European Union Aviation Safety Agency

Comment-Response Document (CRD) 2021-13

RELATED NPA: 2021-13 — RELATED ED DECISION: 2023/020/R — RMT.0184
15.12.2023

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Summary of the outcome of the consultation

There are 168 unique comments on this NPA (168 in total) made on 27 segments by 19 users.

List of the commentators: Airbus, Airbus Helicopters, Boeing, CAA NL, DGAC Fr, Drone Manufacturers Alliance Europe, Federal Aviation Administration (FAA), GE Avio, Gulfstream Aerospace, Honeywell E&PS, Joint ASD/AIA/AIAC, LBA, Pratt&Whitney Canada, Rolls Royce Plc, Safran, Safran Helicopter Engines, Swedish Transport Agency, Transport Canada Civil Aviation (TCCA), one individual.

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The following summarises the comments received, highlighting the most substantial ones and providing the corresponding EASA responses.

Item 1 Compressor and turbine blade failure

In addition to various comments requesting clarification or improvement of the proposed amendments (see individual comments below), the following most substantial comments were received:

Independent certification of an engine

Some engine manufacturers and the FAA commented that the NPA proposal may prevent the type certification of an engine independently from the aircraft certification. These commentators asked EASA to retain this possibility and to revise the proposed CS-E amendment accordingly. EASA confirms that it remains possible to certify an engine independently from an aircraft. However, there is mutual interest for both the engine and the aircraft manufacturers to cooperate in the analysis of the threat posed to the aircraft by an engine blade failure. This cooperation should therefore be used when possible. The proposed AMC E 510 and AMC E 810 have been substantially revised to reflect this situation. AMC E 510 is written in a way that does not prevent the certification of an engine independently from an aircraft. The engine manufacturer may make assumptions regarding the ability of the aircraft to withstand some engine debris impacts, and this should be provided to the aircraft manufacturer (or other engine installer) in the engine installation manual, or equivalent, as required by CS-E 20(d).

Hazardous engine effect

Many comments from industry and aviation authorities indicated that there was a need to clarify how the possibility of a Hazardous Engine Effect should be investigated and mitigated. Some comments pointed at an unclear link between the hazard to the aircraft, the Hazardous Engine Effect classification, the part classification (i.e. critical part), and the associated failure rate. EASA therefore thoroughly revised the proposed AMC E 510 and AMC E 810. In particular, the revised AMC E 510 clarifies when debris resulting from a failure should be considered as uncontained high-energy debris causing a Hazardous Engine Effect. The AMC also explains and differentiates between how the applicant should address engine major rotating parts, blades, and other sources of uncontained high energy debris.

The FAA explained that they do not agree with a probabilistic approach to mitigate released debris. They recommended a deterministic approach to quantify the size and energy that is considered hazardous at the aircraft level under the current regulatory requirements and limit the size and energy of any individual piece of fan blade debris exiting the engine. EASA disagrees with this approach that does not consider the frequency of occurrence. As a general principle, if a Failure can result in debris being released with an energy and trajectory that causes an unsafe condition (refer to AMC1 21.A.3B(b)), such debris should be considered as uncontained high-energy debris causing a Hazardous Engine Effect. This principle has been explained in the revised version of the proposed amendment to AMC E 510. Also, additional guidance has been added to explain how applicants should determine the likelihood that a blade failure results in an unsafe condition. Where possible, the threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer. Assumptions regarding the ability of the aircraft to withstand debris impact should be included in the Manuals required by CS-E 20(d).

Strength

Airbus recommended to maintain in CS-E 520 (c)(1) the current requirement of not resulting in a Hazardous Engine Effect to ensure that the engine manufacturer does not limit its assessment to containment capability but also takes into account longer-term (i.e. post-failure) effects after a blade shedding event. EASA considers that this is not necessary as the new CS-E 520 requires a radial containment. Also, CS-E 810(a) includes a specification addressing potential Hazardous Engine Effects after the radial containment. In addition, the safety assessment of the continued rotation after engine shutdown is already addressed by CS-E 525.

Debris released rearward

Safran Helicopter Engines raised a concern that the consideration of failure conditions leading to rearward debris as potentially Hazardous would increase the complexity of the certification of blade shedding overspeed protections, which are recognised as reliable mechanical overspeed protections. The integration of overspeed protection by blade shedding has been considered as a significant improvement in safety for Safran Helicopter Engines. They proposed to limit the scope of axially released debris to forward debris only, arguing that the issue triggering the proposed CS-E amendment is mainly related to forward debris release after fan blade failure of turbofan engines.

EASA disagrees with the removal of rearward debris from the scope of the safety assessment to be conducted under CS-E 510. The same certification objectives should be used whatever the type of aircraft on which the engine will be installed. It is expected that the engine manufacturer performs a safety assessment of the effect of blade failures. There is no obligation to classify by default non-contained debris as Hazardous Engine Effects. The goal should rather be to design the Engine to prevent damages with such effects. The proposed AMC E 510 and AMC E 810 were updated to clarify how the assessment of the threat should be made.

Item 2 Assumptions — oil consumption

Some clarifications of the terminology used were suggested. This was taken into account to improve the proposed text.

Item 3 Instrument provisions

No comment received. The EASA proposal is retained.

Item 4 Piston engine failure analysis

Some specific questions were raised and answered individually.

Also, the FAA proposed to add a kind of failure condition leading to ‘Loss of power or thrust’ in the list of Hazardous Failure conditions; this was not accepted as such failure condition is also not classified Hazardous for turbine engines under CS-E 510(g). The EASA proposal is retained.

Item 5 Approval of engine use with a thrust reverser

Some clarifications of the terminology used were suggested. This was taken into account to improve the proposed text.

Item 6 Fuel specifications for compression-ignition piston engine

One question was received that has been responded and did not require a change to the proposed text. The EASA proposal is retained.

Item 7 Ice protection

In addition to various comments requesting clarification or improvement of the proposed amendments (see individual comments below), the following most substantial comments were received:

Vibration-induced effects

Comments received against the proposed new AMC E 100 (Strength) (Boeing, ASD/AIA/AIAC), FAA, Rolls Royce, Safran Helicopter Engines, Pratt&Whitney Canada, TCCA), although in agreement with the technical content, recommended to locate the provisions for the assessment of the effects caused by operation into icing, rain, and hail in AMC E 650 (Vibration surveys) instead of creating AMC E 100, as deemed more appropriate to the scope of the subject. They also asked for some clarifications. EASA accepted this proposal and also enhanced the technical content based on comments.

Unacceptable mechanical damage

Several commentators (Boeing, FAA, GE Avio, Airbus) stated that the proposed definition in AMC E 780 was not clear enough and asked for more guidance to support the demonstration of compliance with CS-E 780(a)(i). Some of them considered that it was written like a requirement and not like a definition. The definition has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

Icing threats simulation (Establishment of SLW Test Points for In-Flight Operation)

Several commentators (Boeing, Airbus Helicopters, Safran, Rolls Royce) asked for more guidance on the meaning of 'icing threats' simulation when using a non-altitude test to demonstrate compliance with CS-E 780 for in-flight icing conditions. EASA updated the corresponding paragraph (2.2)(c) of AMC E 780 to provide a (non-exhaustive) list of these threats. In addition, EASA added a description of what constitutes a 'single atmospheric condition' in the frame of the test points selection to simulate the icing threats. Reference is made to the Table 1 standard test points and to the test points identified via the Critical Point Analysis (CPA).

Intent of the ice slab ingestion test

Comments and questions received (Boeing, ASD/AIA/AIAC, GE Avio, Rolls Royce, Safran, Honeywell, Pratt&Whitney Canada) regarding the EASA proposed change to paragraph (4)(a) of AMC E 780 revealed that the proposed text created some confusion and controversy instead of conveying the EASA intended clarification. The proposed change has been withdrawn. Reliance is maintained on the existing CS-E 780 (f)(4) and AMC E 780 paragraph (4)(a) to ensure coordination with the aircraft manufacturer when assessing the ice slab dimensions and shedding frequency.

Item 8: Damage tolerance of critical parts

In addition to comments requesting clarification or improvement of the proposed amendment (see individual comments below), the following most substantial comments were received:

Structure of AMC E 515

Some commentators considered that the structure of the proposed amendment of AMC E 515 was not always logical and difficult to follow, hence it should be reviewed and improved, e.g. to be closer to the structure used in the EASA Certification Memorandum CM-PIFS-007. EASA therefore reorganised the AMC in a better structured way.

Harmonisation with FAA AC 33.70-1

GE Avio commented, regarding the cycle definition, the difference between the proposed amendment of AMC E 515 and FAA AC 33.70-1 Ch.1 and recommended that EASA adopt the definition of 'damage tolerance cycle' provided in AC 33.70-1 Ch.1. EASA does not agree. This difference is already a published Safety Emphasis item (SEI) between EASA and FAA (SEI 8). EASA considers that the analysed engine full flight cycle should include the various flight segments that describe a complete mission such that detrimental effects are appropriately evaluated. Examples of such effects are dwell and minor cycles.

Item 9: Engine critical parts — Static pressure loaded parts

Two comments were received from the FAA, one of them being substantial. The FAA proposed to include in the scope of the life assessment of static, pressure loaded parts, in addition to engine gas path parts, accessory components with high internal pressures such as fuel pumps, fuel metering units, and heat exchangers. EASA does not agree. CS-E 515 and its AMC are specifically written to address Engine Critical Parts (Life Limited Parts per the FAA definition); the applicability is therefore determined based upon the safety assessment and definitions. An Engine Critical Part is a part that relies upon meeting the prescribed integrity specifications of CS-E 515 to avoid its Primary Failure, which is likely to result in a Hazardous Engine Effect. The parts identified in the FAA comment are normally not considered to result in such an assessment.

Item 10: Various corrections

Three minor comments were received that did not result in a change to the NPA proposal. The EASA proposal is retained.

Individual comments and responses

In responding to the comments, the following terminology is applied to attest EASA's position:

(a) **Accepted** — EASA agrees with the comment and any proposed change is incorporated into the text.

(b) **Partially accepted** — EASA either partially agrees with the comment or agrees with it but the proposed change is partially incorporated into the text.

(c) **Noted** — EASA acknowledges the comment, but no change to the text is considered necessary.

(d) **Not accepted** — EASA does not agree with the comment or proposed change.

(General Comments)	-

comment	*2* comment by: *DGAC FR (Mireille Chabroux)* DGAC France would like to thank EASA for this consultation, and inform EASA that we have no position or comment on the proposed document.
response	Noted.

comment	*3* comment by: *LBA* LBA has no comments
response	Noted.

comment	*4* comment by: *Swedish Transport Agency, Civil Aviation Department (Transportstyrelsen, Luftfartsavdelningen)* Thank you for the opportunity to comment on NPA 2021-13 'Regular update of CS-E'. Please be advised that there are no comments from the Swedish Transport Agency.
response	Noted.

comment	*138* comment by: *Joint ASD/AIA/AIAC review* Attachment #1 •The NPA introduces significant changes in the CS-E. §2.2 indicates that those evolutions are non-complex, non-controversial and mature subjects which is not correct in all cases. A mechanism needs to be found in future to introduce changes to CS-E in a timely fashion without using a mechanism that is for non-controversial changes only. Changing the regular update to allow controversial topics and engaging with industry prior to NPA issue might be a way forward. Additionally, there is no impact assessment performed in this NPA.

•We do agree that the relevant data and analysis has to be exchanged between engine manufacturer and aircraft manufacturer (so as to allow aircraft to be certified). However, it is important that it continues to be possible to certify engines independently from a specific airframe. This NPA introduces changes which appear to mandate interaction with an airframer pre-certification. It should be made clear in each case that providing relevant assumptions in the applications assumptions is an alternative.
•ASD/AIA/AIAC fully support harmonising the regulation at least between FAA and EASA. These changes introduce more differences. Is there a plan to bring the two engine certification specification together?
•Item 1, 7, and 8 are the 3 items that have raised the vast majority of the comments. ASD/AIA/AIAC member companies will submit detailed comments on these items separately.
•ASD/AIA/AIAC would appreciate the opportunity to discuss the NPA (particularly item 1), the comments and EASA's response to them in a dedicated meeting prior to the CS-E update.

response

1) Rulemaking process: Noted. The new EASA Management Board Decision No 01-2022 on the Rulemaking Procedure was published and entered into force on 4 May 2022. The new procedure provides for a more efficient, effective and flexible process. This includes flexibility in the way EASA consults its stakeholders, and this could be used for some topics that may require more involvement of stakeholders than through the usual Regular update NPA consultation.
2) Certification of engines independently from a specific airframe: Noted. EASA confirms that the NPA did not intend to mandate an interaction between the engine and the aircraft manufacturers before engine certification. The proposed amendment (item 1) encourages this interaction, but it leaves the possibility to the engine manufacturer to communicate the assumptions made to be taken into account by the installer. The certification of the engine independently from the aircraft on which it will be installed, although not the preferred way, remains possible. This philosophy is retained in the final CS-E text.
3) Harmonisation with the FAA: Noted. Attempts to set up a cooperation with the FAA on item 1 were indeed not successful until the NPA publication. EASA remains open to work together with the FAA in the future and seek for as much harmonisation as possible.

comment

152 comment by: *Boeing*

The attached comprise comments from Boeing Commercial Airplanes submitted to EASA via the Comment Response Tool (CRT) in response to EASA Notice of Proposed Amendment (NPA) 2021-13: Regular Update of CS-E to Address Failure of Engine Fan Blades.

Sincerely,
Mildred Troegeler
Director, Global Regulatory Strategy

The Boeing Company Comments to EASA NPA 2021-13:
Regular Update of CS-E to Address Failure of Engine Fan Blades

COMMENT #1 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page:14 Paragraph: *(iii)*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** no evidence, either from the test, service experience or other analysis, indicating that the conditions of paragraphs (c)(i) and (c)(ii) above would not be satisfied under other possible blade Failure conditions (e.g. blade released at different angular position, partial blade failure, or release at speeds below the maximum to be approved). **REQUESTED CHANGE:** no evidence, either from the test, previous relevant tests, service experience or other analysis, indicating that the conditions of paragraphs (c)(i) and (c)(ii) above would not be satisfied under other possible blade Failure conditions (e.g. blade released at different angular position, partial blade failure, or release at speeds below the maximum to be approved).		
Why is your suggested change justified?	**JUSTIFICATION:** In many cases, Engine manufacturers perform one, or several engineering fan-blade-out (FBO) rig tests, prior to the FBO certification test. Additionally, other engine tests (e.g. bird strike tests) may provide data on fan blade fragment behavior. If applicable, and relevant, data from these tests could further inform the Engine and Airframe manufacturers on potential fan blade fragment threats.		

COMMENT #2 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page:17-18 Paragraph: *Item 7: Ice protection*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** **Item 7: Ice protection** Create AMC E 100 as follows: AMC E 100 Strength		

	When showing compliance with CS-E 100(c) for turbine engines, **REQUESTED CHANGE:** **Item 7: Ice protection** ~~**Create AMC E 100**~~ **Modify AMC E 650** as follows: ~~**AMC E 100 Strength**~~ **AMC E 650 Vibration Surveys:** … (5) Altitude~~**, and**~~ Temperature **and Environmental** Effects CS-E 650(a) requires that conditions throughout the declared flight envelope are evaluated when establishing that the dynamic behaviour of components and systems is acceptable. **This includes the effects due to icing, rain, and hail under which sustained engine operation is expected to occur and which may lead to high rotor imbalance or severe rotor-case interaction.** **…** Changes in operating conditions associated with ambient temperature~~**, and**~~ altitude **and environmental** variations affect Engine performance~~**and,**~~ airflow characteristics **and rotor imbalance**. This can have a significant effect on aerodynamic **and mechanical** forcing and damping, which, in turn, affects the vibratory response and behaviour of certain components. … (9) … (b) Stress Margins … **(1) For Engine parts, repeated exposure to high cycle fatigue stresses in excess of endurance limits for even short periods of time could lead to cumulative fatigue damage and subsequent component failure. If these vibratory stresses exceed the levels demonstrated during compliance with CS-E 650, it should be demonstrated under CS-E 100 that they are not excessive.** **(2) Vibration forces imparted to the aircraft structure due to these conditions should be declared in the Manuals required by CS-E 20(d), and should include assumptions such as mass, stiffness and damping of the aircraft mount system.**
Why is your suggested change justified?	**JUSTIFICATION:** The compliance to CS-E 650(f) already calls for assessing the engine components to the vibration characteristics for the declared flight envelope. What is being clarified with the NPA is also evaluating the vibration characteristics due to icing, rain and hail. This seems NPA change is better suited to be a clarification within the existing framework of AMC E 650 rather than a new AMC to CS-E 100(c). The proposed text is a

	suggested way, but not the only way, to incorporate the new AMC verbiage to the existing AMC E 650 text.

COMMENT #3 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 18 of 36 Paragraph: *(a)(i)*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** **"**It must be established by tests, unless alternative appropriate evidence is available, that the Engine will function satisfactorily in flight and on ground when operated throughout the applicable atmospheric icing conditions"… **REQUESTED CHANGE:** Clarification requested.		
Why is your suggested change justified?	**JUSTIFICATION:** It is respectfully requested to please clarify that the statement "on ground" only refers to the ground icing requirements, and that there is no expectation for the aircraft to operate in the full range of in-flight icing conditions when on the ground.		

COMMENT #4 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 19 Paragraph: *1.1 "Definitions"*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing-induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence. The applicant should make appropriately conservative assumptions regarding the severity and duration of the icing encounters. When determining the acceptability of any damage arising as a result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness." **REQUESTED CHANGE:** Clarification requested.		

Why is your suggested change justified?	**JUSTIFICATION:** It is respectfully requested that the definition of "unacceptable mechanical damage" be moved to a section with other requirements. It is also respectfully requested that additional guidance material be included in the AMC to assist in compliance with the requirement to protect against unacceptable mechanical damage, such as including a definition of "acceptable mechanical damage".

COMMENT #5 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 20 Paragraph: 1.6, "Applicable Environments"		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** **"**These conditions may include ice crystal icing conditions, supercooled large drop icing conditions, and falling and blowing snow conditions." **REQUESTED CHANGE:** Clarification requested.		
Why is your suggested change justified?	**JUSTIFICATION:** It is respectfully asked if the intent of the inclusion of "supercooled large drop icing conditions" is now included for all aircraft. Previously the understanding was that supercooled large drop (SLD) compliance was only required if an aircraft were certified for flight in icing conditions.		

COMMENT #6 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 20 Paragraph: *2.2(c) "Supercooled Liquid Water Icing Conditions"*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** "When a non-altitude test is used to demonstrate compliance for in-flight icing, any differences in Engine operating conditions, LWC, ice accretion and shedding between the altitude condition to be simulated and the test conditions, which could affect the icing threat"… **REQUESTED CHANGE:**		

	Clarification requested.
Why is your suggested change justified?	**JUSTIFICATION:** It is respectfully noted that the term "threat" may have unintended consequences. Was this sentence intended to mean "icing conditions"?

COMMENT #7 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 20 Paragraph: *2.2(c) "Supercooled Liquid Water Icing Conditions"*		
What is your concern and what do you want changed in this paragraph?	**THE PROPOSED TEXT STATES:** This may also require running multiple test points to simulate all icing threats associated with a single atmospheric condition. **REQUESTED CHANGE:** Clarification requested.		
Why is your suggested change justified?	**JUSTIFICATION:** It is respectfully requested that additional clarification be provided on the meaning of a "single atmospheric condition". Could the guidance material provide a more specific link to the critical point analysis (CPA); such as identifying which failure modes are critical to each threat? It is also respectfully requested that the guidance material include a statement to be aware of hazards prior to testing, in order to avoid inadvertent failures during testing.		

COMMENT #8 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 22 Paragraph: *Table 2, Note 1*		
What is your concern and what do you want changed in this paragraph?	**The proposed text states:** "For instance, snow concentrations may need to be increased to address blowing snow, and large drop glaze ice conditions may not be applicable for installation on a given aircraft."		

	REQUESTED CHANGE: Additional details are respectfully requested regarding the statement, "snow concentrations may need to be increased to address blowing snow".
Why is your suggested change justified?	**JUSTIFICATION:** Table 2 lists a snow concentration of 0.9 g/m3. If additional requirements are being implemented by the above note, it is respectfully requested that guidance on the desired snow condition, such as concentration boundaries, are also defined within this section of the guidance material.

COMMENT #9 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page: 23 Paragraph: *4(a), "Ice Ingestion"*		
What is your concern and what do you want changed in this paragraph?	**The proposed text states:** Although the test demonstrates tolerance to ice shedding, it cannot be ensured that the ice slab impact results in the maximum possible energy transfer, and therefore this test should not be used to justify inlet designs which routinely accumulate and release ice during a continuous icing encounter. **REQUESTED CHANGE:** Clarification requested.		
Why is your suggested change justified?	**JUSTIFICATION:** Clarification is respectfully requested on the term "routinely accumulate". Does this refer to de-icing or anti-icing? Also, it is requested that guidance be provided on how to justify those inlet designs which routinely accumulate and release ice?		

COMMENT #10 of 10			
Type of comment (check one)	***Non-Concur***	***Substantive X***	***Editorial***
Affected paragraph and page number	Page 24, paragraph 5 under Section 6, "Ice Protection Systems Activation and Deactivation"		

What is your concern and what do you want changed in this paragraph?	**The proposed text states:** "Consideration should also be given to the effects of delays in deactivating an ice protection system, or to inadvertent operation of an anti-ice system when the engine is not in icing conditions." **REQUESTED CHANGE:** Clarification requested.
Why is your suggested change justified?	**JUSTIFICATION:** Clarification is respectfully requested for this sentence regarding ice protection systems (IPS) when the engine is not in icing conditions. Should this be moved to another section if it is referring to the engine operation when not in icing conditions?

response

Comment 1: Accepted.

The commented paragraph has been removed and replaced by a new paragraph (1)(c) of AMC E 810. The wording used in this new paragraph should address this comment.

Comment 2: Accepted.

The proposal to amend AMC E 100 has been withdrawn. Instead, AMC E 650 is amended.

Comment 3: Accepted.

CS-E 780(a)(2) has been clarified.

Comment 4: Partially accepted.

What is acceptable under an icing test is not necessarily acceptable for another test (e.g. large flocking bird test), therefore this definition is better placed under AMC E 780.

The definition of unacceptable mechanical damage has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

Comment 5: Not accepted.

As already specified in CS-E 780(a)(2) the applicability of additional conditions (including SLD) depends on the conditions applicable to the air intake system of the aircraft on which the Engine is to be installed. Please refer to CS-E 780(a)(2) to find the exact wording.

Comment 6: Accepted.

Paragraph (2.2)(c) has been updated to provide a non-exhaustive list of 'icing threats' to be considered.

Comment 7: Accepted.

Paragraph (2.2)(c) has been amended and it now provides guidance on what could be a single atmospheric condition.

Comment 8: Partially accepted.

The required snow concentrations to address e.g. blowing snow are dependent on the aircraft on which the engine is to be installed. For instance, some guidance is provided as part of AMC 25.1093(a) 1.6. A reference to this AMC has been added in Note 1 of Table 2.

Comment 9: Noted.

EASA decided to withdraw the proposed amendment of AMC E 780(4)(a) and therefore the original text is maintained. The proposal created more confusion than clarification and appeared to be controversial. EASA expects that the compliance with CS-E 780(f)(4) ensures coordination with aircraft manufacturer and that aircraft ice slab dimensions and shedding frequency are assessed.

Comment 10: Not accepted.

This sentence is intended to address potential adverse engine effects due to ice protection systems being activated in the absence of icing conditions. EASA investigated if another AMC paragraph would be more appropriate to deal with this issue but concluded that AMC E 780 is adequate.

1. About this NPA p. 3

comment	*24* comment by: *Civil Aviation Authority the Netherlands* No comments from the Netherlands on this NPA.
response	Noted.

1.1. How this NPA was developed p. 3

comment	*29* comment by: *Drone Manufacturers Alliance Europe (DMAE)*
response	Noted.

2.1. Why we need to amend the rules - issue/rationale p. 4

comment	*139* comment by: *Joint ASD/AIA/AIAC review* **For Item 1, main issues identified by ASD, AIA and AIAC are the following :** -Blade failure substantiation at engine level without A/C inputs seems to be nearly excluded even with known architectures

	-There is a already an AIA (with ASD and AIAC member participation) led group based on NTSB recommendations : interaction between engine and nacelle following fan blade out. Why issue this NPA before conclusion of this group ? -Some definitions are understood to be missing or incomplete (hazard to the aircraft, hazard ratio) -The link between hazard to the A/C, Hazardous engine effect, related part classification and associated failure rate is unclear. -NPA 2022-02 for CS-27/CS-29 seems not to be aligned with CS-E proposal for at least blade containment (see AMC 29.901 proposal). -The text relative to "*Engine failures (including blade failures) that can lead to debris being released from the Engine"* should only refer to "*Blade failures*". Indeed, the objective of item 1 is to address the NTSB safety recommendation UNST-2019-007. -Impact on blade shedding overspeed protection is also unclear. Item 1 is considered at this stage the most controversial and requires further discussions with EASA. **For Item 7 (Ice Ingestion), intent is understood but main issues identified by ASD, AIA and AIAC are the following :** -AMC E 780 : attempting to investigate all possible failure modes for every test conditions may lead to unrealistic severe icing test -AMC E 780 : interpretation could lead to have Continuous Maximum and Intermittent Maximum envelopes of appendix C of CS-2X to be considered for ground operation. -AMC E 100 : It is not clearly understood until which point the quantification of the vibratory stress margin vs endurance limits (per E 650 rule) has to be done during rain ingestion test or icing test : engine level or component level ? If measurement is awaited at component level, some test may be impracticable. -AMC E 780 : Ice impact location and test condition for engine ice slab ingestion certification tests are defined so that they represent the most critical conditions for engine parts. Effect of repetitive impacts of smaller ice slabs can be assessed based on test performed with a larger ice slab. Test results would provide direct compliance, or they may be completed with an analysis **For Item 8 (Damage Tolerance Assessment), main comments would be to modify the wording to clarify the proposed text.**
response	Item 1: Noted. EASA confirms that the proposal did not intend to preclude the certification of an engine independently from the aircraft. Regarding the other specific comments, as they are repeated later on specifically to the proposed CS and AMC amendments, please refer to the responses provided below. NPA 2022-01: As CS-29 is amended before CS-E, the AMC 29.903(d)(1) text has been adjusted to clarify that it deals with radial containment/debris only. Item 7: Comment 1: 'AMC E 780: attempting to investigate all possible failure modes for every test conditions may lead to unrealistic severe icing test' Response: Noted. In order to avoid cumulating conservative conditions as required to replicate all critical conditions simultaneously as part of a single test point, resulting in an

unrealistic severe icing test point, the AMC includes specific provisions offering to run multiple test points to assess the individual relevant threats separately. Some paragraphs have been reordered to emphasise that critical conditions can be assessed separately through multiple test points.

Comment 2: 'AMC E 780 : interpretation could lead to have Continuous Maximum and Intermittent Maximum envelopes of appendix C of CS-2X to be considered for ground operation.'

Response: Partially accepted.

CS-E 780 has been revised to clarify the conditions that are applicable to ground operation only.

Comment 3: '-AMC E 100 : It is not clearly understood until which point the quantification of the vibratory stress margin vs endurance limits (per E 650 rule) has to be done during rain ingestion test or icing test : engine level or component level ? If measurement is awaited at component level, some test may be impracticable.'

Response:

Partially accepted. The proposed amendment to AMC E 100 has been withdrawn and, instead, AMC E 650 is amended to clarify that environmental conditions such as icing, rain and hail conditions need to be considered when showing compliance with CS-E 650, which allows compliance to be shown by validated analysis.

Comment 4: '-AMC E 780 : Ice impact location and test condition for engine ice slab ingestion certification tests are defined so that they represent the most critical conditions for engine parts. Effect of repetitive impacts of smaller ice slabs can be assessed based on test performed with a larger ice slab.

Test results would provide direct compliance, or they may be completed with an analysis'

Response: Noted.

EASA decided to withdraw the proposed amendment of AMC E 780(4)(a) and therefore the original text is maintained. The proposal created more confusion than clarification and appeared to be controversial. EASA expects that the compliance with CS-E 780(f)(4) ensures coordination with aircraft manufacturer and that aircraft ice slab dimensions and shedding frequency are assessed.

Item 8: Accepted.

20 2 1 -20 2 p. 5

comment *6* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
7	Item 7 Icing	"Icing induced	Ice formation or ice accretion are major	Suggest revising	Conceptual

	induced vibrations	vibrations: EASA has identified the need to clarify what effects should be taken into account when showing compliance with CS E 100(c) for turbine engines. This includes, among other items, the effect of ice ingestion."	contributors to fan blades increased vibratory amplitude and reduced flutter margin.	last sentence to include the effect of ice accretion.	

response | Accepted.

comment | *153* comment by: *Transport Canada Civil aviation*

Item 5 - last sentence

In “EASA considers that the content of this CM is sufficiently mature to be reflected in CS-E.” ; can EASA identify in which Section of CS-E is this reflected ?

Suggested resolution:
Suggest to add text, if needed

response | Accepted.
Please refer to page 9 of the NPA: CS-E 10(b) and AMC E 10(b).

comment | *154* comment by: *Transport Canada Civil aviation*

Item 6 - last sentence

In “This is however not indicated in CS-E.”; can EASA identify in which Section of CS-E this is not indicated?

Suggested resolution
Suggest to add text, if needed

response | Not accepted.

As the provision at stake does not exist, there is no CS-E paragraph to be mentioned. Therefore, a new AMC E 240 was proposed in the NPA.

2.3. How we want to achieve it - overview of the proposed amendments p. 8

comment | *7* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
8&9	2.3(c)(3)	add a paragraph specifying that some engine failures may result in debris being released from the engine, forward, rearward, or otherwise outside of the containment structure. If such failures may result in debris being released with an energy and trajectory that could cause a hazard to the aircraft, they should be considered as causing a Hazardous Engine Effect.	The paragraph is forcing the engine manufacturer to resolve an issue typically handled by the engine installer, that is the hazard to the aircraft posed by the defined engergy and trajectories of the engine debris. We have typically relied on a "fail safe" philosophy when it comes to fan blade failure in engine design and installation requirements. Th e proposed ammendment opens a path that would allow something other than the fail safe design philosophy when it comes to engine blade failure.	For the Aircraft vs. Engine requirement, it should be up to the Airplane requirements to manage the safety of the airplane given the debris exiting the engine. It is impossible for the engine manufacturer to define and mitigate the hazards to the airplane after debris has exited the engine. Simply on calling it a hazardous engine effect abandons the "fail safe" philosophy of fan blade airfoil failure. Propos ed resolution is to maintain the fail-safe philosophy and require the	Conceptual

				engine installer to mitigate energy and trajectories of that debris defined by the engine manufacturer.	
9	Item 2	"...flight duration and the engine maximum average oil consumption.."	A certified engine may be used on multiple aircraft models including future, unknown models, whereas "flight duration" is linked to a specific aircraft model.	Change from requiring an oil consumption rate to "a maximum allowable oil loss", and then have each aircraft AFM and flight line maintenance manual state the maximum allowed oil loss rate.	C
9	Item 2	"...flight duration and the engine maximum average oil consumption.."	The terms "maximum" and "average" are separately understood, but the term "maximum average" is confusing. It either requires change or an explanation.	Replace the term "maximum average" with "maximum", or (if insisting upon having a loss rate) state "maximum rate".	C
9	Item 2	"...flight duration and the engine maximum average oil consumption for the oil system."	The statement assumes that the oil system for the engine bearings supporting the rotating turbomachinery is integrated with the accessory gear box oil system which may not be the case	Add "accessory gear box".	C

respons e

Comment 1: Not accepted. The intention of the NPA is to ensure that the engine manufacturer retains the responsibility for assessing and mitigating the threat presented by forward/rearward debris. If it cannot be shown that there is no threat to the aircraft, established either by installation manual limitations or through coordination with the airframer, then the engine manufacturer must show that the probability of a blade failure leading to an unsafe condition is Extremely Remote. To do this, the engine manufacturer may need to assess the reliability pedigree of the blade design, and the likelihood that a failure results in the release of hazardous forward/rearward debris.

In the case that the engine manufacturer cannot establish that no unsafe condition exists (and successfully shows that the probability is Extremely Remote), the threat will continue to be detailed in the installation manual. Therefore, the aircraft manufacturer responsibility to address the threat will remain as before.

Comment 2: Partially accepted. The term 'maximum allowable average oil consumption' has been selected to align with the aircraft certification specifications related to oil systems (e.g. CS 25.1011(b)). 'Flight duration' has been deleted.

Comment 3: Partially accepted. The term 'maximum allowable' has been selected to align with the aircraft certification specifications related to oil systems (e.g. CS 25.1011(b)).

Comment 4: Partially accepted. The intent of the comment is agreed, but different wording has been used: when separate oil systems exist, the respective maximum allowable oil consumptions.

comment *50* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive: X	Editorial
Affected paragraph and page number	Page: 8, 9, 11, 12, 13 & 14 - CS-E (or AMC) 510, 520 & 810 Paragraph: § 2.3 item 1 et § 3.1 item 1		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Page 8 & 9: (a) CS-E 520 ('Strength'), paragraph (c)(1) is proposed to be amended to require that compressor and turbine blades are 'radially' contained after their failure, instead of the current requirement to demonstrate no Hazardous Engine effect. This would better reflect the actual design and certification practices regarding engine casing strength. The effects of secondary effects associated with the blade failure are addressed by CS-E 810 ('Compressor and Turbine Blade Failure'). ... (c) AMC E 510 ('Safety analysis'), paragraph (3)(d)(iii) on 'Non-		

	containment of high-energy debris' is proposed to be amended to: (1) align with the amendment made to CS-E 520(c)(1) regarding the requirement for blades to be radially contained; ... (d) CS-E 810 ('Compressor and Turbine Blade Failure') is proposed to be amended to align with CS-E 520(c)(1) regarding the 'radial' containment requirement and clarify that Hazardous Engine Effects that may be triggered by the blade failure must not occur at a rate greater than that defined as Extremely Remote. The current wording requiring to demonstrate that no Hazardous Engine Effect can happen is not considered as adequate as some debris may be released outside of the radial containment area and this must be addressed and mitigated. page 11, 12, 13 & 14 AMC E 510 Safety Aanalysis (3) Specific means (d) Hazardous Engine Effects (iii) Non-containment of high-energy debris. The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)) ... CS-E 520 Strength (c) (1): The strength of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine casing. (See AMC E 520(c)(1)) ... CS-E 810 Compressor and Turbine Blade Failure (a) It must be demonstrated that any single compressor or turbine blade will be radially contained by the Engine casing after Failure and that the blade Failure will not lead to a Hazardous Engine Effect before Engine shutdown at a rate greater than that defined as Extremely Remote following a blade Failure. ... AMC E 810 Compressor and Turbine Blade Failure (2) Containment (c) Condition after Tests. On completion of the tests, a complete power Failure is acceptable, but there should be: (i) radial containment by the Engine within its containment structure without causing significant rupture or hazardous distortion of the Engine outer casing or the expulsion of blades through the Engine casing or shield REQUESTED CHANGE: The proposed text must clarify that the requirement is

	applicable only for blade stages which are enclosed within a casing.
Why is your suggested change justified?	JUSTIFICATION: In the proposed text, CS-E 810 & CS-E 520 require that a fan blade release will be radially contained by the Engine casing after Failure and that the blade Failure will not lead to a Hazardous Engine Effect before Engine shutdown at a rate greater than that defined as Extremely Remote following a blade Failure. Regulation should not restrain the development of next generation engines, which may include open fan designs. By definition, an open fan does not have any fan containment case and no fan blade release will be contained.

response Noted.

It is acknowledged that for the time being CS-E does not take into account open rotors and that some changes would be needed to certify such engines. However, this was not the purpose of this NPA. Please note that EASA published an NPA (2015-22) on this subject.

comment *51* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur: X	Substantive: X	Editorial
Affected paragraph and page number	Page: 8 & 11 - CS-E (or AMC) 510, 520 & 810 Paragraph: § 2.3 item 1 et § 3.1 item 1		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: page 8: (c) AMC E 510 ('Safety analysis'), paragraph (3)(d)(iii) on 'Non-containment of high-energy debris' is proposed to be amended to: (1) align with the amendment made to CS-E 520(c)(1) regarding the requirement for blades to be radially contained; page 11: AMC E 510 Safety Aanalysis (3) Specific means (d) Hazardous Engine Effects (iii) Non-containment of high-energy debris. The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)). ... Furthermore, Engine failures (including blade failures) can		

	lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect. REQUESTED CHANGE: Since the purpose of the item 1 amendments is to improve the consideration of consequences following a blade failure: - the modifications should be made in AMC E 810 ('Compressor and Turbine Blade Failure') and not in AMC-E 510 which addresses any kind of failure in the engine - the text should address blade failures and not other engine failures, therefore it is proposed to be written as follows: "Blade failures may result in debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure. If such failures may result in debris being released with an energy and trajectory that could cause a hazard to the aircraft, they should be considered as causing a Hazardous Engine Effect."
Why is your suggested change justified?	JUSTIFICATION: In the NPA proposed text, it is proposed to modify AMC E 510 paragraph specifying that: - the shedding of compressor or turbine blades has to be contained - some engine failures including blade failures may result in debris being released from the engine, forward, rearward, or otherwise outside of the containment structure. If such failures may result in debris being released with an energy and trajectory that could cause a hazard to the aircraft, they should be considered as causing a Hazardous Engine Effect. In the regulation : - requirements about blade failure are in CS-E 810 Compressor and Turbine Blade Failure - CS-E 510 Safety Analysis is specified a safety analysis and associated requirement and may address any kind of failure in the engine and is not specific to the blade failure As specified on page 3 and 4 of the NPA, the objective of item 1 is to address the NTSB safety recommendation (UNST-2019-007) to EASA: 'Expand your certification requirements for transport-category airplanes and aircraft engines to mandate that airplane and engine manufacturers work collaboratively to (1) analyze all critical fan blade impact locations for all engine operating conditions, the resulting fan blade fragmentation, and the effects of the fan-blade-out-generated loads on the nacelle structure and (2) develop a method to ensure that the analysis findings are fully accounted for in the design of the nacelle structure and its components.'

	The purpose mandate from NTSB to EASA and FAA is consequently, for them to propose amendements to the regulation following fan blade failure events resulting in uncontained high-energy debris of parts other than the blade itself. These amendments have to address consequences of a blade failure event and improve their taking into account. In the regulation, blade failure is addressed by CS-E 810 and therefore the amendments should concern CS-E 810 and not CS-E 510.

response

Not accepted.

The scope of AMC E 510(3)(d)(iii) is not restricted to blade failures. Other types of failures and debris have to be considered. For clarification, the first sentence of the current AMC E 510(3)(d)(iii) text has been added back (it was deleted in the NPA proposed text).

2.2. What we want to achieve - objectives p. 8

comment *126* comment by: *Safran Helicopter Engines*

the NPA introduces significant changes (see SAFRANHE detailed comments) in the CS-E but §2.2 indicates that those evolutions are non-complex, non-controversial and mature subjects. Additionally, there is no impact assessment performed in this NPA.

response

Noted.

NPAs on Regular update of a CS do not include impact assessments.

comment *137* comment by: *Honeywell E&PS Certification Office*

Section 2.3 (c)(2) The linkage should address life limiting and, since a subtopic of Non-Containment of high energy debris, a probability target as well. Can reference be provided for guidance on mitigations and risk? Mitigations like life limiting and risks along the lines of probability requirements.

Section (c)(3) This could be added, however, a conditional probability for this hazard given a blade release may be difficult to substantiate. This would likely lead to a conservative assessment and higher risk. Can EASA give guidance on the Probability of contained vs Probability of missing the containment system if they have data on this issue?

response

Comment 1: Not accepted. The sentence added actually provides the reference to the certification specifications applicable to critical parts that allow to mitigate the associated risk of failure, i.e. CS-E 515, 840 and 850.

Comment 2: Not accepted. It is expected that the Engine manufacturer uses its own available data to evaluate the probability.

2.4. What are the expected benefits and drawbacks of the proposed amendments p. 10

comment *8* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
10	1st para. Of section 2.4	The proposed amendments are expected to contribute to reflecting the state of the art of engine certification in CS-E and improve the harmonisation of CS-E with the FAA regulations.	The proposed amendments to Item 1, "Compressor and turbine blade failure", will not improve harmonization but will create dis-harmonization with the FAA requirements. The reason for dis-harmonization occurs because FAA wants to certify the engine independent of the airplane, and the NPA would prevent that. In addition, the prediction of energies and trajectories of fragments resulting from every possible FBO failure sequence is not within the state of the art.	Do not publish proposed amendments to AMC E-510, page 10, AMC E-520 (c)(2) page 12, CS E-810 and AMC E-810 pages 13 & 14. The proper FBO assessment will be done at the aircraft level, i.e. during the aircraft certification under Part 25 or CS-25 regulations, as part of the safe installation on an airplane of an existing engine.	Conceptual

respons e

Not accepted.

The proposal does not prevent certification of an engine independently from the aircraft. The proposal is to introduce an additional step during engine certification to better manage the threat from engine blade axially released debris. If a potential threat from axially released debris is identified, the engine manufacturer must consider using one of the following options:

Demonstrate that there is no unsafe condition,

Demonstrate that an identified hazardous threat is extremely remote.

Both options may require cooperation with the aircraft manufacturer and/or the establishment of installation limitations(s).

The proposal also does not mandate to predict the 'energies and trajectories of fragments resulting from every possible FBO failure sequence'.

There may be other means to demonstrate either the non-Hazardous effect or the Extremely remote probability.

comment *103* comment by: *Rolls-Royce Plc*

Comment
This paragraph implies that the changes, in general, increase harmonisation between CS-E and the FAA regulations. This is incorrect as a general statement. Some of the changes result in greater harmonisation whilst others do not.
Suggested resolution
Modify the statement to clarify that only some elements will be closer to the FAA regulations.

response Noted.

This comment will be taken into account when writing the explanatory note to the ED Decision. The NPA will not be re-published.

AMC E 510 Safety A a nalysis p. 11

comment *9* comment by: *FAA*

Page Numb er	Paragraph Number	Referenced Text	Comment/Rati onale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
11	AMC E 510(3)(d)(iii	"Furthermore , Engine failures (including blade	The additional text has the effect of changing the regulation. The	Quantify the size or energy that is considered	Conceptual

		failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect."	current regulation requires the applicant to include the energy and trajectory of debris that exits the engine forward or aft of the containment ring in the installation manual. The proposed AMC adds a new hazardous engine effect to CS-E 510 and thus requires the applicant to demonstrate that such debris will not be released at greater than 10E-7/flight hour. Given that such debris might be caused by bird ingestion, for example, how can the applicant definitively state that debris release would occur at less than the prescribed frequency, except by making the blades so strong that no debris will ever be released?	hazardous at the airplane level under current regulatory requirements, and limit the size and energy of any individual piece of fan blade debris exiting the engine to that size.	

11	AMC E 510 paragraph (d)(iii)	However, the Engine containment structure is not required to contain major rotating parts should they be released. Fail ures resulting in the release of discs, hubs, impellers, large rotating seals, and other similar large rotating components should therefore be considered to represent potential high-energy debris.	AMC E 510 claims that major rotating parts do not need to be contained if they are released. CS-E 520, on the contrary, says that blades need to always be contained. Are compressor and turbine blades not considered "major rotating parts?"	Please reword or correct AMC E 510 or CS-E 520 in order for them to not be (or sound like they are) contradicti ng each other.	Conceptual/Edi torial
11	Proposed changes in: AMC E 510 (3)(d)(iii); CS-E 520(c)(1); CS-E 810(a)	The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations , will be radially contained by the Engine containment structure	What is the safety enhancement achieved by the proposed change to add the word "radially" for the containment structure? The "radial" capability of the containment structure to resist penetration from a failed blade through out its long axis is inherently	Recommen d abstaining to use the word "radially" as it does not offer any safety enhancem ents to the existing rule wording and it may lead to confusion and misdirectio n.	

			implied by design of an axisymmetric cylindrical containment case. The capability of the containment case to resist penetration from a failed blade is expected, by regulatory requirements, to be demonstrated in its entirety and not just in the plane of rotation of the blade, if the word radially is taken literally.		
11	AMC E 510(3)(d)(iii)	Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of	This is a new requirement introduced by advisory material and will result in disharmonization with FAA's requirement. The proposed change would require the engine manufacturer to determine what debris energy and trajectory could cause a hazard to the aircraft. This cannot be done because the engine manufacturer	Do not publish proposed amendments to AMC E-510	Conceptual

		such debris should be considered as a Hazardous Engine Effect.	does not have the airplane design and associated dynamic aircraft model. In addition, engines are certified (a) prior to aircraft certifications and (b) for being used on multiple aircraft certification projects. This assessment will be done at the aircraft level requirements, Part 25 or CS-25		

respon se

Comment 1: Not accepted. The current rule places the burden for addressing the released debris on the aircraft manufacturer. EASA considers that the engine manufacturers should be responsible for the safety of the engine. But EASA disagrees with the proposed deterministic approach that does not take into account the frequency of occurrence. As a general principle, if a Failure can result in debris being released with an energy and trajectory that cause an unsafe condition (refer to AMC1 21.A.3B(b)), such debris should be considered as uncontained high-energy debris causing a Hazardous Engine Effect. This principle has been explained in the revised version of the proposed amendment to AMC E 510. Also, additional guidance has been added to explain how applicants should determine the likelihood that a blade failure results in an unsafe condition. Where possible, the threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer. Assumptions regarding the ability of the aircraft to withstand debris impact should be included in the Manuals required by CS-E 20(d).

Comment 2: Not accepted. EASA confirms that blades are not considered as 'major rotating parts' and they are required to be radially contained. This is the case in the current CS-E amendment and no change is proposed on this matter. However, the proposed amendment of AMC E 510 has been revised and complemented to clarify the sources of high-energy debris.

Comment 3: Not accepted. The commented sentence reflects the specification being referred to. Please note that this specification has been amended.

Comment 4: Not accepted. Please refer to the response to comment 1.

comment *30* comment by: *GE Avio*

Regarding the text: "Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect ."

As a consequence of a generic engine failure, the release of debris rearward, i.e. from the engine tail pipe, may involve debris of very different size and mass. The release of debris rearward cannot be considered a Hazardous condition, unless after a dedicated study done together with the airframer. Also in this case, the analysis done with the airframer may conclude that the hazardous condition is present only on one engine position (e.g. on engine nr. 2 in a four engine application), and would be applicable for one aircraft kind only.
As a result, the engine safety analysis would be applicable "on type" only, therefore the new requirement as written in the NPA is not applicable / feasible.

This change is inappropriate; it would require the engine manufacturer to use detailed knowledge of the airplane design “energy and trajectory which could cause a hazard to the aircraft” which is not part of engine certification and may not be available to the engine manufacturer. The proposed change is not technically practicable; prediction of energies and trajectories of fragments resulting from every possible failure sequence is not within the state of the art. These considerations make the proposed change outside the scope of “non controversial” and therefore a separate rulemaking task should be created to develop this change further.

Regarding the text:" The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)). "
The sentence should not be placed in the gudiance for safety analysis. Rather it should be placed in the guidance for CS-E 520 Stength.

response First comment: Partially accepted.

The proposed AMC E 810 subparagraph (2)(c)(ii) provides guidance on how the applicant should assess the potential hazard caused to the aircraft. A clarification has been made to indicate that the coordination to be made with the aircraft manufacturer is an objective, while recognising that it is not always possible.

Furthermore, this paragraph has been moved in AMC E 510 as it is considered a better place and this was suggested by other comments.

Second comment: Not accepted. The commented sentence provides the context of the guidance provided thereafter by referring to what is required under CS-E 520.

comment *44* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
Identify the section of the proposed document you have a concern with, such as: §25.1234 (a)1…
Page 11/36 – AMC E510, §(3)(d)(iii) - Non-containment of high-energy debris.
"Furthermore, Engine failures (including blade failures) can lead to debris being released from
the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with
an energy and a trajectory that could cause a hazard to the aircraft"

2. PROPOSED TEXT / COMMENT:
Be specific about the change you are requesting: specific wording change, deletion, addition…
Improve wording to be explicit on what is a 'hazard to the A/C'

In CS-E amdt 6, there is already the use of:

- **"hazard the aircraft" in AMC E 70**
- **"hazard to the aircraft" in AMC E 810**

but there is no definition of a "hazard to the aircraft".

Airbus would therefore recommend introducing a definition of a "hazard to the aircraft" in the frame of fragments AMC E520, §(3)(d)(iii) - Non-containment of high-energy debris.
Proposed wording:
"The engine manufacturer shall liaise with the aircraft manufacturer in order to determine the severity of the high-energy debris. In particular, released debris that could result in the following damages should be considered as creating a hazard to the aircraft:

- **Damages to the nacelle leading to parts departing the aircraft compromising continued safe flight and landing**
- **Fuselage puncture leading to a depressurization or direct injury to occupant(s)**
- **Damages to any other engine leading to loss of thrust beyond the thrust required for continued safe flight and landing**
- **For rotorcraft, damages to the main and/or tail rotor compromising continued safe flight and landing"**

3. RATIONALE / REASON / JUSTIFICATION for the Comment:
What is the reasoning and justification behind the change you are requesting?
Engine OEM applicants can't define what a hazard to the aircraft is without the involvement of the aircraft manufacturer.

response Partially accepted.

The commented sentence has been amended. Instead of 'cause a hazard to the aircraft', the modified sentence reads 'cause an unsafe condition'.

comment *49* comment by: *AIRBUS HELICOPTERS*

COMMENT :
Radial containment means there is no debris released radially outside the engine structure, and there is no opening in the engine radial structure through which hot gases might be released.

JUSTIFICATION :
The statement "*the design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure*" should be clarified as far as what containment means :
Does it mean no high energy debris is radially released ? Or there should not be any opening in the engine casing ? Even without high energy debris release, very hot gases release through opening, for gas generator, might represent a safety issue depending on the application/ the conditions. As an example AC33-5 explicitely mention "casing flanges separation" as a criteria of failure.

response Noted.

The quoted specification CS-E 520(c)(1) indeed requests that no blade is radially released. But, as explained in AMC E 510, some other high-energy debris may be released (e.g. rotor disk fragments).

Note: AMC E 810(2)(c)(i) addresses casing damages including damages that result in the release of hot gas.

comment *66* comment by: *Rolls-Royce Plc*

Comment
Current wording:
"Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect."
The intention is to say that debris that could constitute a hazard to the aircraft is Hazardous so it is proposed to change "…such debris…" to "…debris that could cause a hazard to the aircraft…" Without that clarification "such debris" might be interpreted as any debris released form the engine should be classified as Hazardous which is not the intent.
Suggested resolution
Change "…such debris…" to "…debris that could cause a hazard to the aircraft…"

This is considered a substantive point.

response Partially accepted.

The sentence has been re-worked taking into account this comment and other considerations. The criterion 'unsafe condition' is used instead of 'hazard to the aircraft'.

comment *67* comment by: *Rolls-Royce Plc*

Comment (relates to CS-E 510 and CS-E 810)
CS-E 510 requires consideration of shedding of blades either singly or in likely combinations and debris that might hazard the aircraft is considered to have a Hazardous Engine Effect and hence has to have an Extremely Remote (10-8) occurrence. CS-E 810 requires a demonstration associated with a single blade failure that, after consideration of radial containment and internal damage, there is 'no other Hazardous Engine Effect resulting from the blade failure, incudling due to debris being release...' unless the probability of the HEF can be shown to be extremely remote. There are thus 2 similar but different requirements - one can only be a single blade, the other could be more, one is definitely just debris while the other leaves scope for more. The assessment of the hazard ratio associated with any potential threat to the safety of the aircraft, as required in AMC CS-E 510 should be associated with the CS-E 510 requirement.
Suggested resolution
It is proposed that:
1) The AMC to 510 and 810 are made consisent and refer to each other
2) Only one assessment of HEF related to debris be required.

3) The hazard ratio assessment should be moved to 510 as it is part of the safety analysis

This is a substantive point.

response Accepted.

AMC E 510 and AMC E 810 have been modified and are consistent. AMC E 810(2)(c)(ii) now refers to AMC E 510, regarding the possibility of Hazardous Engine Effect resulting from debris released outside the Engine containment structure.

One single safety assessment is expected to be done for compliance with CS-E 510. The NPA AMC E 810 proposed guidance supporting this assessment for blade Failures has been moved to AMC E 510, as suggested in this comment.

comment *68* comment by: *Rolls-Royce Plc*

Comment
There are lots of references to working with the airframer, and in some cases making assessments of aircraft impacts. Some of them recognise that an engine can be certified without a specific installation and in those case recognise it is sufficient to record the assumptions related to the airframe. However in a number of other places, throughout the proposed amendment this is not made clear. Note this comment is general - it includes CS-E 510 and other proposed changes.
Suggested resolution
It is proposed that it should be explicitly stated on each occasion that the need to work with the airframer on assumptions/effects etc is identified what is acceptable

for the case where an engine is certified without a initial airframe installation being defined.

This is a substantive comment.

response

Partially accepted.

The assessment with the aircraft manufacturer is mentioned in the NPA proposal in AMC E 810 only. The sentence concerned has been amended to reflect that this is to be performed when possible, and it has been moved to AMC E 510.

comment *69* comment by: *Rolls-Royce Plc*

Comment
'Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect.' Often its possible to decide if something is a Hazardous Engine Effect without asking the airframer, eg disk burst, or thrust in the wrong direction. In this case, it's decided by what the airframer says. Whilst in many ways the obvious approach are there potential problems? Is it clear what 'hazards the aircraft' means or is there leeway for a very conservative approach by the airframer, making the engine job harder?
Suggested resolution
Consider if the requirement could have unintended consequences.

response

Noted.

AMC E 510 has been revised to use the criterion ‘unsafe condition’.

Furthermore, AMC E 510 has been revised to make it clear that the assessment of the hazard to the aircraft should be made, where possible, in coordination with the aircraft manufacturer. It is indeed the preferred option.

However, in some cases, the Engine manufacturer may be able to do the assessment without the involvement of the aircraft manufacturer; for instance, if the released debris cannot reach the aircraft, or the debris has size and energy characteristics that obviously do not represent a hazardous threat for the aircraft.

Furthermore, the Engine manufacturer may make installation assumptions so as to meet the required safety level. These assumptions are then incorporated in the Engine Installation Manual or equivalent required by CS-E 20(d).

comment *71* comment by: *Rolls-Royce Plc*

Comment
Extremely remote is defined in CS-E 510(a)(3) and what it means for Hazardous Engine Effects and individual failures leading to HEFs is described. In CS-E 810 a reference to extremely remote has been included. For avoidance of doubt it is proposed that whenever the term Extremely remote is used with respect to an individual failure 10-8 is written in brackets after it.
Suggested resolution

For avoidance of doubt it is proposed that whenever the term Extremely remote is used with respect to an individual failure 10-8 is written in brackets after it.

response

Not accepted.

The term Extremely Remote is defined in CS-E 15 and CS-E 510.

comment *72* comment by: *Rolls-Royce Plc*

Comment (note this comment refers to other requirements as well as 510)
What is the definition of a critical part? Definitions say it's the stuff in CS 515. 515 says it's the things identified in 510. 510 says 'When considering primary Failures of certain single element such as Engine Critical Parts….' This suggests it not the primary failure leading to hazardous engine effects that can't be estimated that defines a Critical part. Does this need to be addressed, or is there currently no confusion in practise?
Suggested resolution
Consider introducing a clear definition of a Critical part.

response

Not accepted.

The definition of Critical Part, and the other associated terms provided in CS-E 15, are deemed adequate.

comment *121* comment by: *Safran Helicopter Engines*

NR	Author	Section, table, figure	Page	Comment summary	Suggested resolution	Comment is an observation or is a suggestion *	Comment is substantive or is an objection**
1	SAFRAN	AMC E 510	11	*Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment*	In a first approach, the evolution could be limited to Fan application and then, it is proposed : "*Furthermore, Engine failures (including blade failures) can lead to*	NO	YES

				structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect. SafranHE has understood that this evolution was first intended for FAN applications for debris being released forward. Fan release issues may not be relevant for all types of engine applications (such as turboshafts for helicopters) and may also not be fully adapted to all rotating assemblies of an engine. Currently, blade debris ejected rearward	*debris being released from the Engine, forward, ~~rearward, or otherwise outside~~ of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect.*" In a mid/long-term, a discussion between Industry and Authorithies for this significant CS-E evolution should be considered (see comment n°2)		

				from the engine are usually classified as Major Engine effect at engine level in accordance AMC E 510 (3)(e) where there is no propagation to Hazardous Engine Effect. SAFRAN HE has well understood that a better coordination with the aircraft manufacture r is expected behind this NPA. However, as engine development is usually performed ahead of the aircraft development , and when applicable based on the existing in-service experience, engine manufacture r should still be allowed to classify blade release as Major Engine Effect. Those				

				kind of low energy debris are defined by engine manufacturer within its installation manual. Classify by principle, in absence of Aircraft data or consideration, as Hazardous Engine Effect all kind of blade release will require, per EASA proposal of AMC E 810, to reach 10-8 rate for blade loss which is not consistent with the failure rate reached with the current technology. Additionally, blade release is used as a safety device regarding overspeed protection (blade shedding) and thus could be considered as Haz Engine Effect at the same gravity than				

				disc burst. Then, it may be more complex to certify blade shedding overspeed protections recognized as reliable mechanical overspeed protections. Integration of overspeed protection by blade shedding has been considered as a significant improvemen t in safety for Safran Helicopter Engines. Then, this proposed change - which equally considers disc and potential blade debris release whereas the speed and energy invloved are different by several orders of magnitude - would significantly reduce safety if overspeed				

				protection by blade shedding cannot be certified anymore. This evolution is perceived as being a deep modification and currently not enough mature for debris ejected rearward. It should be further coordinated between industry and authority in RMT working group				
2	SAFRAN	AMC E 510	11	From SAFRAN HE perspective, this evolution is not perceived as an alignment between FAA and EASA requirements, and if confirmed, could introduce a new difference between		N/A		YES		NO

				both regulations (PART 33 and CS-E). Generally speaking, we support common approach with regulators which harmonize technical requirements.			
3	SAFRAN	AMC E 510	11	*Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a*	It is proposed to add : "*In order to define the potential threat to aircraft, the engine manufacturer should evaluate in coordination with the aircraft manufacturer the consequence of the event on the aircraft (hazard to the aircraft). This evaluation could take into account the probability (named hazard ratio), linked to aircraft installation*	NO	YES

				Hazardous Engine Effect. The notion of hazard to the aircraft is not defined in the CS-E as such. It is used with a specific definition in AMC 130 (ie fire hazard) but without definition in AMC E 70. This notion of hazard to the aircraft is understood to be discussed between the engine manufacturer and the aircraft manufacturer for determination the level of threat while the engine is installed on aircraft or helicopter. This notion of hazard to the aircraft may vary a lot from one aircraft to another. Some aircraft manufacturers may have no specific	*parameters or engine design, that influence the event becoming a hazard at aircraft level. When this coordination could not be adequately performed, engine manufacturer shall declare in the installation and operating manual the relevant data in the engine Installation and operating manual (mass of the debris, trajectory, etc...) to make possible the analysis on the consequence by the aircraft manufacturer. Depending on the consequences on the aircraft, the release of such debris*		

				internal policy on that topic and in that case, the engine manufacturer shall take hypothesis to perform its own certification (and declare them as such in the installation and operating manual). a criterion for low energy debris should be defined corresponding to Major Engine effect, for example depending on the size, energy, etc... of the debris It could be interesting to provide a defintion of "hazard to the aircraft" in CS-Definition as it is used in several regulations (CS-E, CS-23, CS-25 etc...)	*should be considered either as a No Effect, a Minor, a Major or as a Hazardous Engine Effect.*" Provide a definition of 'hazard to the aircraft' in the CS-Definitions		

4	SAFRAN	AMC E 510	11	*However, the Engine containment structure is not required to contain major rotating parts should they be released. Failures resulting in the release of discs, hubs, impellers, large rotating seals, and other similar large rotating components should therefore be considered to represent potential high-energy debris. For such parts, the high level of integrity necessary for compliance with CS-E 510 (a)(3) is ensured through compliance with CS-E 515, 840 and 850. Furthermore, Engine failures (including*	Additional information should be provided to clarify the AMC	NO	YES

				blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect. Currently, parts that represent potential high-energy debris are classified as Critical Parts and as such the high level of integrity necessary for compliance with CS-E 510 (a)(3) is ensured through compliance with CS-E				

				515, 840 and 850. With the proposed evolution, debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft, should be considered as a Hazardous Engine Effect. CS-E 15 defines Engine Critical Part : *means a part that relies upon meeting prescribed integrity specifications of CS-E 515 to avoid its Primary Failure, which is likely to result in a Hazardous Engine Effect*.				

				In that case, it is not clear if such parts generating the debris recognized as Haz engine effect has to be considered has a Critical Part (and then with application of CS-E 515) or not ? Without any further explaination in the rule, it could be easily understood that CS-E 515 should apply to blades (whose failure would lead to Hazard to the aircraft).				
5	SAFRAN	AMC E 510	11	Proposed NPA 2022-02 for CS-27/CS-29 (currently under public comment phase) seems not to be aligned with CS-E proposal for blade / debris containment (see AMC		CS-E and CS-27 / 29 approaches for blade containment / debris should be further coordinated	YES	NO

				29.901 proposal): *(a) Blade containment* *Singe blade containment is a CS-E / CS-APU requirement. Full credit is given to engine certification for blade containment and no specific certification activity is required at helicopter level for blade failure. This approach is supported by the in-service experience.* *(b) Small debris containment at engine level* *Some engine designs feature the capability to retain small debris, featuring, for instance, a reinforced casing. This raises two issues:* *— The containment capability is not required by CS-E and*				

				the corresponding data is not covered by the engine type certificate; the helicopter manufacturer should propose a mechanism to ensure that the data is valid, under their DOA or by validation through the engine type certificate.				

respons e

Comment 1: Not accepted. The same certification objectives should be used regardless of the type of aircraft on which the engine will be installed. It is expected that the engine manufacturer performs a safety assessment of the effect of blade failures. There is no obligation to classify by default non-contained debris as a Hazardous Engine Effect. The goal should rather be to design the Engine to prevent damages with such effects.

Comment 2: Noted. We agree with the harmonisation objective.

Comment 3: Partially accepted. The term 'hazard to the aircraft' used in the proposed amendment to AMC E 510 has been replaced by 'unsafe condition' (which is defined in AMC1 21.A.3B(b)). The assessment should indeed preferably be done in coordination with the aircraft manufacturer, where possible (a clarification has been made in AMC E 510).

Comment 4: Noted. The proposed amendment does not specify that blades, which are not contained and create damages considered as Hazardous Engine Effects, must be considered as critical parts. In fact, the compliance with CS-E 515, although beneficial in term of reliability of the part, does not provide a valid basis to demonstrate an Extremely Remote blade failure probability. Blade reliability is affected by many factors. Whilst some of these are addressed by CS-E 515 (e.g. low and high cycle fatigue, manufacturing quality, service management), others are not (e.g. foreign object damage, edge of bedding wear). This has been explained in a revised version of AMC E 510.

Comment 5: Accepted. As CS-29 is amended before CS-E, the AMC 29.903(d)(1) text has been adjusted to clarify that it deals with radial containment/debris only.

comment	*136* comment by: *Honeywell E&PS Certification Office* Most severe blade failure w/o rotor support: We are not familiar with requirements to demonstrate compliance for a most severe blade failure w/o rotor support failure in a turbine section. The wording in the proposed change does not provide much information on what would be required to satisfy this new requirement. If it is all the requirements listed in AMC E 520(c)(2) it could be a significant amount of extra effort, and seems excessive since the severity of this failure is much less than an event that causes failure of the rotor support structure. What would be needed to demonstrate "Extremely remote rate" of less than 10-9 for the impact of a turbine blade failure on occurrence of a "Hazardous Engine Effect" (previously only required for composite fan blades and overspeed blade shedding)? Can clarification/definition be provided for what might be needed to satisfy "Additional requirements may be applied during aircraft certification"? Could EASA reconsider applying this requirement to turbine blades since the concern that drove this change was based on failure of a fan blade, not a turbine blade?
response	Partially accepted. The commented sentence of AMC E 520(c)(2) has been revised to clarify its intent, namely to state that manufacturers should evaluate the effect of the most severe blade Failure which would not cause the Failure of the rotor structural support. The effect on the Engine and on the loads transmitted to the aircraft should be included in this evaluation. The commented sentence of AMC E 810 has been incompletely quoted and includes an error. The correct sentence is considered clear enough: additional considerations may be applied during aircraft certification to further mitigate the potential effects of blade Failures at the aircraft level. Applicability of "requirement to turbine blades": the commenter does not mention which CS paragraph is commented. The scope of CS-E 520 and 810, also considered within CS-E 510, is unchanged and comprises compressor and turbine blades. Nevertheless, please note that such design feature (the so-called rotor support structure 'fuse') is typically not used at the turbine level, because of the limited size of the blades.

comment	*147* comment by: *Pratt & Whitney Canada* Regarding CS-E text: (3)(iiii) "Non-containment of high-energy debris", specifically the proposed sentence "The design of the Engine must be such that…" "design" requirements should not be imposed in "analysis" (CS-E 510) requirements. Also, the word "radially" could be viewed as constrictive and open to interpretation if, for example, a blade is released by a small angle from "radial", i.e. it should not be misconstrued that the blade can *only* be released "exactly radially". This should

perhaps be reworded to indicate that the casing features designed to contain released blades should not fail in such a way as to release particles outside of the casing, or words to that effect.

Requested action:
Either revert the paragraph or change as suggested.

response

Not accepted.

The quoted AMC E 510 text does not directly provide design specifications on containment, it rather quotes the CS-E 520(c)(1) specification.

The wording 'radially contained' is maintained as it is consistent with CS-E 520(c)(1).

comment

148 comment by: *Pratt & Whitney Canada*

Regarding CS-E text: (3)(iiii) "Non-containment of high-energy debris", specifically the proposed sentence "Furthermore, Engine failures…"

The preamble of the NPA (Section 2.2, page 8) stated that the proposed changes are "not controversial", however the aspects of the subject sentence are still under discussion in the AIA FAR 33.94 FBO working group as of the date of this entry. In particular, there is some question about whether the proposed text "can be implemented in practice [readily]" as implied by the NPA preamble (Section 2.1 first sentence, page 4).

Requested action:
Remove the paragraph.

response

Not accepted.

At the time of publication of the NPA, EASA considered the topic as reasonably non-controversial. Furthermore, the mentioned AIA group has been requested to recommend FAR 33 amendments, not CS-E. EASA therefore decided to propose an amendment of CS-E.

Please note that the NPA will not be re-published and therefore the commented paragraph of the preamble cannot be modified.

comment

155 comment by: *Transport Canada Civil aviation*

EASA states " Casings may therefore need to be …"

Suggested resolution
Suggest to clarify text to add "High-pressure casings may therefore need to be…", if needed

response

Partially accepted.

The commented paragraph has been amended in a way that meets the intent of this comment but with a different wording.

comment	*169* comment by: *Transport Canada Civil aviation* 510(d)(iii) The cross-reference to CS E810(a) has been deleted; it would be relevant to maintain this cross rerference given the proposed wording update to CS E810(a). **Suggested resolution** The cross-reference to CS-E 520(c)(1) should also include a cross reference to CS-E 810(a)(1).
response	Not accepted. A reference to CS-E 810(a) is not deemed necessary. The reference to CS-E 520(c)(1), keeping in mind the new content of this design specification, is adequate for its purpose.

comment	*170* comment by: *Transport Canada Civil aviation* 510(d)(iii) The added text essentially adds a new definition / consideration for what consistutes a 'Hazardous Engine Effect' in terms of uncontained debris that could cause a hazard to the aircraft. The NPA preamble (page 8, para 2.3(c)(3)) contains slightly different language which provides a key distinction: it uses 'may result …' and 'if such failures…' This would naturally lead to the need to coordinate with the airframe OEM to determine whether such uncontained debris has sufficient energy / trajectory to be a hazard to the aircraft. The proposed paragraph added to AMC CS-E810 (2)(c)(ii) could be used in this instance to provide that guidance. **Suggested resolution** Suggest amending the AMC 510 paragraph text to align with the preamble and add a statement regarding coordination with the aircraft OEM, copied or modified from that proposed under CS-E810. For example: Furthermore, Engine failures (including blade failures) may lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure. If such failures have an energy and a trajectory that could cause a hazard to the aircraft, then the release of such debris should be considered as a Hazardous Engine Effect. The hazard ratio associated with any potential threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer. Any installation assumptions, including maximum hazard ratio, required to meet the required safety level should be included in the Manuals required by CS E-20(d). (Note: see later comment re: 'hazard ratio')
response	Partially accepted. The proposed AMC E 510 has been revised in a way that would meet the intent of this comment, although with a different wording.

3.1. Draft certification specifications and acceptable means of compliance for engines (draft EASA decision amending CS-E) p. 11

comment *52* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive: X	Editorial
Affected paragraph and page number	Page: 8, 9, 11, 12, 13 & 14 - CS-E (or AMC) 510, 520 & 810 Paragraph: § 2.3 item 1 et § 3.1 item 1		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Page 8 & 9: (a) CS-E 520 ('Strength'), paragraph (c)(1) is proposed to be amended to require that compressor and turbine blades are 'radially' contained after their failure, instead of the current requirement to demonstrate no Hazardous Engine effect. This would better reflect the actual design and certification practices regarding engine casing strength. The effects of secondary effects associated with the blade failure are addressed by CS-E 810 ('Compressor and Turbine Blade Failure'). ... (c) AMC E 510 ('Safety analysis'), paragraph (3)(d)(iii) on 'Non-containment of high-energy debris' is proposed to be amended to: (1) align with the amendment made to CS-E 520(c)(1) regarding the requirement for blades to be radially contained; ... (d) CS-E 810 ('Compressor and Turbine Blade Failure') is proposed to be amended to align with CS-E 520(c)(1) regarding the 'radial' containment requirement and clarify that Hazardous Engine Effects that may be triggered by the blade failure must not occur at a rate greater than that defined as Extremely Remote. The current wording requiring to demonstrate that no Hazardous Engine Effect can happen is not considered as adequate as some debris may be released outside of the radial containment area and this must be addressed and mitigated. page 11, 12, 13 & 14 AMC E 510 Safety Aanalysis (3) Specific means (d) Hazardous Engine Effects (iii) Non-containment of high-energy debris. The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)) ... CS-E 520 Strength (c) (1):		

	The strength of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine casing. (See AMC E 520(c)(1)) ... CS-E 810 Compressor and Turbine Blade Failure (a) It must be demonstrated that any single compressor or turbine blade will be radially contained by the Engine casing after Failure and that the blade Failure will not lead to a Hazardous Engine Effect before Engine shutdown at a rate greater than that defined as Extremely Remote following a blade Failure. ... AMC E 810 Compressor and Turbine Blade Failure (2) Containment (c) Condition after Tests. On completion of the tests, a complete power Failure is acceptable, but there should be: (i) radial containment by the Engine within its containment structure without causing significant rupture or hazardous distortion of the Engine outer casing or the expulsion of blades through the Engine casing or shield REQUESTED CHANGE: The proposed text must clarify that the requirement is applicable only for blade stages which are enclosed within a casing.
Why is your suggested change justified?	JUSTIFICATION: In the proposed text, CS-E 810 & CS-E 520 require that a fan blade release will be radially contained by the Engine casing after Failure and that the blade Failure will not lead to a Hazardous Engine Effect before Engine shutdown at a rate greater than that defined as Extremely Remote following a blade Failure. Regulation should not restrain the development of next generation engines, which may include open fan designs. By definition, an open fan does not have any fan containment case and no fan blade release will be contained.

response Please refer to the response to comment 50.

comment *53* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur: X	Substantive: X	Editorial

Affected paragraph and page number	Page: 8 & 11 - CS-E (or AMC) 510, 520 & 810 Paragraph: § 2.3 item 1 et § 3.1 item 1
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: page 8: (c) AMC E 510 ('Safety analysis'), paragraph (3)(d)(iii) on 'Non-containment of high-energy debris' is proposed to be amended to: (1) align with the amendment made to CS-E 520(c)(1) regarding the requirement for blades to be radially contained; page 11: AMC E 510 Safety Aanalysis (3) Specific means (d) Hazardous Engine Effects (iii) Non-containment of high-energy debris. The design of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)). ... Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect. REQUESTED CHANGE: Since the purpose of the item 1 amendments is to improve the consideration of consequences following a blade failure: - the modifications should be made in AMC E 810 ('Compressor and Turbine Blade Failure') and not in AMC-E 510 which addresses any kind of failure in the engine - the text should address blade failures and not other engine failures, therefore it is proposed to be written as follows: "Blade failures may result in debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure. If such failures may result in debris being released with an energy and trajectory that could cause a hazard to the aircraft, they should be considered as causing a Hazardous Engine Effect."
Why is your suggested change justified?	JUSTIFICATION: In the NPA proposed text, it is proposed to modify AMC E 510 paragraph specifying that: - the shedding of compressor or turbine blades has to be contained - some engine failures including blade failures may result in debris being released from the engine, forward, rearward, or otherwise outside of the containment structure. If such failures may result in debris being released with an energy and trajectory that could cause a hazard to the aircraft, they

	should be considered as causing a Hazardous Engine Effect. In the regulation : - requirements about blade failure are in CS-E 810 Compressor and Turbine Blade Failure - CS-E 510 Safety Analysis is specified a safety analysis and associated requirement and may address any kind of failure in the engine and is not specific to the blade failure As specified on page 3 and 4 of the NPA, the objective of item 1 is to address the NTSB safety recommendation (UNST-2019-007) to EASA: 'Expand your certification requirements for transport-category airplanes and aircraft engines to mandate that airplane and engine manufacturers work collaboratively to (1) analyze all critical fan blade impact locations for all engine operating conditions, the resulting fan blade fragmentation, and the effects of the fan-blade-out-generated loads on the nacelle structure and (2) develop a method to ensure that the analysis findings are fully accounted for in the design of the nacelle structure and its components.' The purpose mandate from NTSB to EASA and FAA is consequently, for them to propose amendements to the regulation following fan blade failure events resulting in uncontained high-energy debris of parts other than the blade itself. These amendments have to address consequences of a blade failure event and improve their taking into account. In the regulation, blade failure is addressed by CS-E 810 and therefore the amendments should concern CS-E 810 and not CS-E 510.

response Please refer to the response to comment 51.

comment *54* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur: X	Substantive: X	Editorial
Affected paragraph and page number	Page: 11 - AMC E-510 Paragraph: § 3.1 item 1		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: page 11: AMC E 510 Safety Aanalysis (3) Specific means (d) Hazardous Engine Effects (iii) Non-containment of high-energy debris. The design of the Engine must be such that the shedding of		

	compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine containment structure (see CS-E 520(c)(1)). However, The Engine containment structure is not required to contain major rotating parts should they be released. Failures resulting in the release of Discs, hubs, impellers, large rotating seals, and other similar large rotating components should therefore be considered to represent potential high-energy debris. For such parts, the high level of integrity necessary for compliance with CS-E 510 (a)(3) is ensured through compliance with CS-E 515, 840 and 850. Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft. The release of such debris should be considered as a Hazardous Engine Effect. Service experience has shown that, depending on their size and the internal pressures, the rupture of the high-pressure casings can generate high-energy debris. Casings may therefore need to be considered as a potential for high-energy debris. REQUESTED CHANGE: EASA proposal to consider that 'Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, ... with an energy and a trajectory that could cause a hazard to the aircraft.. and that the release of such debris should be considered as a Hazardous Engine Effect' would represent a significant change to the regulation and is a position that diverge from the position of the FAA and IAI. Indeed, considering forward and reaward hygh energy debris and including a wider list of parts potentially uncontained is contradictory to CAAM 3 Technical Report, (see in bold characters in the justification section). Furthermore: - it seems very difficult to define what high energy limit should be considered - it may be considered too conservative that such parts should comply with CS-E 510 (a)(3) and CS-E 515 Therefore it is considered that such a significant change to the CS-E should be further discussed in details with other regulators and Industries, rather than being introduced so quickly, and without sufficient discussions, in a regular CS-E update.
Why is your suggested change justified?	JUSTIFICATION: The FAA/AIA '3rd Technical Report On Propulsion System and Auxiliary Power Unit (APU) Related Aircraft Safety Hazards', published March 30, 2017 defines 'Uncontained' (Appendix 2 'Event Definitions', § 3.a.)

	"Uncontained. A significant safety event that initiates from an uncontained release of debris from a rotating component malfunction (blade, disk, spacer, impeller, drum/spool). In order to be categorized as uncontained, the debris must pass completely through the nacelle envelope. Parts that puncture the nacelle skin but do not escape or pass completely through are considered contained. Fragments that pass out of the inlet or exhaust opening without passing through any structure are not judged to be "uncontained." Starter and gearbox (accessory) uncontainments are specifically excluded." Note that this proposed change exceeds the frame of the NPA2021-13, §2. In summary — why and what, § 2.1. Why we need to amend the rules — issue/rationale (see underlined hereafter): 'The aviation industry is complex and rapidly evolving. CSs and AMC need to be updated regularly to ensure that they are fit for purpose, cost-effective, and can be implemented in practice. Regular updates are issued when relevant data is available following an update of industry standards, feedback from certification activities, or minor issues raised by the stakeholders. Lessons learnt from accident and incident investigations may also be addressed in regular updates when the topic is not complex and not controversial.' Note as well that there is an AIA/FAA 33.94 Working Group, which is discussing with Industries a proposal to answer the NTSB recommendation mentionned in the NPA.
response	Noted. The proposed amendment introduces minor changes in the way turbine engines are designed and certified. The intent is that the engine manufacturer pays more attention to the potential consequences at the aircraft level from debris released after a blade failure. Cooperation with the aircraft manufacturer is therefore encouraged, while the engine manufacturer also has the possibility to declare any assumption in the installation manual, as done already in the past for some engine certifications.

comment	*65* comment by: *Rolls-Royce Plc* Item 1 is broadly supported.
response	Noted.

Thank you for your support.

CS-E 520 Strength p. 12

comment *1* comment by: *Syiad AL-DURI*

The proposed change of CS-E520 is removing the explicit requirement that no Hazardous Engine Effect results from the shedding of compressor or turbine blades. It also removes the requirement to consider the time to shutdown in this context. Instead, it is now sufficient that the released blades will be radially contained.
While the proposed changes to CS-E 810 do require that Hazardous Engine Effects do not occur at a rate in excess of Extremely Remote, CS-E 810 does not point to Hazards potentially resulting from continued rotation with the resulting unbalance.

The dynamic loads generated by the residual rotor unbalance following a blade failure, need to be considered for the strength of both, the engine structural components and the main rotating components. This is particularly important in cases where the blade failure itself does not necessarily result in a self-shutdown of the engine and the unbalance loads could persist for the remainder of the flight. If reliance is placed on engine shutdown by the flight crew to prevent propagation to Hazardous Engine Effects, then adequate and dependable instrumentation is required for flight deck Warning indication of the unbalance condition and adequate instructions are required in the Engine Operating Instructions.

response Partially accepted.

The amended CS-E 810 requires that the blade Failure will not lead to a Hazardous Engine Effect as a result of other damages before Engine shutdown at a rate not in excess of that defined as Extremely Remote.

A new paragraph AMC E 810(1)(d) has been created to ensure that blade failures not detected by the declared instrumentation are considered by applicants (assessing the potential Hazardous Engine Effect resulting from other damages before Engine shut down).

comment *10* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
12	CS-E 520(c)(1)	The strength of the Engine must be such that the shedding of compressor or turbine	The proposed rule change has the effect of prohibiting any blade release material from exiting the engine	Propose a fixed energy or size limit on debris released outside of the	Conceptual

		blades, either singly or in likely combinations, will be radially contained by the Engine casing.	outside the containment ring, or exiting the fan aft of the containment ring even if it remains contained within the engine. Given the dynamics of a rotating blade release, the only way to comply with this regulation as proposed would be to ensure that no blade is ever released.	containment ring, or keep the regulation as-is (delete the proposed change)	

response

Not accepted.

Debris could be released outside the Engine structure used for blade containment; however, this debris does not necessarily constitute a Hazard leading to an unsafe condition.

comment *45* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
Page 12/36 – CS-E 520(c)(1) – Strength analysis

2. PROPOSED TEXT / COMMENT: Suggested change
Keep Hazardous engine effect wording instead of radially contained.

3. RATIONALE / REASON for comment: Justification
Radial containment is only one element of having no hazardous engine effect. Airbus believes the full spectrum of potential hazardous engine effect shall be complied with.

response

Not accepted.

CS-E 810(a) includes a specification addressing potential Hazardous Engine Effects after the radial containment.

comment *61* comment by: *AIRBUS HELICOPTERS*

PROPOSED TEXT :
(c) (1) The strength of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine casing **and will not lead to engine casing opening**.

JUSTIFICATION :
To improve the level of safety at helicopter level, Airbus Helicopters suggests, by adding the text in bold and underlined here above, to consider preventing the case of engine structure opening that could release hot gases in the engine compartment.

response

Not accepted.

CS-E 810(a) includes a specification addressing potential Hazardous Engine Effects after the radial containment. AMC E 810(2)(c)(i) addresses the potential Hazard from Engine casing damage.

comment

73 comment by: *Rolls-Royce Plc*

Comment
Term 'radially contained' requires definition especially when text of AMC to E 520(c)(1) (2) is not revised. Taking in to account this AMC it seems unrealistic to ensure containment of high energy debris at front and rear end of turbine engines in radial direction. Overall and given the intent of the E 520(c)(1), revision to the mentioned AMC to E 520(c)(1) (2), something similar to requirements in Russian airworthiness standard AP-33.19(a), would be one solution rather then proposed changes to E520, E 810 airworthiness standards and AMC to E 810. (See also following comment No. 74.)
Suggested resolution
Consider the approach in AP-33.19(a) as an alternative to better definition of 'radially contained.'

response

Partially accepted.

The current AMC E 520(c)(1) already provides guidance on how to identify radial containment provisions. In particular, the last sentence of paragraph (2) states that: 'This AMC is not meant to impose an obligation on the Engine constructor to provide containment in the direction of the intake and exhaust, provided the limits of the angles to which containment is assured are made available to the aircraft constructor installing the Engine.'

comment

74 comment by: *Rolls-Royce Plc*

Comment
Clarity required on definition of "Radial Containment". AMC E810(2)(c) (i) implies radial containment is within the containment structure. (ii) implies OK if blades protrude through containment structure but remain within external geometry of engine. Log-jamming and low energy rupture of casings is an established and safe outcome from a wide variety of core (and historically fan balde) failures. (See also previous comment No. 73 - either use approach from AP-3319(a) or better define radial containment.)
Proposed resolution
Define "radially contained" better - it is assumed the intention is to contain all debris within the plane of the the affected rotor such that no material is released which

could result in a hazardous condition [this would require agreement with the airframer via the installation manual].
Radially contained: Prevent escape of material from the engine or rupture of casings during the containment event* in the plane of the affected rotor**.
* The containment event can be considered the period during which the initially released element[s] retain kinetic energy from the period immediately prior to release.

** The plane of the rotor should be defined by the manufacturer but is normally considered +/-15 degrees for small fragments [AC20-128A].

This is a substantive comment.

response | Please refer to the response to comment 73.

comment | *77* comment by: *Rolls-Royce Plc*

Comment
Point (c) (2) has been amended to add 'as well as the effect on the engine and aircraft structures and systems of the….' The effect on the aircraft structures must be done in conjunction with the aircraft manufacturer (where there is one).
Suggested resolution
add 'in conjunction with the aircraft manufacturer' (as well as addressing Point 68)

response | Noted.

The commented text of AMC E 520(c)(2) has been modified after the NPA publication in a way that there is no more reference to the effects on aircraft structures and systems. The text now refers only to the loads transmitted to the aircraft.

comment | *171* comment by: *Transport Canada Civil aviation*

(c)(1)

The proposed change in CS-E 520(c)(1) has no corresponding proposed updates to AMC E 520(c)(1). In particular, the term 'radially contained by the Engine casing' should be further explained in the AMC.

Suggested resolution
Add to / Modify the existing AMC to explain what is meant by 'radially contained by the Engine casing'

response | Please refer to the response to comment 73.

AMC E 520(c)(2) Engine Model Validation p. 12

comment | *11* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
12	AMC E 520(c)(2)	Administrative	The title is "AMC E 520(c)(2)", but the proposed changes affect (1), (2), (3) and (5)	Correct citations	
12	AMC E 520(c)(2)	Manufacturers whose engines fail the rotor support structure by design during the blade loss event should also evaluate the effect of the loss of support on engine structural response, as well as the effect on the engine and the aircraft structures and systems of the most severe blade failure which would not cause the failure of the rotor structural support.	The phrase, "as well as the effect on... the aircraft structures and systems" implies the engine manufacturer is competent to provide a showing about the effect of an engine failure on an aircraft structure or system, when the applicant has no knowledge or technical date on the aircraft.	Change the requirement to state that the engine manufacturer must include data on the displacement of engine mounts and physical interfaces with the aircraft.	
12	AMC E 520(c)(2)	The model should be validated based on …, and any other differences between the test	The proposed wording implies the engine manufacturer has definitive knowledge of the aircraft installation at the time if	Change the guidance to state that the applicant should include any assumptions about the	

		configuration and the aircraft installation (e.g. flight inlet replaced by test intake).	engine certification.	installation configuration as limitations in the installation manual.	
13	CS-E 810 (a)	It must be demonstrated that any single compressor or turbine blade will be radially contained by the Engine casing	The proposed rule change has the effect of prohibiting any blade release material from exiting the engine outside the containment ring, or exiting the fan aft of the containment ring even if it remains contained within the engine. Given the dynamics of a rotating blade release, the only way to comply with this regulation as proposed would be to ensure that no blade is ever released.	Propose a fixed energy or size limit on debris released outside of the containment ring, or keep the regulation as-is (delete the proposed change).	
12	CS-E 520 paragraph (c)(1)	The strength of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will be radially contained by the Engine casing.	Guessing that "radially contained" means that the engine containment structure needs to be able to catch and hold a fan, compressor, or turbine blade if it flies off its hub when the engine is operating. However, there may be more to this term than assuming.	You should define what "radially contained" means under CS-E 15 Terminology.	Conceptual

12	AMC E 520 (C)(2)	(2) Manufacturers whose engines fail the rotor support structure by design during the blade loss event should also evaluate the effect of the loss of support on engine structural response, as well as the effect on the engine and the aircraft structures and systems of the most severe blade failure which would not cause the failure of the rotor structural support.	This is a new requirement introduced by advisory material and will result in disharmonization with FAA's requirement. The proposed change would require the engine manufacturer to determine the effects on the airplane structure and systems is not feasible.	Suggest focus the change to require the engine manufacturer to provide to the airplane manufacturer the interface loads, displacements at the interface between engine and airplane only.	Conceptual

response

Comment 1: Noted.

The paragraphs mentioned ((1), (2), (3), (5)) are part of AMC E 520(c)(2). These paragraphs are not linked to the numbering in CS E 520.

Comment 2: Accepted.

The commented sentence has been modified.

Comment 3: Accepted.

Comment 4: Please refer to the response to comment 10.

Comment 5: Please refer to the response to comment 73.

Comment 6: Accepted. The commented sentence has been modified.

comment *31* comment by: *GE Avio*

Regarding the text: "(2) Manufacturers whose engines fail the rotor support structure by design during the blade loss event should also evaluate the effect of the loss of support on engine structural response, as well as the effect on the engine and the aircraft structures and systems of the most severe blade failure which would not cause the failure of the rotor structural support".
The engine manufacturer does not have detailed knowledge of the aircraft structure and systems, and therefore cannot comply with this expectation during engine certification. This text should be removed

Regarding the text:"…Test configuration and the Aircraft installation.."
This approach need to be better defined since there is the risk to have an Engine certified according only to one aircraft configuration.

response

Partially accepted.

First point: The commented text has been modified to require the evaluation of the effect on the Engine and on the loads transmitted to the aircraft.

Second point: Paragraph (3) has been complemented with a sentence requiring that assumptions about the Engine installation configuration be documented in the Manuals required by CS-E 20(d).

comment *122* comment by: *Safran Helicopter Engines*

NR	Author	Section, table, figure	Page	Comment summary	Suggested resolution	Comment is an observation or is a suggestion *	Comment is substantive or is an objection**
6	SAFRAN	AMC E 520 ©(2)	12	*Engine Model Validation (1) and (5): - …. (1) - dynamic displacement of interface features between engine and aircraft (5) - .... including interface features*	*Engine Model Validation : - …. (1) - dynamic displacement of interface features that transfer efforts between engine and aircraft (5) - … including*	YES	NO

				between engine and aircraft The term of "interface features" may refer to all interface between engine and the aircraft, while some interface are inherently flexible, i.e. does not transfer any loads. It is understood here that the considered interfaces are those who may tranfert efforts between the engine and the aircraft.	*interfaces that transfer efforts between engine and aircraft*			

response

Not accepted.

EASA prefers to retain the proposed wording. Loads and displacements may occur at interfaces other than load carrying points; for example, where bleed ducts are connected, etc.

comment

135 comment by: *Honeywell E&PS Certification Office*

In sentence: "Validated data specifically for blade loss analysis typically includes" the last character "s" has been added. This is incorrect. The word data is plural, so the added "s" is mistaken.

response

Not accepted.

Thank you for your comment.

As indicated in oxforddictionaries.com (to which EASA is bound to refer further to the Interinstitutional Style Guide of the EU), the noun 'data' is a mass noun — at least in British English that is used in EU drafting; it should therefore take a verb in singular. This is the reason for adding the 's' at the end of the verb 'include'.

It has been years since the EASA policy on how we deal, linguistically speaking, with certain terms has been defined and applied — one of these terms is 'data'. One can at first glance see that in the EU civil aviation regulatory framework. A characteristic example is Regulation (EU) 2017/373 (ATM/ANS) which among others lays down the requirements for data service (DAT) providers. In the case of CS-E, in the latest issue published (Issue 6), we have multiple occurrences of the term 'data'. The majority of them are used with a verb form that denotes neither plural nor singular (e.g. data must be provided, data should be specified, data to support, the data required, etc.). There are though cases where we have 'these required data are intended' or 'if the data obtained during the execution of the programme indicates that …'. Cases as the former are very few nowadays and are to be found in text of CSs that has not been amended for more than 10 years. On the other hand, cases as the latter are present in either text that is comparatively new or text that has been amended more recently.

comment *145* comment by: *Pratt & Whitney Canada*

Regarding CS-E text: Subparagraph (1) "Validated data..."

This paragraph is not clear. It is called Engine Model Validation, yet it specifies the "validated data". Does it mean for example that in a certification test "dynamic displacement of interface between engine and aircraft" needs to be measured in order to validate the modelling?

Requested action:
Clarify the intent of the paragraph and provide guidance on acceptable criteria for validation of the dynamic displacement modeling.

response Not accepted.

CS-E 520(c)(2) required that 'Validated data (from analysis or test or both) must be established and provided for the purpose of enabling each aircraft constructor (…)'.

In addition, AMC E 520(c)(2), paragraph (3) stipulates that 'The model should be validated based on vibration tests and results of the blade loss test required for compliance with CS-E 810'.

These provisions are unchanged by the proposed amendment and are considered clear enough.

comment *151* comment by: *Pratt & Whitney Canada*

Regarding CS-E text: "(2) Manufacturers whose engines fail the rotor support structure by design during the blade loss event should also evaluate the effect of the loss of support on engine structural response, as well as the effect on the engine and

	the aircraft structures and systems of the most severe blade failure which would not cause the failure of the rotor structural support." In general, the engine manufacturer does not have detailed knowledge of the aircraft structure and systems. This is what the AIA FAR 33.94 FBO working group has been discussing but not yet concluded. This is too restrictive with respect to the engine design, with the underlying assumption/motivation being a single airframe/engine combination. An engine manufacturer does not want to be restricted in this way, and would want to have an engine model, one that meets all the engine requirements (FAR 33/CS-E), to be suitable for multiple applications. The proposed wording may preclude that possibility, i.e. if an engine model is purpose-designed in coordination with one airframer, it may not be suitable for another airframe or may need extensive design for the alternate engine-airframe combination. Requested action: Remove the added clause "… as well as the effect…"
response	Accepted. This paragraph has been re-written.

comment	*156* comment by: *Transport Canada Civil aviation* paragraph 3 EASA writes “(e.g. flight inlet replaced by test intake).” **Suggested resolution** Suggest to clarify and revise text, if needed. “(e.g. production inlet configuration replaced by test intake configuration" in lieu of "e.g. flight inlet replaced by test intake)”
response	Accepted.

comment	*157* comment by: *Transport Canada Civil aviation* paragraph 7 EASA writes “The airframe and engine …” **Suggested resolution** Suggest to revise text to say “The aircraft and engine…”, if needed Reason: The term "airframe" is only used once. EASA may want to consider using "aircraft" to be consistent with the rest of the NPA.
response	Accepted.

CS-E 810 Compressor and Turbine Blade Failure	p. 13

comment *12* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
13	CS E 810	(a) It must be demonstrated that any single compressor or turbine blade will be radially contained by the Engine casing after Failure and that the blade Failure will not lead to a Hazardous Engine Effect before Engine shut down at a rate greater than that defined as Extremely Remote.	This is a new requirement which will result in dis-harmonization with the FAA requirements. The proposed amendment will require the engine manufacturer to calculate the probability of a Hazardous effect at the airplane level from debris being released axially is not practicable because the engine manufacturer does not have the airplane design data. This evaluation will be done under the Part 25 or CS-25 requirements. In addition, if this amendment is adopted will (a) delay the engine certification, and (b) we certify the engine for multiple airplane installations.	Do not publish proposed amendment to CS E 810.	Conceptual

response Please refer to the response to comment 8.

comment *46* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
Page 13/36 – CS-E 810(a) – Compressor and Turbine Blade Failure

2. PROPOSED TEXT / COMMENT: Suggested change
Use the same wording for “radially contained by the Engine containment structure” as in AMC instead of “Engine casing”.

3. RATIONALE / REASON for comment: Justification
Have consistent wording through CS-E.

response

Partially accepted.

The wording ‘radially contained by the Engine’ has been adopted consistently.

comment *47* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
Page 13/36 – CS-E 810(a) – Compressor and Turbine Blade Failure

2. PROPOSED TEXT / COMMENT: Suggested change
Add a requirement for design minimization of risk of high energy debris release towards the aircraft (nacelle, fuselage, other engine).
Proposed text:
“Engine containment structure and blades shall be designed in order to minimize the generation of debris that could cause a hazard to the aircraft after a failure of compressor or turbine blades that is reasonably expected to occur”

The following text could be used as guidance in the AMC:
“When the engine is developed with an intended installation identified, the engine manufacturer shall liaise with the aircraft manufacturer in order to determine the debris characteristics that could cause a hazard to the aircraft.

If this coordination identifies fragments that could cause a hazard to the aircraft, engine and aircraft manufacturers should work together to reduce the fragment threat as far as practicable and adapt the overall aircraft (including engine) design accordingly.

The engine manufacturer should design the engine to minimize the risk of causing a hazard to the aircraft.
Some engine containment systems have been developed with the objective to either capture failed blade or prevent its travel towards the front of the engine casing. Typical design features that are known to have been developed in order to minimize fragments ejection forward are:
Soft containment (typically featuring a kevlar belt)
Physical barrier in hard containment that prevent the blade debris to travel forward
Any alternative with the same intent should be acceptable.

For metallic fan blades, the engine manufacturer should estimate the fragmentation based on tests and experience and consequently design the containment structure.

For composite fan blades, the fragmentation is likely to result in small composite pieces and fragments of metallic leading edge, for which some design precautions should be taken.

3. RATIONALE / REASON for comment: Justification

Updated AMC E520, §(3)(d)(iii) - Non-containment of high-energy debris adds the concept that debris, even though radially contained by the Engine containment structure, could be released from the engine in various manners and could cause a hazard to the aircraft:

"Furthermore, Engine failures (including blade failures) can lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, with an energy and a trajectory that could cause a hazard to the aircraft".
Airbus believes that since this threat is recognized, a new requirement shall be added in order to ensure that design precautions are taken in order to minimize its occurrence. The level of minimization achieved would be measured through the new not greater than Extremely Remote objective introduced in **CS-E 810(a).**

response

Not accepted.

The objective of 'minimization of risk of high energy debris release towards the aircraft' is addressed in AMC E 510, which has been revised taking into account all the comments received on NPA 2021-13. AMC E 810 cross refers to AMC E 510 in the paragraph dealing with 'no other Hazardous Engine Effect resulting from the blade Failure (…)'

comment

75 comment by: *Rolls-Royce Plc*

Comment
Other hazard ratios used under CS-E 510 (say hazard ratio from spinner fairing release to hazarding the aircraft) would be recorded in application assumptions (CS-E 30) rather than installation manual (CS-E 20). There should be a consistent way of doing this.
Suggested resolution
Trajectories and energies of released debris should be recorded against requirements in CS-E 20. Hazard ratio and installation assumptions should be recorded in the application assumptions (CS-E 30).

response

Accepted.

CS-E 30 itself states that 'These assumptions must be included in the Engine instructions for installation required under CS-E 20(d)'. This specification has not been changed by this NPA.

comment

134 comment by: *Honeywell E&PS Certification Office*

Most severe blade failure w/o rotor support:

We are not familiar with requirements to demonstrate compliance for a most severe blade failure w/o rotor support failure in a turbine section. The wording in the proposed change does not provide much information on what would be required to satisfy this new requirement. If it is all the requirements listed in AMC E 520(c)(2) it could be a significant amount of extra effort, and seems excessive since the severity of this failure is much less than an event that causes failure of the rotor support structure. What would be needed to demonstrate "Extremely remote rate" of less than 10-9 for the impact of a turbine blade failure on occurrence of a "Hazardous Engine Effect" (previously only required for composite fan blades and overspeed blade shedding)?

Can clarification/definition be provided for what might be needed to satisfy "Additional requirements may be applied during aircraft certification"?

Could EASA reconsider applying this requirement to turbine blades since the concern that drove this change was based on failure of a fan blade, not a turbine blade?

response

Partially accepted.

The commented paragraph in AMC E 520(c)(2) deals with Engine model validation corresponding to CS-E 520(c)(2). It does not deal with failure-related specifications. This paragraph has been revised to clarify its intent. It now states that manufacturers should evaluate the effect of the most severe blade Failure which would not cause the Failure of the rotor structural support. The effect on the Engine and on the loads transmitted to the aircraft should be included in this evaluation.

comment *150* comment by: *Pratt & Whitney Canada*

Regarding CS-E text in Subparagraph (a):

The word "radially" could be viewed as constrictive and open to interpretation if, for example, a blade is released by a small angle from "radial", i.e. it should not be misconstrued that the blade can only be released "exactly radially". This should perhaps be reworded to indicate that the casing features designed to contain released blades should not fail in such a way as to release particles outside of the casing, or words to that effect.

Requested action:
Revert back to original wording.

response

Not accepted.

AMC E 520(c)(1), paragraph (2) provides guidance on the possibility that the final trajectory of a failed blade may not be directly in the plane of its rotation.

comment *158* comment by: *Transport Canada Civil aviation*

(a)
EASA writes "(…)"

Suggested resolution
Suggest to use ellipsis "[…]" in lieu of brackets "(…)" , if applicable
Reason:
Per this NPA protocol:
an ellipsis '[…]' indicates that the rest of the text is unchanged not (...)
Same applies throughout the rest of this NPA

response | Accepted.

AMC E 810 Compressor and Turbine Blade Failure p. 13

comment *13* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
14	AMC E 810 (2)(ii)	The hazard ratio associated with any potential threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer.	"Hazard Ratio" is a COS term, not a certification term.	Change the proposed wording to require the engine applicant to define the energy and velocity of any debris leaving the engine outside the containment ring. If necessary, define a maximum limit on the energy and velocity of debris leaving the engine outside the containment ring.	
14	AMC E 810 (2)(ii)	NOTE (1): The approximate size and	The proposed new CS-E wording does not allow for any	If the new CS-E wording is	

		weight of debris released during the test, along with an estimate of its trajectory and velocity, should be recorded to enable a determinatio n whether the debris could result in a Hazardous Engine Effect. This data should be documented in the Manuals required by CS-E 20(d). NOTE (2): The above assessment is required to demonstrate that the likelihood of a Hazardous Engine Effect due to blade Failure is low enough to be accepted for engine certification (i.e. Extremely Remote). Additional consideration s may be applied during aircraft certification to further	debris exiting the engine.	retained, delete notes 1 and 2.	

		mitigate the potential effects of blade Failures at aircraft level.			
14	AMC E 810 (2)(c)(ii)	The hazard ratio associated with any potential threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer.	This is a new requirement which will result in dis-harmonization with the FAA part 33 requirements. FAA and EASA historically certified an engine for multiple airplane installations. If this amendment is adopted, it will delay the engine certification process and the engine will only be certificated for a specific airplane (Boeing, or Airbus or …) installation.	Do not publish proposed amendment to AMC E 810.	Conceptual

response

Comment 1: Partially accepted. The commented text has been deleted from AMC E 810. AMC E 510(3)(d)(iii) has been updated, and a new paragraph provides guidance on the evaluation of the threat to the aircraft from blade failure debris. The term 'hazard ratio' is not used anymore.

Comment 2: Not accepted. The commented notes 1 and 2 do not state that debris is not allowed to exit the engine (outside the radial containment structure). The intent is to assess the potential effect from such debris that may be released in the forward, rearward, or otherwise outside the containment structure.

Comment 3: Not accepted. Please refer to the response to comment 8.

comment

32 comment by: *GE Avio*

Regarding the text: "All relevant design features, test and service experience should be considered when estimating the likelihood of a blade failure, as well as the probability of the Failure progressing to cause a Hazardous Engine Effect. "
Calculation of this probability is beyond the state of the art and therefore this poriton of the sentence should be removed.

Regarding the text :"The hazard ratio associated with any potential threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer ."
Airplane level effects of a failure cannot reasonably be assessed by the engine manufacturer; and this approach does not consider the use of a certified engine in multiple applications. There can be more than one airplane manufacturer. Airplane effects should be assessed at the airplane level, as part of the safe installation of an existing engine. Therefore, this sentence should be removed.

Regarding the text: "(iii) no evidence, either from the test, service experience or other analysis, indicating that the conditions of paragraphs (c)(i) and (c)(ii) above would not be satisfied under other possible blade Failure conditions (e.g. blade released at different angular position, partial blade failure, or release at speeds below the maximum to be approved)."
This is so open ended it is not clear any applicant could show compliance, clarification of acceptable Methods of Compliance are necessary.

response

Partially accepted.

The commented texts have been deleted.

The guidance concerning the assessment of the threat from blade failures is now contained in AMC E 510. The content has been fully updated, and it does not use the term 'hazard ratio' anymore.

The guidance related to the consideration of 'other possible blade failure conditions' is now addressed in the beginning of AMC E 810 in a new paragraph (1)(c). This paragraph includes a statement recognising that limitations on prediction capabilities exist, particularly in relation to the prediction of axially released debris. Engineering judgement based on available test and service experience may be used to evaluate these threats.

comment

60 comment by: *AIRBUS HELICOPTERS*

PROPOSED TEXT :
no other Hazardous Engine Effect resulting from the blade Failure, including due to debris being released from the Engine, forward, rearward, or otherwise outside of the containment structure **and leading to engine casing opening**, unless the probability of the Hazardous Engine Effect can be shown to be Extremely Remote.

JUSTIFICATION :
Suggestion of text about the first sentence of § (2) (ii) on page 14 :
The text in bold and underlined in the proposed text here above complements the EASA modification in order to consider preventing the case of engine structure opening that could release hot gases in the engine compartment.

response

Partially accepted.

AMC E 810 (2)(c)(i) addresses the intent of this comment. It has been amended compared to the NPA proposal. It states that there should be no unsafe condition from a possible internal damage to the Engine as a result of blades penetrating the rotor casings, even though they are contained within the external geometry of the Engine.

comment *70* comment by: *Rolls-Royce Plc*

Comment
The term 'hazard ratio' is used by Safety and Reliability specialists who routinely interact with Airframe S&R specialist but there is not a common understanding of how it is used in the rest of the engine community.
Suggested resolution
Define the term hazard ratio.

response Partially accepted.

The term ‘hazard ratio’ has been removed, therefore there is no need for a definition.

comment *76* comment by: *Rolls-Royce Plc*

Comment
Note (1) under the second (ii) states that information on the debris released in the blade off test should be documented 'in the Manuals required by CS-E 20(d).' However the requirement of CS-E 20(d) is to provide manuals with instruction for installing and operating the engine, which is very different from providing data to support the aircraft certification, which is what the debris is for.
Suggested resolution
This data would fit better against CS-E20(e) if the idea of 'engine performance' is stretched somewhat. Alternatively add a new point to CS-E 20 which is the equivalent to the point 'Failure Analysis' in Table 1 of AMC E 30, but where the engine designer is providing data to the airframer to support their safety analysis.

response Not accepted.

The commented text reflects the historical practice and the content of CS-E 30 which has not been changed by this NPA.

comment *78* comment by: *Rolls-Royce Plc*

Comment
Article now has two separate item " (ii) ".
Suggested resolution
Renumbering of article to eliminate confusion.

response Accepted.

The first (ii) was supposed to appear in strikethrough. This has been corrected.

comment *123* comment by: *Safran Helicopter Engines*

NR	Author	Section, table, figure	Page	Comment summary		Suggested resolution	Comment is an observation or is a	Comment is substantive or is an

							suggestion *		**objection** *
7	SAFRAN	AMC E 810	14	*The hazard ratio associated with any potential threat to the safety of the aircraft should be assessed in coordination with the aircraft manufacturer.*		see comment n°3 on AMC E 510	YES		NO
8	SAFRAN	AMC E 810	14	*(iii) no evidence, either from the test, service experience or other analysis, indicating that the conditions of paragraphs (c)(i) and (c)(ii) above would not be satisfied under other possible blade Failure conditions (e.g. blade released at different angular position, partial blade*		*(iii) For engines with a FAN, no evidence, either from the test, service experience or other analysis, indicating that the conditions of paragraphs (c)(i) and (c)(ii) above would not be satisfied under other possible blade Failure conditions*	NO		YES

				failure, or release at speeds below the maximum to be approved). For some internal rotating assemblies with high rotation speeds such as, axial compressors, centrifugal compressors, high and low pressure turbines, it might be impossible to evaluate the angular position of the blade release and then to assess the associated changes in the consequence of the failure. This requirement should be limited to large diameter and low speed rotors such as FAN		*(e.g. blade released at different angular position, partial blade failure, or release at speeds below the maximum to be approved).*			

response	Comment 1: Please refer to the response to comment 121. Comment 2: Not accepted. The comment is not understood. CS-E 810 requires radial containment of any compressor and turbine blade after failure, and this is not a new requirement. The applicant is therefore expected to investigate release angle positions other than the ones occurred during the test. This must not be limited to fan blades only.

comment	*133* comment by: *Honeywell E&PS Certification Office* Section 2(ii): Ensure that "blade Failure" has correct capitalization. Section 2(ii): Ensure that "CS-E 20(d)" has correct placement of a hyphen. Section 2(ii): NOTE (1): The approximate size and weight of debris released during the test, along with an estimate of its trajectory and velocity, should be recorded to enable a determination determine whether the debris could result in a Hazardous Engine Effect. Section 2(c)(ii) appears to be contradictory to the direction provided for Hazardous effects at the rate of Extremely remote, can this be clarified?
response	Comment 1: Accepted. For consistency with the rest of CS-E, 'Failure' has been capitalised in all places. Comment 2: Accepted. This has been corrected. Comment 3: Accepted. Comment 4: Noted. The comment is not understood. EASA does not find a contradiction. Please note that the commented sentence has been amended in the meantime, hopefully clarifying its meaning.

comment	*149* comment by: *Pratt & Whitney Canada* Regarding CS-E text in Subparagraph (iii) "no evidence" A "validated" analysis (and it is likely that this is intended to mean "validated" or would be considered by the Agency as such) may not be possible with the current state of the art from such a highly chaotic event. Requested action: Remove the paragraph.
response	Accepted.

	The commented paragraph has been deleted. However, the subject is now addressed in a new paragraph (1)(c). This new paragraph recognises that some limitations exist on prediction capabilities, in particular for axially released debris.
comment	*159* comment by: *Transport Canada Civil aviation* (2)(c) EASA writes "tests, a complete power Failure is acceptable…" **Suggested resolution** Suggest to revise text to say "tests, a complete engine shutdown is acceptable…", if needed Reason: To prevent misinterpretation
response	Accepted.
comment	*160* comment by: *Transport Canada Civil aviation* (2)(c) New (ii) should be (iii) and New (iii) should be (iv) **Suggested resolution** Suggest to clarify and revise text, if needed
response	Partially accepted. The first (ii) should have been shown in strikethrough, this has been corrected.
comment	*172* comment by: *Transport Canada Civil aviation* AMC CS-E 810 (2)(c)(ii) and AMC CS-E 510(d)(iii) The added text should be consistent between AMC CS-E 520 (NPA page 11) and AMC CS-E 810. The text under AMC CS-E 810 includes a probabilistic aspect ('unless the probability of the Hazardous Engine Effect can be shown to be Extremely Remote.') The AMC text in CS-E 520 does not have this qualifier. **Suggested resolution** Suggest to further adjust the text under AMC CS-E 510 (NPA page 11 + suggested edits per above comment) as follows: Furthermore, Engine failures (including blade failures) may lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, If such failures have an energy and a trajectory that could cause a hazard to the aircraft, then ~~.~~ release of such debris should be considered as a Hazardous Engine Effect unless the probability of the Hazard Engine Effect can be shown to be Extremely Remote.

response | Partially accepted.

The text of AMC E 510 has been amended. It now states that if this debris is released with an energy and trajectory that could cause an unsafe condition (refer to AMC1 21.A.3B(b)), such debris should be considered as uncontained high-energy debris causing a Hazardous Engine Effect. In order to demonstrate the Extremely Remote probability objective necessary for compliance with CS-E 510 (a)(3), the overall probability of occurrence of the unsafe condition should be assessed.

comment | *173* comment by: *Transport Canada Civil aviation*

AMC CS-E 810 (2)(c)(ii) and AMC CS-E 510(d)(iii)

The added text should be consistent between AMC CS-E 520 (NPA page 11) and AMC CS-E 810. The text under AMC CS-E 810 includes a probabilistic aspect ('unless the probability of the Hazardous Engine Effect can be shown to be Extremely Remote.') The AMC text in CS-E 520 does not have this qualifier.

Suggested resolution
Suggest to further adjust the text under AMC CS-E 510 (NPA page 11 + suggested edits per above comment) as follows:
Furthermore, Engine failures (including blade failures) may lead to debris being released from the Engine, forward, rearward, or otherwise outside of the Engine containment structure, If such failures have an energy and a trajectory that could cause a hazard to the aircraft, then ~~.~~release of such debris should be considered as a Hazardous Engine Effect unless the probability of the Hazard Engine Effect can be shown to be Extremely Remote.

response | Please refer to the response to comment 172.

comment | *174* comment by: *Transport Canada Civil aviation*

AMC CS-E 810 (2)(c)(ii)

The term 'hazard ratio' appears in the new proposed text. This is the first instance of this term in CS-E and is not defined in the CS Definitions. It should be clarified what is meant by 'hazard ratio'. Presumably it is intended to mean the ratio of severity / impact to probability of occurrence?

Suggested resolution
Suggest to add what is meant by 'hazard ratio' to avoid any confusion.

response | Partially accepted.

The term 'hazard ratio' is not used anymore. The content of this paragraph is now located in AMC E 510 and it has been amended.

AMC E 210 Failure Analysis p. 15

comment	*80* comment by: *Rolls-Royce Plc* **Comment** The change is supported.
response	Noted.

comment	*130* comment by: *Honeywell E&PS Certification Office* Section (3): This appears to be a rather broad statement. Which components not part of the engine type design are to be considered? Is this to include powerplant installation components only, or all aircraft? If the other components are not Part 33 the effects of failures of Part 25 components is Part 25 responsibility, Coordination with the Part 25 TC holder may be needed, but this is not a Part 33 responsibility. Section (4) How does the agency accept this w/o proper safety analysis to start with? Clarify the criteria for practical use.
response	First comment: Noted. Please note that the proposed amendment is about engines that are usually installed on CS-23 or CS-27 aircraft, not on CS-25 aeroplanes. The scope of paragraph (3) relates to powerplant systems. A typical example is a component of the propeller control system (e.g. an electrical motor of a governor) that is operated by the engine control system. Second comment: Noted. A safety analysis is actually expected to substantiate that the failure of a component is sufficiently remote. Fault Tree Analysis (FTA) and Failure Mode Effects Analysis (FMEA) may be used when conducting this analysis.

comment	*163* comment by: *Transport Canada Civil aviation* paragraph (2) Clarify "Engine mount system". Does it mean to include the engine mount pads on the engine casing or just the aircraft mount system made of struts, links, elastomers, etc.? **Suggested resolution** Suggest to clarify and revise text, if needed
response	Noted. This indeed includes the elements of the engine mount system (e.g. engine attachment points) that belong to the engine type design. The applicant should nevertheless consider all elements of the engine mount system that could fail and lead to separation of the engine.

comment	*164* comment by: *Transport Canada Civil aviation*

Paragraph (3)

Identify where guidance may be found in order for the engine and aircraft OEMs to conduct such analysis. Selection of components by either party may delay engine and / or aircraft certification.

Suggested resolution
Suggest to clarify and revise text, if needed

response

Noted.

The demonstration of compliance with CS-E 210 is the responsibility of the engine manufacturer. Assumptions made regarding components that are outside the engine type design must be declared and included in the Engine instructions for installation required under CS-E 20(d). AMC E 30 Table 1 includes the following for 'Failure analysis': 'Installation aspects and the assumptions made with respect to any safety system that is required for the Engine and which is outside the applicant's control.'

comment *15* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/ Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
16	AMC E 210 paragraph (2)	...the failure effects considered to lead to unsafe Engine conditions beyond the normal control of the flight crew should include, but	The word "ones" is unnecessary.	Remove "ones."	Editorial

		not necessarily be limited to, the following ones:			
16	AMC E 210 paragraph (3)	The analysis should take into account the effects of failures of components...	this part can be reworded to sound clearer.	The analysis should take into account the effects of component failures...	Editorial
16	Item 4 : Piston engine failure analysis	AMC E 210 is proposed to be amended to reflect the content of the above mentioned generic MoC CRI.	The generic MoC CRI para list of hazardous events for Failure analysis needs to include evaluation of fault tolerance to single electronic/ electrical faults or potential shortfalls such as to soft failures. This is particularly important as the piston engine aircraft are	In para (2) add a sub-bullet to the list of hazardous events. - Single electrical or electronic failures that cause Loss of power or thrust below the LOPC/LOTC threshold (85%), and adversel	Conceptual

			predominantly single-engine aircraft. Confirmation of single fault tolerance is an important item for validation for these installations.	y impact the minimum climb performance, continued safe flight and landing capability of intended aircraft. Single failure evaluation should include hard (out-of-range) failures and soft failures (in-range) failures.	
16	Item 4 : Piston engine failure analysis	The failure of individual components of the engine and its installation need not be included in the analysis if the Agency	Para (4) Sufficiently remote wording is too broad and not defined in CS-E 15 Terminology. This provision can be used to exclude component failure modes and rates in fault tree	Delete this para (4), or modify the wording to "The failure of individual components of the engine and its installation need not be	Conceptual

		accepts that the possibility is sufficiently remote.	analyses and lead to optimistic probability numbers for system level failure modes.	included in the analysis if demonstrated to the Agency as extremely remote per CS-E 15 (10-7 to 10-9)".	

response

Comment 1: Not accepted.

Comment 2: Not accepted.

The proposed change would not work with the rest of the sentence.

Comment 3: Not accepted. Loss of power or thrust is also not classified as Hazardous Failure condition under CS-E 510(g) (for turbine engines). Please refer also to AMC E 510(3)(f).

Comment 4: Not accepted.

This paragraph is outside the scope of item 4 of this NPA. It is unchanged since CS-E Initial issue and already existed in JAR-E. The current wording is considered adequate and EASA does not agree with the proposed changes which would make it prescriptive.

AMC E 30 Assumptions p. 15

comment *14* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
15	Item 2, Table 1	"...flight duration and the engine maximum average oil	Comments in Items 1 thru 3 are applicable	Proposals in items 1 thru 3 are applicable.	C

		consumption... "			
15	Item 2, Table 1	CS-E 570	CS-E 570 applies to turbine engines.	Expand the applicability to all engines.	

response

First comment: Please refer to response to comment 7.

Second comment: Accepted.

The reference to CS-E 570 has been deleted from the table. A link has been made with the applicable certification specifications for the aircraft.

comment *48* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
Page 15/36 – AMC E 30 – Assumptions

2. PROPOSED TEXT / COMMENT: Suggested change
Replace: Engine maximum average oil consumption - Flight duration.
with : Engine maximum allowed oil consumption rate with associated possible flight duration and engine operating conditions

3. RATIONALE / REASON for comment: Justification
The assumption that the Engine manufacturer should include in the installation manual is really the maximum allowed oil consumption rate along a flight or a flight phase if the consumption is significantly varying with the engine operating conditions (thrust rating, altitude…)

response

Partially accepted.

The term ‘maximum allowable oil consumption’ has been used to be consistent with CS 25.1011(b) and other equivalent specifications.

comment *55* comment by: *AIRBUS HELICOPTERS*

COMMENT :
Clarify what "*maximum average oil consumption*" means. Clarify what "F*light duration*" means and for which intent it would be put in the installation manual.

JUSTIFICATION :
The requirement that the engine applicant quantifies max average oil consumption is important. But it is difficult to understand 1) what "*maximum average*" mean 2) what "*flight duration*" mean ? For flight duration, is it intended to put it "for information", as a min flight duration for an engine at max oil consumption, and oil filled at max level at beginning of the flight ?

response | Accepted.
The term 'maximum allowable oil consumption' has been selected and the term 'flight condition' deleted.

comment | *56* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive	Editorial: X
Affected paragraph and page number	Page: # 15 AMC E 30 Assumptions Paragraph: TABLE 1		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Engine maximum average oil consumption REQUESTED CHANGE: Engine maximum allowable oil consumption		
Why is your suggested change justified?	JUSTIFICATION: « Maximum average oil consumption » is not clear (combination of « maximum » and « average »). Safran Aircraft Engines's point of view on this terminology: - Maximum allowable oil consumption is the value given for CS 25.1011. - Average oil consumption in operation is the average oil consumption of the engine fleet. This can be a target specified by the airframer for economic/environmental aspects or by TC holder internal requirements. (For CS-E 570, average oil consumption is not necessarily an explicit assumption if not specified by the airframer. It also results from the engine design according to the TC holder design practices and internal requirements. If only an internal requirement, should this be considered as an assumption at CS-E level as it is not directly linked to airworthiness ?) Nota: in case EASA considers that it is necessary to include an average oil consumption, we suggest to use the following wording : "Targeted engine fleet average oil consumption" (if applicable)		

response | Accepted.

comment | *57* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive	Editorial: X

Affected paragraph and page number	Page: # 15 AMC E 30 Assumptions Paragraph: TABLE 1
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Flight duration REQUESTED CHANGE: Endurance of the aeroplane under critical operating condition
Why is your suggested change justified?	JUSTIFICATION: « Flight duration » term should be more precise. We suggest to use wording consistent with CS 25.1011 : "Endurance of the aeroplane under critical operating conditions".

response

Not accepted.

'Flight duration' has been deleted.

A statement has been added to explain that the value to be provided should enable the installer to show compliance with the aircraft certification specifications on oil systems.

comment

79 comment by: *Rolls-Royce Plc*

Comment
No reason is given for proposing that Table 1 in AMC E30 is updated to include 'Engine maximum average oil consumption and 'flight duration. ' Section 2.1 states that 'the oil consumption and the flight duration are also important assumptions that should be listed in Table 1' but does not say why they are important. It is assumed that the intent is to provide information to the airframer as to the maximum flight duration that should be considered in order to ensure there is sufficient oil. Currently no definition of what 'flight duration' is requested is given - it has no connection to maximum oil tank capacity. 'Engine maximum average oil consumption' is also not defined and is open to a range of interpretatations.
Suggested resolution
'- Section 2.1 should be updated to give a clear definition of what the aim of the change to Table 1 is intended to achieve.
- There should be clear definition, relevant to the intent, of any new parameters in Table 1.
- It should be recognised that oil consumption will vary with phase of flight, hence a 'maximum' flight duration should be associated with a flight profile. It is suggested CS-E 570/AMC 570 is updated to support any extra information to be required in Table 1.
- It is not clear why it is proposed to quote an oil consumption, given the oil consumption on its own will not address maximum flight duration (and servicing requirements are already covered under CS-E 25). Any oil consumption quoted should not be considered as a limit.

response

Not accepted.

The term ‘maximum allowable oil consumption’ has been selected and the term ‘flight condition’ deleted.

A statement has been added to explain that the value to be provided should enable the installer to show compliance with the aircraft certification specifications on oil systems (e.g. CS 25.1011(b) in the case of large aeroplanes).

comment

131 comment by: *Honeywell E&PS Certification Office*

How is oil consumption defined? (i.e. per outlined GAG cycle identified by engine manufacturer and/or specific operating conditions?)

response

Noted.

The term ‘maximum allowable oil consumption’ has been selected and the term ‘flight condition’ deleted.

A statement has been added to explain that the value to be provided should enable the installer to show compliance with the aircraft certification specifications on oil systems (e.g. CS 25.1011(b) in the case of large aeroplanes).

comment

161 comment by: *Transport Canada Civil aviation*

Assumptions in Table 1 Engine maximum average oil consumption

The CS-25.1011(b) airplane level requirement states "maximum allowable oil consumption" not "maximum average oil consumption".
Clarify to make the term in AMC E 30 consistent with CS-25 and harmonized with FAA 14 CFR part 25 paragraph 25.1011(b) and other Airworthiness Authorities .

Suggested resolution
Suggest to clarify and revise text, if needed

response

Accepted.

The term ‘maximum allowable oil consumption’ has been selected.

comment

162 comment by: *Transport Canada Civil aviation*

Assumptions in Table 1 Flight duration

Suggest to delete "flight duration" as this is an analysis carried out at aircraft level per CS-25.1011(b)

Suggested resolution
Suggest to clarify and revise text, if needed

response

Accepted.

The term ‘maximum allowable oil consumption’ has been selected.

‘Flight deletion’ has been deleted.

comment *175* comment by: *Transport Canada Civil aviation*

Flight duration is quite vague:
1) Flight could be misunderstood to be only ‘in air’, whereas the term ‘mission’ is more certain and complete.
2) It could be specified as ‘normal’ (typical/average) and ‘maximum’ mission durations.
3) There should be a distinction for ETOPs (normal and maximum).

Suggested resolution
Suggest to alter ‘flight duration’ in Table 1 of AMC E-30 to be more specific, for example:
Mission Duration (e.g. Normal, Maximum, ETOPs Average, ETOPs Maximum, as applicable).

response Partially accepted.

The term ‘flight condition’ has been deleted.

A statement has been added to explain that the value to be provided should enable the installer to show compliance with the aircraft certification specifications on oil systems (e.g. CS 25.1011(b) in the case of large aeroplanes).

AMC E 10(b) Thrust Reversers p. 16

comment *58* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive: X	Editorial
Affected paragraph and page number	Page: 17 AMC E 10 of NPA 2021-13 Paragraph: (b)(b)		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: § AMC E 10(b)(b) is stating: "The thrust reverser definition must then be included in the Manuals required by CS-E 20(d). This may be a reference to the specific thrust reverser of the intended installation, or this may be limited to defining the key design characteristics that must be respected, including, but not limited to, mass, centre of gravity, aerodynamic flow lines and nozzle areas. In this case, the Engine data sheet would contain a note to the effect that the Engine may be used with the specified thrust reverser." REQUESTED CHANGE:		

	It is proposed to add a wording in AMC E 10(b)(b) and in CS 25-934 to require the Aircraft manufacturer to inform the Engine manufacturer of any change to the P/N and/or to the mass, centre of gravity, aerodynamic flow lines and nozzle areas of the Thrust Reverser.
Why is your suggested change justified?	JUSTIFICATION: The AMC requires to reference either the P/N or the characteristics of the Thrust Reverser in the Manuals required by CS-E 20(d). Nevertheless, if the Aircraft manufacturer would, after initial certification, introduce a change to the Thrust Reverser such that it may affect the use of the Engine with its Thrust Reverser, this would impact Engine certification, as well as the associated Manuals and TCDS, and therefore need to be communicated to the Engine manufacturer.

response

Not accepted.

This proposal is considered outside the scope of NPA 2021-13.

comment

104 comment by: *Gulfstream Aerospace Corporation*

Under point (d), suggest adding a sentence: "Coordination between engine manufacturer and aircraft manufacturer may be required to ensure that CS E requirements are satisfied."

response

Not accepted.

The proposed sentence is generic and does not bring clarification to the AMC.

comment

165 comment by: *Transport Canada Civil aviation*

Paragraph (c)

EASA writes "…data sheet is endorsed so that…"

Suggested resolution
Suggest to clarify and revise text to say "…data sheet would contain a note so that…", if needed

response

Partially accepted.

'Endorsed' has been replaced by 'data sheet indicates…'.

comment

166 comment by: *Transport Canada Civil aviation*

Paragraph (d)

EASA writes "…an equivalent duct,…"

Suggested resolution
Suggest to clarify and revise text to say "…a production equivalent thrust reverser,…", if needed

response

Partially accepted.

The commented sentence has been re-worded to refer to a duct equivalent to a production thrust reverser.

AMC E 240 Ignition p. 17

comment *16* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
17	AMC E 10(b)	The intent of CS-E specifications is to give sufficient confidence that the use of the thrust reverser, where this is to be permitted, has no detrimental effects on the Engine itself, such as flutter in a fan, excessive vibrations or loads induced in the Engine carcass, etc.	suggestions on the grammar of this CS-E.	"...where this is permitted..." Add a comma after "vibrations." Remove "etc." because it is redundant.	Editorial

response	Partially accepted. The first proposed change is accepted (‘where this is permitted’). No comma is added after ‘vibrations’ because the adjective ‘excessive’ also applies to ‘loads’. The term ‘etc,’ is maintained to make it clear that the list is not exhaustive.

comment	*129* comment by: *Honeywell E&PS Certification Office* Use of the D8147 test fuel is only recommended and only applicable to Compression Ignition (CI) engines. D8147 includes three options for ignition delay (IG) and one defined lubricity option. Is there a preferred IG version for ignition testing for CI engines?
response	Noted. For the cetane rating/ignition delay of the test fuel, it is up to the applicant to choose a suitable grade. The cetane level of the fuels in the field should be taken into account for this decision.

AMC E 100 Strength p. 17

comment *17* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
17	Item 7 AMC E 100	"...This includes the effects due to icing, rain, and hail, under which sustained engine operation is expected to occur, and which may lead to high rotor imbalance	In addition to high rotor imbalance or severe rotor-case interaction, the vibratory amplitudes and flutter margins are also affected. FAA AC33.63-1 paragraph 5.2.b. page 11 identifies vibratory amplitudes and flutter margins. Proposal will eliminate the related FAA Safety Emphasis Item	Revise the last sentence to: "This includes the effects due to icing, rain, and hail, under which sustained engine operation is expected to occur, and which may lead to high rotor imbalance, severe rotor-case interaction, higher vibratory amplitudes, or flutter".	Conceptual

		or severe rotor-case interaction. "	(SEI) for 14 CFR 33.63 Vibration and AC33.63-1		
17	Item 7 AMC E 100	Paragraph Titled "AMC E 100 Strength"	The FAA Safety Emphasis Item (SEI) for 14 CFR 33.63 Vibration and related AC33.63-1, may be eliminated when addressed per this NPA and the FAA comments and proposed resolutions related to this paragraph.	Adopt or address the proposed resolutions related to this paragraph Item 7 AMC E 100	Conceptual

response

Accepted.

Please note that instead of amending AMC E 100, EASA decided to amend AMC E 650 for the same purpose.

comment *81* comment by: *Rolls-Royce Plc*

Comment
The proposed AMC E 100 requires that vibratin forces imparted to the aircraft structure under certain circumstances should be declared in the Manuals required by CS-E 20(d), and should the associated assumptions. It is suggested that the assumptions should go in the list compiled under CS-E 30 (recognising that these then go in the Installation manual which is required under CS-E 20).
Suggested resolution
Refer to CS-E 30 for the assumptions.

response

Not accepted.

Please note that the proposed AMC E 100 has been withdrawn and reliance is now placed on the existing (unchanged) CS-E 650(h) and on the amended AMC E 650 (taking into account other comments received).

comment *124* comment by: *Safran Helicopter Engines*

NR	Author	Section, table, figure	Page	Comment summary	Suggested resolution	Comment is an observation or is a	Comment is substantive or is an

							suggestion *	objection**
9	SAFRAN	AMC E 100	17/18	*For these applicable conditions, the following effects should be assessed under the full range of engine thrust or power and speed:* *(1) For Engine parts, repeated exposure to high cycle fatigue stresses in excess of endurance limits for even short periods of time could lead to cumulative fatigue damage and subsequent component failure. If these vibratory stresses exceed the levels demonstrated during compliance with CS-E 650, it should be demonstrated under CS-E 100 that they are not excessive.* The origin of this evolution is not fully understood by SafranHE. What is the intent of the agency and what is the Mean of		N/A	NO	YES

				Compliance expected by the Agency? If it is requested at component level to be able to quantify and precisely evaluate stresses in engine rotating parts under icing, rain and hail conditions: in practice this would require to perform icing / rain ingestion tests with strain gauge instrumentation that is perceived to be impracticable. Furthermore, strain gauges on the blades of the engine could compromise the representativeness of the icing test in terms of ice accretion. This item is proposed to be discussed more in detail with the agency.			
10	SAFRAN	AMC E 100	18	*(2) Vibration forces imparted to the aircraft structure due to these conditions*	N/A	YES	NO

				should be declared in the Manuals required by CS-E 20(d), and should include assumptions such as mass, stiffness and damping of the aircraft mount system. Currently SafranHE makes the conservative assumption that aircraft mount system as being infinitely stiff. SAFRAN HE considers that this approach still acceptable in this scope.				

response

Item 9: Noted.

CS-E does not require strain gauges instrumentation during the engine icing test campaign. When it comes to vibration, the purpose of the engine icing test is to characterise the engine accretion and shedding behaviour and to determine the corresponding unbalance and vibration loads. At the component level, other means of compliance could be considered as a complement to a full engine test in icing conditions.

Item 10: Noted.

Generally, conservative assumptions can be accepted by EASA. However, justification may be required.

comment

146 comment by: *Pratt & Whitney Canada*

Regarding CS-E text: Subparagraph (1) "For engine parts..."

The word "forces" should be removed as It is too specific and too restrictive. If acceleration or vibration level are provided, it should be satisfactory.

Also, the paragraph discusses potential instances of high vibrations on components with subsequent accumulation of damage, and then only links vibration durability to

CS E 650, which is limiting. Vibration characteristics are also demonstrated in Component Testing, and the linkage to CS-E 80 (or equivalent of 14 CFR 33.91).

Requested action:
Change the paragraph as noted.
Clarify the intent and add further guidance.

response

Noted.

Please note that the proposed AMC E 100 has been withdrawn and replaced by an amendment of AMC E 650 (taking into account other comments received). The term 'forces' is not used in the new amended AMC E 650.

comment

176 comment by: *Transport Canada Civil aviation*

Cross references to the applicable icing/rain/hail conditions would be helpful (CS-E 780 & 790).

Suggested resolution
Add cross references at the top of page 18:
'…icing (CS-E 780), rain~~,~~ and hail (CS-E 790), ….

response

Accepted.

The proposed references have been added in AMC E 650 that has been amended. The proposed amendment of AMC E 100 has been withdrawn.

CS-E 780 Icing Conditions p. 18

comment

18 comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
18	CS-E 780(a)(ii)	The applicable atmospheric icing conditions shall include the supercooled liquid water conditions defined in CS-Definitions Amendment	1) The proposed wording would still constitute a Significant Standards Difference from FAA 14 CFR 33.68. 2) The proposed wording assumes that engines, installed on aircraft not requiring compliance under	Require the engine to show safe operating characteristics in ICI, SLD and snow.	

		2 under 'Icing Atmospheric Conditions', and any additional conditions (such as ice crystal icing conditions, supercooled large drop icing conditions, snow conditions) applicable to the Engine air intake system in the ice protection specifications (CS 23.1093(b) for CS-23 until Amdt 4 or CS 23.2415 for CS-23 from Amdt 5, CS 25.1093(b), CS 27.1093(b), CS-29.1093(b)) of the Certification Specifications applicable to the aircraft on which the Engine is to be installed, as specified in CS-E 20(b).	the specified conditions, will never encounter those conditions. FAA regulations §§33.68 and 25.1093 (XX.1093) require showings of compliance under the listed conditions for engines even if other aircraft regulations do not require such showings. The reason is that by showing the installed engine will not fail under the listed conditions, pilots who inadvertently encounter such conditions will have time to react and safely exit those conditions, even if the aircraft is otherwise not certified in them. Removing the engine-level requirement nullifies an airplane-level assumption about the capabilities of the engine.		
18	CS-E 780 paragraph (a)(ii)	"shall include"	The use of the word "shall" may not be seen as	Replace "shall" with "must."	Editorial

		(such as ice crystal icing conditions, supercooled large drop icing conditions, snow conditions)	mandatory. Add the word "and" before "snow conditions" since it is the last one listed.	Add "and" before "snow conditions."	
18	Item 7 AMC E 100	Subparagraph (1)	In addition to the effects assessed per paragraphs (1) consider the engine parts or components other than those subject to CS E 650 compliance. Specifically, the equipment, components, and systems affected by rotor imbalance. FAA AC33.63-1 paragraphs 2.2.a.(4) page 4 and 3.2.b. page 7 address the rotor imbalance due to icing. Proposal will eliminate the related FAA Safety Emphasis Item (SEI) for 14 CFR 33.63 Vibration and AC33.63-1	Add a new paragraph alongside paragraphs (1) and (2). Suggested wording: "Icing and ice accretion may produce rotor imbalance in excess of that resulting from the rotor(s) design, manufacturing, and maintenance. Vibration resulting from imbalance could lead to structural or functional failure of equipment, components, and systems. If the rotor(s) imbalance exceeds the levels demonstrated during compliance with CS-Es, it should be demonstrated under CS-E 100 that the	Conceptual

				resulting vibration is not excessive."	
18	Item 7 Ice Protection - AMC E 100 Strength	(1) For Engine parts, repeated exposure to high cycle fatigue stresses in excess of enduranc e limits for even short periods of time could lead to cumulative fatigue damage and subsequent component failure.	Sometimes the term "Engine parts" is construed as the combustion engine mechanical parts, and the accessories are overlooked.	(1) For Engine parts (including accessory drives and components), repeated exposure to high cycle fatigue stresses in excess of endurance limits for even short periods of time could lead to cumulative fatigue damage and subsequent component failure.	Conceptual

respons e

Comment 1: Noted.

CS 25.1093 specifies the icing conditions defined in CS-25 Appendices C, O and P, and falling and blowing snow. Therefore, engines installed on a CS-25 aeroplane must demonstrate 'safe operating characteristics in ICI, SLD and snow'. However, EASA does not consider it appropriate to make the same mandate e.g. for a turboshaft engine installed on a helicopter.

Comment 2: Accepted

Comment 3: Partially accepted.

The FAA principles outlined in the comment are agreed by EASA. The proposed AMC E 100 has been withdrawn and replaced by an amendment of AMC E 650 that contains adequate provisions in paragraphs (5) and (9)(b).

Comment 4: Noted.

The comment is agreed, and it is consistent with the scope of CS-E 650. The proposed AMC E 100 has been withdrawn and replaced by an amendment of AMC E 650.

comment *35* comment by: *AIRBUS*

1. PAGE / PARAGRAPH :
CS-E 780(a)(1)

2. PROPOSED TEXT / COMMENT:
(a)(1)(ii)
The applicable atmospheric icing conditions shall include the supercooled liquid water
conditions defined in CS-Definitions Amendment 2 under 'Icing Atmospheric Conditions', and
any additional conditions (such as ice crystal icing conditions, supercooled large drop icing
conditions, snow conditions) applicable to the Engine air intake system in the ice protection
specifications (CS 23.1093(b) for CS-23 until Amdt 4 or CS 23.2415 for CS-23 from Amdt 5, CS
25.1093(b), CS 27.1093(b), CS-29.1093(b)) of the Certification Specifications applicable to the
aircraft on which the Engine is to be installed, as specified in CS-E 20(b).
On ground, for the supercooled liquid water conditions of CS-Definitions, only the freezing fog conditions 1. and 2. in table 2 of AMC E 780 are applicable.

Where applicable, i.e. if App. O is to the aeroplane, only the condition 4. in table 2 of AMC E 780 is applicable.

3. RATIONALE / REASON / JUSTIFICATION :
Standard practice is to apply freezing fog requirements on ground. The full appendix C icing conditions are not applicable to engine ground operations demonstrations. This is the standard interpretation and it would be helpful and improve clarify to state this in the AMC.

A recommendation to harmonise the large drop test requirements with those of 14 CFR Part 33 (FAA) is made. If this is not in line with the intent of the EASA AMC, then further discussion and/or standardisation activity is required.

response

Partially accepted.

Modifications have been made in CS-E 780(a)(2) to clarify that applicable ground conditions are freezing fog (and any additional conditions applicable to the Engine air intake system).

Regarding harmonisation of large drop test requirements, EASA recognises that, whereas some changes have been proposed as part of NPA 2021-13, which may result in increased harmonisation with the FAA Part 33, full harmonisation with the FAA rule will not be achieved. However, harmonisation workstreams are ongoing for that purpose. In particular, the ARAC Ice Crystals Icing Working Group includes a subtask #5, in the context of which harmonisation of all icing test requirements, including the ones related to supercooled large drops, will be considered.

comment *82* comment by: *Rolls-Royce Plc*

Comment

	We welcome the alteration of the definition of icing envelopes, to reflect changes in CS-23.
response	Noted.

comment	*83* comment by: *Rolls-Royce Plc* **Comment** The specific amendment number of CS-Definitions is used, but is not considered necessary. **Suggested resolution** Replace "conditions defined in CS-Definitions Amendment 2 under 'Icing Atmospheric Conditions'," with "conditions defined in CS-Definitions under 'Icing Atmospheric Conditions',"
response	Not accepted. Although the content of the referenced definition indeed did not change until Amendment 2, for legal certainty it is better to keep the Amendment number.

comment	*84* comment by: *Rolls-Royce Plc* **Comment** The removal of the text "(including freezing fog on ground)" could be interpreted such that the Continuous Maximum and Intermittent Maximum envelopes of CS-Definitions are applicable for ground operation. We do not believe that this would be appropriate as the proxmity of the ground will limit the liquid water content which can be encountered in fog and wonder whether this change might be unintended. **Suggested resolution** Replace "The applicable atmospheric icing conditions shall include the supercooled liquid water conditions defined in CS-Definitions Amendment 2 under 'Icing Atmospheric Conditions', and any additional conditions ..." with "The applicable atmospheric icing conditions shall include the supercooled liquid water conditions defined in CS-Definitions Amendment 2 under 'Icing Atmospheric Conditions' for in-flight operation, and freezing fog conditions for ground operation. Any additional conditions ..." This is a substantive comment.
response	Accepted.

comment	*85* comment by: *Rolls-Royce Plc* **Comment** Envelopes exist to define supercooled liquid water clouds (CS-Definitions), supercooled large drop conditions (Appendix O) and ice crystal conditions (Appendix P). However, there is no freezing fog envelope defined in the rule. **Suggested resolution**

	Add a new definition of freezing fog into CS-Definitions or CS-E 780, using the liquid water content versus ambient air temperature relationship in Figure 9 of the Engine Icing Working Group report DOT/FAA/TC-15/30
response	Not accepted. Condition 4 in Table 2 of AMC E 780 specifies the supercooled large drop conditions that applicants should consider. Changing how those conditions are expressed without prior coordination with bilateral partner authorities would result in dis-harmonisation and is therefore not considered beneficial.

comment	*86* comment by: *Rolls-Royce Plc* **Comment** The subdivision of CS-E 780 (a) into (i) and (ii) is an inconsistent numbering convention with other rules under CS-E. **Suggested resolution** Remove the (i) and (ii) paragraph labels and leave this as a single section as CS-E 780 (a).
response	Partially accepted. (i) and (ii) have been replaced by (1) and (2).

comment *105* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive X	Editorial
Affected paragraph and page number	Page: 18 - CS-E 780 Paragraph: (a)(i)		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: (a)(i) It must be established by tests, unless alternative appropriate evidence is available, that the Engine will function satisfactorily in flight and on ground when operated throughout the applicable ~~condition of~~atmospheric icing conditions ~~(including freezing fog on ground) and falling and blowing snow defined in the turbine Engines air intake system ice protection specifications (CS-23.1093(b), CS-25.1093(b), CS-27.1093(b) or CS-29.1093(b)) of the Certification Specifications applicable to the aircraft on which the Engine is to be installed, as specified in CS-E 20(b) [...]~~ REQUESTED CHANGE: It should be precised what atmospheric icing conditions are applicable for ground conditions. Is it freezing fog?		
Why is your suggested	JUSTIFICATION: The wording “when operated throughout the applicable		

change justified?	atmospheric icing conditions" is misleading for ground conditions. Specific test points for ground operation are established in AMC 780 §2.3 table2 and it is not expected to operate in full App C conditions for ground operation

response

Accepted.

The second sub-paragraph (starting with 'The applicable atmospheric icing conditions') has been revised to clarify what applies to in-flight operations and to ground operations.

comment

128 comment by: *Honeywell E&PS Certification Office*

Section (a)(i) "in flight and on ground …applicable atmospheric icing conditions" - clarification is needed in terms of exactly which conditions will be expected on ground, which are typically not the same as are clearly defined for in flight. In-flight conditions are not representative of on-ground conditions.

response

Accepted.

The second sub-paragraph (starting with 'The applicable atmospheric icing conditions') has been revised to clarify what applies to in-flight operations and to ground operations.

comment

140 comment by: *Pratt & Whitney Canada*

Regarding the CS-E text: "It must be established by tests..." et seq:

"...on ground" is interpreted as meaning including conditions such as freezing fog. In fact, "freezing fog" clause was crossed out. The change does not add clarity in our assessment, and potentially removed clarity that may have been there.

This change is not clear as it implies that ground icing conditions will now be linked to the Appendix C or CS-Definitions icing envelopes (CM & IM). It must be clear that in-flight icing conditions are based on App.C while ground icing conditions are based on freezing fog requirements (LWC = 0.3 g/m^3 & 20 µm)

Requested action: Revert back to "freezing fog" terminology and/or clarify the conditions for on ground icing compliance.

response

Accepted.

The second sub-paragraph (starting with 'The applicable atmospheric icing conditions') has been revised to clarify what applies to in-flight operations and to ground operations.

AMC E 780 Icing Conditions p. 19

comment *19* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
19	Amend AMC E 780 as follows: AMC E 780 Icing Conditions (1.1) Definitions	— Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing-induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence. The applicant should make appropriately conservative assumptions regarding the severity and duration of the icing encounters. When determining	This is not a definition of Unacceptable Mechanical Damage. The presented paragraph provides guidance on what an applicant must address in analyzing this type of damage, but that does not define what it is. I recommend moving the guidance to the safety analysis section to assure these activities are conducted.	Unacceptable Mechanical Damage: Damage that prevents satisfactory engine operation after subjection of repeated icing-induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence.	

		the acceptability of any damage arising as a result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness .			
19	AMC E 780 paragraph (1)(1.4)	The tests may be completed with adequately simulated icing conditions either in an altitude test facility capable of representing flight conditions, or in flight, or under non-altitude test conditions. The crossed out paragraph.	Couple of suggestions on the grammar of the list in the sentence. Why was the second paragraph crossed out? It is in the AMC, not a CS-E.	Remove the word "either" since there are three ways the tests may be conducted. Also, remove the first "or" since this is a list of three options. The second paragraph should be brought back. It explains what should to be done for non-altitude testing in order to simulate altitude conditions that an engine will go through.	Editorial

respons e

Comment 1: Partially accepted.

The intent of this new definition of 'Unacceptable mechanical damage' in AMC E 780 was to provide guidance about what would be considered acceptable specifically in the context of an icing test; in particular, about the fact that damage that occurred as a result of repetitive exposures may be considered unacceptable. Therefore, such guidance is better placed under AMC E 780 than under the general provisions of AMC E 510. EASA recognises that the text proposed in the NPA is more of a guidance in nature than truly a definition, however it appeared to be the most logical location to place it within the current AMC material.

The definition of unacceptable mechanical damage has then been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage provided in FAA AC 20-147A.

Comment 2: Accepted.

Editorial changes are accepted. Regarding the second paragraph, please note that this paragraph has not been completely deleted but rather moved (and modified) under AMC E 780 (2.2) (c), keeping the original intent.

comment *20* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
20	AMC E 780(1.6)	The additional conditions to be addressed are dependent on the conditions applicable to the air intake system of the aircraft on which the Engine is to be installed,	See comment under CS-E 780, above	See comment under CS-E 780, above	

20	AMC E 780 paragraphs (1)(1.6) & (2)(2.2)(c)	defined in CS 23.1093(b), CS 25.1093(b), CS 27.1093(b) and CS 29.1093(b), as appropriate. Appendix C to CS-25 and Appendix C to CS-29.	These parts were crossed out. Assume the 1093 regulations are crossed out is because CS-23 is now performance-based, while CS-25, CS-27, and CS-29 will become performance-based. Thus, 23.1093 is no longer valid, and the other 1093's will become this. Assume that when CS-25 and CS-29 become more performance-based, Appendix C in both of them will be gone as well.	Will the 1093 list be replaced with a list of the performance-based regulations? Will Appendix C in CS-25 and CS-29 be replaced?	

response

Comment 1: Please refer to the response to comment 18.

Comment 2: Noted.

EASA has not planned to convert CS-25 or CS-29 into 'performance-based' or 'objective-based' CS's in a similar way like done for CS-23. If such decision is taken in the future, the approach may not be exactly the same as for CS-23. For instance, some prescriptive elements may be retained.

comment *21* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
22	AMC E 780, paragraph	Note 1: These conditions are provided as a guide, but they may	The last phrase ". . .and large drop glaze ice conditions may not be applicable for	Either delete the phrase ". . .and large drop glaze ice	Editorial

	(2)(c)(2.3)	need to be modified to address the requirements applicable to the intended installation. For instance, snow concentrations may need to be increased to address blowing snow, and large drop glaze ice conditions may not be applicable for installation on a given aircraft.	installation on a given aircraft." seems to be redundant. The description in Table 2, row 4, which is entitled ". Large drop glaze ice condition (Turbojet, turbofan, and turboprop only) (Note 1)." seems to limit applicability explicitly to turbojet, turbofan, and turboprop aircraft only. Is the applicability statement in the Note 1 description intended to limit applicability further than just turbojet, turbofan, and turboprops?	conditions may not be applicable for installation on a given aircraft." from Note 1 or eliminate the "(Turbojet, turbofan, and turboprop only). . ." words from Table 2, row 4.	
23	AMC E 780 paragraph (6)	"...following a delay in the selection of the ice protection system such as might occur during inadvertent entry into icing conditions." This assessment should include, as appropriate, the time for ice condition detection, pilot response time, time for the system to	The grammar in this part of the sentence should be improved. The list is fine, but add the word "and" to indicate the end of the list.	I suggest you replace the words "such as" with the word "that." Add the word "and" between "operational, " and "time for the system to become effective."	Editorial

		become operational, time for the system to become effective.			

response

Comment 1: Not accepted.

As per CS-E 780, those conditions only need to be considered if applicable to the Engine air intake system in the ice protection specifications of the Certification Specifications applicable to the aircraft on which the engine is to be installed. This aspect of Note 1 has been separated and introduced in a new Note 2 for enhanced clarity.

Comment 2: Partially accepted.

The sentence ‘such as might occur during inadvertent entry into icing conditions’ exists since CS-E Initial issue and appears clear enough. The word ‘and’ has been added between ‘operational’, and ‘time for the system to become effective’.

comment

33 comment by: *GE Avio*

The definition of Unacceptable Mechanical Damage is a requirement rather than a definition. For clarity and proper emphasis, it should be moved to the requirements section.

Regarding the text in Note 1, additional details or guidance should be provided regarding "snow concentrations may need to be increased to address blowing snow".

Regarding the text: "Although the test demonstrates tolerance to ice shedding, it cannot be ensured that the ice slab impact results in the maximum possible energy transfer, and therefore this test should not be used to justify inlet designs which routinely accumulate and release ice during a continuous icing encounter."
AMC should provide requirements for the type of inlet system where ice accumulates and sheds routinely. If the ice slab in this case is ingested into the engine and produces no damage, that should be sufficient to justify the inlet design. If the intent is to do repeated tests, then guidance should be provided.

Regarding the text: "Consideration should also be given to the effects of delays in deactivating an ice protection system, or to inadvertent operation of an anti-ice system when the engine is not in icing conditions".
This sentence should be put under a different section (rule). AMC E 780 is specific to operating in icing conditions whereas this sentence is referring to "when the engine is not in icing conditions.

response

Comment 1: Partially accepted.

What is acceptable under an icing test is not necessarily acceptable for another test (e.g. large flocking bird test); therefore, this definition is better placed under AMC E 780.

The definition of unacceptable mechanical damage has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

Comment 2: Not accepted.

Prescribing additional guidance for all installations beyond CS-25 is considered outside the scope of this CS-E regular update.

Comment 3: Noted.

EASA has finally decided to withdraw the proposed addition to AMC E 780 (4)(a) and has reverted to the original text.

Comment 4 : Partially accepted.

An additional sentence has been added to clarify the intent of this new paragraph. However, requiring consideration of potentially common adverse effects of protection systems when used in unintended conditions is considered beyond the scope of NPA 2021-13.

comment *37* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 (1)(1.1)

2. PROPOSED TEXT / COMMENT:
This definition reads as a requirement so it should be in the requirement section (CS-E 780).

There is no mention of impact damage caused by shed ice. It is only focused on vibration. It is requested that additional guidance material be added to the AMC to define what is considered to be acceptable mechanical damage e.g. dispatchable within AMM limits? The assessment shall also consider the effects of repeated icing encounters within the inspection periods.

It is requested that the unchanged definition regarding thrust loss be updated to include a thrust loss requirement as in AC 20-147A?

Also regarding vibration an improvement is recommended below Resulting overall change proposal is

EASA Proposed Text
"Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence. The applicant should make appropriately conservative assumptions regarding the severity and duration of the icing encounters. When determining the acceptability of any damage arising as a

result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness."

Comment:
"Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing encounters. It means that mechanical damage caused by shed ice impact or exposure to induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence shall be such that they would not result in unacceptable thrust losses. The applicant should make appropriately conservative assumptions regarding the severity, duration and repetition of the icing encounters. When determining the acceptability of any damage arising as a result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness. The potential effects of icing induced vibration on the aeroplane and the ability of the pilots to perform their tasks shall be considered when determining acceptability"

3. RATIONALE / REASON / JUSTIFICATION :
The effects of mechanical damage are not limited to vibration but also thrust loss and, operability margins if damage is considerable. Damage can worsen with repeated ice impacts and hence the effect of repeated icing encounters within the inspection periods should be taken into account. Note that guidance on how to assess the acceptability of damage should be included in CS-E to facilitate and enable consistent approaches to be applied.

An engine that is certified to CS-E should be adequate for installation on an aircraft and hence the effect of vibration on the aircraft and aircraft certification should be taken into consideration within the CS-E certification. The acceptability of the level of vibration shall, therefore, take into account the aircraft level effects such as impact on structure and the ability of the pilots to perform their tasks considering the vibration levels induced on the flight deck. This can be challenging to do at the engine level in isolation and would generally require interaction with the aeroplane manufacturer as the vibration at aeroplane level is a function of the engine vibration, engine installation and aeroplane design. Nevertheless the potential impact of engine vibration on the aeroplane and the need to consider this when determining the acceptability of vibration at engine level should be mentioned in the AMC.

response

Partially accepted.

The definition of unacceptable mechanical damage has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

comment *38* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 1.6 Applicable Environments

2. PROPOSED TEXT / COMMENT:

Consider adding CS 25 Appendix O Part 1 and Appendix P figures to CS Definitions for consistency.
In this case, reference to CS Definitions could be made for all icing conditions.

3. RATIONALE / REASON / Justification :
To aid clarity and administration of any future updates of the icing envelopes.

response

Not accepted.

Thank you for this suggestion. As there is a link with the icing conditions applicable to the air intake system of the aircraft on which the engine is installed, a reference to the applicable aircraft CS is needed anyway.

comment *39* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 1.6 Applicable Environments

2. PROPOSED TEXT / COMMENT:
SLD compliance is required if SLD is included in the aeroplane certification basis.

It would be beneficial to update the AMC with the expected SLD compliance activities. During the EHWG rulemaking the in-service history of engine icing events was reviewed. The EHWG concluded that the conservative approaches to compliance in Appendix C icing conditions had led to the safe experience in flight in all supercooled liquid water icing conditions. Some events were identified due to ground icing in large drop icing conditions. For this reason a single standard ground large drop test/analysis icing condition was added to 14 CFR Part 33.

It may be helpful to clarify the EASA approach and expectation to SLD icing compliance for engines in future.

Ideally the same test as required by 14 CFR Part 33 should be specified to improve harmonisation between the EASA and FAA regulations.

Furthermore it would be helpful to identify what should be done if the aeroplane certification basis is updated, as in the case of a derivative, in the cases where engine icing is affected and not affected.

3. RATIONALE / REASON / Justification :
Clarification of the acceptable means of compliance will provide clarity at the beginning of engine development / modification programmes which is beneficial to both the applicant and the agency.

response

Partially accepted.

EASA agrees that further discussion and guidance would be useful in relation to the expected means of compliance for Appendix O conditions. However, this topic is considered outside the scope of NPA 2021-13. This subject should be addressed by an existing or future icing rulemaking working group.

Regarding the EASA/FAA harmonisation, this objective is recorded under Subtask 5 of the currently active ARAC Ice Crystals Icing harmonisation working group.

Regarding the situation whereby the aircraft certification basis may be amended and a new engine type is to be certified, EASA believes that, as per CS-E 780, the applicable conditions at the engine level are those that are described in the latest CS applicable for the intended aircraft category, independently from the certification basis of the individual installation aircraft.

comment *40* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 (2)(2.2) Establishment of SLW Test Points for In-Flight Operation

2. PROPOSED TEXT / COMMENT: Suggested change
"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."

It is recommended to take benefit of this regular update to include in this section guidance related to the following items:

In flight Test Conditions: The current requirements require a 9 kft descent in cycling CM (Tables 1 column a) and IM (Table 1 column b) icing conditions at -10°C or at a lower temperature if required to provoke freezing. Unlike 14 CFR Part 33 the standard test conditions do not include a mandatory 10 minutes descent in IM conditions at warm cold temperatures (at least -20°C). It is recommended to include such a point in the standard EASA tests.

It is also suggested to clarify the AMC by highlighting that the test duration is based on the time to descend through 9 kft and cycling between the Table 1 columns (a) and (b) shall continue for the entire duration of the 9 kft descent. This avoids applicants misinterpreting the requirement and only running a single 28km exposure followed by a single 5km exposure. It is suggested to clarify the descent case duration in the CPA section (2.1).

In addition it may be necessary to run different test conditions to test different parts of the engine. The critical conditions for the booster, core, ice protected (heated) parts,and fan may be different. The scaling from altitude to ground level will also likely be different for different parts of the engine and may be different for ice protection systems and unheated parts of the engine. It is recommended to add this to the AMC E 780 guidance.

Timing of ice shedding is important especially with respect to the handling bleed valve opening/closing schedule. If handling bleed valves open before ice shedding then the test may not be conservative and consideration of this when assessing the results and need for repeat tests has to be taken into account. This should be taken into account in the test plans and CPAs and during the testing. It is recommended to add this to the AMC E 780 guidance.

3. RATIONALE / REASON for comment: Justification
-10°C may not be the critical temperature of the descent case. A CPA may identify a more critical temperature than -10°C. However the CPA condition may not be run across the full 9 kft descent if the applicant applies the Appendix C vertical and horizontal icing exposure extents. This should be clarified and address in the AMC.

It may be helpful to applicants to highlight some guidance on the relevance of different test conditions and scaled condition and techniques for different parts of the engine. What might be a critical scaled condition for a fan might not be critical for the core and vice versa.

response

Partially accepted

Regarding the descent conditions, duration and temperatures, an EASA/FAA harmonisation objective is already recorded under Subtask 5 of the currently active ARAC Ice Crystals Icing harmonisation working group. As a result of this activity, changes to the FAA or EASA rules and AMC material may be considered in order to achieve a higher level of harmonisation.

Regarding the potential need to run different test conditions to test different parts of the engine, and the relevance of different scaled conditions and techniques for different parts of the engine, specific guidance has been proposed to meet that intent in paragraph (2.2) (c) of AMC E 780.

Regarding the timing of ice shedding with respect to the handling bleed valve opening/closing schedule, the current CS-E 780 (b) rule already requires all Engine bleeds permitted during icing conditions to be set at the level assumed to be the most critical. If the concern in question relates to the transient effect likely to occur as the bleed transitions from closed to open state (or vice versa), EASA is reluctant to request applicants to synchronise ice sheds, which are random in nature, with such short-duration transients without first discussing the applicability and the practicality of such a request with engine certification applicants or as part of a rulemaking working group.

Regarding all other suggestions for improvement, EASA agrees that further discussion and guidance would be useful in relation to the expected means of compliance for Appendix O conditions. However, this topic is considered outside the scope of NPA 2021-13. This item should be addressed by an existing or future icing rulemaking working group.

comment

41 comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 (2)(2.2) Establishment of SLW Test Points for In-Flight Operation

2. PROPOSED TEXT / COMMENT: Suggested change
The conditions of horizontal and vertical extent and water concentration defined below are somewhat more severe than those implied by the SLW Icing Conditions in ~~CS- Definitions,~~ Appendix C to CS-25 and Appendix C to CS-29. Encounters with icing conditions more severe than those defined in the standard are considered possible, and it is, therefore, appropriate to ensure that a margin is maintained.

3. RATIONALE / REASON for comment: Justification

The AMC refers to CS Definitions for "small" droplet icing and to CS 25 for other icing conditions. This leads to a risk of misalignment between the aircraft and engine certification standards, if CS 25 App C changes. This must be avoided.

It would be preferable to either include the relevant figures from CS 25 App. O (Part 1) and Appendix P in CS Definitions and refer to this document, or as suggested here, retain the cross reference to CS 25 for all icing conditions. Either approach would be preferable to the current proposal as it is more consistent and less prone to later misalignment between CS 25 and CS-E.

It is noted that the formatting of the icing envelopes in CS 25 and CS Definitions differ. It is recommended to use the same figures in CS Definitions and CS 25.

response

Not accepted.

This RMT will not amend CS-Definitions. If Appendix C to CS-25 or Appendix C to CS-29 are amended in the future, the equivalent conditions in CS-Definitions will also be amended concurrently.

comment *42* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 (2). Table 2

2. PROPOSED TEXT / COMMENT: Suggested change
The note at the end of the table states:

"Note 1: These conditions are provided as a guide, but they may need to be modified to address the requirements applicable to the intended installation. For instance, snow concentrations may need to be increased to address blowing snow, and large drop glaze ice conditions may not be applicable for installation on a given aircraft."

Additional details / guidance on snow concentrations would be helpful to allow the applicant to understand when the snow concentration may have to be modified, what factors drive this decision and how to determine the correct concentration to be considered.

3. RATIONALE / REASON for comment: Justification
The note is unclear, leaving uncertainty about the snow conditions to be considered.

response

Partially accepted.

The intent of Note 1 is to remind applicants that the Table 2 snow conditions may not be adequate to address falling and blowing snow conditions, and that specific snow conditions may need to be considered, as required for the specific engine installation conditions. CS-25 provides some guidance and acceptable means of compliance for falling and blowing snow. Consequently, a reference to AMC 25.1093(a) paragraph 1.6 has been added in Note 1.

comment *43* comment by: *AIRBUS*

1. PAGE / PARAGRAPH / SECTION :
AMC E 780 (4) Ice Ingestion

2. PROPOSED TEXT / COMMENT: Suggested change
Retain the current AMC text.

3. RATIONALE / REASON for comment: Justification
The change proposed by EASA is in contradiction with the FAA guidance included in AC 20-147A and the standard practice applied by many engine manufacturers that has led to safe engine operation and therefore this change should not be applied.

Please could you clarify what is meant by “occasional” and “routinely” in this context (de-icing vs. anti-icing, fully evaporative vs running wet)?

If EASA has a concern then rulemaking or standardisation is required to define what is meant by “inlet designs which routinely accumulate and release ice” and to develop guidance on how to justify such inlets.

response Accepted.

The proposed amendment of AMC E 780 (4)(a) has been withdrawn and the original text is maintained.

comment *59* comment by: *AIRBUS HELICOPTERS*

PROPOSED TEXT :
Due to the potential for inadvertent icing**/snow** encounters, the applicable icing/snow environments always include the SLW conditions defined in CS-Definitions Amdt 2 under ‘Icing Atmospheric Conditions’**, and the snow conditions as per CS27/29 §1093 (b)(1) definition**, even for aircraft not approved for flight in icing/snow conditions.

JUSTIFICATION :
About the first sentence of § (1.6) Applicable Icing Environments on page 20 :
As far as applicable environments are concerned, the proposed wording explains that there are basic icing conditions to which the engine shall comply in any case (icing conditions as defined in CS definitions amendement 2) and additionnal conditions dependent on the aircraft application. This is presented associated to the fact that even for aircraft forbidden to flight into icing conditions, "unadvertent icing should be taken into account". Flight in blowing and falling snow are presented as additionnal conditions dependent on the aircraft applications. Nevertheless, last amendement of CS27 and CS29 includes also a requirement for flight into inadvertent snow conditions, even for aircraft forbidden to flight into snow conditions. Snow conditions should be included as "basic" environment to be substantiated, for consistency purposes.

response Not accepted.

CS-E 780 requires including snow conditions when such conditions are specified in the CS applicable to the engine air intake system and, therefore, snow conditions should not be understood as optional conditions.

comment	*62* comment by: *AIRBUS HELICOPTERS* **COMMENT :** Additional Guidance Material is requested to clarify "*Unacceptable Mechanical Damage*" and "*Acceptable Mechanical Damage*" **JUSTIFICATION :** AMC E780 - § (1.1) Definitions - provides definition for "Unacceptable Mechanical Damage". However the definition focuses on icing induced vibration loads and does not address potential damages induced by the impact of ice block. Furthermore, "Acceptable Mechanical Damage" is not addressed
response	Accepted. The definition of unacceptable mechanical damage has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

comment	*63* comment by: *AIRBUS HELICOPTERS* **COMMENT :** Definition of "Icing Threat" is necessary **JUSTIFICATION :** On page 20, AMC E780 § (2.2) (c) introduces the concept of "Icing Threat" but does not provide any definition. Is it the result of the CPA (Critical Points Analysis) ?
response	Accepted. A non-exhaustive list of relevant icing threats has been added to AMC E 780 (2.2) (c).

comment	*64* comment by: *AIRBUS HELICOPTERS* **COMMENT :** Additional Guidance Material is requested on when increase of snow concentration is needed to address blowing snow conditions **JUSTIFICATION :** On page 22, § (2.3), Note 1 to the Table 2 seems to provide additional guidance for snow concentration in blowing snow conditions. Such increase of snow conditions may not be applicable pending of the representativeness of the test set up.
response	Not accepted. The intent of Note 1 is to remind applicants that the Table 2 snow conditions may not be sufficient to address falling and blowing snow conditions, and that specific snow conditions may need to be considered, as required for the specific engine installation conditions. CS-25 provides some guidance and acceptable means of compliance for falling and blowing snow. Consequently, a reference to AMC 25.1093(a) paragraph 1.6 has been added in Note 1.

comment	*87* comment by: *Rolls-Royce Plc* **Comment** Paragraph (1.1) concerns definitions of terms, but the added text suggests a new requirement for consideration of the cumulative effect of repeat icing encounters. This would represent a significant evolution of the engine icing certification requirements. **Suggested resolution** Remove the word "repeatedly" or move this new requirement to a different section of CS-E 780, AMC E 780 or AMC E 100. This is a substantive comment.
response	Not accepted. Although not mentioned specifically in the current CS-E 780 and the corresponding AMC, cumulative engine damage occurring during the engine icing test was already considered as potentially unacceptable by EASA.

comment	*88* comment by: *Rolls-Royce Plc* **Comment** The definition proposed for unacceptable mechanical damage is focused on vibrational loads, but the most common damage mechanism is related to ice impact. **Suggested resolution** Broaden the definition of Unacceptable Mechanical Damage to something like "Damage which is beyond the inspection limits of the Instructions for Continued Airworthiness or could lead to a hazardous outcome, including consideration of ice impact damage or damage due to icing-induced vibration."
response	Accepted. The definition of unacceptable mechanical damage has been amended and now includes additional guidance. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A and has been broadened in order to include the ICA inspection limit criteria.

comment	*89* comment by: *Rolls-Royce Plc* **Comment** Additional guidance as to the how to derive the assumptions of severity and duration of icing encounters would be helpful. It is also suggested that the assumptions made might be documented and communicated in the CS-E 30 assumptions. **Suggested resolution** Add guidance regarding severity and duration of icing encounters requiring assessment.
response	Noted. The concept of severity and duration of icing encounters is no longer mentioned in the resulting AMC text.

comment	*90* comment by: *Rolls-Royce Plc* **Comment** As for the comments regarding CS-E 780 (a), the wording could be interpreted to require Continuous Maximum and Intermittent Maximum envelopes of CS-Definitions to be considered for ground operation. We consider this inappropriate and wonder whether this change might be unintended. **Suggested resolution** Alter "always include the SLW conditions defined in CS-Definitions Amdt 2 under 'Icing Atmospheric Conditions', even for aircraft not approved for flight in icing." to "always include the SLW conditions defined in CS-Definitions under 'Icing Atmospheric Conditions' for in-flight operation and freezing fog conditions for ground operation, even for aircraft not approved for flight in icing." Reference a new definition of freezing fog as per the above comment for CS-E 780 (a). This is a substantive comment.
response	Accepted. Modifications have been made in CS-E 780 (a)(2) to clarify that applicable ground conditions are freezing fog (and any additional conditions applicable to the air intake system).

comment	*91* comment by: *Rolls-Royce Plc* **Comment** We broadly welcome the proposed changes which reflect improvements in understanding for flight to facility scaling. However, attempting to investigate all possible failure modes for every test condition would be likely to create unrealistically severe icing threats for other failure modes, which could hazard the test campaign. It could also mean an excessive number of test points are required, which could be difficult to achieve when using natural temperature conditions, as is the case in outdoor icing test beds. We would therefore suggest that the applicant should consider which failure modes are of interest for any given test point and need only demonstrate adequate scaling for those modes of importance. For instance, if the test condition is one in which fan icing may be considered unimportant, because other test points exist with higher threat levels for the fan system, it could be considered unnecessary to simulate the icing threat for the fan for this test point. **Suggested resolution** Alter "This could involve modification of Engine operating conditions and other test conditions of this paragraph in order to generate equivalent ice accretion adequately simulate all icing threats." to "This could involve modification of Engine operating conditions and other test conditions of this paragraph in order to generate equivalent ice accretion adequately simulate all icing threats which are of importance for the test condition.". Add a paragraph something like "It may not be necessary to simulate all possible failure modes for each test condition, if a given failure mode is considered to be less probable for a specific test condition than for other test conditions."

This is a substantive comment.

response | Partially accepted.
The AMC text has been revised taking into account this comment.

comment | *92* comment by: *Rolls-Royce Plc*

Comment
We welcome the update to the ice crystal icing susceptible features list, in line with EIWG recommendations.

response | Noted.

comment | *93* comment by: *Rolls-Royce Plc*

Comment
While we agree that the use of inlet designs which routinely accumulate and release ice will present an extra threat to the engine, we suggest that the ice slab ingestion test, or analysis, may still be an appropriate method to use for delayed activation of ice protection systems and for ice released from the airframe.
The proposed wording implies the introduction of a new requirement to consider operation of such inlet ice protection systems where applicable: guidance on how this might be achieved would be of benefit.
Suggested resolution
Change "and therefore this test should not be used to justify inlet designs which routinely accumulate and release ice during a continuous icing encounter." to "and therefore this test should not be used to justify the routine accumulation and release ice during a continuous icing encounter for such inlet designs."
Addition of guidance on an acceptable means of compliance for the routine accumulation and release of ice.

response | Noted.
EASA has finally decided to withdraw the proposed amendment of AMC E 780 (4)(a) and has reverted to the original text.

comment | *106* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur X	Substantive	Editorial
Affected paragraph and page number	Page: 19 - AMC 780 Paragraph: (1) Introduction (1.1) Definitions		
What is your concern and what do you	THE PROPOSED TEXT STATES: Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing-induced vibration loads at		

want changed in this paragraph?	frequencies and magnitudes corresponding to the vibration spectrum predicted using available test evidence. The applicant should make appropriately conservative assumptions regarding the severity and duration of the icing encounters. When determining the acceptability of any damage arising as a result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness. REQUESTED CHANGE: Propose to change "Unacceptable mechanical damage" term by "Unacceptable mechanical damage induced by vibration" Moreover, this definition is read as a requirement, it should be in paragraph (2) of the AMC which provides guidance on how to demonstrate compliance. Additionally it is difficult to understand what conditions are intended to be met when referring to the wording "The applicant should make appropriate~~ly~~ conservative assumptions regarding the severity and duration of the icing encounters" Finally, the word "appropriately" should be replaced by "appropriate"
Why is your suggested change justified?	JUSTIFICATION: Mechanical damage is not limited to the one that could be induced by too high vibration but it can also be the result of impacts from ice.

response Accepted.

The definition of unacceptable mechanical damage has been amended and broadened to include other sources of damage than vibration. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

The word ‘appropriately’ is no longer used in the new definition.

comment *107* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive X	Editorial
Affected paragraph and page number	Page: 20 - AMC 780 Paragraph: (1) Introduction (1.6) Applicable Environments		
What is your concern and	THE PROPOSED TEXT STATES: Due to the potential for inadvertent icing encounters, the		

what do you want changed in this paragraph?	applicable icing environments always include the SLW conditions defined in CS-Definitions Amdt 2 under 'Icing Atmospheric Conditions', even for aircraft not approved for flight in icing. The additional conditions to be addressed are dependent on the conditions applicable to the air intake system of the aircraft on which the Engine is to be installed. These conditions may includes ice crystal icing conditions, supercooled large drop icing conditions, and falling and blowing snow conditions. The test altitude need not exceed any limitations proposed for aircraft approval, provided that a suitable altitude margin is demonstrated, and the altitude limitation is reflected in the manuals containing instructions for installing and operating the Engine. REQUESTED CHANGE: Define or provide guidance for duration of inadvertent icing conditions
Why is your suggested change justified?	JUSTIFICATION: If aircraft is not certified to fly in icing conditions, duration of icing exposure required for engine certification are expected to be reduced. Clarification shall be added for operational requirements e.g. time to exit icing conditions and/or define duration of icing exposure for inadvertent icing

response

Not accepted.

The additional text proposed in AMC E 780 is intended to provide background information in relation to the reasons why EASA requires compliance demonstration in SLW icing conditions, even for aircraft not certified for flight in icing conditions.

However, it was never the intention to provide an alleviation in terms of testing conditions and/or duration as part of this NPA.

comment

108 comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive X	Editorial
Affected paragraph and page number	Page: 20 - AMC 780 Paragraph: (2) Supercooled Liquid Water (SLW) Icing Conditions (2.2) Establishment of SLW Test Points for In-Flight Operation (c) test intallation considerations		
What is your concern and what do you	THE PROPOSED TEXT STATES: When a non-altitude test is used to demonstrate compliance for in-flight icing, any differences in Engine operating		

want changed in this paragraph?	conditions, LWC, and ice accretion and shedding between the altitude condition to be simulated and the test conditions, which could affect the icing threat ~~at the critical locations for accretion or shedding~~, should be taken into account when establishing the test points to be carried out ~~conditions~~ [...] REQUESTED CHANGE: Clarify what is Icing "Threat"
Why is your suggested change justified?	JUSTIFICATION: The term “threat” may have unintended interpretations/consequences. It is unclear as to what constitutes a threat. Is this intended to mean “icing conditions”?

response

Accepted.

A non-exhaustive list of relevant icing threats has been added to AMC E 780 (2.2) (c).

comment *109* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive	Editorial X
Affected paragraph and page number	Page: 23 - AMC 780 Paragraph: (4) Ice Ingestion (a) Intent of Ice Slab Ingestion Test		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: The intent of the ice slab ingestion test required by CS-E 780(f) is to demonstrate tolerance to occasional events ~~of ice ingestion~~ from ice shedding from nacelle surfaces, including due to representative delays in activation of ice protection systems (refer to paragraph (6) of this AMC). REQUESTED CHANGE: Proposal to keep the wording as currently written in the AMC : "The intent of the ice slab ingestion test required by CS-E 780(f) is to demonstrate tolerance to ice ingestion based on ice quantity on inlet due to representative delays in activation of ice protection systems (refer to paragraph (6) of this AMC)"		
Why is your suggested change justified?	JUSTIFICATION: "Occasional event" term might be confusing and it is proposed to be removed. Current wording in AMC 780 (4) table 3 and (6) provides a clear guidance and is a well proven practice. It does not need to be questioned.		

response

Accepted.

EASA has finally decided to withdraw the proposed amendment of AMC E 780 (4)(a) and has reverted to the original text.

comment *110* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur X	Substantive	Editorial
Affected paragraph and page number	Page: 23 - AMC 780 Paragraph: (4) Ice Ingestion (a) Intent of Ice Slab Ingestion Test		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Although the test demonstrates tolerance to ice shedding, it cannot be ensured that the ice slab impact results in the maximum possible energy transfer, and therefore this test should not be used to justify inlet designs which routinely accumulate and release ice during a continuous icing encounter. REQUESTED CHANGE: Proposed change : "Effect of repetitive impact due to inlet designs which routinely accumulate and release ice during a continuous icing encounter might be based on engine ice slab test and/or in combination with an analysis"		
Why is your suggested change justified?	JUSTIFICATION: Ice impact location and test condition for engine ice slab ingestion certification tests are defined so that they represent the most critical conditions for engine components. Effect of repetitive impacts of smaller ice slabs can be assessed based on test performed with a larger ice slab. Test results would provide direct compliance, or they may be completed with an analysis.		

response

Noted.

EASA has finally decided to withdraw the proposed addition to AMC E 780 (4)(a) and has reverted to the original text.

comment *111* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive X	Editorial

Affected paragraph and page number	Page: 24 - AMC 780 Paragraph: (4) Ice Ingestion (a) Intent of Ice Slab Ingestion Test
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: Consideration should also be given to the effects of delays in deactivating an ice protection system, or to inadvertent operation of an anti-ice system when the engine is not in icing conditions. REQUESTED CHANGE: Proposed change : remove this sentence from AMC 780
Why is your suggested change justified?	JUSTIFICATION: This item is not refering to engine performance in icing conditions and should not be part of AMC E780 Would this paragraph be more pertinent in "CS-E 170 Engine Systems and Component Verification"?

response

Not accepted.

This sentence is intended to address adverse engine effects due to ice protection systems being activated in the absence of icing conditions.

No other AMC paragraph appears better suited for that purpose. CS-E 170 and its AMC address the capability of systems or components to perform their intended function in all possible operating and environmental conditions. However, it does not address the risk of a potential adverse engine effect when the system is used outside the operating and environmental conditions for which its use is intended.

comment *118* comment by: *AIRBUS HELICOPTERS*

COMMENT :
Additional Guidance Material is requested to clarify AMC for the wording : "*inlet designs which routinely accumulate and release ice*"

JUSTIFICATION :
On page 23 , AMC E780 § (4)(a) introduces the concept of "*inlet designs which routinely accumulate and release ice*". Additional information should be provided : - "inlet designs": does such an evolution aim to address de-icing vs anti-icing system ? - definition of "routinely" should be provided

response

Noted.

EASA has finally decided to withdraw the proposed amendment of AMC E 780 (4)(a) and has reverted to the original text.

comment *119* comment by: *AIRBUS HELICOPTERS*

COMMENT :

Rationale for introducing consideration about inadvertent activation and delayed deactivation of an ice protection system is to be clarified

JUSTIFICATION :
On page 23, AMC E780 § (6) introduces consideration about inadvertent activation and delayed deactivation of an ice protection system. The rationale for such an addition is not clear. Is the purpose to specifically address the risk of overheating ?

response

Accepted.

Indeed, the purpose is to address potential overheating and damage of components. The paragraph has been updated to clarify its purpose.

comment

125 comment by: *Safran Helicopter Engines*

NR	Author	Section, table, figure	Page	Comment summary	Suggested resolution	Comment is an observation or is a suggestion *	Comment is substantive or is an objection**
11	SAFRAN	AMC E 780 §1.1	19	— *Unacceptable Mechanical Damage: The applicant should show that the engine is sufficiently robust to operate satisfactorily when repeatedly subject to icing-induced vibration loads at frequencies and magnitudes corresponding to the vibration spectrum predicted using available test*	N/A	NO	YES

				evidence. The applicant should make appropriately conservative assumptions regarding the severity and duration of the icing encounters. When determining the acceptability of any damage arising as a result of operation in icing conditions, reference may be made to the inspection limits of the Instructions for Continued Airworthiness . refer to remark #9 on AMC E 100. This means of compliance suggest that vibration survey at component level during icing test is required, which is deemed impracticable.					

12	SAFRAN	AMC E 780 §1.6	20	*Due to the potential for inadvertent icing encounters, the applicable icing environments always include the SLW conditions defined in CS-Definitions Amdt 2 under 'Icing Atmospheric Conditions', even for aircraft not approved for flight in icing. The additional conditions to be addressed are dependent on the conditions applicable to the air intake system of the aircraft on which the Engine is to be installed.* As proportionate requirements exist at aircraft level for indavertant	N/A	YES	NO

				icing and full icing certification, SafranHE would suggest to define corresponding requirements for inadvertent icing at engine level. This would allow proportionality between helicopter (CS-27, CS-29) and engines requirements (CS-E), especially for inadvertent icing conditions clearance.						

response

Item 11: Please refer to the response to comment 124.

Item 12: Not accepted.

The additional text proposed in AMC E 780 is intended to provide background information in relation to the reasons why EASA requires compliance demonstration in SLW icing conditions, even for aircraft not certified for flight in icing conditions.

However, it was never the intention to provide an alleviation in terms of testing conditions and/or duration as part of this NPA.

comment

127 comment by: *Honeywell E&PS Certification Office*

Paragraph 2 of Section (4)(a) needs more explanation. What does maximum possible energy transfer mean? If the ice slab impact does not result in the maximum possible energy transfer, what is an example of an ice impact that does? What does this have to do with inlet designs which routinely accumulate and release ice during icing encounters?

	Section 1.6 "blowing snow conditions" - these need to be clearly defined similarly to how SLW, SLD, and ice crystal are - same note is applied to Table 2 Note 1 .
response	Regarding paragraph 2 of Section (4)(a): Noted. EASA has finally decided to withdraw the proposed addition to AMC E 780 (4)(a) and has reverted to the original text. Regarding section 1.6: Not accepted. Required concentrations to address blowing snow are dependent on the engine installation. Note that guidance and acceptable means of compliance are provided in AMC 25.1093(a) 1.6. A reference to this AMC has been added to Note 1 of Table 2.

comment	*141* comment by: *Pratt & Whitney Canada* Regarding the CS-E text: "Unacceptable Mechanical Damage..." et seq Defining “unacceptable mechanical damage” in this way may be interpreted as vibration is the *only* type of UMD to be considered. In fairness, the AMC E 780 does mention other types of damage in other sections (e.g. in the CPA) section; however pointing out only damage due to vibration in the definition section seems to ignore other types of damage mentioned elsewhere. Also, the AMC E 780 is not nearly as extensive or descriptive as AC 20-147A, and the added paragraph appears to add EASA’s interpretation on what is already in the AC 20-147A on page 25, paragraph 9(n)(6) on “High Vibrations”. Requested action: Rephrase the proposed UMD into the context of all possible damage sources as defined elsewhere. Consider adopting AC 20-147A "High Vibrations" guidance into AMC.
response	Accepted. The definition of unacceptable mechanical damage has been amended and broadened to include other sources of damage than vibration. This new definition has been aligned to the maximum possible extent with the definition of Mechanical Damage included in FAA AC 20-147A.

comment	*142* comment by: *Pratt & Whitney Canada* Regarding Note 1 to Table 2 on page 24: Recent FAA Issue Papers provided some clarity and bounds on the snow conditions to be considered. The EASA proposed wording leaves it far too open to interpretation. It could also lead to disharmonization with FAA guidance on acceptable MOC. Requested action: Provide harmonized bounds on snow conditions to be demonstrated

response | Not accepted.

Required concentrations to address blowing snow are dependent on the engine installation. Note that guidance and acceptable means of compliance are provided in AMC 25.1093(a) 1.6. A reference to this AMC has been added to Note 1 of Table 2.

comment | *143* comment by: *Pratt & Whitney Canada*

On page 23: regarding CS-E text: "(4) (a) Intent of Ice Ingestion", 2nd para starting "Although the test…"`

This guidance would be more suited to aircraft inlet design. The engine I&OM defines the limitations of what the engine can tolerate for ice slabs and airframers are thus constrained to ensuring their designs do not release slab bigger than the engines can tolerate. It is unclear as to what guidance is being provided and raises multiple other questions.

Requested action:
Clarify the intent of the paragraph.

response | Noted.

EASA has finally decided to withdraw the proposed addition to AMC E 780 (4)(a) and has reverted to the original text.

comment | *144* comment by: *Pratt & Whitney Canada*

On page 24; CS-E text starting with "Consideration should also be given..."

This guidance is not linked to icing conditions, and is more appropriate guidance for the Operations Test.

Requested action:
Remove the paragraph

response | Not accepted.

This sentence is intended to address adverse engine effects due to ice protection systems being operated in the absence of icing conditions. No other AMC paragraph appears better suited for that purpose.

AMC E 515 Engine Critical Parts p. 24

comment | *22* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)

25	AMC E 515 paragraph (3)(d)(v)2.	The material anomalies' paragraph.	This paragraph gives examples of anomalies, but I believe these kinds of anomalies should be defined in order for the reader to know what each one is like.	Add a definition to each example given: hard alpha anomalies in titanium, oxide/carbide (slag) stringers in nickel alloys, and ceramic particulate anomalies in powder metallurgy materials unintentionally generated during powder manufacturing.	Conceptual
25	AMC E 515 paragraph (3)(d)(v)2.	The manufacturing anomalies' paragraph.	Most examples here should be defined as well.	forging laps strain-induced porosity tears due to broaching	Conceptual

response

Not accepted.

Consistent with FAA AC33.70-1, this text intends to provide a top-level series of anomaly type examples to be considered. It is not intended to be exhaustive or to provide extensive details around the metallurgy surrounding those anomaly types.

comment

34 comment by: *GE Avio*

Regarding the text:"6) An analysis should be provided that demonstrates that the surface fracture mechanics life for all critical parts exceeds 3 000 representative flight cycles or 50 percent of the Approved Life of the part, whichever is less."
This is not harmonized with FAA AC33.70-1, Chg. 1, which requires "3,000 damage tolerance cycles" and then defines a damage tolerance cycle as "...the major stress-cycle (min-max-min) from the missions used in the LCF certification analysis...". See Section 8.d.(7)(d). The FAA AC guidance is consistent with a long-standing industry approach to successful management of damage tolerance experience. Introducing a

change to this requirement will introduce a new variable when comparing back to successful prior designs. Historically, it was shown that the AC33.70-1, Chg. 1 approach achieves similar results to assessments made for a "representative flight cycle" when an initial flaw size more typical of actual observed damage is used.
Recommend using the FAA AC33.70-1, Chg. 1 cycle definition. For limiting location(s), an additional assessment with a representative flight cycle and a more representative initial flaw size (such as 0.010 x 0.005) could be additionally required.

Regarding the text:" 6) (iii) Any additional assumptions used in this analysis (i.e. material properties, reference engine cycle, operating environment and its effect on the stress cycle, etc.) should be declared;
Recommend listing additional assumptions to further harmonize with AC33.70-1, Chg. 1, Section 8.d.(7)(d). "placed in the most unfavorable orientation and location and may use compressive residual stresses and inelastic stresses"

response

First comment regarding the Cycle definition: Not accepted.

The difference identified by the commentator between the proposed amendment of AMC E 515 and FAA AC 33.70-1 is already a published Safety Emphasis item (SEI) between EASA and FAA (SEI 8). EASA considers that the analysed engine full flight cycle should include the various flight segments that describe a complete mission such that detrimental effects are appropriately evaluated. Examples of such effects are dwell and minor cycles. This difference is well established and has been discussed at length with industry. Further harmonisation in this area is not anticipated. During the revision of FAA AC 33.70-1, which includes the min-max-min cycle definition, EASA raised its concerns related to the limitations of this simplified flight cycle for deterministic evaluation.

Second comment regarding the crack orientation: Partially accepted.

The proposed text has been modified taking into account the comment made.

comment *94* comment by: *Rolls-Royce Plc*

Comment
The update to the section on damage tolerance does not have a logical flow to it and hence is difficult to understand. For example in the section 3) 'Probabilistic Damage Tolerance Risk Assessments' the introductory phrase 'The Damage Tolerance Assessment process typically includes the following primary elements' comes after introducing probabilist damage tolerance risk assessments. CM-PIFS-007 was clearly laid out and some of that clarity has been lost in the transfer to AMC CS-E 515.
Suggested resolution
Review the flow in the revised AMC to ensure its clear even for those less familiar with the details of damage tolerance assessments.

response

Accepted.

It is recognised that certain errors arose during the publication of the proposed AMC text revision. These errors have been corrected.

comment *95* comment by: *Rolls-Royce Plc*

Comment
CM-PIFS-007 identifies 2 ways of doing the design damage tolerance assessment that helps underwrite the critical part life - a probabilistic assessment and a deterministic surface damage tolerance assessment. The revised AMC initially offers only the probabilistic assessment but then adds the design damage tolerance assessment as an option if 'the required data is not available to fully implement the probabilistic approach.' It is not clear what is meant by 'not available' in this case. Some of the data might not be available because of the novelty of a product/material. In this case an alternative method might be reasonable. Data might also not be available to a particular applicant because of their business circumstances. If the alternative was available to such applicants, but not to other applicants producing equivalent products this would not be 'a level playing field.' It is also noted that having the deterministic assessment as an option only available in some cases is a change from CM-PIFS-007 which is not highlighted in the NPA.
Suggested resolution
Clarify what is meant by 'data is not available' and ensure there will be a level playing field. The simple option is to allow a choice of deterministic or probabilistic approach for all organisations.

This is a substantive comment.

response

Not accepted.

EASA recognises the industry progression to probabilistic methods, and that certain TC holders have made individual efforts ahead of industry / authority working groups (e.g. AIA RISC). However, it is recognised that at this time a probabilistic approach is not available for all component features. For this reason, EASA continues to allow the deterministic approach in responding to the damage tolerance requirements of CS-E 515. The sufficiency of an applicant damage tolerance proposal will be evaluated by EASA for each certification project.

Please note that the AMC paragraph dealing with the deterministic approach does not address all types of anomalies. A combination of probabilistic and deterministic approaches would have to be used by the applicants.

comment *96* comment by: *Rolls-Royce Plc*

Comment
There are references to risk assessment and risk evaluations where it is not clear to a non-expert whether the same evaluations are being referred to. Ie Top of P.26 states 'The inputs are integrated in a risk assessment which predicts the relative probability of failure. ' These are compared to design target risk values. The top of P.27 states 'The probabilities of Hazardous Engine Effects that must be met are defined in CS-E 510(a)(3).' It is not clear what should be meeting this rate. The note 'When referring to CS-E 510(a)(3) , an individual failure is considered to be a failure occurring anywhere in the engine as a result of a damage tolerance-related cause and is not related to the failure of an individual component' may be aiming to clarify this point but this is not understood either.
Suggested resolution
Clarify this section.

response

Partially accepted.

Various revisions have been made to the text.

comment

97 comment by: *Rolls-Royce Plc*

Comment
Point (ii) on P.29 includes the criterion for recording damage 'is made available to the type certificate holder or supplemental type certificated holder through existing reporting channels.'
It is assumed that this criterion was included in CM-PIFS-007 to make it clear that organisation were not expected to set up new service monitoring systems to meet the Policy. However for a completely new product with a completely new customer there will be no existing reporting channels. In these cases surely there should be a requirement for these channels to be set up - as they are for other Part 21 reporting requirements.
Suggested resolution
Is this criterion needed? If it is clarify.

response

Partially accepted.

By existing reporting channels, we are referring to the standard practices available to a TC/STC holder between the approval holder and operators and, or maintenance organisations. A note has been added to address new product types/operating practices.

comment

98 comment by: *Rolls-Royce Plc*

Comment
The last point on the AMC states 'During the service life of the part….. Should be made available to the responsible airworthiness authorities.' Responsible for what? Surely this data should just be made available to the State of Design authority - ie EASA. It would not be appropriate for TC holders to provide this data to all authorities where they hold a VTC. Obviously this would not prevent EASA requiring the information under their VTC arrangements with other countries. 'Responsible authority' could also be interpreted by a State of Registry has covering them. Then every State of Registry which has a product on its register could ask for detailed service monitoring data.
Suggested resolution
Adjust to make the data available to EASA. (Cases where other authorities see the data on behalf of EASA would be covered by bilaterals.)

response

Accepted.

comment

99 comment by: *Rolls-Royce Plc*

Comment
AMC E 515 (3) (d) (v) 3. Probabilistic Damage Tolerance Risk Assessments (Page 25 of NPA) contains a cross reference to “service damage monitoring (see paragraph (g))”.Although paragraph (g) of AMC E 515 exists, is this cross reference actually

intended to refer to AMC E 515 (3) (d) (v) 7. Service Damage Monitoring (page 28 of NPA)?
Suggested resolution
Clarify the cross-reference (and give full reference details)

response | Accepted.

comment | *100* comment by: *Rolls-Royce Plc*

Comment
As worded, the requirement is to declare any assumptions (e.g. regarding high temperature time dependent and independent effects on crack propagation, vibration and minor cycles). It is proposed that validation be provided to ensure these assumptions are appropriate.
Suggested resolution
Update AMC E 515 (3)(d)(v)(6)(iii) to require that assumptions should be 'validated' rather than 'declared'.

response | Partially accepted.

As the introduction sentence reads 'This analysis should take account of the following assumptions:', the phrase 'should be declared' is not necessary and it is deleted.

comment | *112* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur	Substantive	Editorial: X
Affected paragraph and page number	Page: # 25 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the Approved Life - Rotating parts, (v) Damage Tolerance, 3. Probabilistic Damage Tolerance Risk Assessments. Paragraph: see below		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: "The probabilistic approach to damage tolerance assessment is one of the two elements necessary to appropriately assess damage tolerance. The second element is service damage monitoring (see paragraph (g)). FAA Advisory Circular (AC) 33.14-1, Damage Tolerance for High Energy Turbine Engine Rotors, includes an example of the probabilistic process that applies to hard alpha material anomalies in titanium alloy rotor components." REQUESTED CHANGE: Add to the following parapgraph: "FAA Advisory Circular (AC) 33.70-2, Damage Tolerance of Hole Features in High Energy Turbine Engine Rotors, includes an example of the probabilistic process that applies to manufacturing anomalies in circular hole features."		
Why is your suggested	JUSTIFICATION: In order to add both AC published by FAA on probabilistic		

change justified?	methodology for Damage Tolerance so that it becomes explicit that they are accepted by EASA

response Accepted.

comment *113* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive	Editorial:
Affected paragraph and page number	Page: # 26 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the Approved Life - Rotating parts, (v) Damage Tolerance, 4. Risk Prediction and Allowable Risk. Paragraph: see below		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: "(e.g. values provided in FAA Advisory Circular (AC) 33.70-2 Damage Tolerance of Hole Features in High-Energy Turbine)" REQUESTED CHANGE: Remove the wording : "(e.g. values provided in FAA Advisory Circular (AC) 33.70-2 Damage Tolerance of Hole Features in High-Energy Turbine)" and replace by the text of AC33.70-1 Chg1 "Note the allowable DTRs can be found in advisory circulars which address specific materials and/or anomaly types".		
Why is your suggested change justified?	JUSTIFICATION: It is preferred to reference AC33.70-2 in §3 (see previous comment) and keep, for consistency with FAA specifications, the text of AC33.70-1 Chg1		

response Partially accepted.

The proposed sentence has been added while keeping the reference to the FAA AC 33.70-2.

comment *114* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive	Editorial: X
Affected paragraph and page number	Page: # 26 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the		

	Approved Life - Rotating parts, (v) Damage Tolerance, 5. Damage Tolerance Assessments Methodologies. Paragraph: see below
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: "Anomaly growth characteristics" REQUESTED CHANGE: Add the following text from AC 33.70-1 Chg1 ":anomaly growth may be based solely on crack propagation, or a combination of crack initiation (i.e. incubation) and crack propagation, depending on the nature of the anomaly/damage."
Why is your suggested change justified?	JUSTIFICATION: Anomalies fatigue behaviour may not solely be described by crack growth analysis. Therefore, and for consistency with FAA specifications, the addition of the text of AC33.70-1 Chg1 is proposed

response

Partially accepted.

The proposed sentence has been added as illustration of the term ‘anomaly growth characteristics’.

comment *115* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive	Editorial: X
Affected paragraph and page number	Page: # 27 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the Approved Life - Rotating parts, (v) Damage Tolerance, 5. Damage Tolerance Assessments Methodologies. Paragraph: see below		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: "The probabilities of Hazardous Engine Effects that must be met are defined in CS-E 510(a)(3). Note: When referring to CS-E 510(a)(3), an individual failure is considered to be a failure occurring anywhere in the engine as a result of a damage-tolerance-related cause and is not related to the failure of an individual component." REQUESTED CHANGE: "The probabilities of Hazardous Engine Effects that must be met are defined in CS-E 510(a)(3) for an individual failure at component level. Note: The damage tolerance individual failure rate at the component level is a portion of the value defined in CS-E 510(a)(3) for an individual failure, which refers to that failure occurring anywhere in the engine as a result of a given cause.		
Why is your suggested change justified?	JUSTIFICATION: In order to be more precise and complete		

response Partially accepted.

The comment has been taken into account to clarify the commented paragraph.

comment *116* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive	Editorial: X
Affected paragraph and page number	Page: # 28 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the Approved Life - Rotating parts, (v) Damage Tolerance, 6. Deterministic Surface Damage Tolerance Assessment. Paragraph: see below		
What is your concern and what	THE PROPOSED TEXT STATES: "An analysis should be provided that demonstrates that the		

do you want changed in this paragraph?	surface fracture mechanics life for all critical parts exceeds 3 000 representative flight cycles or 50 percent of the Approved Life of the part, whichever is less." REQUESTED CHANGE: Proposal to add the text in bold below: "An analysis should be provided that demonstrates that the surface fracture mechanics life for all critical parts exceeds 3 000 representative flight cycles used in the LCF certification analysis for ISA standard day conditions or 50 percent of the Approved Life of the part, whichever is less."
Why is your suggested change justified?	JUSTIFICATION: In order to harmonize as much as possible the Interim Surface Damage Tolerance requirements with FAA, we propose to add the text in bold extracted from FAA AC 33.70-1 Change 1 § 8.d.7.(d)

response

Not accepted

The appropriateness of the flight cycle should be evaluated with the Agency. Please refer also to the response to comment 34.

comment *117* comment by: *SAFRAN*

Type of comment (check one)	Non-Concur : X	Substantive	Editorial: X
Affected paragraph and page number	Page: # 28 AMC E 515 Engine Critical Parts, (3) Means for defining an Engineering Plan, (d) Establishment of the Approved Life - Rotating parts, (v) Damage Tolerance, 6. Deterministic Surface Damage Tolerance Assessment. Paragraph: see below		
What is your concern and what do you want changed in this paragraph?	THE PROPOSED TEXT STATES: "This analysis should take account of the following assumptions: " REQUESTED CHANGE: Add the following paragraph describing an additional assumption for precision and better consistency with FAA AC 33.70-1 Chg 1: "(v) These calculations should be based on the use of linear elastic fracture with cracks placed in the most unfavorable orientation and location and may use compressive residual stresses and inelastic stresses."		

Why is your suggested change justified?	JUSTIFICATION: For precision and better consistency with FAA AC 33.70-1 Chg 1

response

Partially accepted.

Sub-paragraphs (iii) and (iv) have been revised based upon this comment.

comment *167* comment by: *Transport Canada Civil aviation*

Title Paragraph 6

The word "Assessment" should be be changed to read "Analysis" since the text refers to an analysis which is quantitative not qualitative.

Suggested resolution
Suggest to clarify and revise text, if needed

response Accepted.

AMC E 515 Engine Critical Parts p. 29

comment *23* comment by: *FAA*

Page Number	Paragraph Number	Referenced Text	Comment/Rationale or Question	Proposed Resolution	Comment Type (Conceptual, Editorial, or Format)
29	AMC E 515 paragraph (3)(d)(v)7.(ii)	is inconsistent with or exceeds the repairable limits,	Believe you meant to type, "consistent" instead of "inconsistent."	Replace "inconsistent" with "consistent."	Editorial
29	Item 9 – Engine critical parts – Static pressure loaded parts	Para e Establishment of Approved Life - Static, pressure loaded parts - General principles	The general principles which are used to establish the Approved Life are similar to those used for rotating parts. However, for static pressure	At the end of the (i) General Principles paragraph, add note. Life assessment of Static, pressure loaded parts, should include	Conceptual

			loaded parts, the Approved Life may be based on ….We need to make sure this gets applied to pressure loaded parts in critical accessory components such as fuel pumps, fuel metering units, fuel/oil exchangers which are generally designed by subtier suppliers. On some engine models, these fuel component pressures reach 3000 psi.	(in addition to engine gas path parts) accesso ry components with high internal pressures such as fuel pumps, fuel metering units, heat exchangers.	

respons e

Comment 1: Not accepted.

The use of the commented word is confirmed as intended.

Comment 2: Not accepted.

CS-E 515 and its AMC are specifically written to address engine Critical Parts (Life Limited Parts per the FAA definition); the applicability is therefore determined based upon the safety assessment and definitions.

An Engine Critical Part is a part that relies upon meeting prescribed integrity specifications of CS-E 515 to avoid its Primary Failure, which is likely to result in a Hazardous Engine Effect. The parts identified in this comment are normally not considered to result in such an assessment.

CS-E 10 Applicability p. 30

comment *101* comment by: *Rolls-Royce Plc*

Comment (applies to other paragraphs as well as CS-E 10)
CS-E 10 and elsewhere. It's unclear if "Part 21" is a formal name for the Regulation EU No 748/2012. Neither "Part 21" nor "Part-21" are used in CS-Definitions or EU Regulation 748/2012, tho "Part 21" is used in the tite of the AMC/GMs.
Suggested resolution

	CS-Definitions should link the well-known phrase "Part 21" to the relevent EU Regulation.
response	Not accepted. Article 1 of Regulation (EU) No 748/2012, paragraph 1(c) states the following: 'Part 21' means the requirements and procedures for the certification of aircraft and related products, parts and appliances, and of design and production organisations laid down in Annex I to this Regulation. 'Annex I (Part 21)' is then used in many places of the other Articles. Finally, 'Part 21' is present in the title of Annex I and in the first sentence of point 21.1 of Annex I. In order to avoid having to amend CS-E for example when Regulation (EU) No 748/2012 is replaced by a new Regulation, reference to 'Part 21' is deemed preferable and clear enough.

CS-E 25 Instructions for Continued Airworthiness p. 30

comment	*102* comment by: *Rolls-Royce Plc* **Comment** The CS-E 025 amendment removes reference to the P21J regulation 21.A.61 as it is deleted by 2021/699 – this should be replaced with 21.A.7 rather than deleted in full otherwise the CS-E 025 specification will lose the direct link to 21.A.6 (Manuals) and 21.A.7 (Instructions for Continued Airworthiness). EU Commission delegated regulation 2021/699 stated 21.A.61 was deleted however it was in fact replaced with 21.A.7. This link is important to maintain the link back to the relevant AMC and GM. **Suggested resolution** Introduce a reference to 21.A.7
response	Not accepted. The reference to Part 21 is not necessary. Other CSs also do not refer to the Part 21 provisions related to ICA. See, for example, CS 25.1529.

6.3. Other references p. 34

comment	*168* comment by: *Transport Canada Civil aviation* Add : " — FAA Advisory Circular (AC) 33.70-2 Damage Tolerance of Hole Features in High-Energy Turbine Engine Rotors" **Suggested resolution** Suggest to clarify and revise text, if needed

response	Partially accepted. This reference was indeed forgotten in the NPA Section 6.3. However, the NPA will not be re-published. Note: The term 'Engine Rotors' is missing in the reference to this FAA AC in the proposed amendment of AMC E 515. This has been corrected.

Appendix A — Attachments

NPA 2021-13 - ASD_AIA_AIAC view - v2.pdf
Attachment #1 to comment #138