EASA European Union Aviation Safety Agency	**Means of Compliance with the Special Condition EHPS** **Endurance Demonstration**	Doc. No. : **MOC-EHPS.420** Issue : 1 Date : 19 December 2024 Proposed ☒ Final ☐

The document at hand, Doc. No. MOC-EHPS.420, contains the 1st publication of the proposed Means of Compliance to the SC E-19 requirement EHPS.420 - Endurance Substantiation.

All MOC publications of the SC E-19 will be consolidated in a single document in the Easy Access Rules (EAR) format for general convenience.

In this sense, the Statement of Issue and the structure of the document is the same for all of them.

Deadline to submit comments: 01 March 2025

Statement of Issue

EASA has received several requests for the type certification of electric engines and EHPS propulsion systems. In the absence of suitable certification specifications for the type certification of this type of product, a complete set of dedicated technical specifications in the form of a Special Condition for Electric/Hybrid Propulsion System was developed.

Specifically, the EHPS.10 requirement establishes the scope of application of the special condition, in which elements such as certified turbines and reciprocating engines or APUs having an ETSO could be reused in an EHPS.

The SC-E 19 design and safety objectives has been initiated from the CS-E while extracting the prescriptive text and therefore some paragraphs of the SC E-19 cover known technologies and designs of today's combustion engines and APUs.

In addition, the requirements of SC E 19 follow the approach previously used for the development of CS-23 Amendment 5, avoiding limiting technical innovation by describing prescriptive design solutions as certification standards.

The proposed Means Of Compliance (MOC) contained within this document fill this gap addressing the applicant's requests for clarification of EASA's interpretation of these objectives and of possibilities how to demonstrate compliance with them.

In this sense, the MOC included in this document may be updated with any necessary complement or modification, while additional MOC with different objectives in the Special Condition may also be incorporated in this document as necessary. During these revisions, EASA may recognise available Industry Standards as accepted SC E 19 Method of Compliance.

EASA may also accept other means to demonstrate compliance with the objectives contained in the Special Condition during the certification of a particular design. In doing so, EASA will thoroughly evaluate all MOC proposals and analyse their merits and associated justification. Subsequently EASA will establish whether the proposed MOC will ensure that the relevant safety objective in the Special Condition can be demonstrated as being fully met by it. The goal being to provide flexibility in the design of the EHPS whilst ensuring that the objectives of the Special Condition are satisfied and demonstrated by the applicant.

Structure of the document

The document provides clarifications of the rationale and intent of the SC- E 19 requirements referenced in the Scope of the document, as well as the links to other relevant requirements associated to these requirements.

For each specific relevant EHPS configuration (electric, reciprocating or turbine), one or more Means Of Compliance are then proposed.

When necessary, the document refers to Methods of Compliance, also defined as Level 3 MOC documents. The Method of Compliance can be parts or extracts from regulatory texts such as CS-E, FAR 33, AC guidance material, Certification Memo, Special Conditions, or Industry Standards.

Table of contents

1 List of Acronyms

Acronym/Term	Definition
A/C	Aircraft
AC	Advisory Circular
APU	Auxiliary Power Unit
CPA	Critical Point Analysis
CS	Certification Specification
EHPS	Electric Hybrid Propulsion System
EPDS	Electrical Power Distribution
ESD	Energy Storage Device
MOC	Means Of Compliance
SC	Special Condition

2 References

(1) CS-E, amendment 7
(2) CS-APU, amendment 1
(3) SC E-19: Electric / Hybrid Propulsion System, issue 1
(4) EUROCAE ED-321 Guidance Material for Endurance substantiation of Electric/Hybrid Propulsion Systems EHPS
(5) SC E-11 Transient over-temperature, over-speed and over-torque limit approval

3 Scope

This document proposes Means Of Compliances for EHPS.420 Endurance Substantiation for electric hybrid propulsion systems. It explains the strategy how to use existing AMC material and published standards to show Compliance to EHPS.420. It also clarifies the relation with other paragraphs of SC E-19.

Other elements of the EHPS propulsion system, such as the propulsion batteries and the distribution system, as well as their interaction with other regulations where necessary, are not included in the scope of this document.

Finally, the scope of this document includes the proposed Means of Compliance for those EHPS systems that include turbines or piston engines in hybrid-electric architectures.

The sections of the SC E 19 where no appropriate means to demonstrate compliance (ie. Industry Standard) has been published yet and, consequently, there is no Method of Compliance associated, are tagged as “Reserved”.

4 Requirements

4.1 SC E-19

4.1.1 Requirements

The requirements to be considered within this MOC are provided in Reference [3].

- EHPS.420 Endurance Demonstration

Additional requirements are related to this MOC:

- EHPS.40 Ratings
- EHPS.410 General conduct of tests
- EHPS.440 Calibration Assurance
- EHPS.450 Teardown Inspection
- EHPS.480 (c) Specific operation

4.1.2 EHPS.420 General information

The SC E-19 has been created having in mind that certified turbines and reciprocating engines or APU's certified as ETSO could be installed within an EHPS.

The SC E-19 has been developed from the CS-E while extracting, and therefore some paragraphs of the SC E-19 cover known technologies and designs of today's combustion engines and APU's.

The objective of endurance substantiation is to:

- Establish the EHPS operating limitations,
- Demonstrate engine durability and reliability,
- Demonstrate the capability to deliver the declared ratings.

4.1.2.1 EHPS - Hybrid systems

When the EHPS includes already certified turbines, reciprocating engines or APU's, credit may be taken from the performances, limitations and installation procedures established in the approved type certificate.

4.1.2.2 Rating definition of EHPS emergency electric engines.

EHPS systems intended for emergency and only used to provide additional power in the event of a LOP must also undergo an Endurance test demonstration.

4.1.3 Associated Interpretative Material / Means of Compliance of SC E-19

EHPS.420: The Means of Compliance should at least cover CS-E 690 (Engine Bleed), CS-E 440 (Endurance Tests) and CS-E 470 (Contaminated Fuel).

EHPS.420 (b): The Means of Compliance should at least cover the existing Special Condition "Transient over-temperature, over-speed and over-torque limit approval".

EHPS.420 (c): The Means of Compliance should at least cover CS-E 820 (Over-torque Test), CS-E 870 (Exhaust Gas Over-temperature Test), CS-E 830 (Maximum Engine Over-speed), overvoltage, overcurrent.

EHPS.480 (c): The Means of Compliance should at least cover CS-E 920 (Over-temperature Test).

EASA SC E-11 Transient over-temperature, over-speed and over-torque limit approval

SC E-11 explains that if the design allows possible in-service transient speed, temperature, or torque excursions above the to-be-approved steady state limits of certain ratings, these excursions need to be approved. These transient conditions mean an overshoot occurring before reaching steady state limit values during normal engine operation, i.e. following a rapid engine acceleration. These overshoots are predictable and inherent to the engine design.

To account for these excursions, the Applicant needs to reproduce expected in-service transient over-temperature, over-speed, or over-torque conditions as part of the accelerations to these ratings during the endurance test, in a representative manner.

The SC E-11 also provides guidance on how expected transients can be addressed. A similar approach can be used to address transient overshoots for EHPS Endurance substantiation.

EUROCAE ED-321 Guidance Material for Endurance Substantiation of Electric-Hybrid Propulsion: ED-321 provides detailed Guidance on the intend of EHPS.420 and the strategy to demonstrate compliance to the endurance substantiation. At this stage the scope of the Methods of Compliance within ED-321 is limited to the EHPS' electrical engine. The battery and electrical Power distribution is considered out of the scope for the endurance test.

4.2 CS - E

4.2.1 Link with CS-E 440, E 470, E 690, E 820, E 830 and E 870

The following CS-E paragraphs are written with the intend to certify piston or gas turbine engines. However, its content is important to understand the background and philosophy of the endurance substantiation that is valid for the certification of EHPS as well.

CS-E Piston engines

CS-E 440	Endurance Test
CS-E 470	Contaminated Fuel

CS-E Turbine Engines

CS-E 670	Contaminated Fuel
CS-E 690	Engine Bleed
CS-E 820	Over-Torque test
CS-E 830	Maximum Engine Over-speed
CS-E 870	Exhaust Gas Over-temperature test

CS-E 479 CS-E 670 should stablish the capability of the EHPS hybrid systems to function satisfactorily with fuel containing contamination.

CS-E 690 should establish the bleeding limits to be used in the endurance testing of gas turbine engines. A comparable treatment should be considered for EHPS when includes hybrid systems (ie. turbines or turbogenerators).

CS E 820, -830 and -870 are intended to cover inadvertent occurrences for periods up to 20 seconds of over-temp, over-speed or over-torque following which rejection of the engine from service or maintenance action is not required (*apart from correcting the cause*).

5 Means of compliance for *electric engines*

5.1 Methodology 1

The objective of endurance substantiation is to establish the EHPS limitations, by demonstrating the engine durability and reliability under extreme usage. It is used to demonstrate the capability to deliver the declared ratings, under extreme usage, at any time between overhauls and/or large maintenance actions.

This is a different purpose than durability substantiation that is intended to validate the required maintenance to be performed (maintenance program). In general, this means that an endurance test will include maximum stresses applied to the EHPS for a limited duration whereas during the durability test the stresses applied will be commensurate to the mission profiles that represent EHPS cycles in service, for longer duration in alignment with the maintenance program.

ED-321

The EUROCAE ED-321 provides "Methods of Compliance" for demonstrating compliance to EHPS.420 Endurance substantiation.

Chapter 2 defines the possible EHPS architectures and associated subsystems. However, it limits its scope to the endurance demonstration of electric engines. Energy storage device (ESD) is considered outside the scope of endurance under this guidance material. Similarly, electrical power distribution (EPDS) is also considered outside the scope of endurance testing.

The diagram below illustrates the steps to be followed for endurance demonstration, linking these steps to the related EHPS requirements.

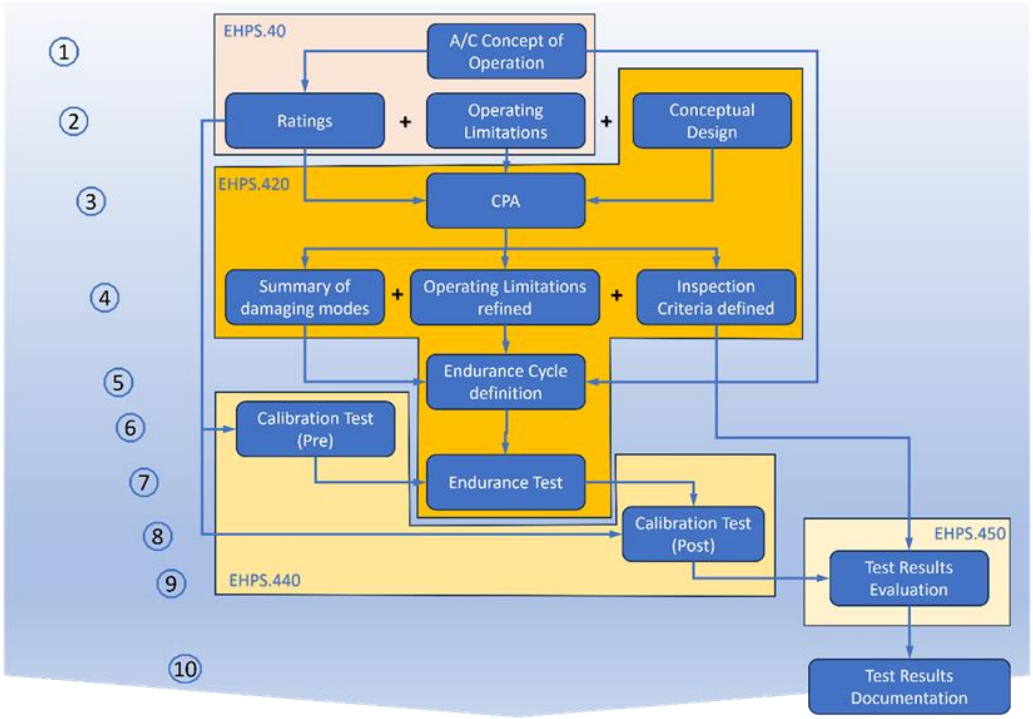

Figure 1: Endurance Logic – Concept of Operation (Source EUROCAE ED-321)

- The ED-321 also provides Guidance on the logic and relation between EHPS.40, EHPS.440, EHPS.450 in the context of the endurance substantiation by EHPS.420.
- The ED-321 is based on the related CS-E paragraphs and refers to it when clarifying the intent of the requirements and the rationale for the Methods of Compliance.

Compliance Strategy Endurance test by ED-321

The strategy to show compliance is to perform a Critical Point Analysis to determine the suitable EHPS test conditions and test cycles based on the identified damaging modes and scenarios. By this, Ratings and limitations can be defined and confirmed.

After performing the endurance test, the ED-321 provides "Methods of Compliance" on the teardown inspection in Chapter 9, Post Tests Evaluation.

6 Means of compliance to EHPS.420 for *turbine engines*

[Reserved]

7 Means of compliance to EHPS.420 for *piston engines*

[Reserved]

8 Means of compliance to EHPS.420 for *Turbo generator(s)*

[Reserved]

9 Means of compliance to EHPS.420 for emergency electric engines.

[Reserved]