European Union Aviation Safety Agency

Explanatory Note to Decision 2018/014/R

Regular update of CS-E — CS-E Amendment 5

RMT.0184

Engine bird ingestion

RELATED NPA/CRD: 2017-16 — RMT.0671

EXECUTIVE SUMMARY

The objective of this Decision is to maintain a high level of safety for aircraft engines and ensure that it reflects current technology and the latest status of the Certification Specifications for Engines (CS-E).

Amendment 5 will improve the ability of aeroplane turbine engines to cope with the ingestion of birds that can reasonably be expected to be experienced during the service life of an engine.

In addition, it includes the incorporation or improvement of the CSs and the related acceptable means of compliance (AMC) for:

— a '30-Minute Power' rating;
— the fireproofing of engine mounts;
— ignition and relighting in flight;
— engine casing strength;
— transient fuel icing conditions;
— rain and hail ingestion;
— compressor and turbine blade failures; and
— compressor, fan and turbine shafts.

Overall, it is expected that this Amendment will improve safety and maintain harmonisation with the US FAA Part 33 regulations.

Action area:	Regular updates/review of rules (RMT.0184); design and maintenance improvements (RMT.0671)		
Affected rules:	CS-E		
Affected stakeholders:	Engine manufacturers		
Driver:	Efficiency/proportionality (RMT.0184); safety (RMT.0671)	**Rulemaking group:**	No
Impact assessment:	Light	**Rulemaking Procedure:**	Standard (RMT.0671); accelerated (RMT.0184)

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1. About this Decision

The European Union Aviation Safety Agency (EASA) developed ED Decision 2018/014/R in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the EASA 5-year Rulemaking Programme[3] under rulemaking tasks RMT.0184 and RMT.0671. The scope and timescales of these tasks were defined in the related Terms of Reference[4,5].

(a) The text of this Decision relating to 'Engine bird ingestion' (RMT.0671) has been developed by EASA based on the recommendations of the Engine Harmonization Working Group (EHWG) (formed by the Transport Airplane and Engine (TAE) Subcommittee of the US Aviation Rulemaking Advisory Committee (ARAC)). All interested parties were consulted through Notice of Proposed Amendment (NPA) 2017-16[6]. 29 comments were received from all the interested parties. EASA reviewed the comments received during the public consultation. The comments received and EASA's responses to them are presented in Comment-Response Document (CRD) 2017-16[7].

(b) The text of this Decision relating to the 'Regular update of CS-E' (RMT.0184) has been developed by EASA and has been consulted with its Advisory Bodies (ABs) in accordance with Article 16 'Special rulemaking procedure: accelerated procedure' of MB Decision No 18-2015. EASA took the decision to follow the procedure laid down in Article 16 as these amendments are expected to have a negligible impact, and they address issues of a non-controversial nature. Prior to the consultation with the ABs, the majority of these changes had been previously consulted with stakeholders in the form of certification memoranda (CM), special conditions (SCs) and equivalent safety findings (ESFs).

EASA reviewed the comments received during the AB consultation. The comments received and EASA's responses to them are summarised in Section 2.4 below.

The major milestones of these rulemaking activities are presented on the title page.

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1 Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1) (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1467719701894&uri=CELEX:32008R0216).

2 EASA is bound to follow a structured rulemaking process as required by Article 52(1) of Regulation (EC) No 216/2008. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the 'Rulemaking Procedure'. See MB Decision No 18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by EASA for the issuing of opinions, certification specifications and guidance material (http://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-18-2015-rulemaking-procedure).

3 http://easa.europa.eu/rulemaking/annual-programme-and-planning.php

4 https://www.easa.europa.eu/sites/default/files/dfu/ToR%20RMT.0184%20%28E.015%29%20Issue%201.pdf

5 https://www.easa.europa.eu/sites/default/files/dfu/ToR%20RMT.0671%20Issue%201.pdf

6 In accordance with Article 52 of the Basic Regulation, and Articles 3, 6(3), 7 and 8 of the Rulemaking Procedure.

7 https://www.easa.europa.eu/document-library/comment-response-documents

2. In summary — why and what

2.1. Why we need to change the CSs/AMC

RMT.0184 'Regular update of CS-E': 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, can be implemented in practice, and are in line with the latest ICAO requirements.

Regular updates are issued when relevant data is available following an update of industry standards, or feedback from certification activities or minor issues raised by the stakeholders.

With the current Decision, EASA has adopted a number of specifications and the related means of compliance of non-complex and non-controversial nature. Such subjects vary in nature and some are directly driven by safety issues, while others are primarily driven by other factors such as the arrival of new technologies that are not yet addressed in the CSs.

These subjects included:

— a '30-Minute Power' rating;

— the fireproofing of engine mounts;

— ignition and relighting in flight;

— engine casing strength;

— transient fuel icing conditions;

— rain and hail ingestion;

— compressor and turbine blade failures; and

— compressor, fan and turbine shafts.

RMT.0671 'Engine bird ingestion': The United States (US) National Transportation Safety Board (NTSB) issued several safety recommendations (SRs) to EASA following their investigation of the accident to US Airways Airbus A320, registered N106US, which ditched in the Hudson River on 15 January 2009[8]. Both engines were operating normally until they each ingested at least two large birds (weighing about 8 pounds each), one of which was ingested into each engine core, causing mechanical damage that prevented the engines from being able to provide sufficient thrust to sustain flight.

The number and size of the birds ingested by the engines exceeded the CS-E bird ingestion standard for the applicable range of turbine engine inlet throat areas.

Due to the fact that birds were ingested into the cores of the engines during a phase of flight for which CS-E did not require any testing, the NTSB concluded that the current bird tests would be more realistic if the lowest expected fan speed for the minimum climb rate were used instead of the current fan speed for 100 %-rated take-off thrust, which would allow more bird material to enter into the engine core.

In the US, the Federal Aviation Administration (FAA) responded to the NTSB recommendations by assigning a task to the Aviation Rulemaking Advisory Committee (ARAC) in order to address them. The Transport Airplane and Engine (TAE) Subcommittee accepted the tasking and agreed to provide

[8] Refer to National Transportation Safety Board (NTSB) Accident Report NTSB/AAR-10/03, adopted on 4 May 2010, entitled 'Loss of thrust in both engines after encountering a flock of birds and subsequent ditching on the Hudson River – US Airways Flight 1549 – Airbus A320-214, N106US – Weehawken, New Jersey – January 15, 2009'.

recommendations to ARAC regarding the bird-ingestion-certification-test standards. The TAE formed an Engine Harmonization Working Group (EHWG) to carry out the task and provide recommendations to the TAE. EASA actively participated in the EHWG and subsequently developed the relevant amendments to CS-E.

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 1 of Regulation (EU) 2018/1139[9]. This Decision will contribute to the achievement of the overall objectives by addressing the issues outlined in Section 2.1.

The specific objectives of this Decision are, therefore, to:

— for RMT.0184, reflect the state of the art and best practices for engine certification, based on the selection of non-complex, non-controversial, and mature subjects. The ultimate goal is to maintain safety and ensure efficiency;

— for RMT.0671:

- mitigate the safety effects of an engine bird ingestion event through the introduction of improved test parameters for aeroplane turbine engine bird ingestion testing based upon service experience; and
- maintain efficiency by minimising any differences between the EASA bird-ingestion-testing provisions and those of other certification authorities such as the FAA.

2.3. How we want to achieve it — overview of the amendments

This Decision amends CS-E in the following specific areas:

<u>'30-Minute Power' rating</u>

The '30-Minute Power' specifics that are already applied today through Special Condition SC-E-06, Turboshaft Engines Approval of 30-Minute Power Rating, dated 21 September 2011, are now included in CS-E.

More specifically, the following provisions are amended:

— CS-E 40 to include 30-Minute Power in the list of ratings for multi-engined Rotorcraft;

— CS-E 740 to include the endurance test schedule for the 30-Minute Power rating;

— AMC E 25 to require that usage limitations should be specified in the instructions for continued airworthiness (ICA);

— AMC E 40(b)(3) to include an explanation of the 30-Minute Power rating; and

— AMC E 515 to ensure that the usage of the 30-Minute Power rating is considered in the engine flight cycle when establishing the approved life of engine critical parts.

[9] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (OJ L 212, 22.8.2018, p. 1) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1139&qid=1543590554849&from=EN).

In addition, the following AMC is created:

— AMC E 740(c)(2)(i) to clarify the 30-Minute Power rating endurance test criteria.

Fire protection

CS-E 130 is amended to clarify the requirements for the fireproofing of engine mounts and structure based upon the ESF on 'Fire protection — Engine attachment points'.

Ignition and relighting in flight

CS-E 240 is amended to include the specification already applied today through an SC (SC-E-05) for a 'continued ignition capability for self-ignition piston engines'. This amendment should ensure that a piston engine will not stop functioning within the declared flight envelope as long as the engine operating procedures are followed. There are currently no specific requirements for self-ignition diesel engines, and diesel engines do not have any inherent in-flight relight capability similar to that of spark ignition engines.

AMC E 910 is created to reaffirm the link with AMC 25.903(e)(2) and to recommend active coordination between the engine type certificate applicant and the aircraft type certificate applicant when addressing the functional requirements of an in-flight relighting system. This AMC is based on the current EASA interpretative material contained in EASA Certification Memorandum CM-PIFS-010 Issue 1[10]. In addition, the AMC now explains the specific threats that should be considered in the demonstration of compliance.

Strength — local failures

AMC E 520(d) is created to clarify the need to consider local failures of the engine casing.

Transient fuel icing conditions

AMC E 560 and AMC E 670 are amended to include the need to consider engine malfunctions under transient fuel icing conditions. Events, including one multi-engine event, have occurred on a number of different engine types and aircraft installations. Transient fuel icing conditions are defined as short duration exposures to high concentrations of ice in the fuel delivered to the engine, caused by the accumulation and subsequent shedding of ice within the aircraft fuel system.

The form of the ice has been found to be soft and compactable, such that flow blockages may occur around entries to fine passages, or on filter elements or strainers. Previously, this fuel icing mechanism was not anticipated during engine certification, and it is not addressed by conventional contaminated fuel certification testing, which simulates evenly distributed ice in fuel at a defined maximum concentration. The amendment of AMC E 560 and AMC E 670 will formalise the need for transient fuel icing conditions to be considered during certification.

Rain and hail ingestion

AMC E 790(a)(2) is amended to introduce a new critical point test for high-concentration hail, and describe the acceptance criteria for the test.

10 https://www.easa.europa.eu/document-library/product-certification-consultations/easa-cm-pifs-010

AMC E 790(a)(1) has been created to introduce the potential use of parametric analysis for the certification of design changes or derivative engines without the need to conduct a full engine test. This AMC is based on an ESF previously determined by EASA (ESF E 04). The AMC stipulates that there should not be a variation of more than 10 % in the critical impact parameter used to substantiate the original base engine. In accordance with the ESF, a similar approach to that used for the bird ingestion provisions in AMC E 800(4)(i) is proposed.

Based upon comments received during the consultation of the above, CS-E 790 was also amended to clarify under which circumstances alternative evidence such as that from engine tests, rig tests, analysis (or an appropriate combination of these) can be used.

Compressor and turbine blade failure

The use of carbon graphite composite fan blades that feature special geometries, composite structural materials and manufacturing methods is becoming more prevalent in engines. EASA has used an SC (SC-E-07) to address the specifics of composite fan blades on recent certification programmes.

Previously, AMC E 810(2)(b)(i) specified that the release of the fan blade should be from the top of the retention member. However, some composite fan blades have unusual design features (relative to the design practices for metallic blades), and a failure cannot reasonably be expected to occur at the outer retention member.

To reflect the differences between metallic and composite blades, CS-E 810 and AMC E 810 have been amended (based upon an SC) to include a clarification of the blade retention requirements for composite fan blades.

Compressor, fan and turbine shafts

AMC E 850 has been amended to clarify the definition of a non-hazardous shaft failure. This AMC is based on the current interpretative material issued by EASA in EASA Certification Memorandum CM-PIFS-003 Issue 1[11]. In addition, this amended AMC will elaborate on the options available to demonstrate that the consequences of a shaft failure are non-hazardous through either test or analysis.

Engine bird ingestion

CS-E 800 and AMC E 800 are amended to require the applicant to demonstrate the ability of a turbine engine to cope with the ingestion of a medium flocking bird (MFB) into the engine core under defined engine conditions. These engine conditions are either:

— the mechanical rotor speed of the first exposed stage or stages that, on a standard day, would produce the lowest expected power or thrust required during a climb through 3 000 ft above ground level; or

— if no bird material is ingested into the engine core using the above conditions, the mechanical rotor speed of the first exposed stage or stages that is consistent with a minimum approach idle setting, on a standard day, at 3 000 ft above ground level.

[11] https://www.easa.europa.eu/sites/default/files/dfu/certification-memoranda-import-EASA%20CM-PIFS-003%20Issue%2001_Turbine%20Over-speed%20Resulting%20from%20Shaft%20Failure_PUBL.pdf

Editorial corrections

Several editorial changes are introduced to improve the references and the clarity of some of the text.

2.4. What are the stakeholders' views

Bird ingestion

Comments were received during the consultation of NPA 2017-16 on the following aspects:

— requests to improve the clarity of the engine conditions under which the bird ingestion test should be conducted;

— a request to limit the applicability of the new MFB core ingestion test to turbofan engines only;

— the need to improve consistency regarding the power lever movement between the climb condition test and the approach condition test;

— suggestions to improve the run-on schedule after the ingestion of the bird;

— requests for clarification on the intent of the target location for the bird test.

These comments were taken into account in the final composition of the amended CSs and AMC for bird ingestion testing.

Regular update

Comments were received during the consultation of the draft Decision with the ABs on the following aspects:

— the need for coordination between the engine and aircraft manufacturer when considering transient fuel icing conditions;

— clarification on the criteria for engine shutdown and relighting in flight;

— clarification on the test schedule for the 30-Minute Power rating during the endurance test;

— the scope and type of engines that the engine fire protection requirements for engine attachment points should apply to;

— a request to improve the applicability criteria for when a read-across for ingestion of rain and hail certification can be utilised for design changes or derivative engines without conducting a full engine test.

2.5. What are the benefits and the drawbacks

For the bird ingestion elements of this Amendment, it is anticipated that there will be an improvement in safety due to the introduction of a new test requirement to demonstrate the ability of an engine to ingest a MFB into the engine core. The test will be conducted under conditions that are representative of the engine thrust during the climb phase of flight, which has been shown to be a potential gap in the current engine bird ingestion testing. There will be an associated cost to engine manufacturers due to the cost of conducting the new bird ingestion test, but the impact has been assessed as being very low. This has been further assessed in the impact assessment (IA) of NPA 2017-16.

For the regular update elements of this Amendment, it is considered that the updates reflect the state of the art of engine certification, and that they consolidate the existing CM, SCs and ESFs into the CSs. Overall, this is expected to improve safety, to have no social or environmental impacts, and to provide some minor economic benefits by streamlining the certification process. Due to the fact that this was a regular update rulemaking task, no impact assessment was required or conducted.

The associated safety benefits from this update to CS-E stem from the alignment of CS-E with the latest engine designs, technology and standards. This alignment will ensure a consistent and sustainable level of safety for the certification of engines.

2.6. How do we monitor and evaluate the rules

For the bird ingestion elements of this Amendment, it is proposed by ARAC that a dedicated group should meet annually and add recent experience to the bird ingestion database. A number of suggested means of improving the quality of the database were also suggested, which this new working group could address. The working group could also provide recommendations on any deficiencies seen in the current rules, needs for rulemaking on new technology engines, and recommendations for other means to mitigate the ingestion threat, such as bird detection and avoidance.

EASA will closely monitor the development of this working group whilst also monitoring the number of bird ingestion events that result in engine thrust issues.

For the regular update elements of this Amendment, no specific monitoring or evaluation is proposed. EASA constantly strives to improve product certification specifications, and will monitor the feedback from applicants on the implementation and usage of these proposed changes to CS-E.

3. References

3.1. Affected decisions

— Decision No. 2003/9/RM of the Executive Director of the Agency of 24 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for engines (« CS-E »), as amended