UNITED STATES COAST GUARD
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MARINE SAFETY ALERT

Inspections and Compliance Directorate

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Safety Alert 14-25

LITHIUM-ION (LI-ION) BATTERY SYSTEM INSTALLATIONS

An integrated Li-ion battery bank recently caught fire onboard an inspected passenger vessel when loosely crimped lugs overheated. While no one was injured and the vessel sustained minimal damage, this casualty highlights safety hazards unique to Li-ion batteries. All integrated (installations used for propulsion and electrical power) Li-ion battery systems on inspected vessels must undergo engineering plan review, be fitted with supporting safety systems, be tested and inspected at installation and periodically afterward, and be properly maintained by competent mariners, regardless of the battery bank size or end consumer.

Unique Safety Considerations

Energy Density: Li-ion batteries are used on vessels because their high energy densities allow for longer voyages and full electrification. However, high energy density increases risk because if a fire occurs, it will burn hotter and longer.

Thermal Runaway: Upon internal failure or short circuit, Li-ion batteries may release high-temperature flammable gases that can catch fire or explode. The heat output of a fire can increase the rate of off-gassing, and those off-gasses in turn increase the size of the fire in an uncontrolled chain reaction.

Fire Suppression Resistance: A thermal runaway fire is very difficult to suppress once it has begun to propagate to other battery modules. Instead, fire management strategies focus on early detection, fire containment, and heat absorption with a water-based suppression system.

Toxic Off-Gasses: In thermal runaway, Li-ion batteries release varied toxic gases, many in excess of their "Immediately Dangerous to Life or Health" thresholds, placing passengers and crew in potential danger. Further, the composition of off-gasses varies dramatically across different Li-ion battery chemistries and manufacturer makes and models.

Battery Management: Li-ion batteries will often have a battery management system to prevent degradation from overcharging, undercharging, or over-cycling. Propulsion, electrical loads, topping loads, and recharging cycles are managed by complex integration systems, which are key in mitigating the increased risks of Li-ion battery systems.

Design Requirements

The Coast Guard provided design guidance for integrated Li-ion battery systems in CG-ENG Policy Letter 02-19 (PL 02-19), Design Guidance for Li-Ion Battery Installations Onboard Commercial Vessels, which incorporates American Society for Testing and Materials (ASTM) F3353-19, Standard Guide for Shipboard Use of Li-ion Batteries. These "integrated" systems are hardwired to power the ship's electrical loads; plug-in electronics and Li-ion batteries as cargo are not addressed by this Safety Alert. (See Safety Alert 01-22 for more information on Li-ion batteries as cargo.) As Li-ion battery technology evolves, additional guidance may be released.

PL 02-19 and ASTM F3353-19 address the following major safety considerations for Li-ion battery hazards: ship specific risk/safety assessments, battery management systems, qualitative failure analyses for vital ship systems, design verification test procedures (DVTPs), periodic safety test procedures (PSTPs), hazardous area plans (for toxic off-gasses), structural fire protection, fire/smoke/gas detection systems, water-based fixed fire suppression systems, and exhaust ventilation. Due to the unique safety risks and design considerations, the Coast Guard does not conduct expedited plan review under Navigation and Vessel Inspection Circular (NVIC) 10-92.

Owner and Operator Guidance

Li-Ion Battery Identification: Packaged Li-ion batteries often visually resemble traditional lead acid batteries, regardless of type, so the best way to identify them is by reading the nameplate specifications. Li-ion batteries can be identified in a variety of ways depending on electrode, electrolyte, and separator materials. Some common types in maritime use are Lithium Iron Phosphate (LFP), Lithium Nickel Manganese Cobalt Oxide (NMC), Lithium Cobalt Oxide (LCO), Lithium Nickel Cobalt Aluminum Oxide (NCA), and Lithium Titanate (LTO). New chemistries continue to emerge as technology advances.

Plan Review: Plan review and proper design testing procedures (DVTPs and PSTPs) should be completed early in the construction process. If plan review and system design testing have not been approved by delivery, marine inspectors may require plan review to be completed through the Marine Safety Center.

Material Condition: Batteries should be visually inspected for signs of deterioration, such as bulging cells or corroded electrical connections. Documentation on the completion of required maintenance should be maintained.

Operational and Maintenance Procedures: Crew members responsible for battery operation and maintenance should be well-trained in the manufacturer's guidelines and operational procedures and familiar with the functioning of the battery management system. They should also know how to respond to abnormal battery conditions or fires. Safety drills for Li-ion battery fires should be performed, and Li-ion battery system arrangements and risks should be taken into account when conducting other drills.

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