Battery fires at sea

A fire involving a Lithium-Ion battery (Li-Ion) can be particularly fierce, producing large amounts of heat whilst emitting substantial amounts of flammable and toxic gas.

> Thermal runaway is when a Li-Ion battery cell enters a self-heating state (exothermic reaction) and the heat generated is greater than the heat dissipated. This uncontrolled, irreversible self-heating will continue producing more heat and more gas until a violent failure occurs.

Due to their flexibility and convenience, the use of Li-Ion batteries as power sources continues to grow in the large yacht sector.

However, there are several emerging risks associated with Li-Ion batteries in a marine setting in addition to those that are usually recorded. For this reason, vessel owners, operators, and crews must follow precautions and take actions to minimise the possibility of catastrophic fire.

Due to the potential dangers of Li-Ion batteries, a flag state or classification society of individual yachts may have specific rules around the usage of Li-Ion power sources onboard. These rules must always be checked and followed.

The UK Maritime and Coastguard Agency has also recently published MGN 681, which provides some excellent guidance on the current best practice for safe stowage and operation of electric-powered craft and other vehicles on yachts. We would encourage this guidance to be followed where applicable, and the content shared as far as practicable.

Vessel owners, operators, and crews should keep up to date with this information and pay particular attention to battery management, battery charging, crew training and firefighting.

While this article is intended to cover the use of Li-Ion batteries used for watercraft, much of the guidance can also be applied to the proper use and handling of other Li-Ion powered devices, including those that are for personal use (e.g., mobile phones and laptop computers).

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Battery management

The efficient management and control of Li-Ion batteries is of utmost importance. We recommend that a nominated lead (the Chief Electrician/Engineer) is designated as responsible on board, and that this information is recorded in the vessel safety management system or procedures.

A log or record should be maintained of all Li-Ion batteries onboard. This document should detail the manufacturer/type, age, and capacity of each battery. Original equipment manufacturer (OEM) operating manuals must be supplied onboard to allow staff to follow the correct procedures at all times.

Regular visual checks of the batteries should be conducted along with any maintenance recommended by the manufacturer. This can be conducted by the Chief Electrician/Engineer or another crew member who has sufficient experience.

We strongly recommend that a handheld infra-red hotspot scanner is made available as part of the yacht inventory. In addition, a supplementary precaution could be to purchase mobile phones with infra-red (IR) camera capabilities – or buy attachments for mobile phones that add IR camera capabilities to a standard phone.

Temperature monitoring can also provide advance notice of a problem with the battery – some estimates suggest a temperature between 60°C and 70°C can initiate thermal runaway.

If any damage is noted to a battery, it should be quarantined, and offloaded in accordance with local regulations as soon as practicable. Consideration should be given to having a fireproof box purely for this task, filled with sand or some other suitable material. Otherwise, a suitable area should be identified for safe quarantine, where the battery can be observed and dealt with if its condition deteriorates.

Storage locations for when batteries are not in use requires careful consideration. This should be a well-ventilated space, with fire detection and fire protection arrangements in place. As far as possible, the space should be clear of combustible material and must never have dangerous goods located inside. Temperature control of batteries is paramount, and it is therefore advisable that chosen locations are always maintained at a reasonable range of temperatures.

Purpose built, fireproof storage cabinets are available for this task and are a good solution where space allows.

Owners should reduce the number of Li-Ion batteries carried onboard to the minimum considered necessary. We would discourage the carriage of e-bikes, e-scooters, or any other shoreside purchased equipment. Exposure to water, particularly sea water, is a substantial risk factor for Li-Ion batteries, and this type of equipment introduces an unnecessary risk onboard. If it is considered essential to carry these devices onboard, we would recommend that charging of them is not permitted on the vessel.

Batteries that are no longer used, i.e., obsolete devices or equipment no longer carried, should be disposed of following local regulations as soon as practicable. This helps reduce the potential for fire onboard and should not be neglected.

We would also advise owners to review the onboard risk assessments for any activities involving battery powered devices. This is of particular importance if equipment has been replaced with a battery powered device. Consideration should be shown to the possibility of battery damage and fire, for all activities involving these devices.

Some causes of thermal runaway are:

- Overcharging
- Over-discharging followed by rapid charging
- Internal or external short circuit
- Exposure to extreme temperatures both high and low
- Physical damage to the battery via crushing, impact or puncture
- Manufacturing defects

Charging can be considered as one of the riskier operations involving the use of Li-Ion batteries. Damage to batteries during charging has been proven to be a cause of thermal runaway, and maximum caution should be exercised.

As the charging of mobile phones, portable radios, power tools and other similar devices is such a commonplace task, it is easy to become complacent. We would caution against this and ask all personnel involved to monitor charging in the same way that any refuelling would be.

A fuel hose would not be left unattended whilst refuelling a jet ski, and a similar mindset must be applied to charging.

All charging equipment should be sourced from the OEM. Non-approved replacement charging devices have been known to cause battery fires and must be avoided. If there is any doubt to the provenance of a charging device, we advise that it should be removed from service and replaced with an approved device. To prevent mixing up of chargers, we would encourage that clear labelling is affixed to each device detailing what it is to be used for. Chargers should also be recorded in the battery log and regularly checked for good condition.

The OEM's instruction manual must always be followed for charging. Devices can and do have different charging instructions. If appropriate, the relevant page(s) can be reproduced, and copies placed adjacent to the charging location to assist personnel in following the correct procedure.

Consideration should also be given to the optimum location for charging. Batteries must always be secured against movement but should have sufficient air flow to allow for the optimum temperature range to be maintained. High temperatures are a known factor in causing thermal runaway, therefore charging in direct sunlight or in locations with a high ambient temperature is not recommended.

If charging on an external deck, we recommend that this is only conducted within a fireproof container or on a fireproof mat. If charging in an internal space, this must be within a fire-rated compartment with sufficient fire detection and suppression capabilities.

Purpose-built fireproof storage cabinets are available with charging capability installed. This can include fire or gas detection monitors and is good solution where space allows.

Always think about fire:

- Does the charging location block any escape routes?
- Can the electricity supply to the charger be isolated remotely?
- Can ventilation to the space be controlled remotely?
- Is the space clear of extraneous combustible material?

Charging should be continually supervised. Ideally Li-Ion batteries should only be charged during daylight hours when most personnel are alert and present. Batteries must not be left charging on an unattended yacht, and this applies to all devices containing Li-Ion including rechargeable toothbrushes or mobile phones.

This is important, as early intervention can stop a thermal runaway from progressing and reduce the chances of a catastrophic fire.

Training

Training should be provided for all staff onboard regarding the potential dangers of Li-Ion batteries, appropriate to their level of exposure. This training should primarily raise awareness of the dangers associated with this type of power source, and why the risks differ from more conventional energy sources.

Crew members should be encouraged to report any suspected damage to batteries. Typical signs that a battery has been damaged are (Biffa, 2024):

1. Bulging: If your battery appears bloated, it is a clear indication of internal damage. This is usually caused by the buildup of gas or electrolyte inside the battery.
2. Leaking electrolyte: A damaged battery may leak electrolyte, which is a fluid or gel-like substance.
3. Unusual smells: Strong or unusual smells can indicate internal damage. Any acidic or chemical-like odours should be taken seriously.
4. Overheating: These batteries should not become excessively hot during normal operation.
5. Device malfunctions: If a device powered by the battery starts to behave erratically, it could be a sign the battery is damaged.

Advice should be provided on what to do if a battery is found to be damaged. Personal Protective Equipment (PPE) appropriate to handling a suspect battery should be provided and the location of a quarantine area to be clearly identified.

Training should be provided on the correct method of charging batteries and the warning signs to be alert to.

The most notable indication of a problem with a battery during charging is a steady increase in temperature. If thermal cameras are employed to monitor the temperature of batteries, the proper use should be explained to the personnel responsible.

Other indicators include hissing, whistling, or popping noises, and evidence of 'chemical' smells. Most seriously, any vapour issuing from the battery is an indication of critically advanced thermal runaway and a need to take immediate action.

It should be heavily emphasised that tampering, modifying, or exposing batteries to naked flames is extremely dangerous.

Firefighting training should be provided with the scenario of a Li-Ion battery fire. This may include the use of specific fire extinguishing medium, both fixed and portable.

Fire fighting

While it is unclear if Li-Ion batteries are more likely to result in a fire than, for example, a watercraft powered by internal combustion engine, the increasing use and number of batteries onboard will undoubtedly result in more fires or dangerous conditions involving batteries.

A review of emergency response procedures should be conducted, considering the potential of battery fire.

If a fire occurs in port, we recommend that the emergency services are contacted immediately. Specialist firefighting skills are required, and these are most properly delivered by the emergency services.

If a battery fire is caught at a very early stage, the use of fire suppression blankets or specialised Li-Ion battery portable fire extinguishers may be sufficient to contain or extinguish any fire. However, it is important to remember that thermal runaway will not have stopped, and the battery will still be capable of producing extreme heat and dangerous gases, or reigniting, even if the fire appears to have been extinguished.

As previously advised, Li-Ion fires rapidly produce extreme heat and toxic gas/vapours. This makes it highly likely that access to any space with a battery fire will not be possible, other than in full firefighting PPE with self-contained breathing apparatus.

The most effective means of tackling these fires is to suppress flames around the device as they repeatedly flare up while allowing the battery to burn itself out.

The extreme heat produced by a battery fire means that boundary cooling remains necessary, and consideration should be given to how this will be delivered in the event of a fire.

The suppression of flames around the device may not be feasible in a confined space on a yacht. In which case remotely activated water drenching is the most realistic firefighting medium to extinguish the fire or keep controlled. It should be noted that introducing large amounts of water changes the fire hazard into an explosion hazard, which would have to be prepared for.

Larger amounts of water are required to extinguish a Li-Ion battery fire than would be expected in a fire without a Li-Ion component. Sufficient de-watering capacity should be confirmed as available in case mass drenching is required.

If a fire contingency plan relies on personnel donning firefighting PPE and entering compartments with active fires, we would recommend that the firefighting suits are confirmed as Level 2 heat protection, water penetration and water vapour resistance in compliance with BS EN 469:2020.

It is essential that electrical isolation of any charging equipment connected to the batteries is carried out as soon as possible if a fire is suspected or confirmed. A manual emergency stop mounted near the chargers (if in a dedicated charging bay) or external to the space containing the chargers is vital. If possible, this can be connected to the fire detection system and occur automatically on detection of fire.

Remote control of ventilation within battery storage locations is essential. Venting of toxic vapours may be required and may override the conventional advice to close all ventilation to a compartment with a fire. Li-Ion fire vapours are hazardous, and personnel safety should be assured before allowing venting.

Finally, it must always be understood that re-ignition of a battery remains a possibility for weeks or even months after its apparent suppression. A fire damaged Li-Ion battery must be continuously monitored by personnel with firefighting equipment ready for immediate use until it can be safely disposed to a shore reception facility.

References

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