



AEROSPACE INFORMATION REPORT

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Design and Development of Rechargeable Lithium Battery Systems for Aerospace Applications

RATIONALE

Rechargeable lithium battery systems have become an accepted product in the aerospace industry. However, there are limited resources for guidance on how to properly design and develop these products for safe application aboard aircraft.

1. SCOPE

This AIR is intended to provide a basic overview of methodologies that should be utilized when undertaking the design and development of rechargeable lithium battery systems for aerospace applications. The battery system includes the battery cells, monitoring and control electronics, and battery charger as applicable. The methodologies presented herein apply to "installed" equipment which would be part of the original or supplemental type certification or military airframe qualification.

1.1 Purpose

The purpose of this document is to draw attention to the need for a standardized, methodical approach to rechargeable lithium battery system design and development. The purpose of this approach is to achieve safe performance of these products in aerospace applications.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP4754 Guidelines for Development of Civil Aircraft and Systems

ARP4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

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2.1.2 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA DO-160G	Environmental Conditions and Test Procedures for Airborne Equipment
RTCA DO-178C	Software Considerations in Airborne Systems and Equipment Certification
RTCA DO-254	Design Assurance Guidance for Airborne Electronic Hardware
RTCA DO-311A	Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems

2.1.3 Other Publications

Using COTS Parts for High Reliability Batteries, by Daniel E. Wesolowski, Ashley N. Allen, Hans W. Papenguth, Sandia National Laboratories, Proceedings 46th Power Source Conference 2014, Paper 1.4.

Screening of COTS Cells for Advanced Li-Ion Batteries, by Eivind Listerud, Jason Rhuems, Kris Pritchard, EaglePicher Technologies, LLC, Proceedings 46th Power Source Conference 2014, Paper 1.5.

Evaluation and Characterization of COTS Li-ion Cells for Military Applications, by Svetlana Trebukhova, Chad Deroy, Frank Puglia, Rob Gitzendanner, EaglePicher Technologies, Proceedings 48th Power Source Conference 2018, Paper 21-1.

3. CURRENT PRACTICE

In recent years, both military and commercial aircraft manufacturers have allocated significant resources toward electrification of aircraft systems and subsystems. These programs have drawn upon successes in many areas of technological advancement, such as microprocessor computing power, electronic component miniaturization, and hybrid circuitry development. As a consequence, engineers have been able to conceptualize many new applications which were unattainable without these new devices. This has led to the proliferation of new or redesigned equipment, offering significant improvements in performance and functionality, and has, on occasion, led to a paradigm shift in some areas such as flight control systems, where mechanical actuation devices are increasingly replaced by electric actuators.

The increased electrical system loads resulting from these new applications has placed higher demands on the power generation and distribution systems of the aircraft. This has created an increased demand on energy storage systems to meet these growing requirements. The classic 28 VDC power bus has now been augmented by distributed buses in the 270 VDC range, and other bus voltages are evolving to meet application specific requirements. Traditional lead-acid and nickel-cadmium batteries, with their well-known performance characteristics, are not well suited to meet these new demands. As a result, these new requirements are being addressed by technologies with higher energy and power density factors. The predominant chemistry chosen to meet these new demands is lithium-ion, which is sub-divided by the numerous chemistry variations that comprise this technology.

It is often the case that technology quickly outpaces development of industry standards for the design and implementation of new products and processes, and that is most certainly true in the case of lithium-ion battery systems. Consumer products were the first to realize the important advantages of the technology, and it did not take long before more “industrial” type applications were developed around this novel technology. Unfortunately, a great deal has been learned about the performance characteristics of the technology “after the fact.” That is to say that there was a great deal about operational safety that was not well understood before application of the technology in a number of products. Highly publicized product failures brought to light the need for a better understanding of the failure modes of the technology, which has driven the research and development of “safer” chemistry variations. The drive to improve understanding of the technology, accompanied by the development of a number of new chemistry variants has, to some degree, further complicated the application of this technology.