An Overview of the Part Acceptance Process for Regulated Lithium Ion Batteries in Transportation
Outline

- Introduction
- Ground Vehicle Applications
- Maritime Propulsion
- Aviation
- Testing Standards Overview
- Summary
Introduction

- Lithium ion battery systems go through many of the same types of testing that power electronics do
  - product validation/qualification
  - hazardous voltage safety requirements
- Lithium ion batteries and systems have extra requirements because of other safety concerns
  - Thermal runaway
- This presentation focuses on the testing procedures or requirements
  - ground transportation, maritime, and aviation industries
  - Mostly for propulsion, so these can be large batteries.
  - Definition: “regulated” means that the battery or battery system has a capacity of more than 100 Wh, which requires special shipping containment and testing
Propulsion Batteries in Ground Transportation

- Passenger vehicle applications are the most mature
- Early development of consortia in the US and Europe specifically addressed the need for testing standards
  - EUCAR in Europe
  - USABC/FreedomCar in the US
    - Developed in cooperation with Sandia National Labs.
    - You can find the test manuals on the USCAR website
      - Link at the end of the presentation
- Commercial vehicle standards are less mature
  - Starting point for creating tests tend to be the passenger car standards
Propulsion Batteries for Maritime Applications

- The US Navy developed requirements last decade, mainly because Li-ion batteries were useful for small underwater vehicles
  - A good guide to the Navy battery safety program can be found in a link at the end of this presentation
  - It is a very difficult set of requirements and tests
    - Safety Data Package
    - Safety Testing
    - Safety Review
    - Approval
- Lithium Iron Phosphate chemistry is able to pass
In commercial applications, Scandinavian countries such as Norway are leading the way forward:

- Hybrid and electric ferries or excursion boats
- Risk management companies, such as DNV-GL, are developing testing standards.
- Starting point was US Navy test standards
- Li Iron Phosphate chemistry can pass
- The Flag Country has the ultimate approval
- You can find manuals for lithium battery approval for ships at a website included at the end
Hybrid Fjord Tour Boat Docked in Flam, Norway

- Diesel and/or Electric propulsion
- Li battery for limited “quiet” electric operation
- Quick dockside recharge
View from the Boat While in All Electric Propulsion – Maritime Battery Forum, Sep 2016

- Glaciers and waterfalls in the Aurlandsfjorden region
Li-ion in aviation - research

- Propulsion capable batteries for aircraft are still in the research stage
  - Studies by Boeing, NASA, and others set specific energy goals quite high—
    - 4 times more than today’s batteries
- A web resource by the National Academies Press summarizes the various studies and goals for electric propulsion (Included at end)
  - A committee of the National Academies of Sciences, Engineering and Medicine looked at various architectures
    - All electric
    - Hybrid electric — Parallel hybrid
    - — Series hybrid
    - — Series/parallel partial hybrid
    - Turboelectric — Full turboelectric
    - — Partial turboelectric
- Conclusion – partial turboelectric likely first
Image of Architectures

From: https://www.nap.edu/read/23490/chapter/7
Li-ion in aviation – in use

- There are lithium ion batteries of the “regulated” size on the Boeing 787, Airbus A350, and the F-35 fighter.
  - They are not for propulsion
  - Accepted by authorities, like the FAA, on a case-by-case basis
- The aircraft transport industry is quite concerned about lithium ion batteries as cargo
  - Recommendations and compliance for shipping go through the IATA
  - a large group of aviation industry companies
  - A good resource page for guidance material is listed at the end
An Overview of Battery Testing Types and Standards

- If you plan to have a Li-ion battery as part of your system, there is a list of the test types and standards that you could be asked to perform
  - Depends on the customer and the application
- Standards for testing have been created by well-known organizations
  - UL, NEMA, IEEE, and SAE
- The type of tests include –
  - external short circuits, abnormal charge, reverse charge, internal short circuit, and environmental testing
- There is a very good table of types and standards
  - Presentation called “Safety Li-ion management” from RECHARGE, the Advanced Rechargeable & Lithium Battery Association (website included at the end)
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<th>UL 1642</th>
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Summary

- For propulsion sized lithium ion batteries ground transportation applications are the most mature
  - There are many examples of safe use in the field
  - This is mainly because of an early and earnest to develop standard tests
- Maritime applications are becoming more common in select areas
- Aviation is focused on the transport of large li-ion batteries as cargo
  - Usefulness for propulsion is in the research phase.
- Many well-known international bodies have developed testing standards
- Power electronics manufacturers will be interested in knowing about such tests if they also provide power systems that include li-ion batteries
  - Project planning needs to take this into account
Referenced Websites

- USCAR

- US NAVY

- Commercial ships/boats

- National Academy of Sciences, Engineering and Medicine Study
  - https://www.nap.edu/read/23490/chapter/7

- IATA
  - http://www.iata.org/whatwedo/cargo/dgr/Pages/lithium-batteries.aspx

- RECHARGE
Contact

- LinkedIn – Eric Schneider, Technical Specialist – Development and Application of Power Electronics, Energy Storage, and Rotating Machines
  - Send a message/question and I will get notification and respond