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**Safe Lithium Battery Management Strategies for Marine Buoy Systems**

# Summary

This proposal outlines a comprehensive approach for managing lithium batteries safely within marine buoy systems. It encompasses establishing standardized design guidelines, securing specialized engineering capabilities, building safety evaluation and certification frameworks, investing in mid-to long-term R&D, and updating related laws and policies. These measures are expected to enhance safety protocols, improve maritime safety, comply with international standards, and ensure global safety levels through international collaboration.

# Background

The increasing importance of maritime navigation aids, driven by rapid climate changes and growing concerns over maritime safety, underscores the critical role buoys play in maintaining safe navigation routes and providing essential information in marine environments. Recent advancements in buoy technology have integrated various sensors and communication functions, necessitating higher energy sources, thereby increasing the use of lithium-ion batteries. These batteries are preferred over lead-acid batteries due to their higher energy density and lower internal losses, making them an efficient energy storage solution.

However, lithium batteries pose potential risks of fire and explosion. An investigation into a major fire incident in New York City on March 9, 2023[1], caused by an electric scooter battery, required the deployment of about 200 firefighters and resulted in at least seven injuries. The New York City Fire Department reported that over 200 fires related to electric scooters and bicycles occurred last year alone, leading to six fatalities. These incidents underscore the critical need for safe management and handling of lithium batteries.

The risks associated with lithium battery fires and explosions are particularly concerning in remote systems like maritime navigation aids. The accessibility constraints in the event of an incident make initial responses challenging, potentially leading to greater damage. Thus, implementing enhanced safety measures and systematic safety management processes is essential when integrating lithium batteries into maritime navigation aids.

In this context, we aim to develop safety guidelines for applying lithium-ion batteries in maritime navigation aids. These guidelines will reflect international standards and safety criteria for safely integrating lithium-ion batteries into buoy systems, thereby enhancing the reliability and safety of buoy systems and contributing to maritime safety.

# Discussion

**The Necessity of Safety Procedures**

With the integration of sensors, communication, and data processing functionalities, there has been a significant increase in power demand in maritime navigation aids. Transitioning to high-performance power systems like lithium batteries, which offer higher energy density and stability, is essential. However, the relative risks of fire and explosion associated with lithium batteries are a significant concern, especially in remote systems like maritime navigation aids, where initial incident response could be challenging due to accessibility issues.

In terms of lithium battery safety evaluation, international standards such as IEC 62619[2] and IEC 62620[3] are prevalent. These standards specify the safety requirements and testing methods for lithium-ion batteries. IEC 62619 provides electrical, mechanical, and environmental test methods and criteria for evaluating the safety of lithium-ion batteries, while IEC 62620 addresses the test methods and requirements for assessing the performance and durability of lithium-ion batteries.

In Korea, national standards KC 62619[4] and KC 62620[5] have been established under the Electrical Appliances and Consumer Products Safety Control Act[6] to assess the safety of lithium-ion batteries. These standards are based on IEC 62619 and IEC 62620, respectively, and adapted to suit domestic conditions.

These international and national standards serve as critical guidelines for objectively evaluating and demonstrating the safety of lithium batteries. When applying lithium batteries in maritime navigation aids, conducting the safety tests required by these standards and verifying compliance is essential.

However, in the unique environment of maritime navigation aids, additional safety measures beyond the general safety evaluation criteria are necessary. The high humidity, salinity, and temperature variations in the marine environment can degrade battery performance and pose safety risks.

Therefore, when implementing lithium batteries in maritime navigation aids, compliance with relevant international/national standards is crucial, along with establishing customized safety procedures considering the marine environment's specificities. These should include comprehensive safety measures like battery protection casing design, cooling systems, waterproof/moisture-proof designs, and monitoring and control systems.

Such standardized safety procedures are vital in ensuring the safe operation and management of lithium batteries, minimizing the risks of fire and explosion, and enhancing the reliability and safety of the maritime navigation aid systems.

**Safety Procedures for Lithium Batteries in Maritime Navigation Aids**

* **Electrical Safety Testing**

o**bjective:** To pre-emptively prevent electrical risks within the system and ensure safe operation

Ensure the electrical stability of the battery system and prevent electrical hazards by conducting voltage fluctuation checks, insulation status inspections, capacity testing, and self-discharge tests.

* **Functional Safety Review**

**Objective:** To verify the system's functional stability and maintain safety, particularly in abnormal situations.

Assess the functional stability of the battery system and detect any abnormal operations to maintain system safety through functional performance reviews, abnormal operation detection system evaluations, emergency response capability assessments, and rapid response system evaluations.

* **Overcharge/Over-discharge Prevention**

**Objective:** To avoid damage from excessive charging or discharging, maintaining system safety.

Prevent excessive charging or discharging of the battery to extend its life and maintain safe operation by checking overcharge prevention systems, verifying over-discharge prevention systems, assessing voltage monitoring systems, and reviewing charge/discharge control circuits.

* **Overcurrent Prevention**

**Objective:** To prevent battery damage from excessive current, ensuring system safety.

Prevent battery damage due to excessive current by checking overcurrent detection systems, evaluating current control circuits, reviewing overcurrent protection devices, and assessing current monitoring systems.

* **Overheat Prevention**

**Objective:** To prevent battery damage and fire risks due to overheating, maintaining system safety.

Ensure safe system operation by preventing battery overheating through verifying temperature monitoring systems, evaluating thermal management systems, reviewing overheat detection and response systems, and assessing thermal diffusion and emission systems.

* **Waterproof/Moisture Protection**

**Objective:** To protect the battery from external environmental factors, maintaining safety and extending system life.

Protect the battery from seawater intrusion or moisture to ensure safe operation by checking waterproof/moisture-proof functionalities, evaluating enclosure integrity, reviewing external intrusion prevention systems, and assessing moisture resistance.

* **Dust/Shock Protection**

**Objective:** To maintain battery safety and system longevity through protection from external conditions.

Protect the battery from salt or shocks to ensure safe operation by inspecting dust/shock protection systems, evaluating durability, reviewing shock absorption systems, and assessing robustness against environmental changes.

* **Remote Monitoring/Control**

**Objective:** To enhance system operation safety and efficiency through remote monitoring and control.

Maintain safe operation by real-time monitoring and remote controlling of the battery status through system checks, communication stability evaluations, remote control functionality reviews, and remote access security inspections.

* **Thermal Management System**

**Objective:** To maintain battery safety and improve system reliability through effective temperature management.

Manage battery heat effectively to maintain stable temperatures and ensure system safety through thermal monitoring system evaluations, heat dissipation feature checks, thermal system reviews, and thermal stabilization system assessments.

* **Emergency Response Procedures**

**Objective:** To maintain system safety through preparedness for rapid and effective response in emergencies.

Secure system safety in emergencies like fires or overheating through emergency response plan reviews, emergency situation response training evaluations, emergency contact network reviews, and emergency system operation tests.

* **Regular Maintenance**

**Objective:** To continuously maintain battery condition and system safety through regular maintenance.

Maintain system safety by checking for battery aging and performing necessary maintenance or replacement, including battery status inspections, maintenance record verifications, parts replacement considerations, and maintenance schedule management.

**Proposal Summary for Safety Procedure Configuration and Implementation Strategy**

To ensure the safe and efficient management of lithium batteries for maritime navigation aids, a systematic and comprehensive approach to safety procedure configuration is essential. The following steps are proposed to achieve this:

* **Standardization and Guideline Establishment**
  + - Standardize safety design, installation, operation, and maintenance procedures by reflecting international (IEC 62619, IEC 62620) and domestic (KC 62619, KC 62620) standards.
    - Develop customized safety guidelines considering the unique marine environment.
    - Adopt modular design and plug-and-play approaches for cost-effective maintenance.
* Testing Strategy and Procedure Development
  + - Establish battery safety, durability, and performance testing strategies compliant with international standards.
    - Validate safety in real operational environments through harsh condition testing simulating marine settings.
    - Create a safety verification system across the battery lifecycle.
* Certification and Mark Provision
  + - Provide certification for products that pass rigorous safety assessments.
    - Ensure safety and reliability through test results and certifications compliant with international standards.
    - Prioritize certified products for proven safety and cost-effective maintenance.
* Compliance with International Standards and Enhanced Cooperation
  + - Collaborate actively with international standardization bodies like IEC and ISO for standard development and adherence.
    - Engage in technical exchanges and joint research with foreign institutions to advance safety technology.
    - Achieve advanced safety procedures and international alignment through global cooperation.
* Education and Information Provision
  + - Conduct specialized training to enhance the competency of navigation aid management personnel in battery safety management.
    - Distribute the latest information and technology on battery safety promptly and share it widely.
    - Provide manuals and guidelines for efficient and economical maintenance.
* Requirements for Enhanced Safety Procedures:
  + - Establish lithium battery design guidelines optimized for the marine environment, referencing international standards (IEC 62619, IEC 62620) to create internal guidelines or standards and guide documents.
    - Secure engineering personnel with expertise in battery safety, thermal management, communication, and control.
    - Build a certification system based on Safety Integrity Level (SIL) across the design, manufacturing, and operational lifecycle.
    - Continuously invest and innovate for high-energy density, long-life, and low-cost battery technologies.
    - Update laws and policies related to lithium battery handling and accident response.

Through this **multifaceted** approach, we can maximize the safety and operational efficiency of lithium batteries for navigation aids, minimize lifecycle costs, and secure both maritime safety and economic viability. It's crucial to adopt a strategy that prioritizes safety while considering practicality and cost-effectiveness.

**Conclusion**

For the safe and efficient utilization of lithium batteries in maritime navigation aids, a comprehensive and systematic safety procedure configuration is indispensable. This requires a multi-faceted approach that includes establishing safety design and operation guidelines based on international standards, developing testing and certification processes optimized for the marine environment, fostering specialized personnel, and continually investing in technological innovation, along with establishing a robust institutional foundation.

Such efforts will ensure the safety and reliability of lithium batteries while enhancing their cost-effectiveness and maintenance efficiency, achieving the dual goals of bolstering maritime safety and minimizing operational costs.

Lithium batteries can serve as a highly beneficial solution for powering maritime navigation aid systems efficiently and safely. However, to fully harness their potential, prioritizing safety is paramount. A prudent approach that balances safety, practicality, and cost-effectiveness is needed now more than ever. The safety procedures and measures outlined in this proposal are intended to lay the groundwork for the use of lithium batteries in maritime navigation aids, contributing towards the ultimate goals of enhancing maritime safety and achieving economical operation.

# References

1. <https://edition.cnn.com/2023/03/05/us/nyc-bronx-lithium-battery-fire/index.html>
2. **IEC 62619**: "Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications." This standard is established by the International Electrotechnical Commission (IEC) and focuses on the safety requirements for lithium cells and batteries in industrial contexts.
3. **IEC 62620**: "Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for use in industrial applications." Also developed by the International Electrotechnical Commission (IEC), this standard pertains to the performance and safety of lithium cells and batteries specifically designed for industrial applications.
4. **KC 62619**: "리튬 이차전지 - 안전성 시험" (Lithium secondary batteries - Safety testing). This is a Korean national standard, established by the Korea Agency for Technology and Standards (KATS), that specifies the safety testing criteria for lithium secondary batteries.
5. **KC 62620**: "리튬 이차전지 - 단전지 및 조립전지 성능 시험" (Lithium secondary batteries - Single cell and battery pack performance testing). This standard, also set by KATS, outlines the performance testing procedures for single cells and assembled battery packs of lithium secondary batteries.
6. **Electrical Appliances and Consumer Products Safety Control Act**: This law, available from the Korea National Law Information Center, regulates the safety standards and control measures for electrical appliances and consumer products, ensuring that they meet the necessary safety requirements to protect consumers and the public.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-2)
2. Leave open if uncertain [↑](#footnote-ref-3)