Certification of Propulsion Batteries for eVTOL

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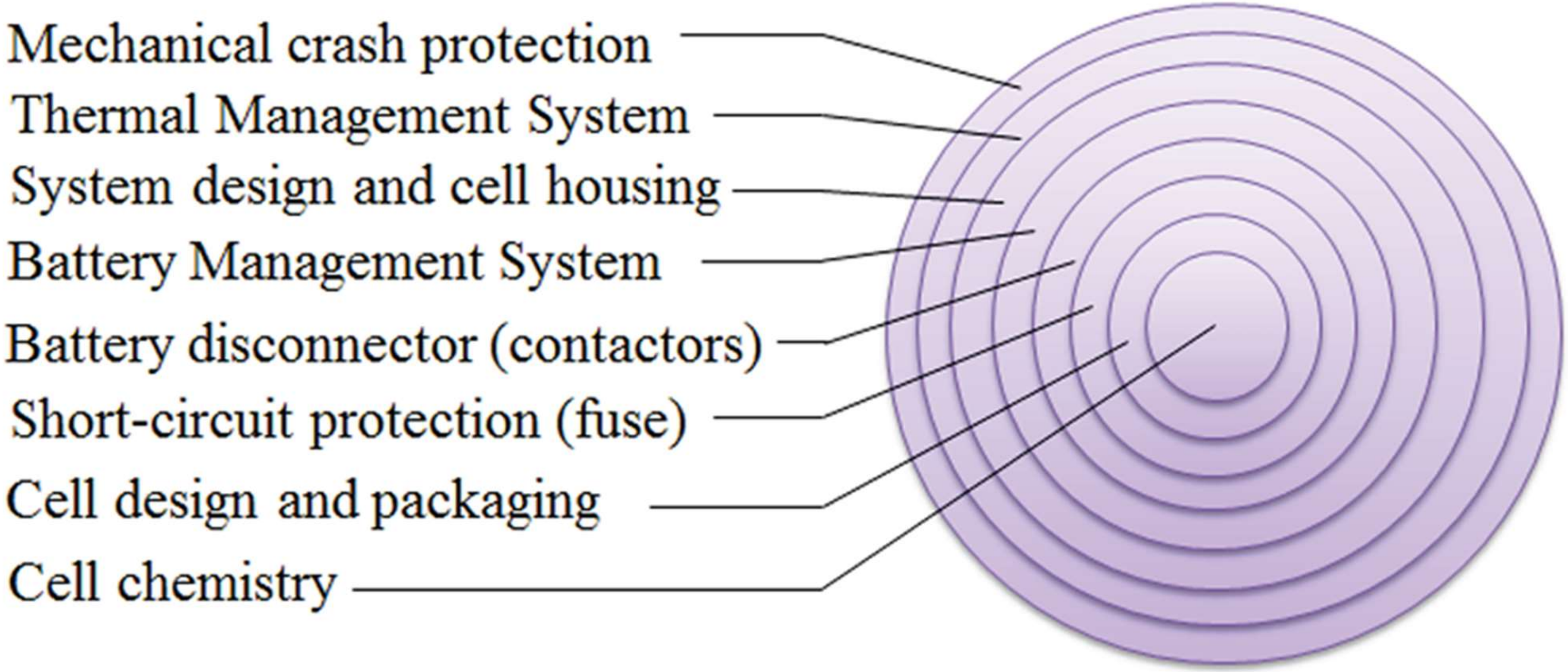
EASA SAFETY STRATEGY FOR PROPULSION BATTERIES

- **Particularities of Propulsion Batteries:**
  - Higher Capacity, size and weight (≈25% of the weight of the aircraft)
  - Higher Voltages (300V-1000V) → Electroshock and corona effects
  - High specific energy/power needed → Lower safety profile (i.e. NMC)
  - New critical function as "e-fuel"
- **Protection Layers from cell to aircraft installation level**
- **Proportionality between different products (from sailplanes to eVTOLs)**
- **Lesson learnt and knowledge acquired during the last decade in aviation and other industries**
- **Based on these EASA is developing/contributing to new means of compliance**

Several initiatives are on going to harmonize with FAA and other authorities

EASA SAFETY STRATEGY FOR PROPULSION BATTERIES

Safety Approach based on different protection layers



Source: Article "Lithium-Ion Battery Aspects on Fires in Electrified Vehicles on the Basis of Experimental Abuse Tests"

EASA SAFETY STRATEGY FOR PROPULSION BATTERIES

- **CELL LEVEL**
  - Quality cells from robust suppliers (Under POA) → Possible issue with some cell suppliers
  - Cell incoming inspection and testing (Uniformity, reduction of manufacturing defects)
  - Proper mechanical layout of cells (Cell clearance and venting orientation)
  - Proper electrical insulation of cells to avoid shorting a cell and between cells
  - Proper mechanical layout of cells (Cell clearance and venting orientation)
  - Proper thermal isolation of cells to avoid propagation of Thermal runaway between cells
  - Full characterization of thermal runaway behaviour at cell level for tests at battery level
    - Different trigger methods (overvoltage and/or overheating as preferred)
    - Different State of Charges
    - Different overheating rates and positions of the heater in the cell

EASA SAFETY STRATEGY FOR PROPULSION BATTERIES

- **BATTERY LEVEL**
  - Manufacturing, design, operation and maintenance guidelines in accordance with DO-311A
  - Containment Tests: Battery System able to safely manage 20% of the cells in the battery or submodule in Thermal Runaway (internal layout, casing, venting, sub-modularization…)
  - Thermal Runaway criticality of more than 2 cells not relaxed due to containment tests
    - Battery Management System (BMS) with protective and warning features with the highest Development assurance level (DAL)
    - High cell reliability imposed (very low cell thermal runaway failure rate)
  - Proper routing practices to protect internal battery system wiring and conductors
    - Short-circuits and corona discharge (due to High Voltage)
    - Heat and chemical damage

EASA SAFETY STRATEGY FOR PROPULSION BATTERIES

- **INSTALLATION LEVEL**
  - The maximum error for the available/accessible energy estimation shall be calculated and considered in the design
  - Available/Accessible energy shall be clearly indicated to the pilot
  - Isolation Monitor to detect any decrease on isolation of the High Voltage system
  - Aircraft installation location shall consider (guidelines DO-311A section 3):
    - Temperatures that the battery may generate during any failure conditions
    - The potential external threats (mechanical and thermal) to the Battery system
    - Venting and draining provisions at A/C level for flammable or toxic gases, smoke or fluids
  - Drop test from 15m for the battery system (Similar to the fuel tank test in Rotorcrafts)
    - No risk of post-crash fire or other harmful release within the time frame compatible with the rescue of seriously injured occupants (15 min.)

CERTIFICATION MATERIAL, MOCs AND STANDARDS

- **VTOL Means of Compliance developed in EASA:**
  - MOC VTOL.2430(a)(3) and (a)(4) Accessible energy in electrical energy storage systems
  - MOC VTOL.2440 Propulsion Batteries Thermal Runaway
  - MOC VTOL.2325(a)(4) Fire Protection - Energy storage crash resistance
  - MOC VTOL.2330 Fire Protection in designated fire zones (Including Battery Explosive Fire Zone)
  - MOC VTOL.2400 (c)(3) Hazards to Crew, Passengers and Ground Personnel by Electromagnetic Fields generated by High Voltage (consultation)
  - MOC VTOL.2525 System power generation, energy storage, and distribution (consultation)

- **Propulsion Batteries - EUROCAE WG 112 VTOL SG-1 Electrical:**
  - ED-289 “Guidance on determination of accessible Energy in Battery Systems for eVTOL Applications”
  - ED-309 “Guidance on VTOL Energy Level Information Provided to the Crew”
  - ED-308 “Guidance on VTOL Charging Infrastructure”
  - ED-312 “Guidance on Determining Failure Modes in Lithium-Ion Cells for eVTOL Applications”
  - DP001 “Crashworthiness Test of Battery Systems for eVTOL Applications” (consultation)
  - DP003 “Testing and Qualification of a Lithium-Ion Battery” (consultation)

CERTIFICATION MATERIAL, MOCs AND STANDARDS

- **High Voltage - EUROCAE WG 112 VTOL SG-1 Electrical:**
  - ED-290 “Guidance on High Voltage Definition and Consideration for Personal Safety”
  - ED-296 “Guidance on Design Assurance for High Voltage Standards and Power Quality for VTOL Applications”
- **High Voltage - EUROCAE WG 116 “High Voltage Systems and Components in Aviation”:**
  - ED-320 “Aging Mechanisms of Electrical Insulation Materials in a High Energy System” (consultation)
  - DP006 “Test Guidelines for Electrical Insulation Materials and Components for a HV System” (consultation)
  - DP001 “Guidance for Aircraft High Voltage Power Quality” (2024)
  - DP004 “Guidance for High Voltage Risk Mitigation at EWIS and Human Safety Level” (2024)
- **New EU Regulation on Batteries and waste batteries (July 2023)**
  - Harmonized regulatory framework for the entire life cycle of batteries in a sustainable and safe way→ Applicable to Aviation (industrial category)
  - Some requirements only applicable for batteries > 2 kWh → Impacting aviation propulsion batteries:
    - Carbon footprint declaration (label, classes, max. threshold limit) from 2025
    - Minimum percentage of recovery and use of active materials (95%→26% Cobalt, 80%→12% Lithium, 95%→15% Nickel)
    - Minimum values of electrochemical performance and durability requirements (i.e. capacity and power fade, efficiency, lifetime)

Thank you
for your attention!

Your safety is our mission.

EASA
European Union Aviation Safety Agency

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