European Aviation Safety Agency

# Comment-Response Document 2012-23

# Turbine Engine Certification Specifications in Icing Conditions — Advisory Material

CRD TO NPA 2012-23 — RMT.0179 (E.009) — 12.3.2015

Related Decision 2015/009/R


**EXECUTIVE SUMMARY**

The aim of rulemaking task RMT.0179 is to upgrade CS-E 780 — 'Turbine Engine Certification Specifications for Operation in Icing Conditions'. This upgrade was mainly triggered by the need to update the icing conditions used to evaluate turbine Engines installed on CS-25 aircraft. A new icing environment, including Supercooled Large Drop (SLD), mixed-phase and ice crystal icing conditions, is being concurrently introduced in CS-25; these changes were proposed under NPA 2011-03. The CS-E Specifications which were proposed under NPA 2011-04 require the Engine to function satisfactorily throughout the conditions of atmospheric icing, including freezing fog and falling and blowing snow, which are defined in the Air Intake System Ice Protection Specifications of the Certification Specifications applicable to the aircraft on which the Engine is to be installed.

This Comment-Response Document (CRD) contains the comments received on NPA 2012-23 (published on 04 December 2012) and the responses provided thereto by the Agency.

NPA 2012-23 proposed Acceptable Means of Compliance (AMC E 780) with the Ice Protection Specifications (CS-E 780) proposed under NPA 2011-03.

The proposed AMC has been updated based on the comments received. These updates consist of clarifications, corrections or addition of Guidance Material, while the substance and main principles of the AMC are maintained. A summary of the major comments, responses, and AMC changes is provided in Chapter 2 of this CRD.

Based on the comments and responses, Decision 2015/009/R was developed.


| Applicability | | Process map | |
|---|---|---|---|
| Affected regulations and decisions: | ED Decision 2003/009/RM; CS-E | Concept Paper: | No |
| | | Terms of Reference: | 4.11.2008 |
| Affected stakeholders: | Turbine engine manufacturers. | Rulemaking group: | No |
| | | RIA type: | None |
| Driver/origin: | Safety. | Technical consultation during NPA drafting: | No |
| Reference: | EASp AER4.2. | Publication date of the NPA: | 6.12.2012 |
| | | Duration of NPA consultation: | 5 months |
| | | Review group: | No |
| | | Focussed consultation: | No |
| | | Publication date of the Opinion: | N/A |
| | | Publication date of the Decision: | 2016/Q3 |

# Table of contents

# 1. Procedural information

## 1.1. The rule development procedure

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

This rulemaking activity is included in the Agency's Rulemaking Programme, under RMT.0179 (E.009). The scope and timescale of the task were defined in the related Terms of Reference (see process map on the title page).

The draft AMC has been developed by the Agency based on: the input of the FAA (Federal Aviation Administration) Aviation Rulemaking Advisory Committee (ARAC) (Task 2 Working Group Report on Supercooled Large Droplet Rulemaking of the Ice Protection Harmonization Working Group (IPHWG)) and the input of the FAA draft Advisory Circular (AC) No 20-147A, the comments received on NPA 2011-04[3], as well as the Agency's experience from previous certification projects and application of current AMC material. All interested parties were consulted through NPA 2012-23[4], which was published on 6 December 2012. 125 comments or letters (listing of comments) were received from 17 interested parties, including industry, National Aviation Authorities (NAAs) and social partners.

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

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

This CRD provides a summary of comments and responses as well as the full set of individual comments and responses thereto received on NPA 2012-23. The resulting text is provided with the ED Decision amending CS-E.

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

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

3 http://easa.europa.eu/document-library/notices-of-proposed-amendments/npa-2011-04

4 http://easa.europa.eu/document-library/notices-of-proposed-amendments/npa-2012-23

# 2. Summary of comments and responses

This is a summary of the most substantial comments received on NPA 2012-23, together with the responses of the Agency. This is not an exhaustive list of the topics addressed as various other detailed technical changes were made. Please refer to the full list of comments and responses provided in Chapter 4 below.

(a) (2.1) Critical Points Analysis (CPA)

Some improvements were requested or suggested by manufacturers on how to use a CPA for supercooled liquid water icing conditions. The corresponding paragraph (2.1) has been updated to clarify that the CPA is primarily intended to identify whether test points should be added to the standard Table 1 test points in paragraph (2.2) and that, when a CPA test point is similar to a Table 1 test point, the more severe of the two should be demonstrated. Other detailed technical changes have also been made in paragraph (2.1).

(b) (2.2) Establishment of Test Points for In-Flight Operation

(1) Industry commentators requested to clarify the first point at power/thrust at or above that required for sustained flight, to relax the proposed durations of the test cycles, and to remove the second point to be run at critical fan speed for turbofan engines or the point at 100 % maximum continuous (MC) thrust/power when no critical fan speed prediction is available. The text has been updated so that the first point has to be run at the Engine minimum power/thrust to maintain sustained flight in the intended installation. Concerning the test cycles durations, the values remain unchanged because

(i) the maximum duration is set in harmonisation with FAR 33 proposed by the FAA; and

(ii) the proposed text allows to stop the test before reaching the maximum duration when a build/shed cycle is established (in this case, the previous AMC values are the minimum durations)

The FAA recommended to remove the option of predicting the critical fan speed and to require multiple power levels, including as a minimum flight idle, 50 % MC and 75 % MC at each icing condition. FAA argued that not only the shed-ice threat should be considered for these tests, but also the core ice accretion. However, core ice accretion is addressed in the test at power/thrust below that required for sustained flight, which has been upgraded compared to the NPA 2012-23 proposal, so that the test is not anymore optional — it is required to test at the minimum power/thrust associated with descent at an ambient temperature of –10°C or lower, if necessary, to ensure splitter icing and/or core inlet icing. Therefore, the critical fan speed test point option has been maintained.

(2) Some comments also addressed the tests at power/thrust below that required for sustained flight. Some manufacturers considered that the test conditions are too severe and not realistic and that the length of the first part of the test cycle should be increased. FAA also commented that the proposed rapid cycling between 6 and 5 km would be very difficult to perform in an actual Engine test, and it is not clear what flight scenario this test represents. After reviewing all the suggestions, the test cycle has been amended to

increase the length of the first part of the cycle from 6 to 28 km, and the duration of the test is changed from a fixed 10 minutes duration to a duration sufficient to cover a 3 000 m anticipated descent (like in the current AMC E 780, which permits to define a realistic operational descent scenario).

(c) (2.3) Establishment of Test Points for Ground Operation

Manufacturers wished to have the option of demonstrating that ambient temperatures below the tested temperature are less critical so that the tested temperature does not necessarily constitute an operational limitation. Similarly, it has been recommended that an applicant may demonstrate unlimited-time operation if complete ice shedding is shown to have occurred during the test. This has been accepted and the text of paragraphs (2.3) and (7) has been updated accordingly.

(d) (4) Ice Ingestion

Some commentators from the industry highlighted the need to mention how the Engine should be operated in sub-paragraph (b) on compliance considerations. It has been accepted that the Engine should be at the maximum cruise power or thrust unless lower power or thrust is shown to be more critical.

There was also a suggestion to add some background information on why the results from the medium bird ingestion test may be used to show compliance with the ice ingestion requirement. Therefore, a statement on the similarities of ice relative to bird in terms of impact behaviour and damage properties has been added.

(e) (5) Engine Air Data Probes

Critical conditions for Engine data probes may differ from the critical conditions for the engine, the Engine air intake and the Propeller (if applicable). This is noted in the proposed paragraph (5) of NPA 2012-23. However, some comments suggested to better clarify this point. Paragraph (5) has, thus, been improved by adding that during the tests in supercooled liquid icing conditions, high airflow conditions like Maximum Continuous Thrust/Power may not have been selected by the applicant, and by mentioning that the applicant should consider both installation effects and Engine airflow dependence along with AMC/GM provided in AMC 25.1324.

Additionally, the need to provide more guidance material on probe criticality, acceptable Engine operations, installation effects which must be accounted for, and pass/fail criteria for the probe has been identified. Manufacturers recommended that further discussions be held on these topics because various approaches to Engine probe certification and integration exist, and that this is taken into account for the next rulemaking activity aiming at upgrading ice protection standards, like the one which should be initiated based on the outcome of the international flight test campaign in ice crystal icing environment. The Agency agrees.

(f) (6) Inadvertent Entry into Icing Conditions or Delayed IPS Activation

Based on the commentators' feedback, there was a need to clarify the time delay assumption for switching the ice protection system (IPS) on. A new statement has been added to paragraph (6) in harmonisation with the text of AMC 25.1093(b) resulting from NPA 2012-22 — i.e. in lack of

other evidence, a delay of two minutes to switch on the IPS should be assumed, and for thermal IPS, the time for the IPS to warm up should be added.

(g) (7) Instructions for Installing and Operating the Engine

The FAA recommended that the applicant should declare to the installer the icing environment which has been used to certify the engine; this has been added to the list of paragraph (7).

Manufacturers explained also that the installer does not need to receive the information on the damage observed after the ice slab ingestion test as this should be assessed against maintenance manual limits, and the installer is satisfied to be informed that the Engine complies with CS-E 780. Similarly, the installer would not need to know the assumed delay in activation of the IPS. Flight crew must select the IPS as early as possible, and informing about the delay assumed during Engine certification may drive them to select the IPS later. These two items have been deleted from the list in paragraph (7).

Finally, airframers explained the need to be informed on the effects that may occur during or after encountering icing conditions (e.g. vibrations, thrust/power level or response effect) so that they can take them into account for the qualification of aircraft systems or for eventual operational limitations. Therefore, a new bullet has been added to also include this information.

# 3. Individual comments and responses

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

(a) **Accepted** — The Agency agrees with the comment and any proposed amendment is wholly transferred to the revised text.

(b) **Partially accepted** — The Agency either agrees partially with the comment, or agrees with it but the proposed amendment is only partially transferred to the revised text.

(c) **Noted** — The Agency acknowledges the comment but no change to the existing text is considered necessary.

(d) **Not accepted** — The comment or proposed amendment is not shared by the Agency.

| **(General Comments)** | - |
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| comment | 1 comment by: SVFB/SAMA<br>Provisional comment on 121231<br>SAMA will probably not comment this NPA<br>It is to be answered by Engine Manufacturers. |
| response | Noted. |

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| comment | 6 comment by: UK CAA<br>Please be advised that the UK CAA do not have any comments on NPA 2012-23: Turbine Engine CSs in Icing Conditions - Advisory Material. |
| response | Noted. |

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| comment | 44 comment by: AIRBUS<br>Airbus supports the position provided by the EIWG and AIA with notable exceptions that are subject to detailed comments submitted to the CRT. |
| response | Noted. |

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| comment | 65 comment by: DGAC FRANCE<br>DGAC France has no adverse comments on this NPA. |
| response | Noted. |

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| comment | 69 comment by: FAA<br>Attachment #1<br>**General Comments:** |

- The FAA and EASA have an excellent working relationship in our joint effort to maintain harmonized engine icing airworthiness certification requirements. This NPA is another good example of EASA's collaboration with the industry and the FAA in developing standards.
- Although this NPA is a significant step toward rule harmonization, we endeavor to work with EASA and we encourage continued EASA efforts to work with the FAA to resolve any significant rule differences.
- The proposed in-flight icing conditions described in Table 1 and sections (2.2) (a) and (b) should be the subject of potential rule harmonization between FAA and EASA, to avert potential significant regulatory differences. The FAA is currently planning on visiting EASA in June 2013 to discuss our respective proposed rules. A detailed discussion and comparison of the in-flight icing condition would be helpful.

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Page: 5 of 20
Paragraph: Content of the Decision
The text states: "The proposed CS-E rule update requires the engine to function satisfactorily throughout the conditions of atmospheric icing, including freezing fog, and in falling and blowing snow which are defined in the air intake system ice protection specifications of the Certification Specifications applicable to the aircraft on which the engine is to be installed."
**REQUESTED CHANGE:** The FAA suggests that the engine icing airworthiness certification standards should stand on their own and should not be linked to the aircraft icing approval.
**JUSTIFICATION:** The FAA is concerned that philosophically this approach of tying the engine icing requirements to the aircraft installation requirements moves the industry toward a less conservative approach to engine icing certification. Historically, both EASA and FAA have embraced the approach that the engine must be approved for icing and at a higher level of certification than the aircraft. This philosophy has resulted in no engine caused icing accidents in many years.

response

Not accepted.
The Agency agrees that it should maintain the current principle that the Engine must be certified for flight in icing conditions and that the corresponding requirements are conservative to a certain degree compared to the aircraft icing requirements. The same applies to the Engine air intake and we consider that there must be consistency between the Engine air intake requirements and the Engine requirements. The amended CS-E 780 rule makes this link with the aircraft Engine air intake icing requirements, thus ensuring consistency.

comment

73 comment by: Luftfahrt-Bundesamt

The LBA has no comments on NPA 2012-23.

response

Noted.

comment

83 comment by: Swiss International Airlines / Bruno Pfister

SWISS Intl Air Lines take note of NPA 2012-23 wiithout further comments.

response

Noted.

comment

99 comment by: Aerospace Industries Association

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| | Attachment #2<br><br>Please see attached letter from the Aerospace Industries Association (AIA) regarding its comments submitted on behalf of AIA and the Engine Icing Working Group (EIWG). |
| response | Noted.<br>You will find the responses to each individual comment below. |

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| comment | 106 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Sometimes "liquid water content" is used and sometimes the abbreviation "LWC"<br>Comment Resolution<br>The NPA should be consistent in the use of "liquid water content" or LWC |
| response | Accepted.<br>'LWC' is now used in the part of the AMC following the definition of 'Liquid Water Content' which also introduces the acronym. |

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| comment | 125 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Repeated references to CS-E 780(f) appear incorrect (Pages 16-20)<br>Comment Resolution<br>Replace references to CS-E 780 (f) with CS-E 780 (h) |
| response | Not accepted.<br>The reference CS-E 780(f) is correct, please refer to the final rule resulting text in CRD 2011-04. |

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| comment | 127 comment by: General Electric Company<br><br>Attachments #3 #4<br><br>Please see attached files<br>**Andrew May** Manager, Airworthiness and Certification – Large Engines GE Aviation<br>T +1 513 552 2185 M +1 513 706 2958 F +1 513 552 2185<br>andrew.may@ge.com One Neumann Way, MD Y75 Cincinnati, OH 45215 |
| response | Noted.<br>Your comments are addressed in the appropriate sections below. |

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| comment | 130 comment by: Poonam Richardet<br><br>Attachment #5<br><br>Please See comments from Cessna Aircraft Company on the following-"**NOTICE OF PROPOSED AMENDMENT (NPA) 2012-23."**<br>Thank you.<br>**Poonam Richardet**<br>**Analyst Engrg Procedures** |

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| | **Regulatory Affairs/Dept.-381**<br>**Cessna Aircraft Company**<br>**Carlos Ayala**<br>International Certification and Regulatory Affairs<br>Cessna Aircraft Company |
| response | Noted.<br>Your comments are addressed in the appropriate sections below. |

**NOTICE OF PROPOSED AMENDMENT (NPA) 2012-23 'Turbine Engine Certification Specifications in Icing Conditions — Advisory Material' — General comments** p. 1-3

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| comment | 80 comment by: Aerospace Industries Association |
| response | Noted.<br>Empty comment field. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART A — GENERAL** p. 6-7

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| comment | 58 comment by: Turbomeca<br>In this table of AMC E 30, Engine ingestion capabilities should be added in accordance with AMC E 780 (4)(f) and also with AC29-2_AC29.1093(c) (4)).<br>It is proposed to add in the right column " Engine ingestion capabilities" |
| response | Accepted. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (pp. 7-10)** p. 7-10

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| comment | 2 comment by: Vereinigung Cockpit / German ALPA<br>Freezing Fraction and Ice Formations<br>As the terms total and static temperatures are defined below in icing conditions, it is not clear, what is meant by just "temperature" to define clear, rime and mixed ice.<br>The freezing fraction, beside others, is depending on the removal of the heat of fusion from the freezing process. This heat is transferred either to the aircraft skin and/or the inside of the boundary layer. If the aircraft is moving, kinetic energy from the air is partially recovered in the boundary layers. Increasing speed will decrease heat transfer and so reduce the freezing fraction.<br>As in definition "Freezing Fraction" it is stated, that it will determine type of ice formation, there is no doubt, that formation of rime or clear ice is also dependent of airspeed: High freezing fraction with formation of rime ice at low speed will lead to low freezing fraction favoring clear ice with increasing speed. Note, that the energy recovery is increasing with the square of the speed.<br>Example: |

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| | Environment SAT -10°C, high LWC:<br>An aircraft flying with 150KTS will encounter TAT ~ -8°C with high freezing fraction and formation of rime ice.<br>If speed is increased to 300KTS, TAT will be ~+2°C and freezing fraction will be low favoring formation of clear ice with possible run back. As recovery downstream of stagnation points is incomplete, ice formation is still possible at TAT a few degrees above 0°C. |
| response | Noted.<br>The definitions of glaze ice, rime ice and mixed or intermediate ice are the ones provided by the IPHWG. The temperature used in the definitions should be the total temperature associated with the icing cloud environment. Temperatures referred to in Appendices C, O and P to CS-25 are static ambient temperatures. When conducting a test point analysis, the local total temperatures at the Engine inlet should be based on the Appendices C, O and P static temperatures and the assumed flight Mach number. |

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| comment | 3 comment by: Vereinigung Cockpit / German ALPA<br><br>**Droplet Diameters**<br>Defined are MVD and MMD. Later in table 1 the term MED (Median Effective Diameter) is also used but is not defined. |
| response | Noted.<br>In Table 1 the term 'Mean Effective Drop Diameter' is used, provided in the 'Supercooled Liquid Water Icing Conditions' of the aircraft (e.g. Appendix C to CS-25). |

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| comment | 4 comment by: Vereinigung Cockpit / German ALPA<br><br>**Temperature Definitions TAT and SAT**<br>To my knowledge according to standard definition TAT is SAT + 100% energy recovery.<br>TAT = SAT ( 1 + 0,2* Ma2 )<br>*TAT and SAT in Kelvin! The factor 0,2 is from (y – 1) / 2 with y (isentropic coefficient air) set 1.4 .<br>In "Total Temperature" the expression ambient temperature (not defined) is used. What is the difference between ambient temperature and SAT?<br>The definition "Static Temperature" being the difference between "local measured temperature minus the temperature rise from velocity effects" is not clear, as recovery factor and heat added/removed from freezing/melting/condensation/evaporation processes must also be considered.<br>For example, the local temperature on an iced surface with freezing fraction above 0 and below 1, temperature will be exactly 0°C. Using this temperature to calculate static temperature by just subtracting the temperature rise from velocity effects in my opinion is not very helpful. |
| response | Noted.<br>The 'total temperature' definition provided in the AMC is in the context of an Engine test cell. Thus, the ambient temperature refers to the temperature of the room which surrounds the Engine (static temperature). |

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| comment | 7 comment by: CAA-NL |

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| | AMC to E 780 Icing Conditions, paragraph 1.3 “Test Configuration - Engine”<br>“It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid for the particular installation…”<br>Proposal: “It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid **or surpass the certification** for the particular installation…”<br>Explanation: In this way, the aircraft manufacturer can opt for the situation to install an engine which is capable of flights (of short duration) in severe conditions as the aircraft itself is certified for. This may lead to a situation where the aircraft might safely depart from an inadvertent encounter of severe icing conditions as expected. These situations cannot always be avoided by detection and avoidance. |
| response | Not accepted.<br>The phrase ‘surpass the certification’ is not understood.<br>Note that this paragraph deals with the behaviour of the Engine air intake, Propeller and air data probe and their effect on the engine, whenever they are not tested together with the engine. It does not address the severity of icing conditions. |

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| comment | 9 comment by: Boeing<br><br>Page: 7<br>Paragraph: (1.1) Definitions<br><br>The proposed text states:<br>Freezing Fraction. The ratio or percentage of water that impacts a surface and freezes. The fraction is defined as a number between 0 and 1, and will determine the type of ice formation.<br>**REQUESTED CHANGE:**<br>Freezing Fraction. The ratio or percentage of water that impacts a surface and freezes. **The fraction of water flux entering a control volume that freezes within the control volume.** The fraction is defined as a number between 0 and 1, and will determine the type of ice formation.<br><br>**JUSTIFICATION:** We note that the definition in the NPA is inconsistent with that in NASA CR 2005-213852 (Evaluation and Validation of the Messinger Freezing Fraction) and the FAA Aircraft Icing Handbook. The change that we have requested brings the definition in line with NASA CR 2005-213852. |
| response | Not accepted.<br>The definition has been updated to adopt the definition of SAE ARP5624. |

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| comment | 10 comment by: Boeing<br><br>Page: 8<br>Paragraph: (1.1) Definitions<br><br>The proposed text states:<br>Scoop Factor (concentration factor). The ratio of nacelle inlet highlight area (AH) to the area of the captured air stream tube (AC) [scoop factor = AH/AC]. Scoop factor compares liquid water available for ice formation in the inlet, to that available in the low-pressure |

compressor or Engine core, as a function of aircraft forward airspeed and Engine power condition. The scoop factor affect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine.
**REQUESTED CHANGE:**
Scoop Factor (concentration factor). **Inertial Concentration factor.** The ratio of nacelle inlet highlight area (AH) to the area of the captured air stream tube (AC) [scoop factor = AH/AC]. **The ratio of the captured droplet stream tube area (A0W) to the area of the captured air stream tube (A0) [concentration factor = A0W/A0].** Scoop factor compares liquid water available for ice formation in the inlet, to that available in the low-pressure compressor or Engine core, as a function of aircraft forward airspeed and Engine power condition. **Concentration factor compares liquid water available for ice formation in the inlet, to that available in the free stream.** The scoop factor affect **effect** depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine.

**JUSTIFICATION:** The definition in the NPA appears to relate inconsistently between the engine intake scoop factor and a similar scoop factor for the core inlet. Our suggested change defines the scoop factor as applied to the engine intake, and describes the change in the liquid water content in the intake compared to the free stream.
"Scoop Factor" is a term to describe the effects of water droplet or ice particle inertia that allows these particles to cross aerodynamic streamlines and increase or decrease the local water/air ratio into the engine inlet. This concentration factor will require the use of complex CFD codes to account for a secondary effect, which will have little influence, if any, on the outcome of the test.
"Scoop" is a term used typically for rain/hail calculations and is reasonable to use in those cases, since particle sizes and masses are relatively large (mass is proportional to diameter3: a typical 1500 micron raindrop is 1E6 times heavier than a 15 micron icing droplet. Drag is proportional to diameter2; inertia increase 10x faster than drag as size increases).

In icing clouds, the inertia effects are relatively minor, since the small, light particles often can follow streamlines closely. We recommend not using the term "Scoop Factor" and instead refer to "Inertial Concentration" effects - or other term - to avoid confusion between different regulations.

response

Not accepted.
This definition is harmonised with the FAA proposed AC 20-147A.

comment

11 comment by: Boeing

Page: 9
Paragraph: (1.3) Test Configuration – Engine

The proposed text states:
(1.3) Test Configuration – Engine
Because the Engine behaviour cannot easily be divorced from the effects of the Engine air intake and Propeller, where possible, it is recommended that the tests be conducted on an Engine complete with representative air intake, Propeller (or those parts of the Propeller which affect the Engine air intake), and Engine air data probes. Separate assessment and/or testing of the air intake, Propeller and air data probes are not excluded, but in such circumstances the details of the assumed Engine installation will be defined in the manuals

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| | containing instructions for installing and operating the Engine (under CS-E 20(d)). It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid for the particular installation, taking into account:<br>**REQUESTED CHANGE:**<br>(1.3) Test Configuration – Engine<br>Because the Engine behaviour cannot easily be divorced from the effects of the Engine air intake and Propeller, where possible, it is recommended that the tests be conducted on an Engine complete with representative air intake, Propeller (or those parts of the Propeller which affect the Engine air intake), and Engine air data probes. Separate assessment and/or testing of the air intake, Propeller and air data probes are not excluded **may be required**, but **and** in such circumstances the details of the assumed Engine installation will be defined in the manuals containing instructions for installing and operating the Engine (under CS-E 20(d)). It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid for the particular installation, taking into account:<br><br>**JUSTIFICATION:** The change is suggested because rigorous validation of the intake, propeller, and air data probes may require separate assessment, as their critical conditions may not coincide with the engine critical points. |
| response | Not accepted.<br>The proposed change does not change the meaning of the sentence. |

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| comment | 12 comment by: Boeing<br><br>Page: 9<br>Paragraph: (1.3) Test Configuration – Engine<br><br>The proposed text states:<br>The shedding into the Engine of air intake and Propeller ice of a size greater than the engine is able to ingest;<br>**REQUESTED CHANGE:**<br>The shedding into the Engine of air intake and Propeller ice of a size greater than the engine is able to ingest; **The demonstrated ice ingestion capability per this CSE;**<br><br>**JUSTIFICATION:** This change is respectfully requested due to the airframe manufacturer being the entity that assesses the maximum capability of the engine, and if it doesn't cover the potential sources from the airframe, the engine must be re-certified. |
| response | Not accepted.<br>This paragraph is written in the frame of Engine testing with or without the air intake and Propeller. Therefore, the original wording is preferred, although it is agreed that in the end, for aircraft certification, the aircraft manufacturer will have to assess all non-Engine ice shedding sources against Engine ice ingestion capability. |

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| comment | 13 comment by: Boeing<br><br>Page:10<br>Paragraph: (1.6) Applicable Icing Environments<br><br>The proposed text states: |

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| | The applicable icing environments are those applicable to the aircraft on which the Engine is to be installed, defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate. This includes atmospheric icing conditions (including freezing fog on ground) and falling and blowing snow conditions. Falling and blowing snow conditions are defined in AMC 25.1093(b)<br>**REQUESTED CHANGE:**<br>The applicable icing environments are those applicable to the aircraft on which the Engine is to be installed, defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate. This includes atmospheric icing conditions (including freezing fog on ground) and falling and blowing snow conditions. Falling and blowing snow conditions are defined in AMC 25.1093(b)**, and section (7) of this AMC**.<br><br>**JUSTIFICATION:** Since there have been engine compressor damage events related to snow ingestion during ground operations, we suggest that some guidance be included for the applicant to assess these conditions. (Please see our other comment regarding necessary additions to this section.) |
| response | Not accepted.<br>The reference to AMC 25.1093(b) is deemed adequate as AMC 25.1093(b) provides more guidance than what you are proposing to add here. |

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| comment | 14 comment by: Boeing<br><br>Page:<br>Paragraph: [Add guidance for falling and blowing snow]<br><br>We request that the following be inserted in the NPA<br>**"(7) – Falling and blowing snow**<br>**CS-E 780 (a) requires that each engine, with all icing protection systems operating, operate satisfactorily in falling and blowing snow throughout the flight power/thrust range, and ground idle. Falling and blowing snow is a weather condition which needs to be considered for the powerplants and essential auxiliary power units (APU) of transport category aeroplanes.**<br>**Although snow conditions can be encountered on the ground or in flight, there is little evidence that snow can cause adverse effects in flight on turbojet and turbofan engines with traditional pitot-style air intakes where protection against icing conditions is provided. However, service history has shown that ground snow (and mixed phase) conditions have caused power interruptions due to compressor damage as a result of exposure to prolonged periods of falling snow ingestion during ground operation. Based on our review of service events we have found that airports have continued to operate with falling snow concentrations that result in a 0.25 mile or less visibility (about 0.9 gm/m3).**<br>**Engine core icing in service events in snow conditions confirm the critical snow accretion temperature range is 26° to 32° F (-3° to 0° Celsius). Within this range, water content in the form of supercooled liquid drops is considered negligible. This environment is also conducive to ice accretion aft of the fan on the core inlet and first stages of the engine, at low engine power.**<br>**For turbofan engines, demonstration of compliance with the falling and blowing snow specification on ground should be conducted by tests and/or analysis."**<br><br>**JUSTIFICATION:** There is a new snow test/analysis requirement that needs accompanying |

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| | advisory material. Our suggested addition is taken from the FAA's draft AC 20-147. A revision that is harmonized with the FAA's (to-be- published) material, and that includes assumptions for testing with liquid water in substitution for snow, and wind speed, is also needed. |
| response | Not accepted.<br>See response to your comment 13 above. |

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| comment | 45 comment by: AIRBUS<br><br>Section 1.3<br>Current text:<br>Apart from tests carried out under […], in which case the tests should be carried out using the minimum dispatch configuration for flight in icing conditions.<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Apart from tests carried out under […], in which case the tests should be carried out using the minimum dispatch configuration for flight in icing conditions in all flyable configurations.<br>Rationale/justification:<br>Ice accretion area can be changed depending on activation (or not) of IPS and ice accretion due to IPS activation might have different consequences on engine behaviour. |
| response | Partially accepted.<br>The sentence is updated to require that tests should address all configurations approved for aircraft dispatch. |

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| comment | 46 comment by: AIRBUS<br><br>Section 1.4<br>Current text:<br>The ice thickness and rotor speed at the time of the shed defines the impact threat.<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>The ice thickness, ice properties and rotor speed at the time of the shed defines the impact threat.<br>Rationale/justification:<br>Ice properties (hardness and ice density) might change the weight of the ice block. |
| response | Accepted. |

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| comment | 59 comment by: Turbomeca<br><br>(1.7)<br>Compliance of rotorcraft Engines to icing conditions<br>It is said " specific provisions for rotorcraft Engines are currently not included in this AMC. Until guidance has been established, ....".<br>Turbomeca would support any initiative to complement this AMC to cover specific aspects of Rotorcraft Engines in order to clearly establish acceptable means of compliance for Rotorcraft Engines. Turbomeca would be ready to participate to a dedicated working group. |

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| response | Noted. |

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| comment | 60 comment by: Turbomeca<br><br>(1.7) Compliance of rotorcraft Engines to icing conditions :<br>- Up to now, for turboshafts, the demonstration of operating under snow conditions is limited, for Engine certification, to demonstrate ingestion capacities. These engine ingestion capacities are included in the instructions for Installation.<br>Verification/validation of satisfactory behaviour, under snow conditions, of the engine and of the complete rotorcraft/engine air intake is done for Rotorcraft certification (i.e. post engine certification). This demonstration is generally based on flight testing under natural snow conditions according to AC29-2_AC29.1093 (c).<br>In case of any accumulation in the inlet, it is shown that the amount was not greater than the amount the engine is able to ingest (ref. AC29-2_AC29.1093(c) (4)).<br>- It is understood that the intent of this NPA 2012-23 is not to put into question the current process described above regarding snow conditions (except the additional point for ground operation under snow conditions defined in table 2). Your proposed AMC is not clear regarding demonstration required for snow conditions at turboshaft engine certification level. Please confirm that the current process described above regarding snow conditions remains valid. |
| response | Noted.<br>As stated in paragraph 1.7, this AMC does not include provisions for rotorcraft turboshaft engines and it, therefore, does not put into question currently accepted means of compliance. |

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| comment | 70 comment by: FAA<br><br>Paragraph: (1.7) Compliance for rotorcraft Engines to icing conditions<br>The proposed text states: “Specific provisions for rotorcraft Engines are currently not included in this AMC.”<br>**REQUESTED CHANGE:** Rotorcraft engine compliance methods should be addressed at least to a limited extent within the AMC, until such time as harmonized requirements are agreed. The FAA is available to discuss with EASA some initial standardized rotorcraft engine requirements that could be included in EASA’s AMC.<br>**JUSTIFICATION**: Although the FAA recognizes the need for guidance material to be developed with industry for turboshaft engines, we believe that some basic guidance on icing should still be provided. The FAA is concerned that the proposed wording of the AMC relative to turboshaft engines would result in non-standard and possibly non-harmonized turboshaft engine icing compliance. This could result in a potential significant regulatory difference and additional validation effort for both agencies and industry. |
| response | Noted.<br>It is agreed that there is a need to define harmonised rotorcraft engines guidance material. However, this rulemaking task should not be delayed at this point to work on this subject. |

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| comment | 74 comment by: Snecma<br><br>Attachment #6 |

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| | Please see attached file (Part 1) |
| response | Page 7, paragraph 1.1. The proposed text states:<br>Freezing Fraction. The ratio or percentage of water that impacts a surface and freezes. The fraction is defined as a number between 0 and 1, and will determine the type of ice formation. .<br>REQUESTED CHANGE<br>Freezing Fraction. The fraction of water flux entering a control volume that freezes within the control volume. The fraction is defined as a number between 0 and 1, and will determine the type of ice formation.<br>JUSTIFICATION: The definition in the NPA is inconsistent with that in NASA CR 2005-213852 or the FAA Aircraft Icing Handbook. The change requested brings the definition in line with NASA CR 2005-213852.<br>Response: Not accepted. The definition is updated to adopt the definition of SAE ARP5624.<br><br>Page 8, paragraph 1.1. The proposed text states:<br>Scoop Factor (concentration factor). The ratio of nacelle inlet highlight area (AH) to the area of the captured air stream tube (AC) [scoop factor = AH/AC]. Scoop factor compares liquid water available for ice formation in the inlet, to that available in the low-pressure compressor or Engine core, as a function of aircraft forward airspeed and Engine power condition. The scoop factor affect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine.<br>REQUESTED CHANGE<br>Inertial Concentration factor Scoop Factor (concentration factor). The ratio of the captured droplet stream tube area (A0W) to the area of the captured air stream tube (A0) [concentration factor = A0W/A0]. Concentration factor compares liquid water available for ice formation in the inlet, to that available in the free stream. The scoop factor effect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine.<br>JUSTIFICATION<br>The definition in the NPA appears to relate inconsistently between the engine intake scoop factor and a similar scoop factor for the core inlet. The requested change defines the scoop factor as applied to the engine intake and describing the change in the liquid water content in the intake compared to the freestream.<br>Scoop Factor is a term to describe the effects of water droplet or ice particle inertia which allows these particles to cross aerodynamic streamlines and increase or decrease the local water/air ratio into the engine inlet. This concentration factor will require the use of complex CFD codes to account for a secondary effect which will have little influence, if any, on the outcome of the test.<br>Scoop is a term used typically for rain/hail calculations and is reasonable to use in those cases since particle sizes and masses are relatively large (mass is proportional to diameter 3 a typical 1500 micron raindrop 1E6 times heavier than a 15 micron icing droplet. Drag is proportional to diam 2, inertia increase 10x faster than drag as size increases).<br>In icing clouds the inertia effects are relatively minor since the small, light particles often can |

follow streamlines closely. It is recommended not to use the term Scoop Factor and instead refer to Inertial Concentration effects - or other term - to avoid confusion between different regulations.
Response: Not accepted. The definition is harmonized with the proposed FAA AC 20-147A.

Page 8/9, paragraph 1.1. The proposed text states:
Sustained Power/Thrust Loss. This is a permanent loss in Engine power or thrust. Power or thrust losses that are not sustained are temporary in nature and may be related to the effects of ingesting super-cooled water or ice particles, or possibly the effects of ice accumulation or ice shedding. The Engine's momentary response during shedding may be from the thermodynamic Engine response to the ice ingestion and is not a sustained power loss. :
REQUESTED CHANGE
Sustained Power/Thrust Loss. This is a permanent loss in Engine power or thrust **at the engine's primary power set parameter (for example, fan rotor speed, engine pressure ratio)**. Power or thrust losses that are not sustained are temporary in nature and may be related to the effects of ingesting super-cooled water or ice particles, or possibly the effects of ice accumulation or ice shedding. The Engine's momentary response during shedding may be from the thermodynamic Engine response to the ice ingestion and is not a sustained power loss.
JUSTIFICATION: Snecma suggests to complete the definition with AC20-147 definition
Response: Not accepted. Our definition should be harmonized with FAA AC 20-147A which does not include this proposal.

Page 9, paragraph 1.3. The proposed text states:
The shedding into the Engine of air intake and Propeller ice of a size greater than the engine is able to ingest;
REQUESTED CHANGE:
The demonstrated ice ingestion capability per this CSE.
JUSTIFICATION: The airframer assesses the max capability of the engine, and if it doesn't cover the potential sources from the airframe, the new conditions must be re-certified at engine level.
Response: Not accepted. See response to comment 12.

comment 81 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 7<br>Paragraph: (1.1) Definitions |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>Freezing Fraction. The ratio or percentage of water that impacts a surface and freezes. The fraction is defined as a number between 0 and 1, and will determine the type of ice formation.<br>**REQUESTED CHANGE:** |

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| | Freezing Fraction. **The fraction of water flux entering a control volume that freezes within the control volume.** The fraction is defined as a number between 0 and 1, and will determine the type of ice formation. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that the definition in the NPA is inconsistent with that in NASA CR 2005-213852 or the FAA Aircraft Icing Handbook. The change requested brings the definition in line with NASA CR 2005-213852. |

response

Not accepted.
The definition has been updated to adopt the definition of SAE ARP5624.

comment

82 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 8<br>Paragraph: (1.1) Definitions |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>Scoop Factor (concentration factor). The ratio of nacelle inlet highlight area (AH) to the area of the captured air stream tube (AC) [scoop factor = AH/AC]. Scoop factor compares liquid water available for ice formation in the inlet, to that available in the low-pressure compressor or Engine core, as a function of aircraft forward airspeed and Engine power condition. The scoop factor affect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine.<br>**REQUESTED CHANGE:**<br>**Inertial Concentration factor** Scoop Factor (concentration factor). **The ratio of the captured droplet stream tube area (A0W) to the area of the captured air stream tube (A0) [concentration factor = A0W/A0].** The ratio of nacelle inlet highlight area (AH) to the area of the captured air stream tube (AC) [scoop factor = AH/AC]. **Concentration factor compares liquid water available for ice formation in the inlet, to that available in the free stream.** Scoop factor compares liquid water available for ice formation in the inlet, to that available in the low-pressure compressor or Engine core, as a function of aircraft forward airspeed and Engine power condition. **The inertial concentration** scoop factor **effect** affect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** The definition in the NPA appears to relate inconsistently between the engine intake scoop factor and a similar scoop factor for the core inlet. The requested change defines the scoop factor as applied to the engine intake and describing the change in the liquid water content in the intake compared to the freestream. |

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| | Scoop Factor is a term to describe the effects of water droplet or ice particle inertia which allows these particles to cross aerodynamic streamlines and increase or decrease the local water/air ratio into the engine inlet. This concentration factor will require the use of complex CFD codes to account for a secondary effect which will have little influence, if any, on the outcome of the test.<br>Scoop is a term used typically for rain/hail calculations and is reasonable to use in those cases since particle sizes and masses are relatively large (mass is proportional to diameter3: a typical 1500 micron raindrop is 1E6 times heavier than a 15 micron icing droplet. Drag is proportional to diameter2; inertia increase 10x faster than drag as size increases).<br>In icing clouds, the inertia effects are relatively minor since the small, light particles often can follow streamlines closely. It is recommended not to use the term Scoop Factor and instead refer to Inertial Concentration effects - or other term - to avoid confusion between different regulations. |

response

Not accepted.
The definition is harmonised with the proposed FAA AC 20-147A.

comment

84 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 9<br>Paragraph: (1.3) Test Configuration – Engine |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(1.3) Test Configuration – Engine<br>Because the Engine behaviour cannot easily be divorced from the effects of the Engine air intake and Propeller, where possible, it is recommended that the tests be conducted on an Engine complete with representative air intake, Propeller (or those parts of the Propeller which affect the Engine air intake), and Engine air data probes. Separate assessment and/or testing of the air intake, Propeller and air data probes are not excluded, but in such circumstances the details of the assumed Engine installation will be defined in the manuals containing instructions for installing and operating the Engine (under CS-E 20(d)). It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid for the particular installation, taking into account:<br>**REQUESTED CHANGE:**<br>(1.3) Test Configuration – Engine<br>Because the Engine behaviour cannot easily be divorced from the effects of the Engine air intake and Propeller, where possible, it is recommended that the tests be conducted on an Engine complete with representative air intake, Propeller (or those parts of the |

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| | Propeller which affect the Engine air intake), and Engine air data probes. Separate assessment and/or testing of the air intake, Propeller and air data probes **may be required** are not excluded, **and** but in such circumstances the details of the assumed Engine installation will be defined in the manuals containing instructions for installing and operating the Engine (under CS-E 20(d)). It would then finally be the responsibility of the aircraft manufacturer to show that the Engine tests would still be valid for the particular installation, taking into account: |
| **Why is your suggested change justified?** | **JUSTIFICATION:** The change is suggested because rigorous validation of the intake, propeller and air data probes may require separate assessment as their critical conditions may not coincide with the engine critical points. |
| **Affected paragraph and page number** | Page: 9<br>Paragraph: (1.3) Test Configuration – Engine |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The shedding into the Engine of air intake and Propeller ice of a size greater than the engine is able to ingest;<br>**REQUESTED CHANGE:**<br>**The demonstrated ice ingestion capability per this CSE** The shedding into the Engine of air intake and Propeller ice of a size greater than the engine is able to ingest; |
| **Why is your suggested change justified?** | **JUSTIFICATION:** This change is respectfully requested due to the airframer being the entity which assesses the max capability of the engine, and if it doesn't cover the potential sources from the airframe, the engine must be re-certified. |

response

First comment:
Not accepted.
The proposal does not change the meaning of the sentence.
Second comment:
Not accepted.
Please refer to the response to comment 12.

GE comment on Page: 9, paragraph 1.3:
The proposed text states: Test Configuration – Engine, statement made : "Apart from tests carried out under paragraph (6) of this AMC, the icing tests should be carried out with all ice protection systems operating, unless dispatch is to be permitted with some ice protection systems inoperative, in which case the tests should be carried out using the minimum dispatch configuration for flight in icing conditions.
REQUESTED CHANGE: Test Configuration – Engine, statement made : "Apart from tests carried out under paragraph (6) of this AMC, the icing tests should be carried out with all ice protection systems operating, unless dispatch is to be permitted with some ice protection systems inoperative, in which case the tests **(or tests augmented by analysis)** should be carried out using the minimum dispatch configuration for flight in icing conditions.

JUSTIFICATION: Analysis should be able to be used to augment the minimum dispatch configuration versus the configuration practically achievable for the test.

Response: Partially accepted. The sentence has been updated to require that the tests should address all configurations approved for aircraft dispatch.

comment 85 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page:10<br>Paragraph: (1.6) Applicable Icing Environments |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The applicable icing environments are those applicable to the aircraft on which the Engine is to be installed, defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate. This includes atmospheric icing conditions (including freezing fog on ground) and falling and blowing snow conditions. Falling and blowing snow conditions are defined in AMC 25.1093(b)<br>**REQUESTED CHANGE:**<br>The applicable icing environments are those applicable to the aircraft on which the Engine is to be installed, defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate. This includes atmospheric icing conditions (including freezing fog on ground) and falling and blowing snow conditions. Falling and blowing snow conditions are defined in AMC 25.1093(b), **and section (7) of this AMC** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** Since there have been engine compressor damage events related to snow ingestion during ground operations, it is respectfully suggested that some guidance be included for the applicant to assess these conditions. Please see Comment #6. |
| **Affected paragraph and page number** | Page:<br>Paragraph: Add guidance for falling and blowing snow |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>**REQUESTED CHANGE:**<br>**(7) – Falling and blowing snow**<br>**CSE-780 (a) requires that each engine, with all icing protection systems operating, operate satisfactorily in falling and blowing snow throughout the flight power/thrust range, and ground idle. Falling and blowing snow is a weather condition which needs to be considered for the powerplants and essential Auxiliary Power Units (APUs) of transport category aeroplanes.**<br>**Although snow conditions can be encountered on the ground or in flight, there is little evidence that snow can cause adverse effects in flight on turbojet and turbofan engines with traditional Pitot style air intakes where protection against icing conditions is provided.**<br>**However, service history has shown that ground snow (and mixed phase) conditions have caused power interruptions due to compressor damage as a result of exposure to prolonged periods of falling snow ingestion during ground operation. Based on our** |

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| | **review of service events we have found that airports have continuted to operate with falling snow concentrations that result in a 0.25 mile or less visibility (about 0.9 gm/m3).**<br>**Engine core icing in service events in snow conditions confirm the critical snow accretion temperature range is 26 to 32 F (-3 to 0 Celsius). Within this range, water content in the form of supercooled liquid drops is considered negligible. This environment is also conducive to ice accretion aft of the fan on the core inlet and first stages of the engine, at low engine power.**<br>**For turbofan engines, demonstration of compliance with the falling and blowing snow specification on ground should be conducted by tests and/or analysis.** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** There is a new snow test/analysis requirement which needs accompanying advisory material. The above suggestion is from the FAA draft AC20-147. A revision which is harmonized with the FAA to be published material, and includes assumptions for testing with liquid water in substitution for snow, and wind speed is also needed. |

response

First comment:
Not accepted.
Please refer to the response to comment 13.
Second comment:
Not accepted.
Please refer to the response to comment 14.

comment

100 comment by: Rolls-Royce plc (ZM)

1) Comment Summary
The definition of Freezing Fraction in the NPA is inconsistent with that in NASA CR 2005-213852 or the FAA Aircraft Icing Handbook. The change requested brings the definition in line with NASA CR 2005-213852.
Suggested Resolution
Replace definition with "The fraction of water flux entering a control volume that freezes within the control volume. The fraction is defined as a number between 0 and 1, and will determine the type of ice formation."

response

Not accepted.
The definition is harmonised with the proposed FAA AC 20-147A.

comment

101 comment by: Rolls-Royce plc (ZM)

2) Comment Summary
The definition "Mixed or Intermediate Ice" is not used in the NPA - "mixed phase" is frequently used and the only reference to "intermediate" appears to be when referring to the intermediate compressor.
Suggested Resolution

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| | Revise definition to be consistent with the NPA or NPA to be consistent with the definition. |
| response | Accepted.<br>The definition has been deleted as it is not used in the AMC. |

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| comment | 102 comment by: Rolls-Royce plc (ZM)<br><br>3) Comment Summary<br>Missing opening parenthesis in definition of ice shed cycles and the definition should be for "Ice Shed Cycle" to be consistent with the rest of the NPA<br>Suggested Resolution<br>"An ice shed cycle can be identified visually (for example, high-speed cameras), and Engine instrumentation (such as vibration pickups, temperature probes, speed pickups, etc.)." |
| response | Accepted. |

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| comment | 103 comment by: Rolls-Royce plc (ZM)<br><br>4) Comment Summary<br>Refine definition of Total Temperature<br>Suggested Resolution<br>Replace definition "Total Temperature" with "Total Air Temperature" to be consistent with Table 2 column heading, also "ram rise" should be "ram temperature rise" |
| response | Accepted. |

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| comment | 104 comment by: Rolls-Royce plc (ZM)<br><br>5) Comment Summary<br>Refine definition of Static (ambient) Air Temperature and include as part of the definition of Total Air Temperature<br>Suggested Resolution<br>"Static temperature" is only used in the definition of "Total Air temperature" and therefore should be addressed as part of the Total Air Temperature definition. Total Air Temperature is described as "The ambient temperature plus the ram temperature rise" and therefore ambient (static) temperature is the measured total air temperature less the ram temperature rise. |
| response | Not accepted. |

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| comment | 105 comment by: Rolls-Royce plc (ZM)<br><br>6) Comment Summary<br>The definition of scoop factor in the NPA appears to relate inconsistently between the engine intake scoop factor and a similar scoop factor for the core inlet. The term "scoop factor" can also be confusing, as it is normally applied to ballistic scenarios, such as hail ingestion. The requested change defines the concentration factor as applied to the engine intake and describing the change in the liquid water content in the intake compared to the freestream.<br>Suggested Resolution<br>Consider replacing with "Inertial Concentration Factor. The ratio of the captured droplet |

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| | stream tube area (A0W) to the area of the captured air stream tube (A0) [scoop factor = A0W/A0]. The inertial concentration factor compares liquid water available for ice formation in the inlet, to that available in the free stream. The inertial concentration factor effect depends on the droplet diameter, the simulated airspeed and the Engine power level as well as the geometry and size of the Engine." |
| response | Not accepted.<br>The definition is harmonised with the proposed FAA AC 20-147A. |

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| comment | 107 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>In cases where a change in Engine bleed or power offtake has no significant effect on icing, it will clearly not be possible to determine the "most critical" condition, but testing at all such conditions would be inappropriate as the results obtained would be of equal severity. It is therefore suggested that supplementary tests should only be required where the test results would be expected to be sufficiently different.<br>Comment Resolution<br>Replace "If it is not possible to establish clearly which position is most critical, the test should be repeated to ensure satisfactory operation in all permitted configurations." with "If it is not possible to establish clearly which condition is most critical, the test should be repeated to ensure satisfactory operation in all permitted configurations considered to be critical and for which different test outcomes are predicted" |
| response | Partially accepted.<br>The sentence has been updated by adding 'if necessary, in order to ensure satisfactory operation in all permitted configurations'. |

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| comment | 108 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Reference to CS-E 780(b) appears incorrect<br>Comment Resolution<br>Replace reference to CS-E 780(b) with CS-E 780(c) |
| response | Not accepted.<br>The reference is correct; please refer to the updated rule text in CRD 2011-04. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (pp. 10-15)** p. 10-15

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| comment | 5 comment by: Vereinigung Cockpit / German ALPA<br><br>**Table 1**<br>MED (Mean Effective Diameter) is not defined under definitions above.<br>For icing tests an unrealistic atmosphere with homogenous droplet diameters could be used disregarding larger and smaller sizes. Consequently a value indicated under Mean Effective Droplet Diameter is only acceptable, if a natural spectrum of droplet sizes is also mandatory. |

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| response | Partially accepted.<br>A definition has been added adopting the SAE ARP5624 definition. |

GE comment on page: 13, table 1:
The proposed text states: Table 1
REQUESTED CHANGE: Add clarification to Table 1. Are the conditions averages over the test point or minimums or maximums? What are the appropriate ranges and/or minimum values for all the conditions in Table 1.
JUSTIFICATION: It is impractical to conduct a test at the specified LWC, MEDD and temperature without allowances for variations due to environmental conditions and test facility capability especially for alternating clouds. A applicant will not be able to determine if the conditions are met without additional guidance provided in this AMC.

Response: Not accepted.
The standard test points table is already present in the current AMC E 780, and it should be used as a set of objectives to be reached making the best use of available tools. The Agency does not consider there is a need to prescribe tolerances based on experience from previous certification projects.

GE comment on page: 10, paragraph (1.6):
The proposed text states: If repeat build/shed cycles have been established, the acceleration should be delayed to maximise the impact energy of the ice shed.
REQUESTED CHANGE: If repeat build/shed cycles have been established, the acceleration should be delayed to maximise the impact energy of the ice shed.
JUSTIFICATION: It is not clear how to execute the certification test when repeated ice build/shed cycles are encountered. The requirement is subject to interpretation and can be impractical on test depending on the period of the build/shed cycles. The criteria used to determine a build/shed cycle relative to maximize the impact energy of the shed is impractical during the execution of the test point.

Response: Not accepted.
The Agency considers that the objective of this statement is clear. It is agreed that, depending on the characteristics of the build/shed cycle, the determination of the optimum time to initiate the acceleration may not be simple to establish. The Agency cannot prescribe a methodology which could fit all the possible build/shed cycles; it is expected that the applicant analyses it and determines the best timing for the acceleration. We do not agree to delete this statement as we want to ensure that the applicant considers the timing of the acceleration.

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| comment | 15 comment by: Boeing<br><br>Page: 10<br>Paragraph: (2.1) Critical Point Analysis<br><br>The proposed text states:<br>The CPA test points can replace the standard Table 1 test points below when they can be shown to be equivalent or more severe. Otherwise they supplement the Table 1 standard test points.<br><br>**REQUESTED CHANGE:**<br>The CPA test points can replace the standard Table 1 test points below when they can be |

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| | shown to be equivalent or more severe. Otherwise they supplement the Table 1 standard test points. **Where a CPA test point is at a similar condition to a Table 1 test point, the more severe of these should be demonstrated.**<br><br>**JUSTIFICATION:** We suggest that if a CPA point is similar to, but less severe than, a Table 1 point, then only the Table 1 test point should need to be tested. |
| response | Accepted. |

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| comment | 16 comment by: Boeing<br><br>Page: 11<br>Paragraph: (2.1) (a) (ii) General principle<br><br>The proposed text states:<br>The CPA should also include an energy balance of critical engine surfaces (for example, latent heat and heat of fusion effects, metal-to-ice heat transfer effects, and ice insulating effects).<br>**REQUESTED CHANGE:**<br>Delete this statement.<br><br>**JUSTIFICATION:** In practice, this analysis has not been conducted as part of the CPA for unheated engine parts for past certification programs for many legacy engines. As a general rule, the parts within an aircraft engine that will accrete ice are known. For example, it adds no value to conduct an energy balance for the inlet guide vane to the low pressure compressor, as it is a known icing location. |
| response | Not accepted.<br>An energy balance assessment of unheated critical Engine surfaces is considered necessary. |

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| comment | 17 comment by: Boeing<br><br>Page: 11<br>Paragraph: (2.1) (a) (iii) General principle<br><br>The proposed text states:<br>(iii) For anti-iced parts, the CPA should identify a critical test point determined from energy balance calculations of required heat loads encompassing the range of possible combinations of icing condition and Engine power/thrust. In glaze ice conditions, assessing the effects of non-aerodynamic ice formations and their shedding is more complex<br>**REQUESTED CHANGE:**<br>(iii) For anti-iced parts, the CPA should identify a critical test point determined from energy balance calculations of required heat loads encompassing the range of possible combinations of icing condition and Engine power/thrust. In glaze ice conditions, assessing t**The** effects of non-aerodynamic ice formations and their shedding, is more complex **as well as runback ice shedding, should be assessed.**<br><br>**JUSTIFICATION:** We suggest that the engine manufacturer should account for the possibility of runback ice forming as a result of the internal engine ice protection system and shedding into the engine**;** glaze ice is not the only type of icing to be assessed. |

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| response | Accepted. |

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| comment | 18 comment by: Boeing<br><br>Page: 11<br><br>Paragraph: (2.1)(b) (i) (B) Compressor Damage<br>The proposed text states:<br>When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50%, 75% or 100% of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition.<br><br>**REQUESTED CHANGE:**<br>When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they **the critical condition may** occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50%, 75% or 100% of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition.<br><br>**JUSTIFICATION:** We suggest that the applicant should find the critical condition, which may or may not be a glaze ice condition. |
| response | Accepted. |

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| comment | 19 comment by: Boeing<br><br>Page:12<br>Paragraph: (2.2) Establishment of Test Points for In-Flight Operation<br><br>The proposed text states:<br>The test conditions outlined below are intended as a guide to establish the minimum testing necessary to comply with CS-E 780. These test points should be supplemented or, if applicable replaced, by any test points identified by the CPA as applicable.<br>**REQUESTED CHANGE:**<br>Move this text to paragraph (1.6) and make it clear that the CPA is now expected. |

**JUSTIFICATION:** Within the advisory material, it is not clear what the minimum number of test points are. Our suggested change would clarify this.

response

Not accepted.
This sub-paragraph has to remain within paragraph 2. ('Supercooled Liquid Water Icing Conditions') as it has been created for this purpose. The reference to the requirement for a CPA is included in the second sentence of 2.2,.

comment

20 comment by: Boeing

Page:12
Paragraph: (2.2) (a)

The proposed text states:
… If an acceptable means to predict the critical fan speed is not available tests at 50%, 75% and 100% of maximum, continuous power/thrust should be run.
**REQUESTED CHANGE:**
… If an acceptable means to predict the critical fan speed is not available tests at 50% **and** 75% and 100% of maximum continuous power/thrust should be run.

**JUSTIFICATION:** We suggest that "100%" be removed, as it has never proven to be a critical point, and it increases applicant costs unnecessarily, as well as increasing test facility costs, to be able to test at sustained high power. If the engine is not tested at 100%, we recommend that the engine probe, which might be critical at high airflows, must be assessed separately.

response

Not accepted.
The 100 % thrust/power point is required only in the case where an applicant is not able to determine the critical fan speed.

comment

21 comment by: Boeing

Page: 12
Paragraph: (2.2) (a) (ii)

The proposed text states:
(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed
**REQUESTED CHANGE**:
Delete this paragraph.

**JUSTIFICATION:** We suggest that the requirement of paragraph (ii) be deleted, as retaining the requirement would:

- allow for an unrealistically short duration of cycles,
- pose challenges to accomplish accurately in a test facility, and

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| | • result in a very severe test. |
| response | Not accepted.<br>This alternative test is already present in the current AMC E 780 and some Engine manufacturers have been using it. Note that this is still an alternative option. |

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| comment | 22 comment by: Boeing<br><br>Page: 13<br>Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight<br>The proposed text states:<br>(b) Tests points at power/thrust below that required for sustained flight<br>If the test points of (2.2) (a) are carried out at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br>**REQUESTED CHANGE:**<br>(b) Tests points at power/thrust below that required for sustained flight<br>If the test points of (2.2) (a) are carried out **repeated** at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br><br>**JUSTIFICATION:** We request that EASA clarify this requirement in order to ensure that the applicant does not assume that just three minimum power points are needed for certification. |
| response | Not accepted.<br>The changes made to improve paragraph 2.2 led us to delete the sentence subject to this comment. |

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| comment | 23 comment by: Boeing<br><br>Page:13<br>Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight [2nd paragraph]<br><br>The proposed text states:<br>… Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle<br>**REQUESTED CHANGE:**<br>… Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure **splitter**/core **inlet** icing, consisting of repetitions of the following cycle<br><br>**JUSTIFICATION:** We recommend this refinement of terms as indicated. Due to terminology differences between manufacturers, the word “core” could be misinterpreted to mean the high pressure compressor (HPC); whereas, the terminology intended is actually the “splitter” and the “inlet” to the propulsor. |
| response | Accepted. |

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| comment | 24 comment by: Boeing<br><br>Page: 13<br>Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight [3rd paragraph]<br><br>The proposed text states:<br>… A 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes<br>**REQUESTED CHANGE:**<br>… A **6 28** km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes<br><br>**JUSTIFICATION:** Our suggested change results in a more realistic ratio of continuous maximum icing and intermittent maximum icing distances.<br>Engines tested to the existing regulations are not known to have any icing problems through supercooled water droplets in descent conditions and, therefore, we are not aware of a need to increase the severity of such tests. The test in the NPA produces a water exposure of approximately 280% of the existing AMC E 780 (paragraph 8.b.) test, an increase which appears to be unnecessary.<br>It is noted that the test outlined in the NPA corresponds to the existing hold power test in AMC E 780 (paragraph 3.b.) and thus, to the current regulations, would certify the engine for continuous operation -- which is surely not the case, as an aircraft at this power cannot sustain level flight.<br>A cycle of Max Continuous and Max Intermittent water contents will occur approximately every 70 seconds at flight speeds and temperatures typical of a descent profile. Such changing of the water content on average every 35 seconds is impractical in some test facilities and will result in poor control over the test.<br>We further note that the test described in this NPA is inconsistent with that of the FAA's parallel NPRM (Notice 10-10) and is substantially more severe than the FAA tests for core inlet icing. The FAA NPRM, in §33.68.c., calls for a total air temperature of between -6°C and -4°C in the Table 1 test at 2 gm3, which may not lead to significant core inlet icing and will result in a low ice adhesive strength if ice does indeed form.<br><br>FAA's §33.68.b.2.ii.A. calls for a descent test, which is similar in nature to the existing EASA AMC E 780 (paragraph 8) test. Therefore, the proposal outlined in NPA 2012-23 appears to be inappropriate and substantially more severe than required by the FAA. |
| response | Accepted.<br>The 28 km proposal has been adopted. The 10 minutes minimum duration of the test has been changed to the current AMC E 780 provision , ie 'for sufficient duration to cover an anticipated descent of 3 000 m'. The reason for this change is that a 3 000 m descent is more meaningful in terms of an operational descent scenario and it gives the freedom to the Engine and aircraft manufacturers to define the descent profile. |

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| comment | 25 comment by: Boeing<br><br>Page: 13 |

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| | Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight [5th paragraph]<br><br>The proposed text states:<br>… At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing.<br>**REQUESTED CHANGE:**<br>… At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed **an** acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing.<br><br>**JUSTIFICATION:** We suggest that the engine should be accelerated from the test power setting to maximum power. It is not clear what the purpose of timing the acceleration is, if there is no time requirement. In addition, if there were a requirement, the results from a ground test facility would not be representative of an in-flight acceleration. |
| response | Accepted.<br>The proposed wording was based on the current paragraph (9) of AMC E 780, but we agree with the proposed simplification. |

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| comment | 26 comment by: Boeing<br><br>Page: 13<br>Paragraph: (2.2) (c) Test Installation Considerations<br><br>The proposed text states:<br>Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is the preferred method of compliance because this approach enables the test to be carried out in the most representative way, requiring the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe.<br>**REQUESTED CHANGE:**<br>Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is the preferred **a** method of compliance because this approach enables the test to be carried out in the most representative way, requiring **with** the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe.<br><br>**JUSTIFICATION:** We recommend that no preference for altitude facilities be indicated, as both ground simulations and altitude simulations have their advantages and challenges. |
| response | Partially accepted.<br>The sentence has been updated to read: 'Therefore the use of an altitude test cell is the most |

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| | direct method of compliance because this approach enables the test to be carried out in the most representative way, requiring the minimum of correction to correlate Engine and icing test conditions to the real operating environment.' |
| comment | 27 comment by: Boeing<br><br>Page:14<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation [2nd paragraph]<br><br>The proposed text states:<br>… The conditions established during the test, in terms of time, temperature and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met<br>**REQUESTED CHANGE:**<br>… The conditions established during the test, in terms of time, temperature **(if a limitation exists)** and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met.<br><br>**JUSTIFICATION:** A clarification is needed, as this paragraph precedes the paragraph that allows an analytical means to show lower temperatures are not more critical. |
| response | Partially accepted.<br>A new sentence has been added stating that an analysis may be performed to demonstrate that ambient temperatures below the tested temperature are less critical. |
| comment | 28 comment by: Boeing<br><br>Page:14<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation<br><br>Add the following text to this paragraph:<br>**The applicant may demonstrate unlimited capability if measurement evidence can prove the engine is free of ice after the run-up.**<br><br>**JUSTIFICATION:** This additional text is requested in order to allow for the possibility that the run-up is an adequate ice clearing procedure. |
| response | Accepted.<br>A new sentence has been added providing the applicant with the possibility to demonstrate unlimited time operation if complete ice shedding is shown to have occurred during the test, either through repeatable ice build/shed cycles or by using a run-up procedure. |

Cessna comment on paragraph (2.3):
If a repeatable, non-hazardous build/shed cycle can be demonstrated then there should be no time limit imposed on operation.
If colder temperatures can be validated analytically, then that should be allowed instead of imposing a temperature limitation on the engine based on solely the ground test points defined in Table 2 and the actual conditions tested.

Suggested Change:
The conditions established during the test, in terms of time, temperature and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met. **If a repeatable, non-hazardous build/shed cycle is demonstrated, then the time of the test need not be defined as an operating limitation.**
**The temperature conditions during the test will be deemed to be an operating limitation unless an analysis can be completed showing colder temperatures are not more critical than the temperature during the test.**
In order to avoid any unsafe condition resulting from operation outside the demonstrated conditions, these limitations will be defined in the manuals containing instructions for installing and operating the engine.

Response: Partially accepted.
Concerning the temperature limitation, the original sentence is maintained but a new sentence has been added stating that an analysis may be performed to demonstrate that ambient temperatures below the tested temperature are less critical.
A new sentence has been created providing the applicant with the possibility to demonstrate unlimited time operation if complete ice shedding is shown to have occurred during the test, either through repeatable ice build/shed cycles or by using a run-up procedure.
We have also updated the first paragraph so that the acceleration to take-off power or thrust should be performed at the time when the maximum ice accretion is likely to have occurred.

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| comment | 29 comment by: Boeing<br><br>Page: 14<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation<br><br>Add the following text to this paragraph:<br>**In addition to the requirements of CS E 780(a)(1)-(4), any elevated engine vibration during the test must be compared to the certified tolerance of the engine, and communicated to the airframe manufacturer for their acceptance.**<br><br>**JUSTIFICATION:** We request that the additional text above be added, as high vibrations need to be communicated in order that the airframe manufacturer can ensure that the airplane systems are designed to tolerate such levels. |
| response | Partially accepted.<br>The requirement to include vibration effects in the installation manual has been added in paragraph (7). |

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| comment | 30 comment by: Boeing<br><br>Page: 15<br>Paragraph: Table 2 – Demonstration Methods for Specific Icing Conditions<br><br>• Row: 2. Glaze Ice Condition<br>• Column: Total Air Temperature<br><br>The proposed text states:<br>-7 to -1 °C<br>(20 to 30 °F)<br>**REQUESTED CHANGE:** |

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| | -7 to -1 °C **-9 to -1 °C**<br>(20 to 30 °F) **(15 to 30 °F)**<br><br>**JUSTIFICATION:** We believe that there is a typographical error in the temperature range listed for the glaze ice condition. It should define the temperature range as 15° to 30° F or -9° to -1° C, to be consistent with the FAA. (It is expected that this change will be accepted after the NPRM comment review.) |
| response | Accepted. |

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| comment | 31 comment by: Boeing<br><br>Page: 15<br>Paragraph: Table 2 - Demonstration Methods for Specific Icing Conditions<br><br>• Row: 4. Large drop glaze ice condition (Turbojet, turbofan, and turboprop only)<br>• Column: Mean Effective Particle Diameter<br><br>The proposed text states:<br>100 µm (minimum)<br>**REQUESTED CHANGE:**<br>100 µm (minimum)<br>**3000 µm maximum**<br><br>**JUSTIFICATION:** A range of drops allows flexibility depending on whether the applicant is using test or analysis. Our suggested change is necessary in order to be consistent with the FAA's parallel requirements. (It is expected that this change will be accepted after the FAA-NPRM comment review.) |
| response | Accepted. |

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| comment | 43 comment by: Boeing<br><br>Page: 12<br>Paragraph: (2.2) (a)<br><br>The proposed text states:<br>(a) Tests points to demonstrate icing capability at a power/thrust at or above that required for sustained flight<br>One test point should be run to simulate each of the conditions of Table 1 at an Engine operating condition no higher than the minimum power/thrust to maintain sustained flight in the intended installation. …<br><br>**REQUESTED CHANGE:**<br>Please clarify this paragraph. The title indicates that above thrust is required for sustained flight, but the text states "no higher than minimum power" is needed to sustain flight.<br><br>**JUSTIFICATION:** We request that the text be clarified, as the sentence suggests that minimum idle could be used. If minimum idle is used, Paragraph (2.2) (b) suggests that the |

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| | applicant need not conduct any further testing -- which would not result in a rigorous certification program. |
| response | Accepted.<br>The first paragraph is updated to state that: 'One test point should be run to simulate each of the conditions of Table 1 at the Engine minimum power/thrust to maintain sustained flight in the intended installation.' |

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| comment | 47 comment by: AIRBUS<br><br>Section 2.1.a<br>Current text:<br>None<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Method and tools description and validation demonstration used as part of CPA shall be included in certification dossier.<br>Rationale/justification:<br>Need for tools validation demonstration. |
| response | Accepted.<br>A new sentence has been inserted to state that compliance evidence should include a description of the methodology and tools used as part of the CPA. The validation of these tools should also be addressed. |

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| comment | 48 comment by: AIRBUS<br><br>Section 2.1.a<br>Current text:<br>The CPA test points can replace the standard Table 1 test points below when they can be shown to be equivalent or more sever. Otherwise they supplement the Table 1 standard test points<br>EIWG/AIA proposed text:<br>Where a CPA test point is at a similar condition to a Table 1 test point, the more severe of these should be demonstrated<br>Airbus proposed text:<br>The CPA test points supplement the Table 1 standard test points<br>Rationale/justification:<br>The robustness of the engine testing is critical to the success of the Part 25 certification demonstration and in-service operation.<br>The AMC as written does not explicitly require the critical test conditions identified by the CPA to be tested. On the other hand it does allow the standard in flight test points to be reduced if a CPA test is shown to be more critical. This could lead to a reduction in the existing conservatism.<br>The quality of the CPA potentially has a significant impact upon the robustness of the certification test program. Different applicants have different CPA methodologies which could consequently lead to varying levels of testing. It is therefore strongly recommended that very detailed CPA criteria should be put in place before allowing test points to be reduced on the basis of such analyses. |

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| | The Table 1 standard test points should be considered as a minimum and typically additional tests are needed to address all aspects of engine icing. It is not necessary to define additional mandatory test conditions as each engine configuration has its own specific critical points and hence additional tests should be based on the CPA results. It is necessary to allow some flexibility but the basic tests of Table 1 are unlikely to be the only critical test conditions. |
| response | Not accepted.<br>We have adopted the proposal of the Engine Icing Working Group (EIWG), stating that where a CPA test point is in a similar condition to a Table 1 test point, the more severe of the two should be demonstrated. |

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| comment | 49 comment by: AIRBUS<br><br>Section 2.2.a<br>Current text:<br>The test conditions outlined below are intended as a guide to establish the minimum testing necessary to comply with CS-E 780. These test points should be supplemented or, if applicable replaced, by any test points identified by the CPA as applicable<br>EIWG/AIA proposed text:<br>Move this text to section 1.6 an make it clear that CPA is now expected<br>Airbus text:<br>The test conditions outlined below are intended as a guide to establish the minimum testing necessary to comply with CS-E 780. These test points should be supplemented by test points identified by the CPA as applicable.<br>Rationale/justification:<br>See comment on Section 2.1.a |
| response | Not accepted.<br>Please refer to the response to comment 48 of yours. |

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| comment | 50 comment by: AIRBUS<br><br>Section 2.2.a<br>Current text:<br>If an acceptable means to predict the critical fan speed is not available tests at 50%, 75% and 100% of maximum continuous power/thrust should be run<br>EIWG/AIA proposed text:<br>If an acceptable means to predict the critical fan speed is not available tests at 50% and 75% of maximum continuous power/thrust should be run<br>Airbus proposed text:<br>If an acceptable means to predict the critical fan speed is not available tests at 50%, 75% and 90% of maximum continuous power/thrust should be run<br>Rationale/justification:<br>Airbus disagrees with the assertion that high power (around MCT) has never been the critical point. Airbus has experience with undesirable engine behaviour in icing conditions in climb phases with engines at max climb power. Hence it is recommended to keep a test point around this level of power/thrust. |
| response | Not accepted.<br>We agree that the high power point should be maintained. We keep the existing 100 % |

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| | thrust/power point which is required when the applicant has not identified a critical fan speed. |
| comment | 52 comment by: AIRBUS<br><br>Section 2.2.b<br>Current text:<br>None<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Add: Any adverse effect (vibrations, thrust loss, etc…) that may lead to operational limitations or to a need for extended qualification of aircraft systems, shall be recorded during the tests and documented in test report.<br>Rationale/justification:<br>May lead to operational limitations and/or enhanced qualification need for aircraft systems. |
| response | Partially accepted.<br>We have added a new bullet in paragraph (7) ('Instructions for Installing and Operating the Engine') referring to the effects that may be observed during or after the icing conditions' encounter, such as vibrations, temporary power/thrust loss, change in Engine power/thrust response. |
| comment | 57 comment by: AIRBUS<br><br>Section 2.2.b<br>Current text:<br>If the test points of (2.2)(a) are carried out at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br>Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle:<br>A 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes.<br>If the temperature required to ensure core icing is below an ambient temperature of -10°C the LWC should be determined by interpolating between the conditions defined in Table 1.<br>EIWG/AIA proposed text:<br>If the test points of (2.2)(a) are carried out repeated at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br>Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure splitter/core inlet icing, consisting of repetitions of the following cycle:<br>A 6 28 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes.<br>If the temperature required to ensure core icing is below an ambient temperature of -10°C the LWC should be determined by interpolating between the conditions defined in Table 1.<br>Airbus proposed text: |

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| | If the test points of (2.2)(a) are carried out repeated at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br>Otherwise, an additional tests at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure the critical ambient temperature necessary to ensure splitter/core inlet icing, consisting of repetitions of the following cycle. The following conditions must be tested:<br>A 6 28 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes.<br>A run at the –10°C liquid water content condition of Table 1 Column (a), for sufficient duration to cover an anticipated descent of 3 000 m, at the critical level of airspeed and air temperature<br>A run to test an high altitude 'rime ice' condition, at an ambient temperature of -25°C, a minimum LWC of 1g/m3 and a median volume drop diameter of 15 microns, for a total duration of 10 minutes.<br>If the temperature required to ensure core icing is below an ambient temperature of -10°C the LWC should be determined by interpolating between the conditions defined in Table 1.<br>Rationale/justification:<br>Airbus considers that, consistently with the US FAR 33.68 approach, more than one test point must be conducted at the minimum engine idle power, since this condition is critical for core inlet icing. Airbus recommends that better FAR/CS harmonization be achieved on this topic at the occasion of the present rulemaking effort. Hence the proposal for requiring as a minimum three test points at the minimum engine idle power. It is not reasonable to certify engines on the basis of only one test at this low power considering the criticality of the condition.<br>The proposed conditions are a merge of the FAR 33.68, current AMC E 780 and EIWG/AIA proposal and are considered by Airbus (based on experience) as providing a robust demonstration for the engine. |
| response | Partially accepted.<br>We have updated paragraphs (2.2)(a) and (2.2)(b) in a way that (2.2)(b) is not anymore optional.<br>The 28 km proposal has been adopted. The 10 minutes minimum duration of the test has been changed to the current AMC E 780 provision , ie for sufficient duration to cover an anticipated descent of 3 000 m'. The reason for this change is that a 3 000 m descent is more meaningful in terms of an operational descent scenario and it gives the freedom to the Engine and aircraft manufacturers to define the descent profile.<br>The second proposed point on glaze ice conditions is considered to be covered by the first point.<br>The third point proposing rime ice conditions has not been adopted as it would add significant conservatism to the current test assumptions of the proposed AMC (e.g. account of the forward speed and altitude). |

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| comment | 61 comment by: Turbomeca<br><br>B -.I - .SUBPART E- Turbine engines; type substantiation-AMC E 780 – (2) (2.1) (b)(ii) Engine Operability and Compressor rematch:<br>It is proposed to modify current text as follows:<br>Engine Operability and Compressor Rematch. Ice shed from upstream components may enter the core compressor. The presence of ice or water from melted ice in the gas path may |

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| | cause Engine component cycle changes. Additionally, the Engine should be capable of accelerating from minimum flight idle and ground idle to take-off power/thrust in any icing condition, without power/thrust loss or instability (surge or stall). Ice sheds should not result in flameout, rollback, or surge. **Acceptable engine operation precludes continued or non-recoverable surge or stall. A momentary /pop surge or stall that arrests itself without operational intervention (e.g. without throttle manipulation) is acceptable**. Any anomalous Engine behaviour should be reported to the Agency for evaluation and if found acceptable, it should be documented in the manuals containing instructions for installing and operating the Engine. The applicant should consider as part of their CPA Engine accelerations and decelerations relative to operability challenges (for example, surge and stall). The minimum Engine bleed schedule allowed for the condition being tested should be assumed to minimize the operability margin. CPA testing should demonstrate those conditions where the minimum operability margin is expected.<br>Explanation:<br>Saying that any surge or stall is not acceptable is too simply and is not a satisfactory wording. This AMC should clarify which types of surge/stall are not acceptable in line with CS-E 500(a) which says "the engine must be free from dangerous surge and instabilities" and also in line with AMC E 790 (a)(2)(5)(c)(vi) – acceptance criteria – which says "Acceptable engine operation precludes….continued or non-recoverable surge or stall. A momentary surge or stall that arrests itself without operational intervention (e.g. without throttle manipulation) is acceptable”".<br>Acceptance criteria in icing conditions should be consistent with acceptance criteria for operation in raining conditions. Therefore for consistency within CS-E , it is proposed to use the same wording as the one already used in AMC 790. |
| response | Not accepted.<br>This part of the paragraph has been removed to focus on how to determine the critical test conditions, but the pass/fail criteria are not to be mentioned here. |

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| comment | 62 comment by: Turbomeca<br><br>B – I – SUBPART E - Turbine engines; type substantiation - AMC E 780 – (2) (2.2) second subparagraph – Establishment of test points for in-Flight Operation:<br>It is said: "than those implied by the icing atmospheric conditions of CS-Definitions". It is not understood why it is made reference to CS-definitions whereas CS-E 780 (NPA 2011-04) refers to the CS-X of Aircrafts (CS 23/25/27/29). Therefore it is proposed to replace the reference to "CS-Definitions" by reference to " CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate." |
| response | Partially accepted.<br>The intent was to refer to the currently used Supercooled Liquid Water Icing Conditions, i.e. the ones provided in CS-Definitions, Appendix C to CS-25 and Appendix C to CS-29. Note that CS-27 makes reference to Appendix C to CS-29 and CS-23 refers to CS-Definitions.<br>The text has been revised to clarify our reference. |

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| comment | 63 comment by: Turbomeca<br><br>B – I – SUBPART E - Turbine engines; type substantiation - AMC E 780 – (2) (2.2) – Establishment of test points for in-Flight Operation - second subparagraph:<br>In §1.6 it is said: |

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| | "(1.6) Applicable Icing Environments<br>The applicable icing environments are those applicable to the aircraft on which the Engine is to be installed, defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b) as appropriate."<br>This wording is consistent with the "rule" of CS-E 780 ((NPA 2011-04).<br>However, second § of §2.2 says:<br>" The conditions of horizontal and vertical extent and water concentration defined below are **somewhat more severe** than those implied by the icing atmospheric conditions of CS-Definitions. **Encounters with icing conditions more severe that those defined are considered possible**".<br>. Therefore the AMC would require more than required by the rule. This means that the AMC explicitly says that the rule is not correct. An AMC cannot have requirement more severe than requirement of the rule part.<br>Therefore §2.2 of this AMC should be modified in order to be consistent with CS-E 780. |
| response | Not accepted.<br>The statement reflects the already existing situation; please refer to paragraph (2) of AMC E 780 in Amendment 3, which includes the same sentence with regard to Table 1. This statement remains valid. The additional severity of the Table 1 conditions is limited to an increase of the droplet size from 15 to 20 µm without adjusting the LWC, for continuous maximum conditions only. |

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| comment | 71 comment by: FAA<br><br>Page: 12 of 20<br>Paragraph: (2.2)(a) Test points to demonstrate icing capability at a power/thrust at or above that required for sustained flight.<br>**The proposed text states**: "One test point should be run to simulate each of the conditions of Table 1 at an Engine operating condition no higher than the minimum power/thrust to maintain sustained flight in the intended installation. For turbofan Engines, a second point should be run at a higher power/thrust condition, ..."<br>**REQUESTED CHANGE:** It is recommended that multiple power levels should be run at each table condition. It is recommended to run, flight idle, 50% MC and 75% MC as a minimum at each icing condition.<br>**JUSTIFICATION:** The proposed wording could result in non-turbofan engines only running three flight icing conditions, all potentially at flight idle descent. Flight idle descent power alone is insufficient to fully evaluate engine operation in-flight during icing conditions. Also, a 45-minute flight idle descent test does not seem realistic or helpful in fully evaluating an engine's icing capability.<br>Page: 12 of 20<br>_____<br>Paragraph: (2.2)(a) Test points to demonstrate icing capability at a power/thrust at or above that required for sustained flight.<br>**The proposed text states**: "For turbofan Engines, a second point should be run at a higher power/thrust condition, if it is predicted to result in a higher energy of ice shed from the fan blades. If an acceptable means to predict the critical fan speed is not available tests at 50 %, 75 % and 100 % of maximum continuous power/thrust should be run."<br>**REQUESTED CHANGE:** We recommend that multiple power levels should be run at each table condition. The multiple power levels should include, as a minimum, flight idle, 50% MC and 75% MC as a minimum at each icing condition. We recommend removing the option for |

predicting the critical fan speed.
**JUSTIFICATION:** The proposed wording appears to assume that the kinetic energy from shed ice is the primary threat from inflight icing for turbofan engines. Shed ice mass energy is not the only threat from inflight icing. Additionally there is core ice accretion and the resulting shed which can cause flameout, damage, or surge/stall. All of these threats should be assessed through test during compliance demonstration.

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Paragraph: (2.2)(a)(ii) Test points to demonstrate icing capability at a power/thrust at or above that required for sustained flight.
**The proposed text states**: "6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) ..."
**REQUESTED CHANGE:** Instead of rapidly cycling between 6 km and 5 km, it is recommended to use a single LWC value in a steady state condition for the defined time period.
**JUSTIFICATION:** The proposed cycle of 6 km followed by 5 km horizontal cloud extents would be very difficult to perform in an actual engine test and it is not clear exactly what flight scenario it is intended to represent.

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Page: 13 of 20
Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight.
**The proposed text states**: "… descent in icing conditions should be conducted at an ambient temperature of -10°C ...."
**REQUESTED CHANGE:** It is recommended that multiple ambient conditions should be run including a rime condition to supplement the proposed glaze ice condition.
**JUSTIFICATION:** The proposed wording only provides a glaze ice condition of -10 C ambient, which is approximately a 0 C total inlet temperature. A descent in rime ice conditions near a total temperature of -18 C should also be evaluated.

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Page: 13 of 20
Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight.
**The proposed text states**: "At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing."
**REQUESTED CHANGE:** We recommend deleting the requirement to reset the power lever to flight idle before the burst to power for shed.
**JUSTIFICATION:** The proposed wording potentially would require the applicant to pull the power lever back to flight idle prior to bursting to high power for shed. This is not representative of either an actual throttle motion nor is it representative of a typical shed procedure, and therefore introduces a new variable in a standard icing test.

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Page: 13 of 20
Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight.
**The proposed text states**: "At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing."
**REQUESTED CHANGE:** We recommend removing the term "timed acceleration".
**_JUSTIFICATION:** An icing test is typically not equipped to perform timed accelerations, due

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| | to both the engine configuration and the test facility accommodation for icing testing. Also the engine is not typically configured as it would necessarily be in flight with the representative horsepower extraction and customer bleed air extraction.<br>_____<br>Page: 13 of 20<br>Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight.<br>**The proposed text states**: "At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing.."<br>**REQUESTED CHANGE:** We recommend replacing the term "maximum power/thrust" with "maximum continuous power".<br>**JUSTIFICATION:** The proposed wording would require the applicant to burst to full power and not maximum continuous power, as is normally the case. This is not representative of either an actual throttle motion nor is it representative of a typical shed procedure, and therefore introduces a new variable in a standard icing test.<br>_____<br>Page: 13 of 20<br>Paragraph: (2.2) (b) Tests points at power/thrust below that required for sustained flight.<br>**The proposed text states**: "Whenever a minimum power/thrust is required for safe operation of the Engine in icing conditions, the applicant should ensure that this minimum power/thrust will be selected when the aircraft is operating in icing conditions. If any action is required from the installer to fulfill this requirement, then the minimum power/thrust should be declared as a limitation in the manuals containing instructions for installing and operating the Engine."<br>**REQUESTED CHANGE:** We recommend adding clarification that the engine manufacturer should work with the installer to provide an automatic means to set this minimum power/thrust.<br>**JUSTIFICATION:** A flightcrew procedure to manually reset throttle to a higher power setting is not acceptable to meet this requirement for a 14 CFR part 25 installer. The applicant and installer should coordinate how to best implement this automatic feature without throttle lever movement.<br>_____<br>Page: 14 of 20<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation<br>**The proposed text states**: "In order to avoid any unsafe condition resulting from operation outside the demonstrated conditions, these limitations will be defined in the manuals containing instructions for installing and operating the Engine."<br>**REQUESTED CHANGE:** We recommend adding "The applicant should also set the engine accessory loads, including horsepower and customer bleed air extraction, to the most critical condition during the operation and run up procedures."<br>**JUSTIFICATION:** The installer may need to reevaluate the engine run up procedures if accessory loads are increased when the engine is installed. The applicant and installer should coordinate the accessory loads if possible to reduce testing.<br>_____ |
| response | Comment 1 on Paragraph (2.2)(a), recommending that multiple power levels should be run at each table condition.<br>Response: Partially accepted.<br>We have updated paragraph 2.2(a) in a way that one point is required at holding power, and, |

for turbofan engines, either a second point at the critical fan speed or three additional points at 50 %, 75 % and 100 % of maximum continuous power/thrust. Furthermore, paragraph 2.2(b) has been updated to require an additional test for descent at minimum power/thrust.

Comment 2 on Paragraph (2.2)(a), recommending that multiple power levels should be run at each table condition and removing the option for predicting the critical fan speed.
Response: Partially accepted.
Please refer to our response above. The critical fan speed option is maintained. The core icing susceptibility is addressed through the test for descent at minimum power/thrust.

Comment 3 on Paragraph (2.2)(a)(ii): Instead of rapidly cycling between 6 km and 5 km, it is recommended to use a single LWC value in a steady state condition for the defined time period.
Response :Not accepted.
The applicant can chose between a 28 km/5 km cycle and a 6 km/5 km cycle, as already provided in the current AMC E 780. Some Engine manufacturers already elected to use the 6 km/5 km cycle. Note also that GE commented that the option should be maintained.

Comment 4 on Paragraph(2.2)(b), recommending that multiple ambient conditions should be run (beyond -10°C), and that a rime ice condition near a total temperature of -18 C be added to the proposed glaze ice condition.
Response: Partially accepted.
The proposed text did not limit the temperature to –10°C; the ambient temperature should be –10°C or lower if necessary to ensure splitter/core inlet icing. The proposed rime ice condition has not been adopted as it would add significant conservatism to the current test assumptions of the proposed AMC (e.g. account of the forward speed and altitude).

Comment 5 on Paragraph (2.2)(b), recommending to delete the requirement to reset the power lever to flight idle before the burst to power for shed.
Response: Accepted.

Comment 6 on Paragraph (2.2)(b), recommending to remove the term ‘timed acceleration’.
Response: Accepted.

Comment 7 on Paragraph(2.2)(b), recommending to replace the term ‘maximum power/thrust’ with ‘maximum continuous power’.
Response: Not accepted.
The intent is to simulate a balked landing, not a shed-ice procedure.

Comment 8 on Paragraph (2.2)(b), recommending to add a clarification that the Engine manufacturer should work with the installer to provide an automatic means to set this minimum power/thrust.
Response: Partially accepted.
We agree with the intent of the comment, i.e. that there should be a means to automatically select the minimum power/thrust without requiring a pilot action to adjust the throttle. This is already reflected in the proposed advisory material for CS-E and CS-25. The AMC E 780 text recommends that the Engine manufacturer ‘should ensure that this minimum power/thrust will be selected when the aircraft is operating in icing conditions’. The AMC also foresees that some action may be needed from the aircraft manufacturer and, in this case, the Engine manufacturer has to provide the adequate information in the manual containing instructions

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| | for installing and operating the Engine. To ensure that, in fine, the automatic function is reached at aircraft level, the proposed AMC 25.1093(b) text under NPA 2012-22 includes the following statement in paragraph 2.1: 'If there is a minimum power/thrust required for descent to insure satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be automatic when in icing conditions, and this minimum power/thrust associated with descent in icing conditions should be assessed against the conditions in Table 1.'<br><br>Comment 9 on Paragraph (2.3), recommending to add 'The applicant should also set the Engine accessory loads, including horsepower and customer bleed air extraction, to the most critical condition during the operation and run up procedures.'<br>Response: Partially accepted.<br>We agree with the intent. However, this objective is already clearly mentioned in the CS E 780 rule and reminded in the AMC E 780 paragraph (1.3) 'Test Configuration — Engine'. |

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| comment | 75 comment by: Snecma<br><br>Attachment #7<br><br>Please see attached file (Part 2) |
| response | Affected paragraph and page number<br><br>Comment #5, page 10, paragraph 2.1 — Critical Points Analysis<br>What is your concern and what do you want changed in this paragraph?<br>The proposed text states:<br>The CPA test points can replace the standard Table 1 test points below when they can be shown to be equivalent or more severe. Otherwise they supplement the Table 1 standard test points.<br>REQUESTED CHANGE<br>Where a CPA test point is at a similar condition to a Table 1 test point, the more severe of these should be demonstrated.<br>Why is your suggested change justified?<br>JUSTIFICATION: If a CPA point is similar to but less severe than a Table 1 point, only the Table 1 test point should need to be tested.<br>Response: Accepted.<br><br>Comment#6: Page:10, Paragraph: 2.1 (a)<br>What is your concern and what do you want changed in this paragraph?<br>The proposed text states:<br>The applicant should consider pertinent service experience as well as the anticipated use of the aircraft when selecting critical icing test points.<br>REQUESTED CHANGE<br>The applicant should consider pertinent service experience as well as **the declared operating envelope of the engine** the anticipated use of the aircraft when selecting critical icing test points.<br>Why is your suggested change justified?<br>JUSTIFICATION: Snecma suggests to base rationale on declared engine limitation for its certification.<br>Response: Not accepted. |

The intended use of the aircraft should also be taken into account.

Comment#7, page, 11, paragraph 2.1(a)(ii)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
The CPA should also include an energy balance of critical engine surfaces (for example, latent heat and heat of fusion effects, metal-to-ice heat transfer effects, and ice insulating effects).
REQUESTED CHANGE: Delete the text
Why is your suggested change justified?
JUSTIFICATION: In practice this analysis has not been conducted as part of the CPA for unheated engine parts for past certification programs for many legacy engines. As a general rule the parts within an aircraft engine that will accrete ice are known. For example, it adds no value to conduct an energy balance for the inlet guide vane to the low pressure compressor as it is a known icing location.
Response: Not accepted.
An energy balance assessment of unheated critical engine surfaces is considered necessary.

Comment#8, page 11, paragraph 2.1(B) — Compressor Damage
What is your concern and what do you want changed in this paragraph?
The proposed text states:
When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50 %, 75 % or 100 % of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition :
REQUESTED CHANGE
When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they **the critical condition may** occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50 %, 75 % or 100 % of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition
Why is your suggested change justified?
JUSTIFICATION: the applicant should find the critical condition which may or may not be a glaze ice condition.
Response: Accepted.

Comment#9, page:11, paragraph 2.1(a)(ii)
What is your concern and what do you want changed in this paragraph?

The proposed text states:
The CPA should include ice accretion calculations that account for freezing fraction and aerodynamic effects of the ice as it moves into the air inlet.
REQUESTED CHANGE:
Why is your suggested change justified?
Snecma suggests to clarify the end of the sentence.
Response: Noted. The text quoted and the following sentence appear to be clear enough. They are also harmonised with the FAA proposed AC 20-147A.

Comment#10, page 12, paragraph 2.2(a)(i) and (ii)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
(i) 28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 45 minutes, or 30 minutes if clear evidence of repeat build-shed cycles has been observed. :
or the cycle:
(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed
REQUESTED CHANGE: (i) 28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of **30** minutes.
or the cycle:.
(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of **10** minutes,
Why is your suggested change justified?
JUSTIFICATION: Replace 45 minutes for (i) and 20 minutes for (ii) with the historical times in current advisory material – increasing the severity of the test by 1.5 – 2 X is not justified by in service experience.
Response: Not accepted.
The 45 minutes maximum duration for the 28 km/5 km cycle was adopted with the intent to harmonise with the FAA proposed FAR Part 33 rule. It was nevertheless deemed reasonable to also maintain the original AMC minimum test duration, which allows to be confident with the establishment of a stable build/shed cycle. Then, the same principle was applied to the alternative 6 km/5 km cycle. In both cases, when a build/shed cycle is established, it is possible to stop the test after 30 or 10 minutes as in the original AMC.

Comment#11, page 12, paragraph 2.2(a)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
(a) Tests points to demonstrate icing capability at a power/thrust at or above that required for sustained flight
One test point should be run to simulate each of the conditions of Table 1 at an Engine operating condition no higher than the minimum power/thrust to maintain sustained flight in the intended installation.
REQUESTED CHANGE: Clarify – title says above thrust required for sustained flight, text says

no higher than min power to sustain flight
Why is your suggested change justified?
JUSTIFICATION: Is this light weight hold and above? Clarification is needed as the sentence suggests you could use min idle.
Response: Accepted.
The text has been updated to require the Engine minimum power/thrust to maintain sustained flight, which was the actual intent. Associated with this change, (2.2)(b) has also been updated so that it is not anymore optional but required (at the minimum power/thrust associated with descent in icing conditions).

Comment#12, page13, paragraph 2.2(b)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
A 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes
REQUESTED CHANGE: A **28** km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes
Why is your suggested change justified?
JUSTIFICATION: The proposed change results in a more realistic ratio of continuous maximum icing and intermittent maximum icing distances.
Engines tested to the existing regulations are not known to have any icing problems through supercooled water droplets in descent conditions and therefore we are not aware of a need to increase the severity of such tests. The test in the NPA produces a water exposure of approximately 280% of the existing AMC E 780 para 8.b test, an increase which appears to be unnecessary.
It is noted that the test outlined in the NPA corresponds to the existing hold power test in AMC E 780 para 3.b and thus, to the current regulations, would certify the engine for continuous operation, which is surely not the case as an aircraft at this power cannot sustain level flight.
A cycle of Max Continuous and Max Intermittent water contents will occur approximately every 70 seconds at flight speeds and temperatures typical of a descent profile. Such changing of the water content on average every 35 seconds is impractical in some test facilities and will result in poor control over the test.
It is further noted that the test described in this NPA is inconsistent with that of the FAA's NPRM 10-10 and is substantially more severe than the FAA tests for core inlet icing. The NPRM calls, in §33.68 (c), for a total air temperature of between -6°C and -4°C in the Table 1 test at 2 g m-3, which may not lead to significant core inlet icing and will result in a low ice adhesive strength if ice does indeed form. §33.68 (b.2.ii.A) calls for a descent test which is similar in nature to the existing EASA AMC E-780 para 8 test and therefore the proposal outlined in NPA 2012-23 appears to be inappropriate and substantially more severe than demanded by the FAA.
Response: Accepted.
The 28 km proposal has been adopted. The 10 minutes minimum duration of the test has been changed to the current AMC E 780 provision, i.e. 'for sufficient duration to cover an anticipated descent of 3 000 m'. The reason for this change is that a 3 000 m descent is more meaningful in terms of an operational descent scenario and it gives the freedom to the engine and aircraft manufacturers to define the descent profile.

Comment#13, page 13, paragraph 2.2(b)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle
REQUESTED CHANGE: Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure **splitter**/core **inlet** icing, consisting of repetitions of the following cycle
Why is your suggested change justified?
JUSTIFICATION: Due to terminology differences between manufacturers, the word core could be mis-interpreted to mean the HPC. What is intended is the splitter and the inlet to the propulsor.
Response: Accepted.

Comment#14, page 13, paragraph 2.2(c)
What is your concern and what do you want changed in this paragraph?
The proposed text states:
Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is the preferred method of compliance because this approach enables the test to be carried out in the most representative way, requiring the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe. :
REQUESTED CHANGE: Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is **a** method of compliance because this approach enables the test to be carried out in the most representative way, requiring **with** the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe.
Why is your suggested change justified?
JUSTIFICATION: Both ground simulations and altitude simulations have their advantages and challenges, so we recommend not indicating a preference for altitude facilities
Response: Partially accepted.
The sentence has been updated to read: 'Therefore, the use of an altitude test cell is the most direct method of compliance because this approach enables the test to be carried out in the most representative way, requiring the minimum of correction to correlate Engine and icing test conditions to the real operating environment.'

Comment#15, page 14, paragraph 2.3 — Establishment of Test Points for Ground Operation
What is your concern and what do you want changed in this paragraph?
REQUESTED CHANGE: (add the following)
**The applicant may demonstrate unlimited capability if measurement evidence can prove the engine is free of ice after the run-up**

Why is your suggested change justified?
JUSTIFICATION: Allow for the possibility the run-up is an adequate ice clearing procedure
Response: Accepted. A new sentence is added after the second paragraph of the NPA text, which addresses your comment.

Comment#16, page14, paragraph 2.3 — Establishment of Test Points for Ground Operation
The proposed text states:
The conditions established during the test, in terms of time, temperature and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met.
REQUESTED CHANGE: The conditions established during the test, in terms of time, temperature **(if a limitation exists)** and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met
Why is your suggested change justified?
JUSTIFICATION: since this paragraph is before the paragraph which allows an analytical means to show lower temperatures are not more critical, a clarification is needed
Response: Partially accepted.
A new sentence has been added stating that an analysis may be used to show that ambient temperatures below the tested temperature are less critical.

Comment#17, page 15, Table 2
What is your concern and what do you want changed in this paragraph?
The proposed text states:
-7 to -1 °C
(20 to 30 °F)
REQUESTED CHANGE
-9 to -1 °C
(15 to 30 °F)
Why is your suggested change justified?
JUSTIFICATION: There is a typographical error in the temperature range listed for the glaze ice condition. It should define the temperature range as 15 to 30F or -9 to -1C, to be consistent with the FAA (it is expected that this change will be accepted after the NPRM comment review)
Response: Accepted.

Comment# 18, page 15, Table 2
What is your concern and what do you want changed in this paragraph?
The proposed text states:
100 µm (minimum) :
REQUESTED CHANGE
100 µm (minimum)
3000 maximum
Why is your suggested change justified?
JUSTIFICATION: A range of drops allows flexibility depending on whether the applicant is using test or analysis. To be consistent with the FAA (it is expected that this change will be accepted after the NPRM comment review)
Response: Accepted.

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| comment | 86 | comment by: Aerospace Industries Association |
| | **Affected paragraph and page number** | Page: 10<br>Paragraph: 2.1 Critical Point Analysis |
| | **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The CPA test points can replace the standard Table 1 test points below when they can be shown to be equivalent or more severe. Otherwise they supplement the Table 1 standard test points.<br>**REQUESTED CHANGE:**<br>**Where a CPA test point is at a similar condition to a Table 1 test point, the more severe of these should be demonstrated.** The CPA test points can replace the standard Table 1 test points below when they can be shown to be equivalent or more severe. Otherwise they supplement the Table 1 standard test points. |
| response | Accepted. | |

Comment from GE on page 10, paragraph 2.1(a)(i)
The proposed text states:
Applicants should ensure that their analysis is supported by test data.
REQUESTED CHANGE: Applicants should ensure that their analysis is supported by test data **or relevant service experience for Supercooled Large Droplet (SLD) icing.**"
JUSTIFICATION: The paragraph should not applicable to SLD conditions. SLD is a new certification requirement and has not been identified as an engine specific issue. Compliance should be allowed to rely more on service experience than other icing types.

Response: Not accepted.
This paragraph is relative to the identification of critical test points through analysis. The absence of in-service events is not a means to identify a critical point.

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| comment | 87 | comment by: Aerospace Industries Association |
| | **Affected paragraph and page number** | Page: 11<br>Paragraph: 2.1 a ii |
| | **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The CPA should also include an energy balance of critical engine surfaces (for example, latent heat and heat of fusion effects, metal-to-ice heat transfer effects, and ice insulating effects).<br>**REQUESTED CHANGE:**<br>The CPA should also include an energy balance of critical engine surfaces (for example, latent heat and heat of fusion effects, metal-to-ice heat transfer effects, and ice insulating effects). |
| | **Why is your suggested change justified?** | **JUSTIFICATION:** In practice this analysis has not been conducted as part of the CPA for unheated engine parts for past certification programs for many legacy engines. As a general rule, the parts within |

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| | an aircraft engine that will accrete ice are known. For example, it adds no value to conduct an energy balance for the inlet guide vane to the low pressure compressor as it is a known icing location. |
| **Affected paragraph and page number** | Page: 11<br>Paragraph: 2.1 a iii |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(iii) For anti-iced parts, the CPA should identify a critical test point determined from energy balance calculations of required heat loads encompassing the range of possible combinations of icing condition and Engine power/thrust. In glaze ice conditions, assessing the effects of non-aerodynamic ice formations and their shedding is more complex<br>**REQUESTED CHANGE:**<br>(iii) For anti-iced parts, the CPA should identify a critical test point determined from energy balance calculations of required heat loads encompassing the range of possible combinations of icing condition and Engine power/thrust. In glaze ice conditions, assessing the effects of non-aerodynamic ice formations and their shedding **as well as runback ice shedding should be assessed.** is more complex |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is suggested that the engine manufacturer should account for the possibility of runback ice forming as a result of the internal engine ice protection system and shedding into the engine; glaze ice is not the only type of icing to be assessed. |
| **Affected paragraph and page number** | Page: 11<br>Paragraph: 2.1 (B) Compressor Damage |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50 %, 75 % or 100 % of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition.<br>**REQUESTED CHANGE:**<br>When ice formations on static components shed, they often result in damage to the next downstream rotor stage. For instance, this type of damage has occurred on the first blade set in the high pressure compressor (intermediate pressure compressor for three spool Engines). Establishing the critical conditions for these glaze ice |

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| | accretions therefore, requires careful consideration as they **the critical condition may** occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. The critical conditions may not occur during any of the power settings discussed in this AMC (for example, flight-idle, 50 %, 75 % or 100 % of maximum continuous power/thrust), and so the power/thrust setting at the critical condition should be evaluated. Applicants should evaluate any Engine compressor damage that results from ice testing against the possibility of multiple occurrences, since icing is a common environmental condition |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that the applicant should find the critical condition, which may or may not be a glaze ice condition. |

response

Comment 1: Not accepted.
An energy balance assessment of unheated critical Engine surfaces is considered necessary.

Comment 2: Accepted.

Comment 3: Accepted.

Comment from GE on page 11, paragraph (2.1)(b)(ii)
The proposed text states:
Additionally, the Engine should be capable of accelerating from minimum flight idle and ground idle to take-off power/thrust in any icing condition, without power/thrust loss or instability (surge or stall).
REQUESTED CHANGE: Additionally, the Engine should be capable of accelerating from minimum flight idle or ground idle to take-off power/thrust in any **flight or ground** icing condition, respectively, without power/thrust loss or instability (surge or stall).
JUSTIFICATION: Clarification

Response: Not accepted.
This part of the paragraph has been removed to focus on how to determine the critical test conditions, but the pass/fail criteria are not to be mentioned here.

Comment from GE on page 12, paragraph (2.1)(b)(ii)
The proposed text states:
The minimum Engine bleed schedule allowed for the condition being tested should be assumed to minimize the operability margin. CPA testing should demonstrate those conditions where the minimum operability margin is expected.
REQUESTED CHANGE: The minimum Engine bleed schedule allowed for the condition being tested should be assumed to minimize the operability margin. CPA testing should demonstrate those conditions where the minimum operability margin is expected, **including consideration of all engine bleed schedules allowed for each condition.**
JUSTIFICATION: The first sentence sets an assumption that may not be appropriate for all type design engine designs. The second sentence can address the need to have the CPA cover minimum type design engine operability configuration(s).

Response: Partially accepted.
We agree with the principle of your comment; the sentence has been revised so that the most adverse Engine bleed settings for the condition being analysed should be assumed to minimise the operability margin.

comment 88 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page:12<br>Paragraph: 2.2 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The test conditions outlined below are intended as a guide to establish the minimum testing necessary to comply with CS-E 780. These test points should be supplemented or, if applicable replaced, by any test points identified by the CPA as applicable.<br>**REQUESTED CHANGE:**<br>Move this text to section 1.6 and make it clear that CPA is now expected |
| **Why is your suggested change justified?** | **JUSTIFICATION:** Within the advisory material, it is not clear what are the minimum number of test points. |
| **Affected paragraph and page number** | Page: 12<br>Paragraph: 2.2(a) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(a) Tests points to demonstrate icing capability at a power/thrust at or above that required for sustained flight<br>One test point should be run to simulate each of the conditions of Table 1 at an Engine operating condition no higher than the minimum power/thrust to maintain sustained flight in the intended installation.<br>**REQUESTED CHANGE:**<br>Please clarify – title says above thrust required for sustained flight, text says no higher than min power to sustain flight |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully requested that the text is clarified, as the sentence suggests that minimum idle could be used. If minimum idle is used, Paragraph 2.2(b) suggests the applicant need not conduct any further testing, which would not result in a rigorous certification program. |
| **Affected paragraph and page number** | Page: 12<br>Paragraph: 2.2 a (i) and (ii) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(i) 28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 45 minutes, or 30 minutes if clear evidence of repeat build-shed cycles has been observed.<br>or the cycle: |

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| | (ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed<br>**REQUESTED CHANGE:**<br>(i) 28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of **30** 45minutes, **total duration may be reduced** or 30 minutes if clear evidence of repeat build-shed cycles has been observed.<br>or the cycle:<br>(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of **10** 20 minutes, or **total duration may be reduced** 30 minutes if clear evidence of repeat build-shed cycles has been observed |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that replacements be made as follows: replace 45 minutes for (i) and 30 minutes for (ii) with the historical times in current advisory material, as increasing the severity of the test by 1.5 – 2x is not justified by in-service experience. For power settings higher than hold power, a lower duration should be allowed, since it is no longer a holding scenario. |
| **Affected paragraph and page number** | Page:12<br>Paragraph: 2.2a |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>If an acceptable means to predict the critical fan speed is not available tests at 50 %, 75 % and 100 % of maximum continuous power/thrust should be run.<br>**REQUESTED CHANGE:**<br>If an acceptable means to predict the critical fan speed is not available tests at 50 %, 75 % and 100 % of maximum continuous power/thrust should be run. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that 100% be removed, as it has never proven to be a critical point, and increases applicant costs unnecessarily, as well as increasing test facility costs to be able to test at sustained high power. If the engine is not tested at 100%, it is suggested that the engine probe, which might be critical at high airflows, must be assessed separately. |
| **Affected paragraph and page number** | Page: 12<br>Paragraph: 2.2(ii) |
| **What is your concern and what do you want** | The proposed text states:<br>(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km |

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| **changed in this paragraph?** | in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed<br>**REQUESTED CHANGE**:<br>(ii) 6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is suggested that the requirement above be deleted, as keeping the above requirement would allow for an unrealistically short duration of cycles, pose challenges to accomplish accurately in a test facility, and result in a very severe test. |

response

Comment 1: Not accepted.
This sub-paragraph has to remain within paragraph (2) ('Supercooled Liquid Water Icing Conditions') as it has been created for this purpose. The reference to the requirement for a CPA is present in the second sentence of paragraph 2.2..

Comment 2: Accepted.
The text has been updated to require the Engine minimum power/thrust to maintain sustained flight, which was the actual intent. Associated with this change, (2.2)(b) has also been updated so that it is not anymore optional but required (at the minimum power/thrust associated with descent in icing conditions).

Comment 3: Not accepted.
The 45 minutes maximum duration for the 28 km/5 km cycle was adopted with the intent to harmonise with the FAA proposed FAR Part 33 rule. It was nevertheless deemed reasonable to also maintain the original AMC minimum test duration, which allows to be confident with the establishment of a stable build/shed cycle. Then, the same principle was applied to the alternative 6 km/5 km cycle. In both cases, when a build/shed cycle is established, it is possible to stop the test after 30 or 10 minutes as in the original AMC.

Comment 4: Not accepted.
The 100 % power point is required only in the case where an applicant is not able to determine the critical fan speed.

Comment 5: Not accepted.
This alternative test is already present in the current AMC E 780 and some Engine manufacturers have been using it. Note that this is still an alternative option. Note also that GE commented that the option should be maintained.

**GE comment on 2.2(ii)**: GE believes that the option for a shorter duration alternating cloud should be retained.

Response: Accepted.

comment 89 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 13<br>Paragraph: b |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(b) Tests points at power/thrust below that required for sustained flight<br>If the test points of (2.2)(a) are carried out at the minimum power/thrust for descent in icing or lower, no further test points are necessary.<br>**REQUESTED CHANGE:**<br>(b) Tests points at power/thrust below that required for sustained flight<br>If the test points of (2.2)(a) are carried out **repeated** at the minimum power/thrust for descent in icing or lower, no further test points are necessary. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** Is it possible to clarify the above requirement in order to ensure that the applicant does not assume just three minimum power points are needed for certification? |
| **Affected paragraph and page number** | Page:13<br>Paragraph: 2.2 (b) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle<br>**REQUESTED CHANGE:**<br>Otherwise, an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure **splitter**/core **inlet** icing, consisting of repetitions of the following cycle |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully requested that the refinement of terms be included. Due to terminology differences between manufacturers, the word core could be misinterpreted to mean the HPC, whereas the terminology intended are the splitter and the inlet to the propulsor. |
| **Affected paragraph and page number** | Page: 13<br>Paragraph: 2.2 (b) paragraph 3 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>A 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes<br>**REQUESTED CHANGE:** |

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| | A **28** 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes |
| **Why is your suggested change justified?** | **JUSTIFICATION:** The proposed change results in a more realistic ratio of continuous maximum icing and intermittent maximum icing distances.<br>Engines tested to the existing regulations are not known to have any icing problems through supercooled water droplets in descent conditions and therefore we are not aware of a need to increase the severity of such tests. The test in the NPA produces a water exposure of approximately 280% of the existing AMC E 780 para 8.b test, an increase which appears to be unnecessary.<br>It is noted that the test outlined in the NPA corresponds to the existing hold power test in AMC E 780 para 3.b and thus, to the current regulations, would certify the engine for continuous operation, which is surely not the case as an aircraft at this power cannot sustain level flight.<br>A cycle of Max Continuous and Max Intermittent water contents will occur approximately every 70 seconds at flight speeds and temperatures typical of a descent profile. Such changing of the water content on average every 35 seconds is impractical in some test facilities and will result in poor control over the test.<br>It is further noted that the test described in this NPA is inconsistent with that of the FAA's NPRM 10-10 and is substantially more severe than the FAA tests for core inlet icing. The NPRM calls, in §33.68 (c), for a total air temperature of between -6°C and -4°C in the Table 1 test at 2 g m-3, which may not lead to significant core inlet icing and will result in a low ice adhesive strength if ice does indeed form. §33.68 (b.2.ii.A) calls for a descent test which is similar in nature to the existing EASA AMC E-780 paragraph 8 test and therefore the proposal outlined in NPA 2012-23 appears to be inappropriate and substantially more severe than demanded by the FAA. |
| **Affected paragraph and page number** | Page: 13<br>Paragraph: 2.2 (b) paragraph 5 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing.<br>**REQUESTED CHANGE:**<br>At the conclusion of the test, the Engine should be set to flight idling power and then subjected to a**n** timed acceleration, using a one second power/thrust control lever movement, to maximum power/thrust conditions, so as to simulate a balked landing. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is suggested that the engine should be accelerated from the test power setting to maximum power. It is not clear what the purpose of timing the acceleration is, if there is no time |

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| | requirement. In addition, if there were a requirement, the results from a ground test facility would not be representative of an in-flight acceleration |
| **Affected paragraph and page number** | Page: 13<br>Paragraph: c |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is the preferred method of compliance because this approach enables the test to be carried out in the most representative way, requiring the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe.<br>**REQUESTED CHANGE:**<br>Altitude and ram effect have a significant impact on the Engine operating conditions, ice accretion and ice shedding. Therefore use of an altitude test cell is **a** the preferred method of compliance because this approach enables the test to be carried out in the most representative way, requiring **with** the minimum of correction to correlate Engine and icing test conditions to the real operating environment. It also allows accurate control of the icing conditions. However, it is recognised that such facilities are not always available, and alternative test methods are also considered acceptable, providing that evidence demonstrates that such testing is at least as severe. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully recommended that no preference for altitude facilities be indicated, as both ground simulations and altitude simulations have their advantages and challenges. |

response

Comment 1: Not accepted.
The changes made to improve paragraph 2.2 led us to delete the sentence subject to this comment.

Comment 2: Accepted.

Comment 3: Accepted.
The 28 km proposal has been adopted. The 10 minutes minimum duration of the test is changed to the current AMC E 780 provision , i.e. ‘for sufficient duration to cover an anticipated descent of 3 000 m’. The reason for this change is that a 3 000 m descent is more meaningful in terms of an operational descent scenario and it gives the freedom to the Engine and aircraft manufacturers to define the descent profile.

Comment 4: Accepted.

Comment 5: Partially accepted.
The text has been updated to read: 'Therefore, the use of an altitude test cell is the most direct method of compliance […]'.

comment 90 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page:14<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The conditions established during the test, in terms of time, temperature and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met<br>**REQUESTED CHANGE:**<br>The conditions established during the test, in terms of time, temperature **(if a limitation exists)** and run up procedures will be deemed to be the limitations necessary for safe operation in the applicable environment, provided that the acceptance criteria of CS-E 780(a) are met |
| **Why is your suggested change justified?** | **JUSTIFICATION:** A clarification is requested, as this paragraph precedes the paragraph which allows an analytical means to show lower temperatures are not more critical. |
| **Affected paragraph and page number** | Page:14<br>Paragraph: (2.3) Establishment of Test Points for Ground Operation |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>**REQUESTED CHANGE:** (add the following)<br>**The applicant may demonstrate unlimited capability if measurement evidence can prove the engine is free of ice after the run-up** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** An addition is respectfully requested in order to allow for the possibility that the run-up is an adequate ice clearing procedure. |
| **Affected paragraph and page number** | Page: 14<br>Paragraph: 2.3 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>**REQUESTED CHANGE:** (add the following)<br>**In addition to the requirements of CSE780(a) 1-4, any elevated engine vibration during the test must be compared to the** |

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| | **certified tolerance of the engine, and communicated to the airframer for their acceptance** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is requested that the additional text above be added, as high vibrations need to be communicated in order that the airframer can ensure the airplane systems are designed to tolerate such levels. |

response

Comment 1: Partially accepted.
A new sentence has been added stating that an analysis may be used to demonstrate that ambient temperatures below the tested temperature are less critical.

Comment 2: Accepted.
A new sentence has been added addressing this comment.

Comment 3: Partially accepted.
In paragraph 7, a new bullet has been created on the effects that may be observed during or after an icing conditions' encounter, such as vibrations, temporary power/thrust loss, change in Engine power/thrust response.

comment 91 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 15<br>Paragraph: Table 2, Glaze Ice |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>-7 to -1 °C<br>(20 to 30 °F)<br>**REQUESTED CHANGE:**<br>**-9 to -1 °C** -7 to -1 °C<br>**(15 to 30 °F)** (20 to 30 °F) |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully noted that there is a typographical error in the temperature range listed for the glaze ice condition. It should define the temperature range as 15 to 30F or -9 to -1C, to be consistent with the FAA (it is expected that this change will be accepted after the NPRM comment review). |
| **Affected paragraph and page number** | Page: 15<br>Paragraph: Table 2 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>100 µm (minimum)<br>**REQUESTED CHANGE:**<br>100 µm (minimum)<br>**3000 µm maximum** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** A range of drops allows flexibility depending on whether the applicant is using test or analysis. This change is requested in order to be consistent with the FAA (it is expected that |

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| | this change will be accepted after the NPRM comment review). |
| response | Comment 1: Accepted.<br><br>Comment 2: Accepted. |

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| comment | 109 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>If a CPA point is shown to be less severe than a Table 1 point then in testing the Table 1 point this will by definition demonstrate margin relative to the less severe CPA point<br>Comment Resolution<br>Replace "Otherwise they supplement the Table 1 standard test points" with "Where the CPA test points can be shown to be less severe than the standard Table 1 test points below, the Table 1 conditions should be demonstrated" |
| response | Partially accepted.<br>The entire sub-paragraph has been changed to read: 'Where a CPA test point is in a similar condition to a Table 1 test point, the more severe of the two should be demonstrated.' |

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| comment | 110 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>An energy balance may not always be appropriate in carrying out the CPA, that is it may not necessarily enhance the quality/discrimination of the analysis<br>Comment Resolution<br>Propose "Where appropriate the CPA should also include an energy balance of ....." |
| response | Not accepted.<br>An energy balance assessment of unheated critical Engine surfaces is considered necessary. |

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| comment | 111 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>The critical conditions for compressor damage due to icing need not necessarily be associated with glaze ice<br>Comment Resolution<br>Replace "Establishing the critical conditions for these glaze ice accretions therefore, requires careful consideration as they occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities. " with "Establishing the critical conditions for these ice accretions therefore, requires careful consideration as the critical condition may occur at specific limited conditions of low freezing fractions over a range of local Mach numbers and air densities." |
| response | Accepted. |

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| comment | 112 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>The increased water exposure of the proposed changes to the existing test will increase the severity of the current test by a factor of between 1.5 to 2. The need for the significantly increased test severity is contrary to good service experience at these operating conditions and therefore the need for the increased severity is not clear. The NPA does not provide the rationale. Clearly the proposed increase in exposure will significantly affect the economics of carrying out the engine testing.<br>For test conditions higher than hold power, a lower exposure would be more appropriate as the test conditions really reflect those that could be encountered during a stabilised hold condition.<br>Comment Resolution<br>Replace "28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 45 minutes, or 30 minutes if clear evidence of repeat build-shed cycles has been observed."with "28 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 30 minutes. The total duration may be reduced if clear evidence of repeat build-shed cycles has been observed.".<br>Replace "6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 20 minutes, or 10 minutes if clear evidence of repeat build-shed cycles has been observed." with "6 km horizontal extent in the liquid water content conditions of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content conditions of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes. The total duration may be reduced if clear evidence of repeat build-shed cycles has been observed."<br>NPA to provide the rationale behind the proposed/finalised changes to the increased severity of existing icing tests |
| response | Not accepted.<br>The 45 minutes maximum duration for the 28 km/5 km cycle was adopted with the intent to harmonise with the FAA proposed FAR Part 33 rule. It was nevertheless deemed reasonable to also maintain the original AMC minimum test duration, which allows to be confident with the establishment of a stable build/shed cycle. Then, the same principle was applied to the alternative 6 km/5 km cycle. In both cases, when a build/shed cycle is established, it is possible to stop the test after 30 or 10 minutes as in the original AMC. |

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| comment | 113 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Engines tested to the existing regulations have good service experience in respect of supercooled liquid water icing in flight at descent idle conditions. We do not therefore see a need for increasing the severity of the tests. The test in the NPA produces a water exposure of approximately 260% of the existing AMC E 780 para 8.b test at a typical descent speed, including around six to eight intermittent maximum encounters, an increase which appears to be unnecessary. |

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| | Recognising the increased test severity will measurably and adversely impact the economics of an engine, it is important to understand the rationale behind the proposed proposed changes to the existing test requirements - the NPA does not provide the rationale.<br>It is recognised that the introduction of a maximum intermittent icing encounter as part of the testing could be justified. It is however noted that the test proposed in the NPA is equivalent to the current AMC E 780 (3).(b) test, which is used to clear unlimited operation in icing conditions. The use of such a test for an idle condition, which the aircraft can only maintain for a limited duration due to the inevitable descent which must ensue, is inappropriate.<br>It is noted that the test described in the NPA is inconsistent with that of the FAA's NPRM 10-10 and is substantially more severe than the FAA tests for core inlet icing. The NPRM calls, in §33.68 (c), for a total air temperature of between -6°C and -4°C in the Table 1 test at 2 g m-3, which may not lead to significant core inlet icing and will result in a low ice adhesive strength if ice does indeed form. §33.68 (b.2.ii.A) calls for a descent test which is similar in nature to the existing EASA AMC E 780 para (8) test and therefore the proposal outlined in NPA 2012-23 appears to be inappropriate and substantially more severe than demanded by the FAA.<br>Comment Resolution<br>Replace "an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle: A 6 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes."with "an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, at the liquid water content of Table 1 Column (a) appropriate to the temperature and a single 5 km encounter in the liquid water content of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes."or "an additional test at the minimum power/thrust associated with descent in icing conditions should be conducted at an ambient temperature of -10°C, or lower if necessary to ensure core icing, consisting of repetitions of the following cycle: A 28 km horizontal extent in the liquid water content condition of Table 1 Column (a) appropriate to the temperature, followed by 5 km in the liquid water content condition of Table 1 Column (b) appropriate to the temperature, for a total duration of 10 minutes.".<br>NPA to provide the rationale behind the proposed/finalised changes to the increased severity of existing icing tests |
| response | Partially accepted.<br>We have updated paragraphs (2.2)(a) and (2.2)(b) so that now (2.2)(b) is not anymore optional.<br>The 28 km proposal is adopted. The 10 minutes minimum duration of the test has been changed to the current AMC E 780 provision , ie 'for sufficient duration to cover an anticipated descent of 3 000 m'. The reason for this change is that a 3 000 m descent is more meaningful in terms of an operational descent scenario and it gives the freedom to the Engine and aircraft manufacturers to define the descent profile. |

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| comment | 114 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Allow for the possibility that the run-up is an adequate ice clearing procedure<br>Allow option to demonstrate a satisfactory repeat accrete-and-shed cycle such that |

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| | unlimited ground operation is freezing fog can be cleared<br>Comment Resolution<br>Add "The applicant may demonstrate unlimited capability if test evidence demonstrates the engine is free of ice following the run-up or that build and shed cycles have been established" |
| response | Accepted.<br>A new sentence has been added addressing this comment. |

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| comment | 115 comment by: Rolls-Royce plc (ZM)<br>Comment Summary<br>There is a typographical error in the temperature range listed for the glaze ice condition. It should define the temperature range as 15 to 30F or -9 to -1C, To be consistent with the FAA (it is expected that this change will be accepted after the NPRM comment review)<br>Comment Resolution<br>Replace "-7 to -1 °C (20 to 30 °F)"<br>with "-9 to -1 °C (15 to 30 °F)" |
| response | Accepted. |

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| comment | 116 comment by: Rolls-Royce plc (ZM)<br>Comment Summary<br>Clarify "analysis" includes "comparative analysis" between the good service experience of previous designs and the new design<br>Comment Resolution<br>For Snow condition - replace "By test, analysis or combination of the two" with "By test, analysis, comparative analysis or combination of these" |
| response | Accepted. |

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| comment | 117 comment by: Rolls-Royce plc (ZM)<br>Comment Summary<br>Clarify "analysis" includes "comparative analysis" between the good service experience of previous designs and the new design<br>Comment Resolution<br>For Large Drop Glaze Ice condition - replace "By test, analysis or combination of the two" with "By test, analysis, comparative analysis or combination of these" |
| response | Accepted. |

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| comment | 120 comment by: Rolls-Royce plc (ZM)<br>Comment Summary<br>The NPA allows for the use of analytical means to show that lower temperatures are not more critical, so tests at those lower temperatures should not be required<br>Comment Resolution<br>Replace "The conditions established during the test, in terms of time, temperature and run |

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| | up procedures "with "The conditions established during the test, in terms of time, temperature (if a limitation exists) and run up procedures". |
| response | Partially accepted.<br>A new sentence has been added stating that an analysis may be used to demonstrate that ambient temperatures below the tested temperature are less critical. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (pp. 15-16)** p. 15-16

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| comment | 8 comment by: CAA-NL<br><br>AMC to E 780 Icing Conditions, paragraph 3 “Mixed phase/Ice crystal conditions”<br>“Validated full scale ground test facilities for mixed and ice crystal icing conditions are currently not available”<br>Proposal: Leave this information out of the AMC material<br>Explanation: Perhaps in a few years these facilities are available. It is then illogic to have this sentence in the AMC material. |
| response | Partially accepted.<br>The sentence has been changed to read: ‘Until validated full-scale ground test facilities for mixed-phase and ice crystal icing conditions are available, compliance […]’. |

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| comment | 32 comment by: Boeing<br><br>Page:15<br>Paragraph: (3) Mixed phase/Ice crystal conditions<br><br>The proposed text states:<br>Validated full scale ground test facilities for mixed-phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary).<br>**REQUESTED CHANGE (reword the sentence) :**<br>Validated full scale ground test facilities for mixed-phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary). **In the absence of validated full scale test facilities for mixed phase and ice crystal icing conditions, compliance should be based on flight test and/or analysis (supported by engine/component tests as necessary).**<br><br>**JUSTIFICATION:** It is requested that the additional text be included to generalize the requirement, and allow for future improvements in analysis and test capabilities. |
| response | Partially accepted.<br>The sentence has been changed to read: ‘Until validated full-scale ground test facilities for mixed-phase and ice crystal icing conditions are available, compliance […]’. |

Cessna comment on paragraph (3):
Planning for the future when test facilities are available.

Proposed wording would allow ground test (when such facilities become available), or flight test and/or analysis. As currently worded, ground test would not be accepted without changes required to the wording.
Suggested change: **In the absence of validated** full scale ground test facilities for of mixed phase and ice crystal icing conditions, are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary).

Response: Partially accepted.
The sentence has been changed to read: 'Until validated full-scale ground test facilities for mixed-phase and ice crystal icing conditions are available, compliance […]'.

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| comment | 33 comment by: Boeing<br><br>Page: 16<br>Paragraph: (3) (a) (viii)<br><br>The proposed text states:<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3).<br>**REQUESTED CHANGE:**<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3).<br><br>**JUSTIFICATION:** We suggest that either the sentence be generalized, or an explanation be included as to why certain bleeds are relevant and others are not. |
| response | Accepted. |

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| comment | 53 comment by: AIRBUS<br><br>Section 3<br>Current text:<br>Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary)<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Therefore compliance should be based on analysis (supported by Engine/component tests as necessary) as detailed below<br>Rationale/justification:<br>The fact that validated full scale ground test facility for mixed phase and ice crystal conditions are currently not available is not a reason to substitute flight tests as a means of compliance. For engine type certification, mixed phase and ice crystal conditions should be handled as supercooled liquid water conditions by engine rig tests and/or analysis.<br>Flight testing has not been shown to be a fully validated and accurate method of compliance. In addition, the rest of the AMC section is not providing any further details on this method, concentrating on the contrary on the analytical method. |
| response | Not accepted.<br>The proposed text does not mandate a flight test as it includes an 'or'. |

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| comment | 54 comment by: AIRBUS |

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| | Section 3.a<br>Current text:<br>None<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Add: Runback water from heated part (engine internal IPS)<br>Rationale/justification:<br>The addition of internal ice protection systems in the engine might lead to ice crystals melting on surfaces where they would normally have bounced (negative temperature) and to runback ice accretion on downstream unheated surfaces where temperature could remain negative. |
| response | Accepted.<br>With a slightly different wording, added as a new bullet (ix) in paragraph (3)(a). |

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| comment | 76 comment by: Snecma<br><br>Attachment #8<br><br>Please see attached file (Part 3) |
| response | Page15, paragraph 3<br>The proposed text states:<br>Validated full scale ground test facilities for mixed-phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary). :<br>REQUESTED CHANGE: Validated full scale **ground** test facilities for mixed-phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary).<br>JUSTIFICATION: make the sentence more general<br>Response: Partially accepted.<br>The text has been slightly differently updated but its meaning remains the same.<br>Page 16, paragraph 3(a)<br>The proposed text states:<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3).<br>REQUESTED CHANGE<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3).<br>JUSTIFICATION: suggest making the sentence more general or explain why certain bleeds are relevant and others are not<br>Response: Accepted. |

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| comment | 92 comment by: Aerospace Industries Association |

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| **Affected paragraph and page number** | Page:15<br>Paragraph: 3 |
| **What is your concern and what do you want changed in this** | The proposed text states:<br>Validated full scale ground test facilities for mixed phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported |

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| **paragraph?** | by Engine/component tests as necessary).<br>**REQUESTED CHANGE (reword the sentence) :**<br>**In the absence of validated full scale test facilities for mixed phase and ice crystal icing conditions, compliance should be based on flight test and/or analysis (supported by engine/component tests as necessary).** Validated full scale ground test facilities for mixed phase and ice crystal icing conditions are currently not available. Therefore compliance should be based on flight test and/or analysis (supported by Engine/component tests as necessary). |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is requested that the additional text be included to generalize the requirement, and allow for future improvements in analysis and test capabilities. |

response

Partially accepted.
The sentence has been revised to read:
'Until validated full-scale ground test facilities for mixed-phase and ice crystal icing conditions are available, compliance should be based […]'.

comment

93 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 16<br>Paragraph: 3 (a) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3).<br>**REQUESTED CHANGE:**<br>(viii) Extraction capability of high stage core bleeds (not combustor / P3). |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that either the sentence be generalized, or an explanation be included as to why certain bleeds are relevant and others are not. |

response

Accepted.

comment

124 comment by: Rolls-Royce plc (ZM)

Comment Summary
Guidance for demonstrating compliance for mixed phase and ice crystal conditions by flight test does not appear to be present.
Whilst mixed phase and ice crystal compliance based on flight test and/or analysis is referred to in the NPA, the AMC material provided focuses on the analysis option without any clear reference to the use of flight test results/data

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| | Comment Resolution<br>Add guidance material addressing flight test requirements for compliance with mixed phase and ice crystal conditions. |
| response | Noted.<br>There is no available detailed guidance regarding flight tests, as the EHWG and the IPHWG did not define such guidance and the Agency/industry have not yet gone through a certification exercise on this subject. Such guidance may be developed in the future. In the meantime, the applicant should propose a flight test programme to the Agency. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (pp. 16-19)** p. 16-19

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| comment | 34 comment by: Boeing<br><br>Page: 17<br>Paragraph: (4) (b) Comparative analysis<br><br>**REQUESTED CHANGE:**<br><br>We recommend that the following text be added to this paragraph:<br>**Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.**<br><br>**JUSTIFICATION:** We suggest that the above text be added, as there are no other references to required engine power in this section. |
| response | Accepted. |

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| comment | 35 comment by: Boeing<br><br>Page: 18<br>Paragraph: (4) (e) (i)<br><br>The proposed text states:<br>(i) **Engine Loss of Performance**. Applicants should evaluate the impact of any fan blade bending or damage on potential sustained Engine power/thrust loss. Power/thrust loss associated with fan damage from the slab should be less than 1.5%. As soft body fan damage is common from medium bird ingestion, applicants may use the medium bird ingestion test results to show compliance with this requirement. If the medium bird ingestion test results in less than 1.5% permanent power/thrust loss, and no cracks, tears or blade piece breakout occurs due to a bird introduced at the outer 33% of the fan blade span, then the CS-E 780(f)(2) requirement is met.<br>**REQUESTED CHANGE:**<br>(i) **Engine Loss of Performance.** Applicants should evaluate the impact of any fan blade bending or damage on potential sustained Engine power/thrust loss. Power/thrust loss |

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| | associated with fan damage from the slab should be less than 1.5%. **Ice and birds are "soft body" objects in their impact behavior, i.e., they are both highly deformable on impact and flow over the structure, spreading the impact load. They also have similar densities; thus, they create similar strain footprints and, consequently, similar damage.** As soft body fan damage is common from medium bird ingestion, applicants may use the medium bird ingestion test results to show compliance with this requirement. If the medium bird ingestion test results in less than 1.5% permanent power/thrust loss, and no cracks, tears or blade piece breakout occurs due to a bird introduced at the outer 33% of the fan blade span, then the CS-E 780(f)(2) requirement is met**, and there is no need for additional substantiation.**<br><br>**JUSTIFICATION:** We suggest that the indicated text be added, as ice and birds have always produced similar types of damage in service, being that they are both "soft body" objects in their impact behavior.<br>Biometric studies (ref. Central Science Lab. International Birdstrike Research Group) showed that the plucked torso of birds range in density from approximately 0.87 to 1.06 g/cc. Glaze Ice formations have densities around 0.92 g/cc, and rime ice can be as low as 0.4 g/cc density. Thus, birds tend to have higher densities than ice.<br>It was agreed during discussions in the industry's Engine Icing Working Group (EIWG) meetings that a bird impact in the outer panel of the fan blade would be similar to an ice slab impact; thus, if the outcome of the medium bird test met the slab test compliance criteria, there was no need for further justification that the ice slab requirements had been satisfied. |
| response | Partially accepted.<br>The last addition at the end of the paragraph is redundant and has not been adopted. |

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| comment | 55 comment by: AIRBUS<br><br>Section 4.b<br>Current text:<br>Compliance may be demonstrated by the standard Engine ice slab ingestion test or by means of a validated analysis procedure that uses equivalent soft body testing.<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Compliance may be demonstrated by the standard Engine ice slab ingestion test or by means of a validated analysis procedure that uses equivalent soft body testing. Demonstration of tools validation shall be included in the certification dossier.<br>Rationale/justification:<br>Need for tools validation demonstration |
| response | Not accepted.<br>It is agreed that any tool used to support an analysis must be validated, and this principle would apply in many cases within an AMC. There is no need to repeat this general principle in all cases. |

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| comment | 56 comment by: AIRBUS<br><br>Section 4.c.i<br>Current text: |

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| | None<br>EIWG/AIA proposed text:<br>None<br>Airbus proposed text:<br>Add (in controlling parameters):<br>·Impact Location<br>Rationale/justification:<br>Depending on the location of impact along chord length, consequences can be more or less severe. |
| response | Accepted. |

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| comment | 64 comment by: Turbomeca<br><br>B -.I - .SUBPART E- Turbine engines; type substantiation-AMC E 780 – (4) (e) (ii) Engine Operability / handling characteristics:<br>it is proposed to modify current text as follows:<br>(ii) Engine Operability/Handling characteristics. Engine damage should not cause surge, flameout, or prevent transient operation. **Acceptable engine operation precludes continued or non-recoverable surge or stall. A momentary/pop surge or stall that arrests itself without operational intervention (e.g. without throttle manipulation) is acceptable.**<br>Explanation:<br>Saying that any surge or stall is not acceptable is too simply and is not a satisfactory wording. This AMC should clarify which types of surge/stall are not acceptable in line with CS-E 500(a) which says "the engine must be free from dangerous surge and instabilities" and also in line with AMC E 790 (a)(2)(5)(c)(vi) – acceptance criteria – which says "Acceptable engine operation precludes….continued or non-recoverable surge or stall. A momentary surge or stall that arrests itself without operational intervention (e.g. without throttle manipulation) is acceptable”".<br>Acceptance criteria in icing conditions should be consistent with acceptance criteria for operation in raining conditions. Therefore for consistency within CS-E , it is proposed to use the same wording as the one already used in AMC 790 |
| response | Not accepted.<br>It is highly unlikely that a surge or a stall would occur on a turbofan or turboprop following this kind of test. Therefore, there is no need to add a provision accepting a momentary surge or stall. |

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| comment | 66 comment by: Federico GARUCCIO<br><br>Ice Slab Ingestion Test is claimed not only to demonstrate tolerance to ice ingestion from ice shedding from nacelle surfaces, but also to establish limits for ice released from other Aircraft surfaces.<br>Consistently, it is clearly specified that: “the applicant should conduct an analysis of the potential installation effects” and “the applicant and the installer should closely coordinate the ice slab sizing”.<br>Table 3 provides minimum ice slab dimensions, related to engine size, based on service experience, apparently for ice-shedding from nacelle surfaces.<br>It might be beneficial for Applicants (and eventually for designers of icing-protection systems) to make explicit that: “minimum ice slab dimensions in Table 3 can fulfil the Ice Slab |

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| | Ingestion Test purposes as long as it can be demonstrated that maximum ice slab dimensions, which can be ingested by the engine form ANY potential ice accumulation site, are below the values reported in Table 3". |
| response | Noted.<br>The substantiation of airframe ice sources is the responsibility of the aircraft manufacturer and this aspect is covered in the CS-25 provisions. This has to be coordinated with the Engine manufacturer and is reminded in the proposed AMC E 780. Table 3 provides the minimum ice dimensions to be covered. |

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| comment | 67 comment by: Federico GARUCCIO<br>Table 3 provides minimum ice slab dimensions based on service experience. Without specifying an orientation with respect to a reference system, the terms "Lengh" and "Width" might be misinterpreted and/or confused.<br>It would help to clearly specify the ice slab initial position, relative to engine axis or inlet circumference, the service experience is based upon. |
| response | Not accepted.<br>Paragraph (4)(c)(i) includes this aspect. |

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| comment | 68 comment by: Federico GARUCCIO<br>paragraph (d) Ice Slab Break Up.<br>Without further definition, the term "Lengh" might be misinterpreted.<br>For example: "Length" might be considered the longer slab dimension, more likely to break, or it can be intended in the same way of the term "length" of the previous Table 3. |
| response | Accepted.<br>'Length' has been replaced by 'greatest dimension'. |

Cessna comment on Table 3:
Typo on conversion from inch to mm
Under Thickness - five rows down
0.35 / 6.35 →
Suggested change: **0.35 / 8.89**

Response: Accepted

Cessna comment on paragraph (4)(d):
Discussion of ice slab break up included in this sections appears to be meant to clarify how the engine manufacturer is to deal with ice slab break up when showing compliance analytically, so it should be included in paragraph (c) as one of the elements of the analysis. This would also prevent confusion from an air framer's perspective of how big a slab needs to be considered from a Part 25 certification perspective.
Suggested change: Renumber section as 4(c)(iv)

Response: Accepted.

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| comment | 77 comment by: Snecma |

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| | Attachment #9<br><br>Please see attached file (Part 4) |
| response | Page 17, paragraph 4(b)<br>REQUESTED CHANGE: (add the following text)<br>Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.<br>JUSTIFICATION: nothing about required engine power is stated in this section<br>Response: Accepted.<br><br>Page 17, paragraph (6) and (7)<br>The proposed text states:<br>(6) The assumed delay in activation of any ice protection system should be declared in the manuals containing instructions for installing and operating the Engine :<br>And<br>(7) The assumed delay in activation of any ice protection system.<br>REQUESTED CHANGE: delete this text<br>JUSTIFICATION: it is not clear why the airframer would need this information so long as the applicant met the CSE-780 requirements<br>Response: Accepted.<br><br>Page 17, paragraph (7)<br>The proposed text states:<br>Damage observed after the ice slab ingestion test<br>REQUESTED CHANGE: delete this text<br>JUSTIFICATION: Any damage from the testing should be assessed against the maintenance manual limits, and if certification is granted, then this information does not need to be provided to the airframer<br>Response: Accepted.<br><br>Page 17, paragraph (7)<br>The proposed text states:<br>For ground icing operation, the conditions established during the test, in terms of time, temperature and run up procedures :<br>REQUESTED CHANGE<br>For ground icing operation, the conditions established during the test, in terms of time, temperature **(if any limitation exists)** and run up procedures<br>JUSTIFICATION: clarifying that the applicant by using analysis may be able to show that the engine is capable below the minimum temperature tested<br>Response: Accepted. |

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| comment | 94 | comment by: Aerospace Industries Association |
| | **Affected paragraph and page number** | Page: 17<br>Paragraph:4(b) |

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| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>**REQUESTED CHANGE:** (add the following text)<br>**Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is respectfully suggested that the above text be added, as there are no other references to required engine power in this section. |

response Accepted.

comment 95 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 18<br>Paragraph: 3(e)(i) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(i) Engine Loss of Performance. Applicants should evaluate the impact of any fan blade bending or damage on potential sustained Engine power/thrust loss. Power/thrust loss associated with fan damage from the slab should be less than 1.5 %. As soft body fan damage is common from medium bird ingestion, applicants may use the medium bird ingestion test results to show compliance with this requirement. If the medium bird ingestion test results in less than 1.5 % permanent power/thrust loss, and no cracks, tears or blade piece breakout occurs due to a bird introduced at the outer 33 % of the fan blade span, then the CS-E 780(f)(2) requirement is met.<br>**REQUESTED CHANGE:**<br>(i)Engine Loss of Performance. Applicants should evaluate the impact of any fan blade bending or damage on potential sustained Engine power/thrust loss. Power/thrust loss associated with fan damage from the slab should be less than 1.5 %. **Ice & birds are "soft body" impactors ie. they are both highly deformable on impact and flow over the structure spreading the impact load. They also have similar densities, thus they create similar strain footprints and consequently similar damage.** As soft body fan damage is common from medium bird ingestion, applicants may use the medium bird ingestion test results to show compliance with this requirement. If the medium bird ingestion test results in less than 1.5 % permanent power/thrust loss, and no cracks, tears or blade piece breakout occurs due to a bird introduced at the outer 33 % of the fan blade span, then the CS-E 780(f)(2) requirement is met, **and there is no need for additional substantiation.** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is suggested that the above text be added, as ice and birds have always produced similar damage-types in service, being that they are both 'soft body' objects in their impact behavior. Biometric studies (Central Science Lab. International Birdstrike |

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| | Research Group) showed that the plucked torso of birds range in density from approximately 0.87 to 1.06 g/cc. Glaze Ice formations have densities around 0.92 g/cc, rime ice can be as low as 0.4 g/cc density. Thus birds tend to have higher densities than ice.<br>It was agreed during discussions in the EIWG meetings that a bird impact in the outer panel of the fan blade would be similar to an ice slab impact and thus, if the outcome of the medium bird test met the slab test compliance criteria, there was no need for further justification that the ice slab requirements had been satisfied. |
| response | Partially accepted.<br>The last addition at the end of the paragraph is redundant and has not been adopted. |

Cessna comments on paragraph (4)(e):
1) Clarification that temporary loss of thrust may be acceptable.
Suggested change: (I) Engine Loss of Performance. Applicants should evaluate the impact of any fan blade bending or damage on potential sustained Engine power/thrust loss. **Sustained** Power/thrust loss associated with fan damage from the slab test should be less than 1.5 %. As soft body…
2) A single, self recovering or mild surge should be acceptable
Suggested change: (B)(ii) Engine Operability/Handling characteristics. Engine damage should not cause **a hazardous** surge, flameout or prevent transient operation.

Response: Partially accepted.
'Sustained' has been added.
It is not considered appropriate to include allowance for non-hazardous operability effects.

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (p. 19)** p. 19

comment 36 comment by: Boeing

Page: 19
Paragraph: (5) Engine Air Data Probe Icing

The proposed text states:
In addition, if data from an Engine air data probe is critical to ensure acceptable Engine operation, then the applicant should demonstrate that Engine air data probe will operate normally without any malfunction under icing conditions. The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe. The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used. In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed.

**REQUESTED CHANGE** We suggest that additional advisory material is needed to define the

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| | following:<br>• probe criticality,<br>• acceptable engine operations,<br>• installation effects that must be accounted for, and<br>• pass/fail criteria for the probe.<br>**JUSTIFICATION:** The Engine Icing Working Group has suggested that further discussions are needed, since there are many varied approaches to engine probe certification and integration with the airplane. Following these discussions, EASA is requested to integrate these recommendations into its advisory material and policy -- the targeted completion date to coincide with the expected revisions resulting from flight testing in ice crystal environment. |
| response | Noted.<br>It is agreed that additional guidance can be added as part of a future rulemaking task, like the one following ice crystal icing research. |

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| comment | 37 comment by: Boeing<br>Page: 19<br>Paragraph: (5) Engine Air Data Probe Icing<br>The proposed text states:<br>… In addition, if data from an Engine air data probe is critical to ensure acceptable Engine operation, then the applicant should demonstrate that Engine air data probe will operate normally without any malfunction under icing conditions. The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe. …<br>**REQUESTED CHANGE:**<br>… In addition, if data from an Engine air data probe is critical to ensure acceptable Engine operation, then the applicant should demonstrate that Engine air data probe will operate normally without any malfunction under icing conditions. The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe -- **in particular, assessing the probe accretion and shedding, as well as measurement capability at high airflows.** …<br>**JUSTIFICATION:** As we suggested earlier, the 100% maximum continuous thrust (MCT) certification for the engine should be deleted, as it is never a worst case; but the proposed AMC text removes a potentially critical icing condition for the probe. Data from other sources can be used to validate the probe. |
| response | Partially accepted.<br>Assessing the probe accretion and shedding is not part of this paragraph (addressed in the paragraph above).<br>Therefore, the proposed additional sentence has been modified and added as follows:<br>‘ […] in particular if high airflow conditions like Maximum Continuous Thrust/Power were not |

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| | selected for the Engine tests in paragraph 2.2 above.' |
| comment | 38 comment by: Boeing<br><br>Page: 19<br>Paragraph: (5) Engine Air Data Probe Icing<br><br>The proposed text states:<br>… The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used. In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed.<br>**REQUESTED CHANGE:**<br>… The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used, **as well as SAE AS5562 (Ice and Rain Qualification Standards for Airdata Probes), along with appropriate consideration of the installation effects and dependence on engine airflow.** In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed**, except with respect to Appendix C, which is applicable to all engines**.<br><br>**JUSTIFICATION:** Installation of sensors in engine inlets poses unique effects that have to be considered in conjunction with testing in the icing environment – that is, the particle trajectories and impingement on the sensor as a function of engine airflow. |
| response | Not accepted.<br>The content of AMC 25.1324 is as much consistent as possible with the revision of AS5562, which is being prepared by EUROCAE WG-89, therefore there is no need to refer to AS5562; furthermore, the future revision of AS5562 must first be published before we are able to refer to it in an AMC.<br>There is no need to remind that Appendix C is applicable to Engines or air intakes as this is already required per CS 2X.1093(b). |

Cessna comments on paragraph (5):
1) Clarify this section is addressing probe icing conditions.
Suggested change: The icing conditions against which the Engine is tested my not cover the icing conditions that are critical for the Engine air data probe. The applicant should determine those critical **probe** icing conditions.

Response: Accepted
2) Clarify this requirement is only applicable for Part 25 aircraft, and clarify that it is the airframe manufacturer's responsibility to show compliance with CS 25.1324, and define the data the engine supplier will need to provide to support that Part 25 certification effort.
Suggested change: Note: When **If** Engine air data probe signals are used by the aircraft system(s) **on a Part 25 airplane**, the aircraft manufacturer **will be responsible for showing** should show that the involved Engine air data probe complies with CS 25.1324 (including rain conditions). **The manuals containing instructions for installing and operating the Engine should provide information on the Engine air data probe(s) including its criticality to proper engine operation and the icing conditions which were determined to be critical for the probe(s).**

Response: Partially accepted.

The note has been modified to make clear that it is applicable to CS-25 certified aeroplanes as proposed. However, the last sentence proposed has not been retained because it deals with probe criticality for the engine, though the note is relevant to the criticality on aeroplane side when its systems use the engine probe data.

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| comment | 79 comment by: Snecma<br><br>Attachment #10<br><br>Please see attached file (Part 5) |
| response | Page 19, paragraph 5<br>The proposed text states:<br>In addition, if data from an Engine air data probe is critical to ensure acceptable Engine operation, then the applicant should demonstrate that Engine air data probe will operate normally without any malfunction under icing conditions. The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe. The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used. In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed.<br>Comment:<br>Advisory material is needed to define the following: probe criticality, acceptable engine operations, installation effects which must be accounted for, and pass fail criteria for the probe. The industry group "Engine Icing Working Group" suggests further discussions are needed since there are many varied approaches to engine probe certification and integration with the airplane. Following these discussions it is requested that EASA integrate these recommendations into their advisory material, and policy – targeted completion date to coincide with the expected revisions resulting from flight testing in ice crystal environment.<br>Noted.<br>It is agreed that additional guidance can be added as part of a future rulemaking task, like the one following ice crystal icing research. |

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| comment | 98 comment by: Aerospace Industries Association |

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| **Affected paragraph and page number** | Page: 19<br>Paragraph: 5 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe.<br>**REQUESTED CHANGE:**<br>The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe. **In particular, assessing the probe accretion and shedding, as well as measurement capability at high airflows.** |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It was suggested earlier that the 100% MCT certification for the engine be deleted as it is never a worst case, but this removes a potentially critical icing condition for the probe; data from other sources can be used to validate the probe. |

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| **Affected paragraph and page number** | Page: 19<br>Paragraph: 5 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>In addition, if data from an Engine air data probe is critical to ensure acceptable Engine operation, then the applicant should demonstrate that Engine air data probe will operate normally without any malfunction under icing conditions. The icing conditions against which the Engine is tested may not cover the icing conditions that are critical for the Engine air data probe. The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used. In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** Advisory material is needed to define the following: probe criticality, acceptable engine operations, installation effects which must be accounted for, and pass/fail criteria for the probe. The industry group "Engine Icing Working Group" suggests further discussions are needed since there are many varied approaches to engine probe certification and integration with the airplane. Following these discussions, it is requested that EASA integrate these recommendations into their advisory material, and policy – targeted completion date to coincide with the expected revisions resulting from flight testing in ice crystal environment. |
| **Affected paragraph and page number** | Page: 19<br>Paragraph: 5 |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used. In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed.<br>**REQUESTED CHANGE:**<br>The applicant should determine those critical icing conditions. In that respect the guidance material of AMC 25.1324 of CS-25 should be used, AS5562**, along with appropriate consideration of the installation effects and dependence on engine airflow.** In doing that the substantiation may be limited to the icing environment applicable to the aircraft on which the Engine is to be installed **except with respect to Appendix C, which is applicable to all engines**. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** Installation of sensors in engine inlets poses unique effects which have to be considered in conjunction with testing in the icing environment, that being the particle trajectories and impingement on the sensor as a function of engine airflow. |

response | Comment 1: Partially accepted.

Assessing the probe accretion and shedding is not part of this paragraph (addressed in the paragraph above).
Therefore, your proposed additional sentence has been modified and added as follows:
'[…] in particular if high airflow conditions like Maximum Continuous Thrust/Power were not selected for the Engine tests in paragraph 2.2 above.'

Comment 2: Noted.
It is agreed that additional guidance can be added as part of a future rulemaking task, like the one following ice crystal icing research.

Comment 3: Not accepted.
The content of AMC 25.1324 is as much consistent as possible with the revision of AS5562, which is being prepared by EUROCAE WG-89, therefore, there is no need to refer to AS5562; furthermore, the future revision of AS5562 must first be published before we are able to refer to it in an AMC.
There is no need to remind that Appendix C is applicable to engines or air intakes as this is already required per CS 2X.1093(b).

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| comment | 119 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Clarification that this section refers to engine intake probes.<br>Comment Resolution<br>Replace "(5) Engine Air Data Probe Icing" with "(5) Engine Intake Air Data Probe Icing" |
| response | Not accepted.<br>The paragraph does not only apply to the Engine air intake probe but also to other probes used for Engine operation. |

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| comment | 126 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Engine intake sensors are located in a very different environment than external airframe probes and these differences must be taken into account in any assessment of the probe's behaviour in icing conditions. In particular, the particle trajectories and thus impingement on the probe, may vary with engine airflow.<br>Comment Resolution<br>Replace "In that respect the guidance material of AMC 25.1324 of CS-25 should be used." with "In that respect the guidance material of AMC 25.1324 of CS-25 should be used, along with appropriate consideration of the installation effects and dependence on engine airflow." |
| response | Accepted. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (p. 20, paragraph 6 Inadvertent** p. 20

**Entry into Icing Conditions or Delayed IPS activation)**

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| comment | 39 comment by: Boeing<br><br>Page: 20<br>Paragraphs:<br>(6) Inadvertent Entry into Icing Conditions or Delayed IPS activation [final paragraph]<br>and<br>(7) Instructions for installing and operating the Engine [final bulleted item]<br><br>The proposed text states:<br>(6) … The assumed delay in activation of any ice protection system should be declared in the manuals containing instructions for installing and operating the Engine.<br>and<br>(7) …• The assumed delay in activation of any ice protection system.<br><br>**REQUESTED CHANGE:**<br>We recommend deleting both of these statements.<br><br>**JUSTIFICATION:** It is not clear why the airframe manufacturer would need this information so long as the applicant met the CS-E 780 requirements. |
| response | Accepted. |

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| comment | 96 comment by: Aerospace Industries Association |

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| **Affected paragraph and page number** | Page: 20<br>Paragraph: (6) and (7) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>(6) The assumed delay in activation of any ice protection system should be declared in the manuals containing instructions for installing and operating the Engine<br>And<br>(7) The assumed delay in activation of any ice protection system.<br>**REQUESTED CHANGE:**<br>(6) The assumed delay in activation of any ice protection system should be declared in the manuals containing instructions for installing and operating the Engine<br>And<br>(7) The assumed delay in activation of any ice protection system. |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is not clear why the airframer would need this information so long as the applicant met the CSE-780 requirements. |

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| response | Accepted. |

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| comment | 118 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>Clarification needed that two minutes is the total delay to be considered.<br>Comment Resolution<br>Replace "a pilot response time of two minutes" with "a pilot detection and response time of two minutes" |
| response | Not accepted.<br>The text has been updated to be consistent with the one retained in AMC 25.1093(b). |

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| comment | 121 comment by: Rolls-Royce plc (ZM)<br><br>Comment Summary<br>It does not seem appropriate to state the assumed delay in activating any ice protection system in either the Engine Operating Instructions or the Engine Installation Manual. Publishing in the Engine Operating Instructions would suggest a delay in activating the ice protection system is part of the operational routine - the requirement is to activate an ice protection system as soon as the requirement becomes evident. Implying a delay is acceptable may possibly drive the wrong crew behaviour. It is not clear why the Airframer needs to be informed of the assumed delay as part of the engine installation - how does that affect the engine installation and what he would do with the Airframer do with the information? The Airframer clearly needs to be informed the engine is compliant with CS-E 780.<br>Comment Resolution<br>Delete "The assumed delay in activation of any ice protection system should be declared in the manuals containing instructions for installing and operating the Engine." |
| response | Accepted. |

**B. Draft Decision — I. Draft Decision amending CS-E — CS-E Book 2; SUBPART E — TURBINE ENGINES; TYPE SUBSTANTIATION — AMC E 780 Icing Conditions (p. 20, paragraph 7 Instructions for installing and operating the Engine)** p. 20

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| comment | 40 comment by: Boeing<br><br>Page: 20<br>Paragraph: (7) Instructions for installing and operating the Engine [5th bulleted item]<br><br>The proposed text states:<br>• Damage observed after the ice slab ingestion test.<br>**REQUESTED CHANGE:**<br><br>Delete this text. |

**JUSTIFICATION:** We suggest that any damage from the testing should be assessed against the maintenance manual limits and, if certification is granted, then this information does not need to be provided to the airframe manufacturer.

response | Accepted.

comment | 41 comment by: Boeing

Page: 20
Paragraph: (7) Instructions for installing and operating the Engine [8th bulleted item]

The proposed text states:
• For ground icing operation, the conditions established during the test, in terms of time, temperature and run up procedures

**REQUESTED CHANGE:**
• For ground icing operation, the conditions established during the test, in terms of time, temperature **(if any limitation exists)** and run up procedures

**JUSTIFICATION:** Our suggested change clarifies that the applicant, by using analysis, may be able to show that the engine is capable below the minimum temperature tested.

response | Accepted.

comment | 72 comment by: FAA

Page: 20 of 20
Paragraph: (7) Instructions for installing and operating the Engine
**The proposed text states**: "The applicant should declare all identified limitations to the installer in the manuals containing instructions for installing and operating the Engine. This should include, but is not limited to, the following items (see background in the previous paragraphs of this AMC):"
**REQUESTED CHANGE:** If the CS-E 780 Icing Conditions requirements are found in CS 2X.1093, then the manuals containing instructions for installing and operating the engine should specifically cite what icing environment it is certified to. It should also be included on the engine type certification data sheet.
**JUSTIFICATION:** The installer should have clear documentation to identify what icing environment the engine has been certified to.

response | Accepted.
A new bullet has been added at the top of the list.

comment | 97 comment by: Aerospace Industries Association

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| **Affected paragraph and page number** | Page: 20<br>Paragraph: (7) |
| **What is your concern and what do you want** | The proposed text states:<br>Damage observed after the ice slab ingestion test |

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| **changed in this paragraph?** | **REQUESTED CHANGE:** delete this text<br>Damage observed after the ice slab ingestion test |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is suggested that any damage from the testing should be assessed against the maintenance manual limits, and if certification is granted, then this information does not need to be provided to the airframer. |
| **Affected paragraph and page number** | Page: 20<br>Paragraph: (7) |
| **What is your concern and what do you want changed in this paragraph?** | The proposed text states:<br>For ground icing operation, the conditions established during the test, in terms of time, temperature and run up procedures<br>**REQUESTED CHANGE:**<br>For ground icing operation, the conditions established during the test, in terms of time, temperature **(if any limitation exists)** and run up procedures |
| **Why is your suggested change justified?** | **JUSTIFICATION:** It is felt that the above requested change clarifies that the applicant, by using analysis, may be able to show that the engine is capable below the minimum temperature tested. |

response

Comment 1: Accepted.

Comment 2: Accepted.

comment

122 comment by: Rolls-Royce plc (ZM)

Comment Summary
It does not seem appropriate to state the assumed delay in activating any ice protection system in either the Engine Operating Instructions or the Engine Installation Manual. Publishing in the Engine Operating Instructions would suggest a delay in activating the ice protection system is part of the operational routine - the requirement is to activate an ice protection system as soon as the requirement becomes evident. Implying a delay is acceptable may possibly drive the wrong crew behaviour. It is not clear why the Airframer needs to be informed of the assumed delay as part of the engine installation - how does that affect the engine installation and what he would do with the Airframer do with the information? The Airframer clearly needs to be informed the engine is compliant with CS-E 780.
Comment Resolution
Delete "The assumed delay in activation of any ice protection system."

response

Accepted.

comment

123 comment by: Rolls-Royce plc (ZM)

Comment Summary

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| | Not clear why the Airframer needs to be informed of the damage observed following the ice slab ingestion test or what it would do with that information. The Airframer clearly needs to be informed the engine is compliant with CS-E 780 ice slab ingestion requirements.<br>Comment Resolution<br>Delete "Damage observed after the ice slab ingestion test;" |
| response | Accepted. |

# 4. Appendix — Attachments

**FAA Response- NPA 2012-23 Engine Icing -Comment Response Doc-Apr 25 2013-Final.pdf**
Attachment #1 to comment #69

AIA Comments on NPA 2012-23.pdf
Attachment #2 to comment #99

GE Comments to NPA2012-23.pdf
Attachment #3 to comment #127

EIWG Comments to NPA2012-23 Mar 26 2013.pdf
Attachment #4 to comment #127

1262 Response_Final.pdf
Attachment #5 to comment #130

3308-RC Part 1 SN comments on NPA 2012-23.pdf
Attachment #6 to comment #74

3308-RC Part 2 SN comments on NPA 2012-23.pdf
Attachment #7 to comment #75

3308-RC Part 3 SN comments on NPA 2012-23.pdf
Attachment #8 to comment #76

3308-RC Part 4 SN comments on NPA 2012-23.pdf
Attachment #9 to comment #77

3308-RC Part 5 SN comments on NPA 2012-23.pdf
Attachment #10 to comment #79