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Establish guidelines for safe management of lithium batteries

# Summary

Lithium-ion batteries have ascended as the predominant secondary energy storage systems, primarily due to their integration in a plethora of mobile electronic devices and electric vehicles. Among the spectrum of rechargeable energy storage systems, lithium-ion batteries exhibit superior gravimetric and volumetric energy densities. This advancement positions them favorably against traditional lead-acid energy storage systems, with lithium-ion variants demonstrating enhanced capacity and elevated operational voltages. Their adaptability has been further exemplified through deployments in specialized environments such as marine and aerospace applications. Notably, the Republic of Korea has pioneered the incorporation of lithium-ion battery modules in its submarine fleet. Concurrently, the Korean Ministry of Oceans and Fisheries is spearheading initiatives to evaluate the feasibility of integrating lithium-ion batteries into buoys. Given the inherent challenges associated with the remote and often inaccessible locations of these buoys, it's imperative that the chosen energy storage solutions guarantee extended operational longevity and robust safety protocols. This document delineates guidelines, emphasizing the safety evaluations and practical applications of lithium-ion batteries within buoys, as championed by the Korean Ministry of Oceans and Fisheries. This rendition represents an augmented version of a document initially presented in 2022.

# Background

Buoys are progressively being equipped with an increasing array of sensors, additional functionalities, and network connections. This allows them to communicate with terrestrial control centers, facilitating decisions regarding the operational status of each buoy, maintenance requirements, and potential sensor installations. The integration of more sensors and communication capabilities in buoys necessitates a higher capacity energy source. This growing demand is gradually shifting the consideration from lead-acid batteries to lithium batteries. Lithium batteries, with their high energy density, have minimal internal losses compared to lead-acid batteries. Traditional evaluation methods for lead-acid batteries are not sufficient for predicting the lifespan and assessing the safety of lithium batteries. This document examines cases where evaluation procedures for lithium batteries have been applied and presents performance evaluation methods based on standardization efforts in Korea.

# Discussion

On March 9, 2023, in New York City, a detailed investigation was conducted into a major fire believed to have been caused by a battery powering an electric scooter. Approximately 200 firefighters responded to the incident, which was classified as a five-alarm fire, and at least seven people were reported injured. According to the accident investigation, the fire appeared to have originated from a lithium-ion battery of a scooter found on the rooftop of the affected apartment building. The New York City Fire Department reported that last year alone, there were over 200 fires involving electric scooters and electric bicycles, resulting in six fatalities.1)

Additionally, the U.S. Federal Aviation Administration (FAA) prohibited the placement of detached lithium-ion metal batteries in checked luggage in 2020. They mandated that, if approved by the airline, such batteries should be carried in carry-on baggage along with the passenger.2)

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| A case of EV fire | A case of ESS fire | A case of Smartphone |

While there have been incidents like the ones mentioned, lithium batteries are generally considered safe and unlikely to fail unless they are defective, damaged, or mishandled. Thus, the manner in which these batteries are handled and whether they have defects becomes a crucial aspect in their application.

We are currently conducting a demonstration of lithium batteries for navigational aids, designed and operated on a modular concept, as part of a project led by the Korean Ministry of Oceans and Fisheries.

For this purpose, we have reviewed various standards and are conducting demonstrations based on these standards.

**Reviewed Standards:**

* Guidelines for Shipboard Battery Systems: IEC 62619, IEC 62620
* Revised Electric Safety Act: KS C IEC 62619, KS C IEC 10031

**Common Elements of the Reviewed Standards:**

Tests are conducted on battery cells, modules, and systems.

* Battery Cell: Refers to a single battery, typically having a nominal voltage of 3.65V, with the manufacturer indicating its current capacity (e.g., 1000mA, 5000mA, etc.).
* Battery Module: A unit configured by connecting battery cells in series or parallel to achieve the desired voltage and current capacity for a specific application (e.g., 14V 20A module).
* Battery System: A system that includes battery modules and a unit that can control charging and discharging, known as the Protection function (e.g., 5 modules + Battery’s Protections Unit).

We are conducting a demonstration based on the aforementioned items

* Battery Module: A unit module based on a modular concept of 14.6V 20A.
* Battery System: Includes a charge-discharge control function in the battery module, and the battery module constitutes the battery system.
* The demonstration period has been from December 2021 to the present, with solar charging and load discharging being conducted every 12 hours.

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| 텍스트이(가) 표시된 사진  자동 생성된 설명 | 벽, 실내, 주방기기이(가) 표시된 사진  자동 생성된 설명 |
| Charging controller | Lithium Battery Modular Test Box |

The following data graph represents the battery system data being operated at the Yeosu office in Korea, recorded during February, which marked the lowest temperature of the month. Each data point represents the real-time State of Charge (SoC) and is displayed alongside the operational status of the BMS/BPU. Additionally, the temperature is indicated, showcasing data recorded at the lowest temperature in February, which was -18°C, and the capacity of the battery that was charged and discharged at that time.

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| Charging and discharging data for 2 weeks February 2022 |

The primary objective of this demonstration is to ensure the safety of applying lithium batteries in navigational aids.

To achieve this, we have established a specialized BMS configuration and secured safety standards before proceeding with the demonstration.

* Specialized BMS: This BMS includes features such as measuring the battery's status (voltage, current, temperature), adjusting variable charge-discharge voltage values, and adding short-circuit functions based on threshold values.
* Safety Standards: We've adopted stringent standardized criteria, including overcharge testing and over-discharge testing.

The safety standards highlighted in this document primarily focus on testing the following aspects:

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| Inspection Criteria | | | |
| kind | | Inspection item | |
| Essential Quality and Performance Requirements | Preliminary Inspection | Serial Number Assignment and Recording | |
| Module and System Information | |
| Visual Inspection | |
| Electrical Testing | Open Circuit Voltage (OCV), | |
| Insulation Testing | |
| Capacity Testing | |
| Self-discharge Testing | |
| Battery System Safety Testing. | | Functional Safety Review | |
|  | Overcharge Voltage Control |
| Overcharge Current Control |
| Over-temperature Control |

Based on these safety standards, we aim to share the demonstration results of the battery modules designed for buoys. Furthermore, we plan to operate technical groups to revise and update the guidelines for safety standards in the future.

# References

1. <https://edition.cnn.com/2023/03/05/us/nyc-bronx-lithium-battery-fire/index.html>
2. <https://www.faa.gov/newsroom/lithium-batteries-baggage#:~:text=Spare%20%28uninstalled%29%20lithium%20metal%20batteries%20and%20lithium%20ion,be%20carried%20with%20the%20passenger%20in%20carry-on%20baggage>.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)