EASA European Union Aviation Safety Agency	**Special Condition**	Doc. No. : Issue : 1 Date : 07/01/2020 Proposed ☒ Final ☐ Deadline for comments: 31/01/2020

SUBJECT : **Electric Propulsion Units for CS-22 Sailplanes and Powered Sailplanes, CS-LSA Light Sport Aeroplanes, CS-VLA Very Light Aeroplanes and CS-23 Normal, Utility, Aerobatic and Commuter Aeroplanes up to Level 1**

REQUIREMENTS incl. Amdt. :

ASSOCIATED IM/AMC[1] : Yes☒ / No ☐

ADVISORY MATERIAL : **AMC 20-115D**

INTRODUCTORY NOTE:

The following Special Condition has been classified as important and as such shall be subject to public consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

IDENTIFICATION OF ISSUE:

An applicant has made an application for the certification of an electric propulsion unit (called hereafter EPU). It consists of an electric motor associated with its controller (inverter). The motor and the inverter are liquid cooled. They are intended to be installed on CS-22 Sailplanes and Powered Sailplanes, CS-LSA Light Sport Aeroplanes, CS-VLA Very Light Aeroplanes and CS-23 Normal, Utility, Aerobatic and Commuter Aeroplanes up to Level 1.
The certification specifications that are usually applicable to aircraft engines are contained in CS-E amendment 5. However CS-E amendment 5 does not consider Electric Propulsion Systems.

The applicant has proposed to use the ASTM F3338-18 "Standard Specification for Design of Electric Propulsion Units for General Aviation Aircraft" as basis to define the certification requirements.

However the scope of the referenced ASTM standard needs to be modified to fully address the intended design of the applicant. Some adjustments are required to take into account the extended scope of the product to be certified, especially the liquid cooling system.

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[1] In case of SC, the associated Interpretative Material and/or Acceptable Means of Compliance may be published for awareness only and they are not subject to public consultation.

The certification specifications necessary to certify a liquid-cooled EPU are considered to be represented by ASTM F3338-18 with the following amended requirements along with the additions below:

[…]

- 5.15: for the certification of an engine, only a "critical part" should be considered. An engine critical part is a part that relies upon meeting the prescribed integrity specifications of 5.15.2 to avoid its Primary Failure, which is likely to result in a Hazardous Engine Effect. Therefore 5.15.1.2, 5.15.3.1, 5.15.3.2, 5.15.3.3 should not be considered.

[…]

- 5.15.2 is replaced by:

  The integrity of the Engine Critical Parts identified under 5.15 shall be established by:

  - (a) An Engineering Plan, the execution of which establishes and maintains that the combinations of; loads, material properties, environmental influences and operating conditions, including the effects of parts influencing these parameters, are sufficiently well known or predictable, by validated analysis, test or service experience, to allow each Engine Critical Part to be withdrawn from service at an Approved Life before Hazardous Engine Effects can occur.

    Appropriate Damage Tolerance assessments shall be performed to address the potential for Failure from; material, manufacturing and service-induced anomalies within the Approved Life of the part. The Approved Life shall be published as required in 5.1.

  - (b) A Manufacturing Plan which identifies the specific manufacturing constraints necessary to consistently produce Engine Critical Parts with the Attributes required by the Engineering Plan.

  - (c) A Service Management Plan which defines in-service processes for maintenance and repair of Engine Critical Parts which will maintain the Attributes consistent with those required by the Engineering Plan. These processes shall become part of the instructions for continued airworthiness.

[…]

- 5.15.3.4: regardless of whether or not the EPU provides containment in the event of a rotor burst , all EPU rotors shall have limitations established by an acceptable procedure which specifies the maximum allowable number of start-stop stress cycles (low cycle fatigue) or running hours representative of the typical EPU usage. A cycle includes, as a minimum, starting the EPU, operating at specific power settings and stopping.

[…]

- 5.18.2: The following requirements shall be added:

  - It shall be shown that Hazardous EPU Effects are predicted to occur at a rate not in excess of that defined as Extremely Remote (probability shall be consistent with the safety objective associated with the intended aircraft application). The estimated probability for individual Failures may be insufficiently precise to enable the total rate for Hazardous EPU Effects to be assessed. For EPU certification, it is acceptable to consider that the intent of this paragraph has been achieved if the probability of a Hazardous EPU Effect arising from an individual Failure can be predicted to be not

greater than [10% of the safety objective associated with the intended aircraft application] per EPU flight hour.

- It shall be shown that Major EPU Effects are predicted to occur at a rate not in excess of that defined as Remote (probability shall be consistent with the safety objective associated with the intended aircraft application).

[…]

- 5.20.3: The purpose of the Endurance and Durability Test is to establish the ratings and the limitations of the EPU as well as assessing the reliability of the EPU overall design. In the absence of detailed Means of Compliance (MoC) in the ASTM F3338-18, the applicant may refer to CS-E 440 and the associated AMC to define an acceptable means of compliance to 5.20.3.

- 5.25: to be deleted.

  Note: If an applicant seeks to include the propeller in the EPU type design, this propeller shall meet all requirements contained in CS-P or CS-22 subpart J depending on the intended aircraft application.

The certification specifications necessary to certify a liquid-cooled EPU are considered to be ASTM F3338-18 as amended above along with the following additions:

- <u>Software Development:</u>
  - In reference with 5.10, for software development, the applicant shall consider AMC 20-115D - Airborne Software Development Assurance Using EUROCAE ED-12 and RTCA DO-178,
- <u>Liquid cooling system:</u>

  <u>EPU cooling</u>
  - For any requirement concerning EPU cooling for which the aircraft manufacturer must demonstrate compliance with in order to ensure the proper functioning of the EPU once installed in the aircraft, this shall be highlighted in the installation manual of the EPU.
  - The degree of EPU cooling shall be sufficient to ensure safe operation under all conditions within the declared operational limitations. Critical limits shall be established for operating fluids, external EPU surface, component operating temperature, as well as other related cooling considerations, such as internal flow-path cooling of rotors, stators, windings, inverters, cases, etc. The safe operational temperatures of all components shall be demonstrated when operating within declared operational limits. Applicants shall ensure that a stable EPU operating temperature conditions is maintained, thereby safeguarding engine component's integrity throughout their design life and/or time to inspection, as appropriate.
    - If aspects of EPU cooling require the installer to ensure that the temperature limits are respected when EPU is operated on the intended application, those limits shall be specified in the Instruction Manual for Installing and Operating the EPU
    - ASTM F3338-18 § 5.7.3 also applies to liquid cooling systems

Liquid fluid system:

- When liquid fluid systems are used for lubrication and/or cooling of EPU components these systems shall meet the following requirements contained in this section. All fluid systems shall be designed and constructed to function as intended and in a safe manner in all flight attitudes and atmospheric conditions in which the EPU is expected to operate.
- When the EPU does not feature a complete cooling system, the EPU fluid systems shall be designed and constructed to allow the installation of an external means to cool the fluid.
- Excluding closed loop systems, that are intended to be pressurised; fluid system tanks or wet sumps shall be vented to atmosphere to preclude the leakage of fluid. Non-closed loop systems, such as most oil return systems, are unpressurised so they are vented to atmospheric pressure.
  - All atmospheric vents in the liquid cooling system shall be located or protected to minimise the ingress of foreign matter or icing that could affect satisfactory Engine functioning. Venting shall be arranged so that condensed water vapour which might freeze and obstruct the line cannot accumulate at any point in the vent system.
  - If the components of the overboard venting system are outside of the responsibility of the EPU manufacturer then the requirements of an acceptable design and the features that are necessary shall be established and articulated in the installation manual
  - A closed loop system does not include features such as a rotating shaft seal where fluid can leak, or where overflow may occur during operation. A traditional pressurised reciprocating engine cooling system is one such example of this.
- The risk of an human error during filling shall be minimised by the following:

  (1) Designs shall minimise the probability of overfilling of the liquid tank (filling of expansion space);

  (2) Each recessed liquid tank filler connection that can retain any appreciable quantity of liquid shall have provision for the fitment of a drain;

  (3) Each liquid tank cap shall provide a liquid-tight seal;

  (4) Each liquid tank filler shall be appropriately labelled. If it is an oil tank, this shall be marked with the word 'oil' along with the permissible oil specifications. If it is a coolant tank, this shall be marked with the word 'coolant' along with the permissible coolant specifications.

  5) Should the cooling fluid confirmed to have flammable characteristics, leakages or spillages shall be prevented to accumulate in any space between the tank and the remainder of the engine or ignition surfaces. Appropriate installation requirements shall be articulated in the EPU installation manual.

  (6) Designs shall minimise the incorrect fitment of the closing device of the fluid filling point.
- Liquid cooling system shall have a means, or provisions for, pre-flight quantity (level) determination. If loss of cooling liquid can lead to hazardous EPU effects, a low quantity warning shall be indicated to the pilot.

Cooling fluid Drains

- A draining means shall be provided to allow safe and complete drainage of the cooling fluid system. A means shall be provided for locking this means in the closed position.
- The draining means shall allow the removal of the liquid from the system while minimising the potential for hazardous accumulation of the liquids within the EPU, the escape into the environment and unintended human contact.

Associated Interpretative Material / Means of Compliance

The associated Interpretative Material / Means of Compliance are published for awareness only and are not subject to public consultation.

1. ASTM F3338-18 - Standard Specification for Design of Electric Propulsion Units for General Aviation Aircraft
2. AMC 20-115D - AMC 20-115D Airborne Software Development Assurance Using EUROCAE ED-12 and RTCA DO-178