European Union Aviation Safety Agency

Terms of Reference

for rulemaking task RMT.0180

Turbine engine endurance and initial maintenance inspection testing, and piston engine time between overhauls substantiation

ISSUE 1

Issue/rationale

This Rulemaking Task (RMT) addresses the following issues:

(a) The turbine engine endurance test conditions that are required by the Certification Spefications for Engines (CS-E) are very hard, if not impossible, to achieve with modern engines.

(b) An initial maintenance inspection (IMI) test for turbine engines is required by the Federal Aviation Administration (FAA) regulations for many years, but not by the European (Joint Aviation Authorities (JAA) and European Union Aviation Safety Agency (EASA)) certification specifications (CSs).

(c) CS-E does not contain a specification for applicants to demonstrate the time between overhauls (TBO) interval. A safety recommendation on this matter was addressed to EASA.

The specific objective of this RMT is to modernise the engine certification test requirements to:

— upgrade the turbine engine endurance test specifications to take into account modern engine design characteristics;

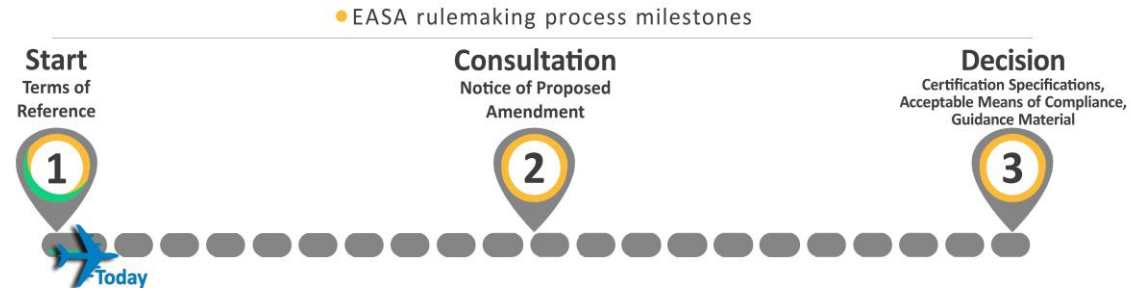
— improve the level of confidence in the robustness of turbine engine designs prior to entry into service, as well as, in some cases, the definition of initial maintenance inspection (IMI) intervals;

— ensure that EASA exercises oversight of the IMI tests and benefits from the resulting knowledge;

— ensure the robust and harmonised substantiation of the TBO and of the maintenance programmes for piston engines; and

— ensure the greatest possible harmonisation with the related FAA regulations and certification policies.

Domain:	Design and production		
Related rules:	CS-E		
Affected stakeholders:	Design organisations applying for the type certification of an engine (turbine or piston) and operators of aircraft equipped with these engines		
Driver:	Efficiency/proportionality	**Rulemaking group:**	No
Impact assessment:	Yes	**Rulemaking Procedure:**	Standard



1. Why we need to amend the rules — issue/rationale

Issue 1 — Turbine engine endurance test

The engine endurance test required by CS-E 740 is an accelerated severity test that is intended to demonstrate a minimum level of engine operability and durability within, and including, the approved engine ratings and operating limitations. The test originated 60 years ago in the days of reciprocating engines and single-shaft turbine engines, and was suitable for the operational characteristics of those engines. The fundamental approach of the test, with the demonstration of concurrent redline speed and temperatures, retained because the test conditions are undeniably conservative and are thus desirable from a safety demonstration perspective.

The issues with the CS-E 740 requirement arose due to the test running conditions becoming harder to achieve, as engine designs and operations evolved to meet the performance demands of the modern air transport market. To achieve the concurrent redline speed and temperatures, applicants often need to modify the configuration of the test engine and the required test sequence.

The current test practice and the accepted means of compliance do allow modifications to the test engine configuration and test sequence, provided certain conditions are met. Specifically, the engine, when modified, must be substantiated as being representative of the intended type design in terms of its durability and operating characteristics. However, experience from more recent engine certification highlighted the complexity of such substantiations, considering the modifications required (e.g. adapted cooling circuits, ground blade tips, the introduction of a thermal barrier coating of the turbine blades, etc.).This introduced the issue of concern, which is the possibility of doubt about the representativeness of the demonstration.

In January 2014, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) to evaluate whether the requirements for engine endurance testing should be revised by introducing requirements for an alternate test. That alternate test would include revised test conditions to minimise the modifications required, whilst retaining the intended severity, and thus ensuring the representativeness of the demonstration. The task was assigned to the Engine Harmonization Working Group (EHWG), which produced a report in January 2017.

CS-E may therefore be amended to introduce specifications based upon the ARAC proposals for an alternate endurance test, which ensure the representativeness of the endurance test.

Issue 2 — Turbine engine IMI test

An initial maintenance inspection (IMI) test is required by Part 33 (refer to 14 CFR 33.90) of the FAA for many years, but not by the European (JAA and EASA) certification specifications. The test is an important element within a series of certification specifications (CSs); valuable safety and harmonisation benefits are thus expected from including it in the EASA CS.

Therefore, an update of CS-E with specifications based upon FAA 14 CFR 33.90 would increase the exposure of the engine to representative service conditions during the certification programme. Consequently, the confidence in the reliability of the engine would increase as well.

The introduction of the IMI-based test requirements for turbine engines would also enhance the harmonisation between the EASA and FAA requirements on this subject.

Issue 3 — Piston engine TBO substantiation

CS-E does not contain any CSs that can be used by applicants to demonstrate the time between overhaul (TBO) interval and the related maintenance programme. Therefore, it is left at the discretion of the applicant to apply for an approval of a TBO by EASA.

Meanwhile, paragraph (c)(5) of CS-E 25 *Instructions for Continued Airworthiness* states: 'Scheduling information for each part of the Engine that provides the recommended periods at which it should be cleaned, inspected, adjusted, tested and lubricated, and the degree of inspection, the applicable serviceability limits, and work recommended at these periods. Necessary cross references to the airworthiness limitations section must also be included. In addition, if appropriate, an inspection programme must be included that states the frequency of the inspections necessary to provide for the continued airworthiness of the Engine.'

However, paragraph (c)(5) of CS-E 25 and the related AMC do not provide any means to substantiate the TBO.

Applicants may substantiate the TBO based on the outcome of the 150-hour engine endurance test that is carried out in accordance with CS-E 440. However, this test may only reveal a limited number of the design deficiencies of the engine. Therefore, based on the CS-E 440 engine endurance test, EASA accepts only a limited initial TBO. As mentioned under Issue 2 above, this situation contrasts with the fact that FAA 14 CFR 33.90 requires an IMI test for turbine engines in addition to the endurance test.

To accept TBO values higher than the commonly accepted initial TBO values, EASA agreed with some applicants on means to provide adequate evidence to support a TBO using a project-specific certification review item (CRI) means of compliance (MoC). Such MoC refers to paragraph (c) of CS-E 25 and provides substantiation based on an engine cyclic endurance test that is run on an engine representative of the type design, and using a cycle profile that is based on estimated aircraft flight profiles. This test is similar to an IMI test. The engine cyclic endurance test is developed by the applicant and agreed with EASA. The maintenance programme associated with the intended TBO is carried out and validated during the engine endurance cyclic test.

Although the above-mentioned CRI process is well established within EASA, a project-specific CRI is not publicly available. This process may be well known among established applicants, but potential new applicants may not be aware of EASA's expectations.

Finally, a safety recommendation was addressed to EASA in 2009, which was related to the accident to a Diamond DA42, registration OE-FCL, on 20 September 2007, close to St. Pantaleon, Austria. That accident was caused by the in-flight failure of the right position engine, followed by a loss of control during an attempt to make an emergency landing. Safety Recommendation (SR) AUST-2009-011 was issued by the Austrian Federal Safety Investigation Authority:

'Amend the certification requirements for piston engines, CS-E:

After the certification of the DA 40 and DA 42 with TAE engine Centurion 1.7 and 2.0 a number of serious incidents and loss of engine power have occurred.

The certification regulations should be amended in such way that before the first delivery to customers, the overall system is proven to be fully functioning over a given time period, within TBO (Time Between Overhaul), without experiencing loss of power, or major mechanical failures.'

Related safety issues

Issue 1 — Turbine engine endurance test

Some turbine engines face unexpected failures shortly after entry into service. Such issues require urgent corrective actions (mandated by airworthiness directives) to control the associated safety risks from multiple engine shutdown occurrences.

The root cause of such failures might be identified during the engine endurance test if the test conditions and the engine configuration are more representative.

Although no fatal or serious injuries are directly attributed to these safety issues, EASA and the industry identified the need to establish a more representative test, and thereby increase the probability of detecting such issues before the entry into service of the engine.

Issue 2 — Turbine engine IMI test

Although an IMI test is required by the FAA, if an applicant applies for EASA CS-E certification only, this test is not required. In this case, the CS-E certification tests may not reveal some design-related issues that may be discovered while running an IMI test, due to the use of unbalance vibration.

This is a safety concern to EASA, as an engine entering into service without an IMI test may create potential unsafe conditions.

Issue 3 — Piston engine TBO substantiation

The absence of CS-E certification specifications (CSs) and acceptable means of compliance (AMC) for the substantiation of the TBO does not ensure a rigorous and harmonised demonstration by different applicants. The approved TBO may, therefore, not be commensurate with the level of the testing performed. Consequently, some engines may be more prone to developing design-related failures, including losses of power, after entry into service and before reaching the certified TBO interval. A safety recommendation (see above) was issued to EASA after the investigation of an accident involving the in-flight failure of an engine, to improve the CSs for the substantiation of the TBO.

2. What we want to achieve — objective

The overall objectives of the EASA system are defined in Article 1 of Regulation (EU) 2018/1139[1] (the 'Basic Regulation'). This RMT will contribute to the achievement of the overall objectives by addressing the issues outlined in Chapter 1.

The specific objective of this proposal is to modernise the engine certification test requirements to:

— upgrade the turbine engine endurance test specifications to take into account modern engine design characteristics;

— improve the level of confidence in the robustness of turbine engine designs prior to entry into service, as well as, in some cases, the definition of IMI intervals;

[1] 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/?qid=1535612134845&uri=CELEX:32018R1139).

— ensure that EASA exercises oversight of the IMI tests and benefits from the resulting knowledge, which can help to understand the potential required corrective actions when turbine engine continuing-airworthiness issues arise,

— ensure the robust and harmonised substantiation of the TBO and of the related maintenance programme for piston engines, and make the related CSs clearly visible to applicants; and

— ensure the greatest possible harmonisation with the related FAA regulations and certification policies.

3. How we want to achieve it

The activities of this RMT will consist in proposing an amendment of CS-E to meet the above-mentioned objectives. The following elements will be considered as a baseline:

Turbine engine endurance test

The amendment of CS-E 740 should be based on the recommendations that are contained in the EHWG report 'Alternate Test to 14CFR33.87 Endurance Test' from 31 January 2017. The EHWG recommended introducing a test as an optional alternative to the current one. The alternative test demonstration would be achieved by evaluating (via a critical point analysis (CPA) of the product's design and intended use (operating envelope)) the critical points representing the most severe operation and defining a hybrid of prescriptive and performance-based severity test for the engine. This alternative test would test the engine type design to its limiting speeds and temperatures (redlines) for the type certificate limits. Further, the proposed alternative test would evaluate the engine's capability to successfully complete running in close proximity to the minimum speed and temperature margins (close to the redlines) as expected while in service, and still operating at a severity level consistent with the intent of the current CS-E 740 or FAA 14 CFR 33.87 prescriptive test.

The proposed test would run for more hours and cycles than is prescribed by the current test schedule. It would, by analysis and evaluation of the potential field service extremes, provide a more severe test of the engine's capability than is intended by the current test, and provide results that are more representative of the responses to the threats characteristic of the revenue service extremes seen in today's engines.

Furthermore, the FAA found that certain ambiguities in the EHWG report could lead to disparate approaches when developing an alternate endurance test. Therefore, after the publication of the EHWG report, in March 2020, the FAA requested clarification on the report's recommendations in the following areas:

(a) the severity equivalence process and its intended purpose;

(b) the severity equivalence process for modes other than creep failure modes, including the failure modes that are not currently addressed by FAA 14 CFR 33.87;

(c) constraints in implementing the recommended hybrid performance-based and prescriptive solutions;

(d) the role of the engine CPA;

(e) simplification of the possible approaches by removing the T_{metal} option; and

(f) the various acceptable outcomes of an alternate endurance test.

The EHWG was therefore reconvened with the participation of EASA.

The outcome of this activity and the related clarifications will be considered in drafting the CS-E amendment.

Turbine engine IMI test

CS-E should be harmonised with FAA 14 CFR 33.90. To establish when the IMI is required, the applicant would then have to complete one of the following tests with an engine that substantially conforms to the type design:

— an approved engine test that simulates the conditions in which the engine is expected to operate in service, including typical start-stop cycles; or

— an approved engine test that is conducted in accordance with the applicable early ETOPS test requirements.

Piston engine TBO substantiation

New CS-E CSs should be introduced to indicate how applicants must substantiate the TBO interval and maintenance programme. Limited credit could be taken from the CS-E 440 endurance test alone. To go beyond this limitation, the substantiation would require running an engine cyclic endurance test on an engine representative of the type design, using a cycle profile that is based on the estimated aircraft flight profiles. The number of cycles should be representative of:

— the TBO intended to be declared; and

— a level of engine deterioration at least equivalent to that of an engine at the end of the intended TBO.

4. What are the deliverables

— An NPA proposing to amend CS-E.

— An ED Decision amending CS-E.

5. How we consult

A public consultation will take place through an NPA in accordance with Article 7 of the Rulemaking Procedure[2].

6. Interface issues

N/a.

[2] EASA Management Board Decision N°18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications, acceptable means of compliance and guidance material ('Rulemaking Procedure').

7. Reference documents

7.1. Related regulations

Commission Regulation (EU) No 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 224, 21.8.2012, p.1-85).

7.2. Related decisions

Decision No. 2003/009/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').

7.3. Reference documents

— Safety Recommendation (SR) AUST-2009-011 on the accident to Diamond DA42, Registration OE-FCL, on 20 July 2007 close to St. Pantaleon, Austria, issued by the Austrian Federal Safety Investigation Authority.

— Engine Harmonization Working Group (EHWG) Task, Federal Register Vol. 79, No. 14, 22 Jan 2014.

— EHWG Report 'Alternate Test to 14CFR33.87 Endurance Test', 31 January 2017.