider changing "coldest temperature" to "lowest temperature".

In the "Operational scenario to compute the relevant airframe ice accretion" section, consider making clear that the demonstrations of "1. Operations in icing conditions above 22,000 feet in CM icing conditions" and "2. Operations in icing conditions above 30,000 feet in IM icing conditions" should be done separately and that the ice accretion should be performed only at altitudes where the IPS is inhibited. Should the operational scenario be considered as operating in dual bleed or single bleed configuration?

Embraer comment ≠7: Page: 6. Paragraph: 2, Embraer suggests to remove the CM envelope above 22,000 feet based on how the Appendix C was developed, where extrapolations to higher altitudes, up to 30,000 ft were deemed applicable only for the IM envelope.Therefore Embraer understands that the proposal for extending the CM envelope above 22,000 feet is not supported by the decision taken at the time of Appendix C implementation. Any extension of CM or IM envelopes should be based on a comprehensive study and empirical atmospherical characterization.

EASA response: See below.

Eventually EASA answered all the comments/remarks received on the AMC material (now associated MOC).

Generally based on the received comments, the AMC material has been completely re-organised; see Explanatory Note 2 about option b) Direct demonstration.

- Comment # 97.1 → Noted. See Explanatory Note 2.
- Comment # 97.2 → Accepted → As anticipated the AMC material has been largely revised. No cumulative of flight phase is considered any longer;
- Comment # 97.3 → Accepted → See Explanatory Note 1;
- Comment # 97.4 → Partially Accepted. The AFM provisions to not operate in icing conditions at altitude where aircraft IPS is not efficient is going into the directions of the commenter' remark.; see also comments #52 and #94
- Comment # 97.5 → Not accepted. This is like comment #72. It is no requested an amount of logged flight cycles on the reference aircraft model for the comparative analysis application. The rationale is in the reply to comment #72.
-
- Comment #97.6 → Noted. As anticipated the AMC material has been completely re-drafted. See Explanatory Note 2.
-
- Comment #97.7 → Partially accepted. This is like comment #84 from another commenter. See reply to this comment and Explanatory Note 1.

Commenter 13: Rolls Royce

Comment # 98

Dear Mr Fico

Rolls-Royce, along with other industry members, are working with AIA to submit a consolidated set of industry review comments in response to the proposed Special Condition (IPS operating above CS-25 Appendix C) – accordingly Rolls-Royce will not be submitting any separate comments.

EASA response: Noted