EASA European Union Aviation Safety Agency	**CRI Consultation paper** **Special Condition**	Doc. No. : SC E-19 Issue : 1 Date : 07/04/2021 Proposed ☐ Final ☒

SUBJECT	:	**Electric / Hybrid Propulsion System**
REQUIREMENTS incl. Amdt.	:	
ASSOCIATED IM/AMC[1]	:	Yes☒ / No ☐
ADVISORY MATERIAL	:	

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:

This Special Condition has been developed to support Applications received by the Agency for the certification of Electric and / or Hybrid Propulsion Systems powered by propulsion batteries and / or fuel.
These EHPS are intended to be certified:

- as part of an aircraft
  or
- as an engine product and dedicated to a known intended aircraft application.

The certification specifications that are usually applicable to aircraft engines dedicated to CS-23, CS-25, CS-27, CS-29, and airships are contained in CS-E amendment 6. However, this certification specification considers neither Electric and / or Hybrid Propulsion Systems nor engines intended for new product architectures such as VTOL aircrafts. Innovative EHPS and aircraft architectures bring new challenges such as new interfaces, new interactions, or new functions.

It is considered challenging at this stage to provide a generic set of requirements for an EHPS that could encompass all possibilities.

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

These are the reasons why this Special Condition provides the certification requirements for an Electric and / or Hybrid Propulsion System when the intended aircraft application is identified. This ensures consistency between the certification requirements of the aircraft and those of the EHPS and therefore would contribute to a proper integration of the propulsion system in the aircraft.

This Special Condition is articulated so as to provide objective based certification requirements which are independent of the propulsion system design or architecture. The type of technology used in the propulsion system will be addressed in the Means of Compliance. Means of Compliance will depend on the type of EHPS that is considered and on the type of aircraft on which the EHPS is intended to be integrated.

Special Condition

Electric / Hybrid Propulsion System (EHPS)

Contents

SUBPART A - GENERAL

EHPS.10 Scope

The purpose of this special conditions is to provide the certification requirements for an Electric and / or Hybrid Propulsion System when the intended aircraft application has already been identified.

This Special Condition is applicable to any Electric / Hybrid Propulsion System, so called hereafter EHPS, which is used to provide or produce lift/thrust/power for flight in a manned and unmanned aircraft, during both normal and emergency operations, except for CS-22, CS-LSA, CS-23 Level 1 Day VFR and Light UAS. It should be noted that for CS-25 aircraft, this Special Condition shall be complemented with appropriate emissions requirements that are yet to be defined for EHPS.

Even if the EHPS contributes to the lift production in some intended aircraft applications like VTOL, the function of control of the lift to ensure the aircraft sustentation, control and manoeuvrability, is an aircraft function and it should be covered by the intended aircraft application certification basis.

Exclusions from the scope of the SC E-19:

EHPS for which no intended aircraft application is identified is outside of the scope of this Special Condition.

As the Type-certification basis for CS-22, CS-LSA, CS-23 Level 1 Day VFR and Light UAS do not systematically provide safety objectives but instead only provide reliability objectives, EHPS that are dedicated to these applications are considered outside the scope of this Special Condition.

EHPS that are not used to produce lift/thrust/power in flight are outside of the scope of this Special Condition. For example, electric motors that drive wheels for taxiing are outside of the scope and should be considered as part of the landing gear system.

Any design that includes the use of hydrogen, whether used to feed fuel cells or combustion engines is considered, at this stage, to be outside the scope of this Special Condition. These designs require further work and research before defining the associated certification requirements.

Propellers are also outside of the scope of this Special Condition as the certification specifications for propellers are already provided in CS-P.

Aircraft Rotors providing lift are also outside of the scope of this Special Condition.

Additional certification requirements beyond this Special Condition will need to be satisfied at the aircraft level in order to safely integrate an EHPS into a manned or unmanned aircraft and these are outside of the scope of this Special Condition.

EHPS.11 Means of compliance

(a) An applicant must comply with this Special Condition using means of compliance accepted by the Agency, which may include consensus standards.

(b) An applicant requesting the Agency to accept a means of compliance must provide the means of compliance to the Agency in an acceptable form and manner.

EHPS.15 Terminology

EHPS	Electric / Hybrid Propulsion System. An Electric / Hybrid Propulsion System may include, but is not limited to, electric engines, turbine engines, piston engines, generators, electrical power generation, distribution, wirings, propulsion batteries, integrated fans, cooling systems, controllers and power management system. An EHPS is intended to produce lift, thrust or power for flight and it should include as a minimum the sub-systems of the EHPS that provide thrust, lift or power to a device that provides thrust or lift, such as a propeller or an aircraft rotor. For examples: - a propulsion battery alone (without any electric engine) cannot be considered as an EHPS. - a propulsion battery associated to an electric engine providing power to a propeller is considered as an EHPS.
Sub-system of EHPS	A sub-system of the EHPS may include examples such as a turbine engine, a piston engine, an electric engine, a generator, an electrical power distribution system, an EHPS control system or, a propulsion battery.
EHPS Control System	A system or device that controls, limits, monitors or protects the operation of the EHPS or a sub-system of the EHPS
Rated Maximum Continuous Power and/or Thrust	The power and/or thrust identified in the performance data for use during periods of unrestricted duration.
Rated Take-off Power and/or Thrust	The power and/or thrust identified in the performance data for use during take-off, discontinued approach and baulked landing.
Emergency rating	Means a rating intended to be used in the event of a failure leading to a power, thrust or lift loss of a sub-system of the EHPS and requiring the remaining sub-systems of the EHPS to compensate fully or partially the associated power and/or thrust loss. A rating is defined for all the sub-systems of the EHPS providing thrust, lift or power to a device that provides thrust or lift, such as a propeller or a rotor.
Normal transient EHPS exceedances	Normal transient EHPS exceedances are short exceedances, limited in both amplitude and duration, of the rated power/thrust which result

	from the EHPS design in order to ensure the safety of the aircraft. For example, transient overtorque following a power request increase may be required to ensure the proper stability of the aircraft. The nature of the transient can be an exceedance on any of the parameters of the EHPS, e.g. voltage, current, torque, speed, temperature…
Inadvertent transient EHPS exceedance	The inadvertent transient EHPS exceedances do not result from the EHPS design but are the result of abnormal operation or failure conditions.
Hazardous EHPS effect	Means the effect of Hazardous EHPS failure condition. The following effects, as a minimum, must be regarded as Hazardous EHPS Effects, unless demonstrated to not be applicable for the intended aircraft application: (i) Non-containment of high-energy debris (including the release of a propeller or an Aircraft Rotor by the EHPS); (ii) Concentration of toxic products in the air of the cabin that is sufficient to incapacitate crew or passengers; (iii) Significant thrust in the opposite direction to that commanded by the pilot; (iv) Uncontrolled fire; (v) Failure of the EHPS mounting system leading to inadvertent EHPS separation; (vi) Complete inability to shutdown any sub-systems of the EHPS containing rotating parts; (vii) Complete inability to isolate the components that could cause a hazard to the aircraft; (viii) Serious or fatal human injury, caused by electrocution, arc flash, arc blast or excessive electromagnetic field.
Hazardous EHPS failure condition	Failure conditions potentially resulting in one of the following effects: (i) Hazardous Aircraft Effect (ii) Catastrophic Aircraft Effect (iii) Hazardous EHPS Effect
Catastrophic Aircraft Effect	Effect of a Catastrophic Aircraft Failure Condition
Catastrophic Aircraft Failure Condition	Failure conditions defined as Catastrophic in the safety assessment of the intended aircraft application.
Hazardous Aircraft Effect	Effect of a Hazardous Aircraft Failure Condition

Hazardous Aircraft Failure Condition	Failure conditions defined as Hazardous in the safety assessment of the intended aircraft application.
Major Aircraft effect	Effect of a Major Aircraft Failure Condition
Major Aircraft Failure Condition	Failure conditions defined as Major in the safety assessment of the intended aircraft application.
Critical Part	Means a part that relies upon meeting prescribed integrity specifications of EHPS.90 to avoid its Primary Failure, which is likely to result in a Hazardous EHPS Effect.
Primary Failure	Means a Failure of a part which is not the result of the prior Failure of another part or system.
Engineering Plan	Means a compilation of the assumptions, technical data and actions required to establish and to maintain the life capability of a Critical Part. The Engineering Plan is established and executed as part of the pre- and post-certification activities.
Manufacturing Plan	Means a compilation of the part specific manufacturing process constraints, which must be included in the manufacturing definition (drawings, procedures, specifications, etc.) of the Critical Part to ensure that it meets the design intent as defined by the Engineering Plan.
Service Management Plan	Means a compilation of the processes for in-service maintenance and repair to ensure that a Critical Part achieves the design intent as defined by the Engineering Plan.
High energy debris	Means a debris that is released following the failure of a component or a part and that, if not contained, may have sufficient energy to cause significant damage to the aircraft or serious or fatal injury of crew or passengers.
Secondary Failure	Means a Failure of a part or system which is the result of the prior Failure of another part or system.
Rotor	Means an individual stage of a fan, compressor or turbine assembly (some assemblies may consist of only one stage) or the rotating part of an electric engine or generator.
Aircraft rotor	Means a device providing essentially lift and that is part of the aircraft type design.
Fuel	In the context of the SC E-19, fuel is considered to be petroleum-based fuels, or petroleum and synthetic fuel blends or equivalent biofuels (also called SAF, Sustainable Aviation Fuel).
Propulsion Battery	Means a battery or a set of batteries intended to provide electrical power to the electric engines of the EHPS. In addition, Propulsion Batteries can be used to provide electrical power to other EHPS sub-systems or to systems of the intended aircraft application.

EHPS.20 EHPS Configuration

(a) The list of all the parts and equipment, including references to the relevant drawings and software builds, which define the proposed type design of the EHPS, must be established.

(b) When the EHPS is certified as part of the Aircraft Type Certificate, this corresponds to the list of all the parts and equipment, including references to the relevant drawings and software builds which define the EHPS configuration for the aircraft type design.

EHPS.22 Identification

Where parts are required to be traceable, or identifiable to manage interchangeability, major turbine engine or reciprocating engine modules, EHPS components and sub-systems that can be changed independently in service must be suitably identified so as to ensure traceability and to enable proper control over the interchangeability with different EHPS variants.

EHPS.25 Instructions for Continued Airworthiness (ICA)

(a) In accordance with point 21A.61(a) of Regulation (EU) No 748/2012, the applicant must prepare Instructions for Continued Airworthiness.

(b) The Instructions for Continued Airworthiness must be provided in dedicated manuals. Alternatively, the Instructions for Continued Airworthiness can be provided in the aircraft relevant manuals if the EHPS is certified as part of the Aircraft Type Certificate.

(c) The Instructions for Continued Airworthiness must contain a Section titled 'Airworthiness Limitations' that is segregated and clearly distinguishable from the rest of the document. This Section must set forth each mandatory action or limitation for in-service maintenance and repair required for type certification. This Section must contain a legible statement in a prominent location that reads: 'The Airworthiness Limitations Section is approved and variations must also be approved'.

EHPS.30 Instructions for installation and operation of the EHPS

(a) The applicant must prepare and make available to the Agency prior to the issuance of the type certificate, and to the installer at the time of delivery of the EHPS, approved instructions for installation and operation of the EHPS.

(b) When the EHPS is certified independently of the aircraft, the instructions must include at least the following:

(1) Installation instructions and requirements for each sub-system which constitutes the EHPS;

(2) Operating instructions, limitations, and Normal transient EHPS exceedances;

(3) The Type-Certification Basis which is (are) assumed as being applicable to the intended aircraft application;

(4) The aircraft parts and equipment that may be mounted on, or driven by, the EHPS, which are not part of the certified EHPS configuration;

(5) Where an EHPS relies on components which are not part of the EHPS, the interface conditions, reliability specifications and safety rationale for those components upon which the EHPS certification is based;

(6) The necessary data to allow the installer to demonstrate the compliance to the requirements identified in the Type-Certification basis of the intended aircraft application;

(7) Any assumptions concerning the conditions that may be imposed on the EHPS when it is installed in the intended aircraft application and that have to be satisfied in order to show compliance with any of the provisions of this Special Condition;

(8) The list of approved fluids to be used in the EHPS.

(c) Alternatively, if the EHPS is certified as part of the aircraft certification, instructions for installation and operation of the EHPS that are pertinent to the operator of the aircraft must be provided in the relevant manuals.

EHPS.40 Ratings and operating limitations

(a) Ratings and operating limitations must be established, including ratings and limitations based on the operating conditions and information specified in this paragraph, and any other information that is necessary for safe operation of the EHPS. Ratings and operating limitations must be approved by the Agency.

(b) The EHPS operating limitations include any limitation to ensure the safe operation of the EHPS and its associated sub-systems.

(c) Ratings must be established for Take-off Power and/or Thrust and for Maximum Continuous Power and/or Thrust, as well as for Emergency Ratings if Emergency Ratings are intended to be used.

(d) The Maximum permitted duration for the use of ratings other than Maximum Continuous Power and/or Thrust Rating must be established.

(e) When requested by the Applicant, other ratings, associated with the maximum permitted duration for the use of each of these ratings, may also be established.

(f) Emergency rating(s) must be established separately from the other ratings, and the specific failures associated with each emergency rating must be defined.

(g) Each selected rating must be for the lowest thrust, lift or power that all affected sub-systems of the EHPS of the same type are capable of producing under the conditions used to determine that rating at all times during the flight and at all times between overhaul periods or other maintenance.

(h) Each Normal transient EHPS exceedance (amplitude and duration) must be established.

SUBPART B – DESIGN AND CONSTRUCTION

EHPS.50 Materials

(a) The suitability and durability of materials used in the EHPS must be established for the intended design conditions of the system. The design values of the relevant properties of materials must be suitably related to the minimum properties stated in the material specification. The design values of the relevant properties of materials must meet or exceed the properties assumed in the design data over the life time of the EHPS.

(b) Manufacturing methods and processes must be such as to produce sound structure and mechanisms, and electrical systems that retain the design properties under assumed service conditions. This includes the effects of deterioration over time, e.g. corrosion, insulation break-down

EHPS.80 Safety Assessment

(a) (1) An analysis of the EHPS, including the control system, must be carried out in order to assess all Failure Conditions that can reasonably be expected to occur. This analysis must take account of:

(i) The intended aircraft application: the evaluation of the EHPS failures conditions and their effects must be made at aircraft level in coordination with the intended aircraft manufacturer who must establish the probability of occurrence of those failure conditions acceptable for the intended aircraft application. This evaluation of the EHPS failure conditions and associated failure rates must be detailed in the installation instructions as required in EHPS.30 (b)(7). Alternatively, this data must be established and provided in the safety assessment of the intended aircraft application if the EHPS is certified as part of the aircraft certification.

(ii) Aircraft-level devices and procedures that are assumed to be associated with the intended aircraft application. Such assumptions must be stated in the analysis, and detailed in the Installation Instructions as required in EHPS.30 (b)(3).

(iii) Consequential secondary Failures and dormant Failures.

(iv) Multiple Failures that result in the Hazardous EHPS Effects, Hazardous Aircraft Effects or Catastrophic Aircraft Effects defined in EHPS.15.

(2) A summary must be made of those Failures Conditions that could result in Major Aircraft Effects, Hazardous EHPS Effects, Hazardous Aircraft Effects or Catastrophic Aircraft Effects together with an estimate of the probability of occurrence of those effects. Any EHPS critical part must be clearly identified in this summary.

(3) It must be shown that the design and construction of the EHPS allows the intended aircraft application to meet the qualitative (including Development Assurance) and quantitative safety objectives defined in the type-certification basis of the intended aircraft application.

(b) If the Primary Failure of certain single elements that are likely to result in Hazardous EHPS Effects cannot be sensibly estimated in numerical terms, reliance must be placed on meeting the prescribed integrity specifications of EHPS.90. These instances must be stated in the safety analysis as required in (a)(2).

(c) If the acceptability of the safety analysis is dependent on one or more of the following items, they must be identified in the analysis and appropriately substantiated:

(1) Maintenance actions being carried out at stated intervals. The maintenance intervals must be published in the Airworthiness Limitations section of the Instructions for Continued Airworthiness (refer to EHPS.25) when necessary for preventing the occurrence of:

(i) Hazardous EHPS Effects at a probability in excess of the Extremely Remote probability defined in the associated Type-Certification basis of the intended aircraft application; or

(ii) Hazardous and Catastrophic Aircraft Effects at probabilities in excess of the probabilities defined by the intended application manufacturer and declared in the installation manual as stated in EHPS.30.

(2) If errors in maintenance of the EHPS, including the EHPS Control System, could lead to Hazardous EHPS Effects, Hazardous or Catastrophic Aircraft Effects, appropriate procedures must be included in the relevant EHPS manuals.

(3) Verification of the satisfactory functioning of safety or other devices at pre-flight or other stated periods. The details of this verification must be published in the appropriate manual.

(4) The provision of specific instrumentation not otherwise required.

(5) Operating instructions. These instructions must be identified:

(i) in the operating instructions manual after an appropriate evaluation at aircraft level in coordination with the aircraft manufacturer; or

(ii) in the intended aircraft application operating manual if the EHPS is certified as part of the aircraft application.

EHPS.90 EHPS Critical Parts

The integrity of the EHPS Critical Parts identified under EHPS.80 must 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 EHPS Critical Part to be withdrawn from service at an Approved Life before Hazardous EHPS Effects can occur. Appropriate Damage Tolerance assessments must 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 must be published as required in EHPS.25.

(b) A Manufacturing Plan which identifies the specific manufacturing constraints necessary to consistently produce EHPS 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 EHPS Critical Parts which will maintain Attributes consistent with those required by the Engineering Plan. These processes must become part of the instructions for continued airworthiness.

EHPS.100 Fire Protection

(a) The design and construction of the EHPS and the materials used must minimise the probability of the occurrence and spread of fire during normal operation and EHPS failure conditions and must minimize the effect of such a fire.

(b) In addition, the design and construction of the EHPS must minimise the probability of the occurrence of an internal fire that could result in structural Failure or Hazardous EHPS Failure.

EHPS.200 Static and fatigue Loads

(a) The loads induced by any part of the EHPS must be established and declared in the Instructions for installation and operation of the EHPS as stated in EHPS.30.

t

(b) The loads induced by the intended aircraft application, provided by the manufacturer of the intended aircraft application, must be declared in the Instructions for installation and operation of the EHPS as stated in EHPS.30.

(c) Each sub-system of the EHPS must be designed and constructed so that it will function properly under all loading conditions determined under EHPS.200 (a) and (b).

EHPS.210 Strength

(a) A mechanical, thermal and electrical stress analysis must show that there is suitable EHPS design margin at the declared operating limits. The suitable design margin must be established in the means of compliance.

(b) Th maximum stresses in the EHPS must be determined by tests, validated analysis, or a combination thereof, and must be shown not to exceed minimum material properties defined in EHPS.50.

EHPS.230 Vibration Survey

(a) The EHPS must be designed and constructed to function throughout its normal operating range of rotor speeds and EHPS output power or thrust, including defined exceedances, without inducing excessive stress in all affected parts of the EHPS caused by vibration and without imparting excessive vibration forces to the aircraft structure.

(b) The applicant must conduct a vibration survey of the EHPS to establish that the vibration characteristics of those components that may be subject to mechanically induced vibrations, aerodynamically induced vibrations, acoustically induced vibrations or electromagnetic field excitation induced vibrations are acceptable throughout the declared flight envelope and EHPS operating range for the intended installation configuration.

(c) The effects on vibration characteristics of excitation forces caused by EHPS Fault conditions must be evaluated and shown not to result in a Hazardous EHPS Effect.

EHPS.240 Overspeed and Rotor Integrity

(a) A rotor overspeed must not result in either rotor burst, rotor growth or other damage that could result in a Hazardous EHPS effect. This must be shown by test, validated analysis, or a combination of both. Applicable assumed speeds must be declared and justified. Failure conditions shall be taken into account, including loss of load.

(b) Rotors must be shown to provide adequate strength margin with respect to burst, growth and damages, that could result in a Hazardous EHPS effect, above the certified operating conditions and speeds assumed in EHPS.240 (a).

EHPS.250 Rotating parts containment

(a) The failure of any rotating component or part of an equipment, electric engine or generator must not lead to the release of high energy debris.

(b) If the EHPS includes a compressor or a turbine, it must be demonstrated that after Failure any single compressor or turbine blade will be contained and that no Hazardous EHPS Effect can arise as a result of other damage to the EHPS that is likely to occur before the EHPS is shut down following a blade Failure.

EHPS.260 Continued Rotation

If any of the EHPS main rotating systems continue to rotate after the EHPS is shutdown while in flight, this continued rotation must be considered in the safety assessment in EHPS.80 and must not result in effects that would be unacceptable.

EHPS.270 Rain conditions

The EHPS must be designed and/or installed such that it is capable of satisfactory operation throughout its specified operating envelope when subject to sudden encounters with rain.

EHPS.280 Icing and snow conditions

The EHPS and any of its sub-systems must function satisfactorily when operated throughout the conditions of atmospheric icing (including freezing fog on ground) and falling and blowing snow defined in the propulsive system installation ice protection specifications of the Type-Certification basis of the intended aircraft application indicated in EHPS.30 .

EHPS.290 Bird, hail strike and impact of foreign matter

(a) The EHPS must be designed and/or installed so that any impact or ingestion of bird or hail, or other impact of foreign matter, that is likely to occur in any one flight will not cause any Hazardous EHPS Effect or Catastrophic Aircraft Effect as defined in EHPS.15.

(b) If defined in the Type-Certification Basis of the intended application, it must also be shown that the impacts defined in (a) will not preclude the continued safe flight and landing of the aircraft as a consequence of an unacceptable:

(1) loss of performance;

(2) deterioration of EHPS/Aircraft handling characteristics;

(3) exceedance of any EHPS operating limitation.

(c) The possibility for multiple impacts must be considered in (a) and (b) unless it can be shown that they are unlikely to occur in any one flight.

SUBPART C – SYSTEMS and EQUIPMENT

EHPS.300 Fuel system

(a) If the EHPS includes a reciprocating engine or a turbine engine, then any fuel system of the EHPS must be designed and constructed so that it will function properly and safely in all flight attitudes and atmospheric conditions in which the EHPS is expected to operate, including negative g.

(b) If the EHPS includes a reciprocating engine or a turbine engine, then evidence must be provided that the complete Engine fuel system is capable of functioning satisfactorily with fuel containing the maximum quantity of liquid/solid contamination (including icing), likely to be encountered in service, for a period sufficient to ensure that the Engine will not malfunction as a result.

(c) Any reliance placed upon the assumed installed conditions or installation requirements must be declared in the instructions for installation as defined in EHPS.30.

(d) All approved fuels and additives must be declared in the instructions for installation and operation of the EHPS as defined in EHPS.30.

EHPS.310 Lubrication system

(a) Any lubrication system of the EHPS must be designed and constructed so as to ensure the proper functioning of the EHPS in all flight attitudes and atmospheric conditions in which the EHPS is expected to operate, including negative g.

(b) All parts of the lubrication system that are not inherently capable of being tolerant to contaminants likely to be present in the lubricant or otherwise introduced into the lubrication system must be suitably protected so as to preclude damage to the EHPS and EHPS equipment and have adequate capacity to tolerate contaminants in relation to the specified servicing intervals.

(c) Any reliance placed upon the assumed installed conditions or installation requirements must be declared in the instructions for installation as defined in EHPS.30.

(d) All approved lubricants and additives must be declared in the instructions for installation and operation of the EHPS as defined in EHPS.30.

EHPS.320 Cooling system

(a) The design and construction of the EHPS cooling system must ensure adequate cooling in all flight attitudes and atmospheric conditions in which the EHPS is expected to operate.

(b) Any reliance placed upon the assumed installed conditions or installation requirements must be declared in the instructions for installation as defined in EHPS.30.

(c) All approved coolants and additives must be declared in the instructions for installation and operation of the EHPS as defined in EHPS.30.

EHPS.330 Equipment

(a) Mountings and drives for all equipment to be installed on the EHPS sub-systems must be designed to permit safe operation of the EHPS with the equipment fitted.

(b) The failure of equipment installed on or driven by the EHPS sub-systems must not result in further damage likely to produce a Hazardous EHPS Effect, Hazardous Aircraft Effect or Catastrophic Aircraft Effect.

(c) Each item of installed equipment must be installed according to the limitations specified for that equipment.

(d) Environmental limits of the equipment identified under EHPS.20 that cannot be adequately substantiated in accordance with endurance tests, validated analysis, or a combination thereof must be demonstrated, via the system, equipment and component tests defined in EHPS.490.

EHPS.340 Ignition system

(a) If a sub-system of the EHPS requires the use of an ignition system, the suitability of the system must be established as a function of the nature of the concerned EHPS sub-system (i.e. continuous, or non-permanent ignition system).

(b) Any ignition system of the EHPS must be designed and constructed so as to ensure the proper functioning of the EHPS in all flight attitudes and atmospheric conditions in which the EHPS is expected to operate, including restart or relight operation as demonstrated in EHPS.460.

(c) Any reliance that is placed upon the assumed installed conditions or installation requirements must be declared in the instructions for installation as defined in EHPS.30.

EHPS.350 EHPS Control System

(a) The EHPS control system must be designed such that:

(1) the EHPS does not experience any unacceptable operating characteristics (including unacceptable power oscillations) or exceed any of its operating limitations

(2) the EHPS performs its intended function throughout the certified operational envelope of the intended aircraft application in a manner which:

(i) enables immediate modulation of EHPS power following a pilot command with adequate sensitivity

(ii) enables selected values of relevant control parameters over changing atmospheric conditions

(iii) complies with the operability specifications under EHPS.460.

(b) Development Assurance

Any software and Airborne Electronic Hardware, including programmable logic devices, must be designed and developed using a structured and methodical approach that provides a level of assurance, that is commensurate with the severity of the hazard associated with the failure or malfunction of the systems using this software or hardware, and is substantiated by a verification methodology acceptable to the Agency.

System aspects are addressed in EHPS.80 (a)(3).

(c) Validation

The EHPS control system must perform the intended functions in all flight attitudes and atmospheric conditions in which the EHPS is expected to operate.

(d) EHPS shutdown and isolation:

(1) There must be means to shutdown rapidly any sub-systems of the EHPS containing rotating parts.

(2) There must be means to isolate rapidly the components that could cause a hazard to the aircraft.

(e) EHPS control system failures.

The EHPS control system must:

(1) Meet the safety objectives of the intended aircraft application;

(2) Not have any single failures that result in Hazardous EHPS Effect(s) or Catastrophic Aircraft Effect; and

(3) Be designed and constructed so that foreseeable Failures or malfunctions leading to local events in the intended aircraft application, such as fire, overheat, electrical arcing or Failure leading to damage to EHPS Control System components, must not result in a Hazardous EHPS Effect or Catastrophic Aircraft Effect due to EHPS Control System Failures or malfunctions.

(f) Protection systems

(1) There must be a means for testing or inspecting any protection system necessary to show compliance with EHPS.80.

(2) It must be shown that any protection system necessary to show compliance with EHPS.80 remains available between tests or inspection and maintenance periods of the complete protection system.

(g) Aircraft-supplied data.

Single failures leading to a loss, interruption or corruption of aircraft-supplied data, or aircraft-supplied data shared between independent EHPS or independent engines of an EHPS must:

(1) Not result in a Hazardous EHPS Effect or Catastrophic Aircraft Effect for any EHPS installed on the aircraft; and

(2) Be detected and accommodated. The accommodation strategy must not result in an unacceptable change in thrust, lift or power or an unacceptable change in the EHPS operating and starting characteristics. The effects of these Failures on EHPS thrust, lift or power, EHPS operability and starting characteristics throughout the flight envelope must be evaluated and documented as part of the Instructions for installation and operation of the EHPS as stated in EHPS.30.

(h) Information system security protection.

EHPS control system, including networks, software and data, must be designed and installed so that they are protected from intentional unauthorized electronic interactions that may result in adverse effects on the EHPS. The security risks and vulnerabilities must be identified, assessed and mitigated as necessary. The applicant must make procedures and instructions for continued airworthiness (ICA) available that ensure that the security protections of the EHPS controls are maintained.

(i) Emergency rating availability

EHPS having an Emergency rating must incorporate means or provision for means for automatic availability and automatic control of the Emergency rating power within its operating limitations.

EHPS.355 Time-Limited Dispatch

(a) If approval is sought for dispatch with Faults present in an EHPS control system, a time limited dispatch (TLD) analysis of the EHPS control system must be carried out to determine the dispatch and maintenance intervals.

(b) For each dispatchable configuration it must be shown by test or analysis that:

(1) The EHPS remains capable of meeting all EHPS specifications for the operability aspects covered by EHPS.460

(2) The ability to control the EHPS within limits is maintained;

(3) Protection is maintained against Hazardous EHPS Effects and Catastrophic Aircraft Effect, if provided solely by the EHPS control system and shown to be necessary by the safety analyses required under EHPS.80 and EHPS.350;

(4) A means is maintained to provide necessary signals to identify EHPS control system Faults;

(5) A further single Failure in the EHPS control system will not produce a Hazardous Engine Effect or a Catastrophic Aircraft Effect;

(6) The EHPS continues to meet its certification specifications for external threats;

(7) The proposed dispatch interval is justified.

(c) The time-weighted-average of the Full-up Configuration and all allowable dispatch configurations with Faults must meet the safety objectives of the intended aircraft application.

(d) The periods of time allowed prior to rectification of Faults must be documented in the appropriate manual(s).

(e) Provision must be made for any no-dispatch configuration to be indicated to the flight crew.

EHPS.360 Aircraft instruments

(a) As defined in EHPS.80, the EHPS parameters to be displayed on the aircraft instruments required to ensure the safe operation of the EHPS must be established as part of the safety assessment process.

(b) Provisions must be made for the installation of the instruments established in EHPS.360 (a).

(c) Any reliance placed upon the assumed installation and operation must be declared in the instructions for installation and operation of the EHPS as defined in EHPS.30.

EHPS.370 Electrical power generation, distribution and wirings

(a) The electrical power generation, distribution and wirings of the EHPS must be designed and constructed so as to meet the Type-Certification basis of the intended aircraft application.

(b) The electrical power generation, distribution and wirings of the EHPS for any sub-system, as applicable, must be designed and installed to supply the power required for operation of connected loads during all intended operating conditions.

(c) Operation of connected loads must have no detrimental effects on the Electrical power generation, distribution and wirings.

(d) Disconnection of loads must have no detrimental effects on the Electrical power generation, distribution and wirings.

EHPS.380 Propulsion Battery

(a) If the EHPS contains a Propulsion Battery, the Propulsion Battery and its management system must be designed and constructed so as to meet the Type-Certification basis of the intended aircraft application.

(b) If the EHPS contains a Propulsion Battery, the Propulsion Battery must be designed and constructed so as to provide the required power supply for the electric engine(s) of the EHPS in order for the intended aircraft application to perform its mission.

(c) If the EHPS allows the electric engine(s) to operate in reverse mode and to recuperate energy in flight or on ground:

(1) the Propulsion Battery must be designed and constructed so as to absorb the power supply from the electric engine(s); or

(2) the energy must be dissipated and must not cause a Hazard to the aircraft.

SUBPART D – SUBSTANTIATION

Compliance with the requirements for Endurance, Durability, Vibration, Over Torque, Temperature limit demonstration, Operation (including Power Response, Rotor Locking, Operation with a variable pitch thruster, and Operation with a fixed pitch thruster) must be substantiated via test, validated analysis, or a combination thereof. The following provisions provide the objectives for these tests.

EHPS.410 General Conduct of Tests

(a) Maintenance of the EHPS is permitted during the tests in accordance with the service and maintenance instructions submitted in the Instructions for Continued Airworthiness defined in paragraph EHPS.25.

(b) The EHPS or its parts must be subjected to any additional tests and maintenance that the Agency finds necessary, if during the tests:

(1) the frequency of maintenance during the testing is excessive;

(2) the number of stops due to EHPS malfunction is excessive;

(3) a major repair is required; or

(4) the replacement of a part is found necessary.

(c) An applicant may use several EHPS or EHPS sub-systems to perform all tests required under Subpart D.

EHPS.420 Endurance Demonstration

(a) The EHPS must be subjected to an endurance demonstration of safe operation under all operational limits to be applied during service operation of the EHPS. The severity of the demonstration must consider the design and intended use of the EHPS and must include sufficient duration with respect to cycles and power settings.

(b) When approval is sought for a Normal Transient EHPS Exceedance, it must be substantiated that the EHPS is capable of operation at the maximum EHPS transient condition of the affected EHPS parameter(s) without maintenance action.

(c) When approval is sought for an Inadvertent Transient EHPS Exceedance, it must be substantiated that the EHPS is capable of operation at the maximum EHPS transient condition of the affected EHPS parameter(s) without maintenance action other than to correct any failure that led to the exceedance.

EHPS.430 Durability Demonstration

The EHPS must be subjected to a durability demonstration to show that each part of the EHPS has been designed and constructed to minimise the probability of failure of the system and sub-systems between overhaul periods, or between replacement intervals of EHPS components/parts. This substantiation must simulate the conditions in which the EHPS is expected to operate in service, including typical start-stop cycles and scheduled maintenance actions and must be of a sufficient duration in order to provide confidence in the durability of the EHPS.

EHPS.440 Calibration Assurance

The EHPS must be subjected to calibration tests that are necessary to establish its power characteristics and the conditions both before and after the endurance and durability demonstrations specified in Subpart D.

EHPS.450 Teardown Inspection

(a) After the endurance and durability tests have been completed, each EHPS must be subject to a strip inspection. The condition of the EHPS must be satisfactory for safe continued operation. EHPS components and equipment that function separately must be functionally checked prior to strip to ensure that any changes in function or settings are satisfactory for normal operation.

(b) Each EHPS component that has any adjustable setting or has a functional characteristic that can be established independent of installation on or in the EHPS, must retain each setting and functional characteristic within the limits that were established and recorded at the beginning of the demonstration.

(c) If the results of the teardown inspection show that the replacement of a part is necessary then the EHPS or its parts must be subjected to any additional tests that the Agency finds necessary.

EHPS.460 Operational Demonstration

(a) The operational demonstration must include tests, validated analysis, or a combination thereof to demonstrate the proper operability of the EHPS throughout its declared flight envelope and operating range.

The declared EHPS operational characteristics must account for installation loads and effects.

(b) *Starting and restarting/relighting*

(1) The applicant must demonstrate the capability of the EHPS to reliably start under all declared ground atmospheric temperature conditions.

(2) The EHPS design must allow the shutdown and restart or the relight of the EHPS, or the affected sub-system of the EHPS, in flight within an established envelope, unless not required for aircraft operation.

(c) *Power Response*

The design and construction of the EHPS must allow the EHPS to provide a power response that is suitable for the safe operation of intended aircraft application.

EHPS.470 Rotor Locking Demonstration

If continued rotation is prevented by a means to lock the rotor(s), the EHPS must be subjected to tests, validated analysis, or a combination thereof that includes repeated locking and unlocking operations to sufficiently establish reliable rotor locking performance.

EHPS 480 EHPS Specific operation

(a) If the EHPS is designed to operate with a propeller or an aircraft rotor, all applicable EHPS demonstrations required by this special condition must be performed with a representative propeller or aircraft rotor.

(b) Other specific operations, for which certification is sought, must be substantiated by specific tests or complementary tests to the endurance and durability tests.

(c) For each declared rating with a duration of two minutes or less, it must be substantiated that the EHPS sub-systems (except the propulsion battery if any) can sustain operation at its temperature limits plus a suitable margin.

EHPS.490 System, equipment and component tests

For those systems and components that cannot be adequately substantiated in accordance with endurance tests, validated analysis, or a combination thereof, additional tests must be conducted to demonstrate that systems or components are able to perform their intended functions in all declared environmental and operating conditions.

Associated Interpretative Material / Means of Compliance

The following notes about Means of Compliance are published for awareness only in order to ease the reading of the Special Condition.

1. The Means of Compliance are intended to be published as a Matrix. The Applicant should select the components that constitute their EHPS. For each component, there will be a proposed means of compliance for each relevant requirement of the Special Condition.
2. The Means of Compliance may be different depending the intended aircraft application.
3. The Means of Compliance will be based on existing material (such as CS-E, ASTM F3338-18, existing Special Conditions…)
4. EHPS.40 (g): "at all time during the flight". The Means of Compliance should at least cover the measurement and control system accuracy as well as the State of Charge and State of Health of Energy Storage Devices such as batteries
5. EHPS.50: The Means of Compliance should at least cover CS-E 70 (Materials and Manufacturing Methods) and CS-E 90 (Prevention of Corrosion and Deterioration).
6. EHPS.80 (b): The Means of Compliance should at least cover CS-E 850 (Compressor, Fan and Turbine Shafts), AMC CS-E 850 and the associated CM.
7. EHPS.200 (a): "The loads induced by any part of the EHPS": The Means of Compliance should at least cover pressure loads, static loads from a sub-system of the EHPS on another, and when applicable LCF (Low Cycle Fatigue)
8. EHPS.200 (c): The Means of Compliance should at least cover CS-E 190 (Engines for Aerobatic Use)
9. EHPS.240: The Means of Compliance should at least cover CS-E 840 (Rotor Integrity)
10. EHPS.270: "and/or installed". The Means of Compliance should at least cover aircraft air protections (cowlings, air intake screens…)
11. EHPS.280: The Means of Compliance should at least cover CS-E 230 (De-Icing and Anti-Icing Precautions)
12. EHPS.290 (a): "and/or installed". The Means of Compliance should at least cover aircraft air protections like on rotorcrafts
13. EHPS.300 (a): "atmospheric conditions". The Means of Compliance should at least cover fuel icing risk
14. EHPS.300 (b): "evidence". The Means of Compliance should at least cover CS-E 670 (b) (Contaminated Fuel)
15. EHPS.300 (c): The Means of Compliance should at least cover CS-E 660 (Fuel Pressure and Temperature)
16. EHPS.320 (a): The Means of Compliance should at least cover CS-E 580 (Air Systems) for protection of air system against dust and sand and CS-E 860 (Turbine Rotor Over-temperature)
17. EHPS.330 (d): The Means of Compliance should at least cover CS-E 80 (Equipment) and its AMC and the use of DO-160
18. EHPS.340: The Means of Compliance should at least cover CS-E 240 (Ignition), CS-E 360 (Detonation Tests), CS-E 460 (Backfire Tests), CS-E 500 (c) (Functioning), CS-E 720 (Continuous Ignition)
19. EHPS.350 (a) : The Means of Compliance should at least cover the recuperation mode (operation of electric engines as generators to recharge any energy storage device) if any
20. EHPS.350 (e): The essentially single fault tolerant criteria that was present in CS-E 50 (Engine Control System) should be part of the Means of Compliance to EHPS.80 when developing a control system for turbine or piston engines

21. EHPS.370: The Means of Compliance should at least cover CS-E 135 (Electrical Bonding)
22. EHPS.370 (b): The Means of Compliance should at least cover the electrical network quality
23. EHPS.380 (b): The Means of Compliance should cover the energy losses with regards to the State of Charge (SoC) and State of Health (SoH) of batteries which could help determining the maximum available power used for aircraft performances calculation.
24. 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)
25. 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"
26. 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.
27. EHP.460 (a): The Means of Compliance should at least cover CS-E 500 (a) (Functioning)
28. EHPS.460 (b)(1): The Means of Compliance should at least cover CS-E 370 (Starting Tests), CS-E 590 (Starter Systems)
29. EHPS.460 (b)(2): The Means of Compliance should at least cover CS-E 910 (Relighting in Flight)
30. EHPS.460 (e)(2): The Means of Compliance should at least cover any other important equipment other than propeller or thrust reverser, specific functions (such as energy recuperation), CS-E 700 (Excess Operating Conditions), CS-E 860 (Turbine Rotor Over-temperature), CS-E 900 (Propeller Parking Brake), CS-E 890 (Thrust Reverser Tests), CS-E 880 (Tests with Refrigerant Injection for Take-Off and/or 2 ½-Minute OEI Power), CS-E 290 (Hand Turning)
31. EHPS.480 (c): The Means of Compliance should at least cover CS-E 920 (Over-temperature Test).
32. EHPS.490: The Means of Compliance should at least cover the qualification tests of equipment (use of DO-160), ignition tests.