Considerations for Response to Shipboard Lithium Ion Battery Fires

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What is happening inside a Lithium Ion Battery Fire?

- When Lithium Ion Batteries (LIB) are damaged, they can short-circuit, causing the components inside to react and decompose quickly.
- These reactions generate heat and many different toxic and flammable gases and particulates, including hydrogen fluoride, carbon monoxide, hydrogen, heavy metal fumes (cobalt, nickel, manganese), and oxygen.

What is happening inside a Lithium Ion Battery Fire?

- One particular reaction, the decomposition of the heavy metal oxides that form the battery's cathode, is the most dangerous.
- It is also known as a metal fire or thermal runaway. It generates its own oxygen, even in a sealed compartment. It also generates high amounts of heat, and is accelerated by heat, so it is a self-accelerating reaction.
- Since it is accelerated by heat, it can be **slowed down by cooling.** However this is most effective in the early stages of the reaction, even before flames are visible.
- There is usually a white smoke that off-gasses before flames appear.

Response Priorities

- The two main priorities for responding to a LIB fire are **isolation** and **cooling**.
- Isolation prevents the fire from spreading to surrounding materials
- Cooling slows the reaction down and allows time for it to burn itself out while minimizing damage to other battery cells, preventing further spread of the fire.
- On land-based fires, the current best practice is to flood the affected battery with massive amounts of water, which is mostly for cooling and preventing spread of the fire.

Possible scenarios for shipboard LIB fires

1. LIB as primary cargo – e.g. vessel carrying large Battery Electric Storage Systems (BESS). Example: M/V Genius Star
2. RORO carrying EVs and hybrid cars. Example: M/V Morning Midas
3. Container ship carrying LIB as part of its cargo
4. Vessels using LIBs as propulsion – e.g. passenger ferries

General

- In each of these scenarios, the ideal isolation method involves engineering and design controls to isolate LIBs from other parts of the ship. This may require containment systems to be put in place as part of the design and construction of the vessel.
- Cooling is even more challenging. Any significant amount of firefighting water brought onboard introduces problems with ballast, and seawater can damage batteries that are not involved in the fire. Ideally, a fire suppression system including drainage would be included in the design of the vessel.
- Also, crew members need specialized training to deal with this type of fire.

Scenario 1: LIB as primary cargo

- Isolation and prevention: Separate battery banks from each other as much as possible, and make sure cabinets are well-secured.
  - On Genius Star, there were two large holds, and fires started in each hold separately. Within each hold, battery banks were enclosed in metal cabinets, which slowed the spread of the fire
  - Fire started due to damage sustained because of high seas. Some of the battery cabinets broke free from their restraints.

Scenario 1: LIB as primary cargo

- Cooling and suppression:
  - CO_2 suppression systems can put out combustible materials fires, which can help slow the spread of fire. However, they will not put out metal fires.

Scenario 2: RORO carrying EVs

- Isolation and prevention:
  - Very difficult on this type of vessel, since cars are closely packed throughout the ship. Maybe if there could be fireproof compartments (i.e. made of concrete to withstand a metal fire) to isolate the spread of a fire to just a few cars.
  - If there are only a few EVs and mostly ICE cars, then the EVs should be positioned near the exits of the RORO.
  - There have been multiple cases of ROROs carrying EVs which have sunk because there was no way to stop the spread of the fire.

Scenario 2: RORO carrying EVs

- Cooling:
  - Ideally, ROROs carrying EVs should have suppression systems that can cool down a metal fire.
  - In the case of the Morning Midas, the salvor estimated that nearly all of the cargo and internal structure of the ship had vaporized in the fire, based on its list and windage before it sank.

Scenario 3: Container Ship carrying LIB cargo

- Isolation and prevention:
  - Containers carrying LIB should be placed in such a manner as to make firefighting easier, and reduce exposure of non-LIB cargo.
  - For example, LIB containers placed together on the outside of the vessel
- Cooling:
  - If the affected container is on the outside of the ship, then it is easier for the fire to be contained by standard firefighting techniques.

Scenario 4: Vessels using LIB as propulsion

- Isolation and prevention:
  - Since these are purpose-built to include LIB in the propulsion system, they should be designed with a firewalled section isolating the LIB from the rest of the ship
- Cooling:
  - Cooling and suppression systems for LIB should be included in the design of the ship, including drainage of the firefighting water