SUBJECT	:	**LSA Propulsion Lithium Batteries**
CERTIFICATION SPECIFICATION	:	CS LSA Amdt 1
PRIMARY GROUP / PANEL	:	5 (Electrics)
SECONDARY GROUPE / PANEL	:	6 (Avionics), 11 (Cabin Safety), 8 (ECS), 3 (Structures), 7 (Power Plant)
NATURE	:	Special Condition

Special condition applicable to LSA Propulsion Batteries

Introductory note:

Lithium Batteries, intended to be used as Energy Storage Device (ESD) as part of the Electric Propulsion Unit (EPU) on LSA aeroplanes, have specific failure and operational characteristics, and maintenance requirements that differ significantly from those of the nickel cadmium (Ni-Cd) and lead acid rechargeable batteries used for energy storage.

At present there is limited experience regarding the use of rechargeable Lithium Batteries in applications involving (commercial) aviation, and even less experience regarding their specific use in Electric and Hybrid Propulsion Systems. However, other users of this technology ranging from smartphones manufacturers to the electric vehicle industry have noted significant safety issues regarding the use of these types of batteries.

Statement of issue

Review of the adequacy of the existing battery requirements with respect to the chemistry and novel use of lithium batteries for Electric Propulsion has shown missing items. Several failure, operational, and maintenance characteristics of lithium batteries used for electric propulsion, that could affect safety and reliability of those battery installations, are not adequately addressed.

Therefore as mandated by Part 21, 21A.16B, the proposed Special Condition is to establish appropriate airworthiness standards for lithium batteries used for electric propulsion for Light Sport Aircraft (LSA).

In the absence of relevant experience, the special condition proposed at the time is generic in nature and does not differentiate between different types of lithium chemistry, battery capacity or intrinsic safety features of the batteries used. It is envisaged that some adaptation will need to be done in the future to tailor the Lithium Propulsion Battery requirements to those different characteristics as the technology develops.

Special Condition SC-LSA-F2480-01, LSA Propulsion Batteries

LSA Propulsion batteries design and installation must comply with the following requirements:

- Each propulsion battery shall be constructed and arranged in such a way to safely ensure a flow of energy as required for the proper engine functioning under any normal operating conditions, including any maneuver for which certification is requested and during which the EPU is permitted to be in operation.

- Effects on the propulsion battery, of the propulsion system in a wind milling condition, when the Engine might work as a generator, shall be considered.

- Safe battery cell temperatures and pressures must be maintained during any normal operating condition (charging or discharging, ground or flight operations).

- Battery design and installation shall preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure at the battery level.

- Characteristics of the batteries, including failure modes (such as: thermal runaway, expansion, explosion, toxic emission) should be identified.

- Batteries cells and other subcomponents of the system should be designed, assembled and installed so as to minimize the effects of these failure modes. Design precautions might include :
    - Mitigating the effect of thermal runaway or fire, and ensuring the surrounding structure is able to withstand the thermal loads, corrosive fluids or gasses.
    - Designing the battery and/or the battery installation compartment to prevent hazardous overpressurization scenarios.

- Li battery installations must have a system to control the charging rate of the battery automatically so as to prevent battery overheating or overcharging, and,
    - A battery temperature sensing and over-temperature warning system with a means for automatically disconnecting the battery from its charging source in the event of an over-temperature condition and,
    - A battery failure sensing and warning system with a means for automatically disconnecting the battery from its charging source in the event of battery failure.

- A protection against overcharge and critical discharge of the batteries shall be provided including deep or unbalanced discharge if necessary for the type of battery.

- The usable ESD energy quantity shall be established.
    - Some designs might prevent using the full energy quantity in order to avoid damaging the energy source. In this case, the remaining corresponding energy quantity shall be declared as unusable.

  - Other designs might allow the crew to use the full energy quantity in case of emergency, with or without requiring a specific crew action. In such cases, the cockpit indication should be designed adequately, and proper instructions for continued airworthiness and servicing shall be provided to ensure the energy source capacity is subsequently restored after the flight.

- Batteries shall be designed and installed in such a way that the occupants may not be harmed or injured. In particular :
  - No leaking fluids and vapors may have direct contact to any occupant.
  - The occupants may not be endangered in case of a forced landing.

- Design precautions shall be provided for battery and its installation, to prevent chafing between its components, supports or the surrounding structure, if such chafing may arise.

- Electric cables shall be installed in such a way that the electromagnetic and reciprocal influencing do not endanger safe operation (for instance, due to induction).

- The design and installation of the batteries and conductors, including routing, attachments and connectors shall minimize the risk of electric shock in high voltage systems (HV).
  - High voltage shall not be exposed at any accessible location on the aircraft during normal routine operation.
  - High Voltage cables shall be clearly identifiable (such as by using a dedicated color code).

- The suitability and reliability of batteries shall be proved based on experience or tests, or based on a plan to be agreed upon with EASA. Battery and Battery cells should be qualified according to accepted standards (for instance: RTCA/DO 311) or based on a plan to be agreed with EASA.

- The maintenance manual must contain procedures for correct storage and management of Propulsion Batteries in spares storage, to prevent the replacement of Propulsion Batteries with batteries that have experienced degraded charge retention ability or other damage due to prolonged storage at low state of charge (SOC).

Useful Standards

- EN ISO 7010 - Graphical symbols — Safety colors and safety signs
- ASTM F2480 - Standard Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft (LSA)
- ASTM F2245 - Standard Specification for Design and Performance of a Light Sport Airplane
- RTCA/DO 311 Minimum Operational Performance Standards for Rechargeable Lithium Battery Systems