EASA European Union Aviation Safety Agency	**Special Condition**	Doc. No. : **SC E-19** Issue : 1 Date : 27/01/2020 Proposed ☒ Final ☐ Deadline for comments: 06/03/2020

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.

The certification specifications that are usually applicable to aircraft engines are contained in CS-E amendment 5 or CS-22 subpart H. However none of these certification specifications consider Electric and / or Hybrid Propulsion Systems.

The purpose of this special conditions is to provide the certification requirements for an Electric and / or Hybrid Propulsion System.

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 Acceptable Means of Compliance. Acceptable 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.

Contents

SUBPART A - GENERAL

EHPS.10 Scope

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 any manned and unmanned aircraft (except CS-25 aircrafts), both during normal and emergency operations. CS-25 aircrafts are excluded at this stage because emissions requirements are not yet defined for EHPS.

This Special Condition is applicable to any Electric / Hybrid Propulsion System without any power range limitations.

Electric / Hybrid Propulsion Systems that are not used to produce lift/thrust/power in flight are outside of the scope of this Special Condition. As an example, electric motors that drive wheels for taxiing or electric motors for air conditioning systems are outside of the scope of this Special Condition.

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

This Special Condition addresses the interface aspects between rotors and/or propellers and the conditions for installation of the Electrical Propulsion Unit into a manned or unmanned aircraft.

Additional certification requirements beyond this Special Condition 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 Acceptable 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, when specifically accepted by the Agency at project level.

(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 motors, inverters, turbine engines, piston engines, generators, electrical wiring interconnection systems, electrical power generation, energy storage systems, integrated fans, cooling systems and power management system. An EHPS is intended to produce lift, thrust or power for flight.
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, a EHPS control system or, an energy storage system
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 excluding any battery or energy storage device management system
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 an engine and/or generator rating intended to be used in the event of a failure leading to a power and/or thrust 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.
Normal rating	Means an engine and/or generator rating intended to be used during normal EHPS operations. It includes normal transient exceedances.
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.
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. As a minimum, the following effects must be regarded as Hazardous EHPS Effects: (i) Non-containment of high-energy debris, (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) Release of the propeller by the EHPS, if applicable, (vii) Complete inability to shut down the EHPS. (viii) Electrocution of crew, passengers, operators or maintainers, sufficient to cause serious or fatal injury.
Hazardous EHPS failure condition	Failure conditions leading to one of the following effects: (i) Hazardous Aircraft Effect (ii) Catastrophic Aircraft Effect
Catastrophic Aircraft Effect	Effect of a Catastrophic Aircraft Failure Condition
Catastrophic Aircraft Failure Condition	Failure conditions defined as Catastrophic in the Type-Certification basis of intended aircraft application.
Hazardous Aircraft Effect	Effect of a Hazardous Aircraft Failure Condition
Hazardous Aircraft Failure Condition	Failure conditions defined as Hazardous in the Type-Certification basis of intended aircraft application
Major Aircraft effect	Effect of a Major Aircraft Failure Condition

Major Aircraft Failure Condition	Failure conditions defined as Major in the Type-Certification basis of 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.

EHPS.20 EHPS Configuration

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

EHPS.22 Identification

(a) The EHPS identification must comply with 21A.801 (a) and (b), and 21A.805.

(b) Major EHPS modules that can be changed independently in service must be suitably identified so as to ensure traceability of parts and to enable proper control over the interchangeability of such modules with different EHPS variants.

EHPS.25 Instructions for Continued Airworthiness (ICA)

(a) In accordance with 21A.61(a), 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 or can be provided in the aircraft relevant manuals if the EHPS is certified as part of the aircraft certification.

(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 replacement time, structural inspection interval, and related structural inspection procedure 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 manual for installing and operating the EHPS

(a) Each 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 installing and operating the EHPS.

(b) The instructions must include at least the following:

(1) Installation instructions for each system which constitutes the EHPS,

(2) Operating instructions and limitations,

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

(4) The Type-Certification Basis which is (are) assumed as being applicable to the intended aircraft application must be identified in the installation instructions,

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

(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.

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 found necessary for safe operation of the EHPS. Ratings and operating limitations shall be approved by the Agency.

(b) EHPS operating limitations includes any limitation required to be monitored 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 needed.

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

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

(e) Emergency rating(s) shall be established separately from the normal ratings, and the specific failures associated with each emergency rating must be defined for each, to enable the aircraft safety analysis to be carried out.

(f) Each selected rating must be for the lowest power that all EHPSs of the same type is 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.

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 properties of materials must be suitably related to the minimum properties stated in the material specification and 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.

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) Aircraft-level devices and procedures assumed to be associated with a typical installation or the intended aircraft application. Such assumptions must be stated in the analysis. , and detailed in the Installation Instructions of EHPS.30.

(ii) Consequential secondary Failures and dormant Failures.

(iii) 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 and quantitative safety objectives defined in the type-certification basis of the intended aircraft application.

(c) 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).

(d) 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:

(i) necessary for preventing the occurrence of Hazardous EHPS Effects at a rate in excess of Extremely Remote; or

(ii) the occurrence of Hazardous and Catastrophic Aircraft Effects at rates in excess of the rates defined in the associated Type-Certification basis of the intended aircraft application(s)

(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) Flight crew actions. These actions must be identified in the operating instructions manual and appropriately substantiated at aircraft level if the intended aircraft application is known.

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 Engine Critical Part to be withdrawn from service at an Approved Life before Hazardous Engine 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 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 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 minimise the effect of such a fire.

(b) In addition, the design and construction of the EHPS must minimize 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 or induced by the intended aircraft application must be established.

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

EHPS.210 Strength

(a) A mechanical and thermal 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) 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.220 Mounting Attachment and Structure

(a) The maximum allowable loads for EHPS mounting attachments and related structure must be specified by the applicant in the Installation Manual to ensure that the installer can develop the appropriate aircraft mount interface.

(b) The EHPS mounting attachments and related structure must be able to withstand the specified loads without failure, malfunction, or permanent deformation.

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, including defined exceedances, without inducing excessive stress in any of the EHPS parts because of 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, aerodynamically induced, acoustically induced or electrical field excitation induced 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 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. Those shall account for failure conditions, 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).

(c) EHPS operating limitations that affect rotor structural integrity must not be exceeded in service.

EHPS.250 Compressor or turbine blade failure containment

If the EHPS contains a compressor or a turbine, it must be demonstrated that after Failure any single compressor or turbine blade will be radially 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 shutdown 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 not result in any Hazardous EHPS Effects.

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 the certification standard concentration of rain.

EHPS.280 Icing and snow conditions

The EHPS and any of its sub-system 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, as specified in EHPS.30 (e).

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

(a) The EHPS must be designed and/or installed so that any impact by 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) It must also be shown that the impacts defined on EHPS.290 (a) will not preclude the continued safe flight and landing (as defined in the Type-Certification Basis of the intended application(s)) 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) Multiple impacts must be included in the demonstration unless it can be shown that they are unlikely to occur in any one flight

SUBPART C – SYSTEMS and EQUIPEMENTS

EHPS.300 Fuel system

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

(b) If the EHPS contains reciprocating engines or turbine engines, 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, 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.

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.

(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.

EHPS.320 Cooling system

(a) The design and construction of the EHPS cooling system must ensure adequate cooling in all normal operating conditions within the declared flight envelope.

(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.

EHPS.330 Equipment

(a) Mountings and drives for all equipment to be installed on the EHPS 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 must not result in further damage likely to produce a Hazardous EHPS 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.

(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.

EHPS.350 EHPS Control System

(a) The EHPS control system must ensure that the EHPS does not experience any unacceptable operating characteristics or exceed any of its operating limitations.

(b) Design Assurance
Any software and complex electronic hardware, including programmable logic devices, shall be designed and developed using a structured and methodical approach that provides a level of assurance for the logic, that is commensurate with the severity of the hazard associated with the failure or malfunction of the systems in which the devices are located, and is substantiated by a verification methodology acceptable to the Agency.

(c) Validation
The EHPS control system must perform the intended functions throughout the declared operational envelope.

(d) Environmental limits.

(1) Environmental limits 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.

(2) The environmental limits must be established and documented in the Installation Manual required by EHPS.30.

(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 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

The design and functioning of EHPS control devices and systems, together with EHPS instruments and operating and maintenance instructions, must provide reasonable assurance that the EHPS operating limitations will not be exceeded in service.

(g) Aircraft-supplied data.
Single failures leading to a loss, interruption or corruption of aircraft-supplied data (other than power command signals from the aircraft), or aircraft-supplied data shared between independent EHPS or independent engines of a 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.

(h) Information system security protection.
EHPS control systems, 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 safety of the aircraft. 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.

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 Engine 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 Instrument and Sensor Connection

Provisions must be made for the installation of instrumentation or sensors necessary to ensure EHPS operation within all operating limitations.

EHPS.370 Electrical power generation and distribution

(a) The electrical power generation and distribution 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 and distribution of the EHPS for any 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 shall have no detrimental effects on the Electrical power generation and distribution.

EHPS.380 Energy Storage System

(a) If the EHPS contains an energy storage device, the energy storage device 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 an electric energy storage device providing electric energy to an electric engine(s), it must be designed and constructed so as to provide the required energy for the electric engine(s) of the EHPS at all time during the flight in order for them to provide the rated powers defined in EHPS.40.

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) Upon completion of the tests in Subpart D, the EHPS and its components must comply with EHPS.450, and be capable of operating at its declared ratings while remaining within limits.

EHPS.420 Endurance Demonstration

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

(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

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

EHPS.440 Calibration Assurance

Each EHPS must be subjected to those calibration tests 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 test have been completed, the EHPS must be completely disassembled. Each EHPS component must be within service limits and eligible for continued operation in accordance with information submitted with the instructions for continued airworthiness provided in EHPS.25.

(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 performance of the EHPS (starting, power cycling, acceleration, overspeeding, etc.) 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 safely start under all declared 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 it is shown that there is no safety benefit of providing this functionality.

(c) *Power Response*

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

(d) *Rotor Locking Demonstration*

If shaft 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.

(e) *EHPS specific operation*

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

(2) Other specific operations, for which certification is sought, must be substantiated by specific tests.

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 Interpretative Material / 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 selects the components that constitute his 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 will be based on existing material: CS-E, CS-22 Subpart H, ASTM F3338-18, existing Special Conditions…
3. EHPS.40 (f): "at all time during the flight". Associated AMC 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
4. EHPS.50: Associated AMC should at least cover CS-E 70 (Materials and Manufacturing Methods) and CS-E 90 (Prevention of Corrosion and Deterioration).
5. EHPS.80 (c): Associated AMC should at least cover CS-E 850 (Compressor, Fan and Turbine Shafts), AMC CS-E 850 and the associated CM.
6. EHPS.200 (a): "The loads induced by any part of the EHPS": Associated AMC should at least cover pressure loads, static loads from a sub-system of the EHPS on another, and when applicable LCF
7. EHPS.200 (b): Associated AMC should at least cover CS-E 190 (Engines for Aerobatic Use)
8. EHPS.240: Associated AMC should at least cover CS-E 840 (Rotor Integrity)
9. EHPS.270: "and/or installed". Associated AMC should at least cover aircraft air protections (cowlings, air intake screens…)
10. EHPS.280: Associated AMC should at least cover CS-E 230 (De-Icing and Anti-Icing Precautions)
11. EHPS.290 (a): "and/or installed". Associated AMC should at least cover aircraft air protections like on rotorcrafts
12. EHPS.300 (a): "atmospheric conditions". Associated AMC should at least cover fuel icing risk
13. EHPS.300 (b): "evidence". Associated AMC should at least cover CS-E 670 (b) (Contaminated Fuel Contaminated Fuel)
14. EHPS.300 (c): Associated AMC should at least cover CS-E 660 (Fuel Pressure and Temperature)
15. EHPS.320 (a): Associated AMC 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)
16. EHPS.330 (d): Associated AMC should at least cover CS-E 80 (Equipment) and its AMC and the use of DO-160
17. EHPS.340: Associated AMC 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)
18. EHPS.350 (a) : Associated AMC should at least cover the recuperation mode (operation of electric engines as generators to recharge any energy storage device) if any
19. EHPS.350 (e): The essentially single fault tolerant criteria that was present in the CS-E 50 (Engine Control System) should be an AMC to EHPS.80 when developing a control system for turbine or piston engines

20. EHPS.370: Associated AMC should at least cover CS-E 135 (Electrical Bonding)
21. EHPS.370 (b): Associated AMC should at least cover the electrical network quality
22. EHPS.380 (b): this covers the energy losses with regards to the State of Charge (SoC) and State of Health (SoH) of batteries for example, i.e., the maximum available power used for aircraft performances calculation in the aircraft flight manual shall be declared for the minimum allowed SoC and SoH.
23. EHPS.420: Associated AMC should at least cover CS-E 690 (Engine Bleed), CS-E 440 (Endurance Tests) and CS-E 470 (Contaminated Fuel)
24. EHPS.420 (b): Associated AMC should at least cover the existing Special Condition "Transient over-temperature, over-speed and over-torque limit approval"
25. EHPS.420 (c): Associated AMC 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.
26. EHP.460 (a): Associated AMC should at least cover CS-E 500 (a) (Functioning)
27. EHPS.460 (b)(1): Associated AMC should at least cover CS-E 370 (Starting Tests), CS-E 590 (Starter Systems)
28. EHPS.460 (b)(2): Associated AMC should at least cover CS-E 910 (Relighting in Flight)
29. EHPS.460 (e)(2): Associated AMC should at least cover any other important equipment other than propeller or thrust reverser, specific functions (like energy recuperation), CS-E 700 (Excess Operating Conditions), CS-E 860 (Turbine Rotor Over-temperature), CS-E 920 (Over-temperature Test), 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)
30. EHPS.490: Associated AMC should at least cover the qualification tests of equipments (use of DO-160), ignition tests.