AIAA G-136-2022

Guide

Guide to Lithium Battery Safety for Space Applications

Guide to Lithium Battery Safety for Space Applications

Sponsored by

American Institute of Aeronautics and Astronautics

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Abstract

This document contains requirements and guidelines related to the safety of lithium-ion batteries used in space systems including but not limited to satellites, launch vehicles, interplanetary probes, rovers and landers.

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FOREWORD

The AIAA G-136-2022 Guide to Lithium Battery Safety for Space Applications has been developed by a team of battery experts under the auspices of AIAA Standards Steering Committee (SSC).

Lithium-based cells and batteries of the non-rechargeable (primary) and rechargeable (secondary) types are increasingly used in human-rated and non-human-rated space applications. The hazards associated with lithium batteries are catastrophic for the human-rated and non-human-rated systems, although the effects may be different in each category. The AIAA G-136-2022 document is a guide for the safe design, use and disposal of lithium-based cells and batteries for all space applications.

The document focuses on all aspects of battery safety from building and designing the batteries to reducing the risk of catastrophic failures. Features related to ground handling and testing, in-orbit and post-flight operations, and disposal or reuse have been factored into the document.

The document includes the background information on the various chemistries associated with the lithium-based primary and secondary batteries, their hazards, mitigation methods, safe design practices, stringent testing requirements that include qualification as well as flight acceptance tests, test procedures for commonly required tests and safety requirements to be followed for ground and on-orbit, and all space operations.

The document can be tailored to be applicable to any space program where a conscious effort is made to not jeopardize the safety of the crew or space vehicle.

This AIAA Guide document was developed as a result of a series of discussions and reviews by the Lithium Battery Safety for Space Applications (LiBSSA COS), SSC and manufacturers and users.

At the time of approval, the members of the AIAA LiBSSA CoS who participated in the nine year review process of this Guide are listed in the table below (see next page).

First Name	Last Name	Company
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INTRODUCTION

The AIAA G-136-2022 Guide to Lithium Battery Safety for Space Applications is applicable to all lithium-based batteries that are to be used on human-rated and non-human-rated space vehicles including those used to power the vehicle, payloads and equipment batteries. It provides information to the designers of the battery systems that are to be used in human-rated and non-human-rated space vehicles, in equipment to be used in both environments, crew suits, payload experiments, etc. It defines the provisions that may be used to design batteries that are safe for ground personnel as well as crew members to handle and operate during all applicable phases of a space mission including the enclosed environment of a human-rated space vehicle, launch vehicles and in unpressurized spaces adjacent to the habitable portion of a space vehicle. The document provides information on hazards, controls, design evaluation and verification. Evaluation of the design and review of the verification of the results may be completed prior to certification for flight and ground operations.

The standard request was first initiated by NASA and was supported by AIAA since there was no agency-level battery safety requirements document. The effort became independent from NASA after three years although the same team was maintained to complete the document. The team members chosen to support the writing of the standard included representatives of NASA centers that have a battery team, academia, cell and battery manufacturers, government agencies, national labs, industry representatives involved with the manufacturing or installation of batteries in space vehicles for human-rated and non-human-rated environments and standards organizations. The standard did not receive the required number of votes to be published and hence the Chairs decided to convert it to a Guide document.

A significant portion of the information originated from the JSC 20793 with substantial additions from the ground safety recommendations provided by NASA GRC's Guidelines on Lithium-ion Battery Use in Space Applications (NASA/TM-2009-215751), Range Safety Requirements (RCC 319 and AFSPCMAN 91-710), the NAVSEA requirements and more recent recommendations from the NTSB (NTSB/AIR-14/01; PB2014-108867). Test procedures described in this document are mostly based on UL, IEC, RTCA, Range Safety, NAVSEA and NASA (JSC Battery safety standard and other work instructions) certification standards.

1 SCOPE

This document contains guidance related to the safety of lithium-ion batteries used in space systems including but not limited to satellites, launch vehicles, interplanetary probes, rovers and landers.

All aspects of the battery acquisition cycles are addressed including design, testing, integration, handling at the launch site and mission use.

This document is intended for space systems only. Requirements for aircraft may be found in documents such as the RTCA DO311a: Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems; and the RTCA DO227a: Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries.

Compliance with this guidance document ensures that the batteries and battery systems can be expected to reliably perform their intended function(s) safely under conditions encountered in space operations and environments. It is mandatory that battery, spacecraft equipment and spacecraft manufacturers, as well as users, thoroughly understand the guidance for performance, capabilities and limitations of the batteries and battery systems. By doing so, safe operation during all aspects of acquisition, transport**,** integration, operation, maintenance and disposal may be achieved. Any regulatory application of this document is the responsibility of the applicable government agency or user organization.

May: This verb is used for stating non-mandatory goals and to refer to best practice methods that can be construed as example methods.

Will: This verb is used for stating facts or declaration of purpose.

2 TAILORING

When viewed from the perspective of a specific program or project context, the guidance defined in this document may be tailored to match the actual requirements of the particular program or project. Tailoring may be undertaken in consultation with the procuring authority where applicable.

NOTE: Tailoring is a process by which individual requirements or specifications, standards and related documents are evaluated and made applicable to a specific program or project by selection, and in some exceptional cases, modification and addition of requirements in the standards.

3 TERMS AND DEFINITIONS

For the purpose of this document, the following terms and definitions apply.

Ampere-hour
Ampere-hour or Ah is a unit for the quantity of electricity that is related to coulombic capacity, obtained by integrating current in amperes over time in hours. Used as a measure of battery capacity (abbreviated Ah).

Battery
One or more electrically connected cells, assembled together with or without a container with a single positive and negative terminal. A battery may include intercell connectors, protective and other devices.

Battery System
Is comprised of the battery, the battery charger and any protective, monitoring and alerting circuitry or