National Aeronautics and Space Administration

NASA

Mitigating Thermal Runaway Risk in Lithium Ion Batteries

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OVERVIEW

The JSC/NESC team has successfully demonstrated Thermal Runaway (TR) risk reduction in a lithium ion battery for human space flight by developing and implementing verifiable design features which interrupt energy transfer between adjacent electrochemical cells. Conventional lithium ion (li-Ion) batteries can fail catastrophically as a result of a single cell going into thermal runaway. Thermal runaway results when an internal component fails to separate electrode materials leading to localized heating and complete combustion of the lithium ion cell. Previously, the greatest control to minimize the probability of cell failure was individual cell screening. Combining thermal runaway propagation mitigation design features with a comprehensive screening program reduces both the probability, and the severity, of a single cell failure.

PIONEERING SPACE & LIFE ON EARTH

Historically, our ability to successfully mitigate the risk of cascading failure within a multi-cell lithium ion battery has been limited by a lack of understanding in how a single cell failure is manifested, and the mechanisms by which the single cell failure propagates within a multi-cell battery. With the development of an improved understanding of the single cell failure mode, and engineering controls suitable for use in high energy density batteries, we have developed verifiable engineering controls which have demonstrated significant severity reduction of the unpreventable, low probability, catastrophic event.

OUTCOMES

The JSC/NESC team characterized energy transfer mechanisms responsible for cascading cell failure, developed and validated a single-cell trigger and battery assessment methodology, and modified an existing lithium ion battery design to demonstrate repeatable tolerance to single cell thermal runaway propagation.

NASA TECHNOLOGY READINESS LEVEL: 7

A custom 384 cell, 4kWhr li-Ion battery weighing less than 32kg with TR propagation mitigation features.

Cascading failure in a custom 45-cell, 53Whr li-Ion battery due to unmitigated TR propagation

INNOVATION

This foundational work proves the severity of catastrophic lithium ion battery failure can be reduced to tolerant levels in energy dense batteries and is directly applicable to virtually any multi-cell, lithium ion battery design.

INFUSION

Thermal runaway mitigation technology is being implemented in custom high-energy Human Space Flight batteries used on ISS and during EVA.

PARTNERSHIPS

JSC collaborated with NESC Electrical Power Technical Discipline Team and experts in Academia, Industry, and Aerospace to develop and mature thermal runaway propagation mitigation technology.

NASA TECHNOLOGY AREA ROADMAP

Space Power and Energy Storage (TA03);
Thermal Management Systems, Heat Transfer (TA14, 2.2.2);
Materials, Structures, Mechanical Systems and Manufacturing (TA12, 2.14)