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LITHIUM-ION BATTERY GUIDANCE

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Introduction

In recent years there has been an increased use of lithium-ion batteries in marine vessels. This is due to them being considered to be more environmentally friendly and safer than traditional wet cell batteries. This document has been developed to highlight key risk elements in relation to the use and management of lithium-ion batteries.

Lithium-ion batteries can still present an increased fire risk that has been highly documented in the media, from exploding hover boards, self-igniting cell phones, power banks not being able to be stowed in the holds of planes, to the ban of electric scooters on the London underground system.

It has been recognised that lithium-ion battery fires have always been a potential hazard on boats and as the development of such batteries has expanded, so has the potential fire threat that they present.

In recent years, there have been a growing number of product recalls involving lithium-ion batteries due to an increasing number of reported incidents involving overheating, fires and explosions that relate to the use of this type of battery. Since 2006[1] there have been 64 recalls involving lithium-ion batteries. The number of recalls grew substantially in 2016-2017 which particularly impacted on LI batteries overheating in hover boards and laptops. For example, LG Energy Solutions recalled 10,000 batteries due to a fire issue in August 2021[2].

AS WITH MANY PRODUCTS THERE ARE BOTH ADVANTAGES AND DISADVANTAGES PERTAINING TO THEM AND THEIR USE.

[1] https://www.retailconsumerproductslaw.com/2020/11/recalls-in-review-lithium-ion-batteries/#:~:text=The%20Commission%20has%20conducted%20at,inside%20hoverboards%20and%20laptop%20computers

[2] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/battery-blazes-breakdowns-underscore-growing-pains-for-energy-storage-70426578#:~:text=recalled%20roughly%2010%2C000%20residential%20batteries,U.S.%20Consumer%20Product%20Safety%20Commission

Advantages

Lithium-ion batteries have advantages over traditional batteries. For example, they:

- Are lighter in weight, compared to other similar types of rechargeable battery.
- Are able to hold their charge better and have the ability to handle an increased level of charge.
- Have a limited self-discharge in comparison with similar types of battery.
- Have limited charge memory problems, since it is not necessary to completely discharge the battery prior to recharging.

Disadvantages

- Lithium-ion batteries have a tendency to begin to degrade soon after their manufacture.
- The average life span of a lithium-ion battery is typically limited to 2 to 3 years from manufacture. The lifetime limitation will occur whether the battery is in use or not.
- Increased heat levels can cause lithium-ion batteries to break down faster than other batteries will. They have an increased sensitivity to high temperatures which must be considered when using or storing. If the battery is not in use, then it is recommended that it is kept in a cool environment which will help to reduce the aging and reduction in quality of the battery. Battery users should be aware of the recommended storage temperatures specified by the battery manufacturers and retain their batteries in the recommended environment.
- Lithium-ion batteries require a battery charge monitor that will manage the charging process. This will ensure that the batteries will be charged as safely, quickly, and fully as possible. However, it needs to be recognised that this monitor also drains power from the batteries during its use which will cause the batteries to degrade and lose power over time.
- In the event that a battery was to become completely discharged, then it would be ruined and unusable.
- Should the battery erode or be damaged, then there is a likelihood that it could overheat and catch alight or even explode.
- If water gets into a lithium-ion cell it can create a chemical reaction with the lithium salt in the electrolyte which releases toxic hydrogen fluoride.
- It is also recognised that sea water can create a short circuit because of its high conductance and corrosive properties which could lead to overheating, fire and/or explosion.

Overheating risk

Lithium-ion batteries internally contain an electrolyte which can be highly volatile and flammable. In the event of the battery overheating it can cause the lithium-ion battery to undertake a 'thermal runaway'. This occurs when an exothermic reaction goes beyond control and drives the battery temperature higher and higher. Explosions can then occur if the flammable gases produced during the thermal runaway either mix with the remaining air within the battery enclosure, or when fresh air enters the battery enclosure from vents or openings.

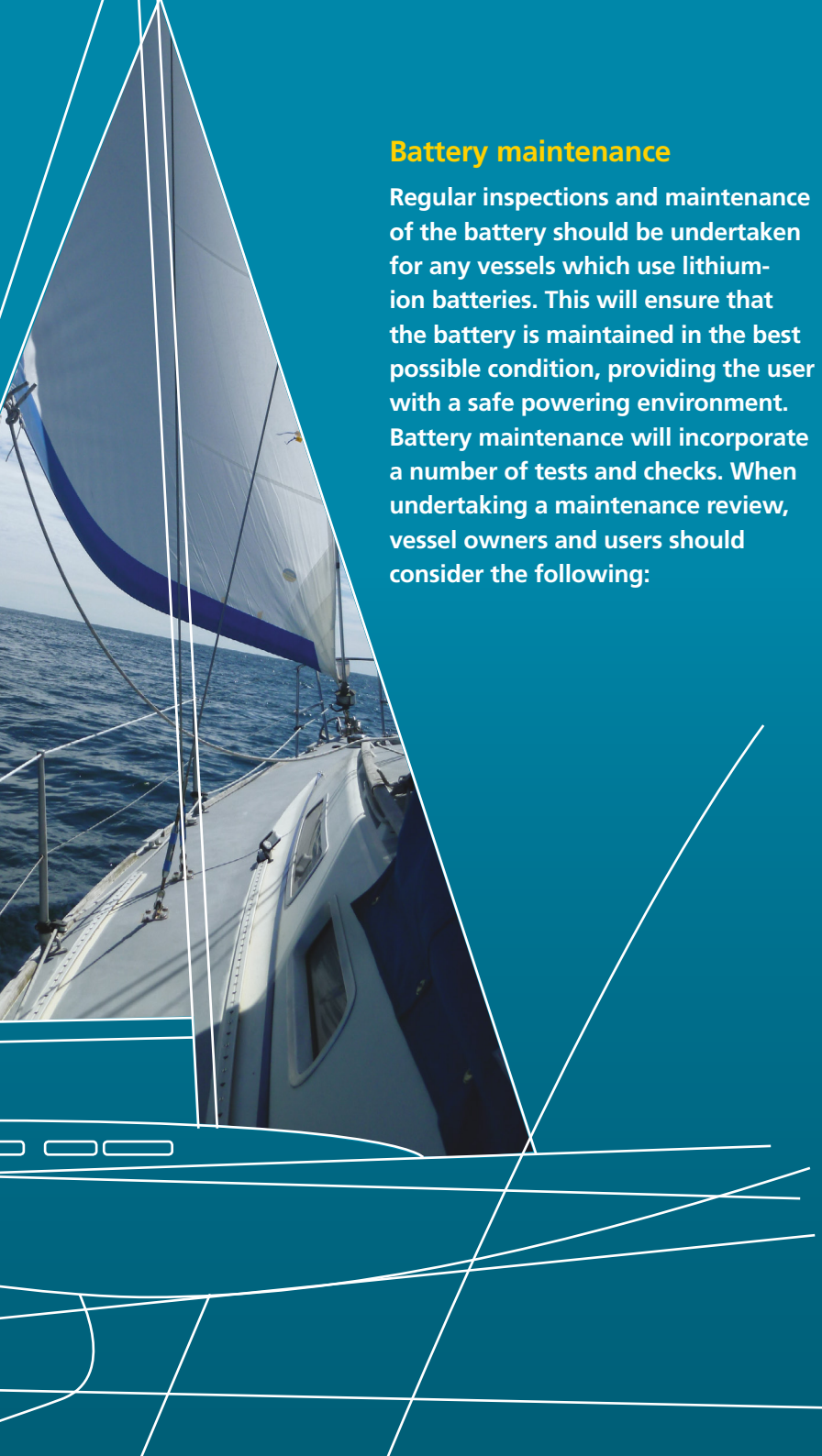
The development of a thermal runaway occurs in the following stages:

As lithium-ion batteries are made of a series of cells, the thermal runaway will typically start in one cell before expanding in a domino effect through the adjacent cells.

There are a number of reasons why a battery can overheat and these include the following:

- Damage to the battery
- Manufacturing defects
- Overcharging
- Over-discharging
- Short circuiting
- Water ingress
- Incorrect use of charger
- Poor quality battery – cell faults
- Poor condition of battery – cell faults
- Age of battery

When using a vessel that contains a lithium-ion battery and utilises it for power, then a fire risk assessment should be undertaken to ensure that the battery is maintained in good condition and used in line with the manufacturers advice. Any increased risks associated with the charging and use of the battery should also be considered from a fire risk perspective. Users should ensure that the correct measures for managing and controlling the fire risk associated with use of the battery are undertaken.



Battery maintenance

Regular inspections and maintenance of the battery should be undertaken for any vessels which use lithium-ion batteries. This will ensure that the battery is maintained in the best possible condition, providing the user with a safe powering environment. Battery maintenance will incorporate a number of tests and checks. When undertaking a maintenance review, vessel owners and users should consider the following:

- Undertake a test and check procedure to ensure that no external damage has occurred to the battery and/or charging equipment. If damage has been recorded to either the battery or the charger this should be noted and use of the items should be ceased with the battery or charging equipment being removed and replaced.
- Users should ensure that there has been careful housekeeping undertaken throughout the life of the battery, including any time whilst spent in a storage facility.
- All electrical wiring and portable appliance testing are to be undertaken and completed as necessary to ensure that there are no failings or hot spots in the device.
- Lithium-ion batteries should be kept in a dry environment. Any water ingress can lead to the deterioration of the battery and create a chemical reaction that could lead to a potential fire or explosion.
- The application of a thermographic camera which will highlight any hotspots or weaknesses in the battery. This can indicate the condition of the battery and ascertain whether there is an increased risk of fire occurring.
- Users should ensure that lithium-ion batteries are always maintained in a good condition. Any batteries that have resulted in any form of damage ought to be removed and isolated to ensure that no likelihood of fire or explosion can arise that could impact the storage environment or vessel.
- Lithium-ion batteries should be kept separate from all combustible items whether in use or not.
- Vessel owners and users should consider the installation and use of a thermal runaway monitor. This device will enable the user to monitor any increased heat levels within the battery.
- Should a battery or charging failure arise then the battery is to be separated from the vessel. Or, in the event of an issue arising with the charger, this should be shut down. Users should ensure that the battery is cooled down in a safe and protected environment, thus ensuring that there is no opportunity for overheating or a thermal runaway to occur.

NOTE: USERS SHOULD BE AWARE OF THE LOCATION OF THE BATTERIES AND THEIR CHARGING POINTS AND ANY EMERGENCY ISOLATION POSITION.

Battery charging

All use of battery chargers and the procedures utilised in their application when charging must be undertaken in accordance with the manufacturer's instructions.

All charging procedures should be recognised, tested in full and documented.

Do not use chargers that have not been specifically developed for use with the battery. This can create charge fluctuations which can lead to overheating, fire and thermal runaway.

Users should ensure that the battery is not exposed to high temperature volumes.

In the event that the vessel owner employs staff who oversee battery charging, they should ensure that the employee have received the appropriate level of training to ensure the safe handling and storage of all batteries. This training should include the implementation of any emergency arrangements for dealing with battery failures and any scenarios that may arise that are associated with a battery fire or explosion.

Fire protection

Because of the potential extreme nature of lithium-ion battery fires, vessel owners and users should ensure that any spare or back-up batteries are stored in a specific location or environment that is able to reduce the potential damage caused in the event of a battery fire or explosion. Should a fire arise that involves a lithium-ion battery, then additional care should be taken when managing the fire and extinguishing it. Because of the chemical composition of lithium-ion batteries, they have a higher burn level and can produce toxic side-effects.

Therefore, it is recommended that a proper detailed fire risk assessment should be undertaken and documented, and the property owner or associated business should create a formal emergency response procedure based on the risks arising and the make-up of the environment in which the batteries are contained.

It is advantageous if the owner's storage contains a sprinkler system. Additionally, the batteries should be stored separately from any other flammable stocks or goods, thus ensuring that in the event of a fire, no flash-over or increased fire loss can occur.

If the batteries are stored in a location that does not contain sprinkler protection then greater cognizance should be applied when considering the associated fire risks and required protection levels.

Key considerations could include such scenarios as:

- What level of access is available to the local fire-brigade? How easy is the building/vessel to access in the event of a fire?
- What availability and levels of water for fire-fighting purposes are available on or near the site?
- Is there any form of fire compartmentation in the building/vessel, and if so how is this arranged?
- Are there any communicating air conditioning or ventilation systems in the building/vessel which could increase or spread a fire?
- What other flammable stocks or goods are stored in the building or on the vessel? Will these provide additional fuel for a fire and are they stored within the reach of aflame from the stored batteries?
- What level of fire resistance is there between areas in which batteries are stored and other parts of the building or vessel?
- Are the batteries kept in a controlled and protected environment?
- Is any charging undertaken in a compartment or area separated from the rest of the building or vessel? This would mean there would be sufficient protection in place should a battery overcharge, catch alight or explode.
- Has the owner undertaken a fire risk assessment as outlined by the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 4-8) and in compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 10). Any assessment should ensure that the battery storage area is separated from any identified hazard areas.
- In the event of batteries being stored in a commercial business environment, consideration should be undertaken of the likely extent of fire damage to property and the implications of a business closure and business interruption losses that may arise from a battery fire.
- Are there sufficient smoke and/or heat alarms installed in the storage area?
- Does the premises have a central station fire alarm installed?
- Is the vessel being charged overnight? Charging of lithium-ion batteries should be supervised to ensure that no likelihood of the batteries overheating can occur. In the event of an overheat, actions can be taken to reduce the impact of the fire.

Individual battery protection

Because of the nature of lithium-ion cells, batteries should be carefully stored when not in use. Lithium-ion batteries should be kept stored in a well-ventilated, dry area and should be away from direct sunlight, heat, water and humidity extinguishing systems. The preferable temperature should be between 40 and 80 degrees Fahrenheit although room temperature is considered as acceptable.

To ensure protection of the battery when not in use, it is often found that the use of a battery storage cabinet is useful, and it can prevent damage to the battery. Often this takes the form of a closed and secure metal container.

When storing the batteries, users should ensure that the battery poles are protected from short circuiting by using terminal covers. Users should ensure that the terminals are not able to contact with other terminals. Likewise, they should ensure that the terminals are unable to contact with any metal shelving/walls in storage.

Fire Extinguishing Systems

Sprinklers

Where there is the likelihood of any combustible material being stored, then it is recommended that a sprinkler system is installed. It is recognised that these can be expensive and not all storage areas are going to be of the size where a system can be viably installed.

Extinguishments

Because of the chemical nature of a cell fire occurring in a lithium-ion battery, standard fire extinguishers, i.e., foam and water, will not work. The only way to extinguish a lithium battery fire is to flood the battery with water.

Additional fire extinguishment can be utilised through the application of various other forms of fire protection including:

- Dry powder extinguishers
- Carbon dioxide extinguishers
- Water mist
- Fire blanket systems

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