Lithium Battery Systems for Aerospace Applications

Technical Standard Order (TSO) Requirements and Minimum Performance Standards (MPS)

Presented to: FAA TSO Workshop

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Outline

- **Provide awareness of the FAA technical standard orders associated with lithium battery and battery systems**
  - Aircraft manufacturers and operators are incorporating rechargeable and non-rechargeable lithium battery TSOs at a rapid pace
  - The minimum performance standards for both rechargeable and non-rechargeable lithium batteries will be utilized for the compliance to the TSOs

Background

- **Benefits from using lithium technology:**
  - Significant weight reduction
  - High energy storage capabilities
  - Reduced maintenance intervals
- **Lithium batteries and battery systems have certain airworthiness considerations**
- **As with any relatively new technology, we continue to learn more about the safety and performance characteristics of both rechargeable and non-rechargeable lithium batteries**

Lithium Batteries

- **Examples of lithium batteries and battery systems:**
  - Cockpit displays
  - Underwater Locater Beacons
  - Emergency Locater Transmitters (ELT)
  - Main and Auxiliary Batteries
  - Brakes
  - Emergency batteries (e.g., EXIT signs)
  - Emergency lighting
  - Seat belt systems

Potential Issues with Rechargeable Lithium Batteries

- **Overcharging:**
  - **In general, rechargeable lithium batteries have different internal failure causes than nickel-cadmium or lead-acid batteries**
    - Thermal runaway: lithium batteries could be overcharged and result in uncontrolled increase in temperature and pressure
    - Can result in overcharging of internal cell components
  - **Battery capacity, not just size, should be considered due to the higher amount of electrolyte and energy**

Potential Issues with Rechargeable Lithium Batteries (Continued)

- **Over-discharging:**
  - **Discharge of some types of these batteries beyond a certain voltage (typically 2.4 volts) can cause corrosion of the electrodes in the cells**
  - **For rechargeable lithium batteries, recharging a damaged battery or battery system can lead to an uncontrollable exothermic reaction**
    - Corroded electrodes become a source of short circuit and may result in a chemical reaction between the electrolyte and the solvent
    - This may result in an uncontrolled increase in temperature and pressure

Potential Issues with Rechargeable Lithium Batteries (Continued)

- **Internal Short Circuit:**
  - **Could be due to many attributes including, but not limited to:**
    - **Manufacturing Defects**
    - **Impurities**
    - **Foreign Object Deposits**
  - This may result in uncontrolled increase in temperature and pressure leading to a thermal runaway
- **Lithium Plating and Dendrites:**
  - **Known to occur at low temperature operation**
  - This may result in uncontrolled increase in temperature and pressure leading to a thermal runaway

Potential Issues with Non-Rechargeable Lithium Batteries

- **Internal Short Circuit:**
  - **Could be due to many attributes including, but not limited to:**
    - **Manufacturing Defects**
    - **Impurities**
    - **Foreign Object Deposits**
  - This may result in uncontrolled increase in temperature and pressure leading to a thermal runaway
- **Reverse Voltage in Non-Rechargeable Lithium batteries:**
  - This is a possibility for a non-rechargeable battery of more than one cell
  - This may also lead to a thermal runaway event

Example of Thermal Runaway Event – Boston Airport in 2013

RTCA Special Committee 225 (SC225) for Rechargeable Lithium Batteries

- **Committee Members**
  - Design experts of lithium battery chemistry
  - Manufacturing and testing experts from the lithium battery industry
  - Installation experts of lithium batteries from the industry
  - Research experts of lithium battery technology
  - The following are some of the committee members: (40 to 60 active members)
    - Cell manufacturers (domestic and foreign)
    - Battery manufacturers (domestic and foreign)
    - Equipment manufacturers (domestic and foreign)
    - NASA
    - Airline Pilots Association
    - Civil Aviation Authorities (FAA, EASA, TCCA, ANAC)

RTCA DO-311A Minimum Operational Performance Standard

- **Approval and Release of RTCA DO-311A document by RTCA**
  - The RTCA Program Management Committee (PMC) approved and released the RTCA DO-311A , Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems on 19 December, 2017

Example of Thermal Runaway Event – Heathrow Airport in 2013

RTCA Special Committee 235 (SC235) for Non-Rechargeable Lithium Batteries

- **Committee Members**
  - Design experts of lithium battery chemistry
  - Manufacturing and testing experts from the lithium battery industry
  - Installation experts of lithium batteries from the industry
  - Research experts of lithium battery technology
  - The following are some of the committee members: (30 to 40 active members)
    - Cell manufacturers (domestic and foreign)
    - Battery manufacturers (domestic and foreign)
    - Equipment manufacturers (domestic and foreign)
    - NASA
    - Airline Pilots Association
    - Civil Aviation Authorities (FAA, EASA, TCCA, ANAC)

RTCA DO-227A Minimum Operational Performance Standard

- **Approval and Release of RTCA DO-227A document by RTCA**
  - The RTCA Program Management Committee (PMC) approved and released the RTCA DO-227A , Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries on 21 September, 2017

FAA Technical Standard Orders (TSOs)

- **For Rechargeable Lithium batteries**
  - **TSO-C179b, *Rechargeable Lithium Batteries and Battery Systems***
    - **Uses RTCA DO-311A, *Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems* as the MPS**
    - **Approved and released March 23,2018**

- **For Non-Rechargeable Lithium batteries**
  - **TSO -C142b, Non-Rechargeable Lithium Cells and Batteries**
    - **Uses RTCA DO-227A, *Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries*, as the MPS**
    - **Approved and released March 26, 2018**

Hybrid/All Electric Aircraft for Small Airplane

- **Some Types of Batteries used in eVTOL and eCTOL application:**

Hybrid/All Electric Aircraft for Small Airplane

- **Means and Methods of Compliance uses Various Processes listed below:**
  - Coordinate early with the Aircraft Certification Policy and Standards Staff
  - Processes to consider:
    - TSO-C179b
    - RTCA DO 311A guidelines & tests
    - Modularization of the Energy Storage and Source device
    - The battery management system
    - The safety assessment (FHA, SSA, FTA, FMEA etc.)
    - The intended function of the Energy Storage device

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Questions

FAA Rechargeable and Non-Rechargeable Battery TSO Policy Contact

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