Lithium-ion battery fires: What we know so far

EDITION 2

APRIL 2026

A guide from the Maritime Professional Council of the UK

Promoting excellence in professional maritime standards

MPC THE MARITIME PROFESSIONAL COUNCIL OF THE UK

The purpose of the **Maritime Professional Council of the UK** is:

- To promote the professionalism and esteem within the British Merchant Navy and to those organisations directly concerned with the sector.
- To provide a central point from which professional opinion on maritime matters can be offered to the Maritime Community, Industry, Government and the Media.
- To provide independent expert advice and guidance based on our combined professional knowledge and experience unhindered by any financial or commercial interests.
- To provide guidance to regulators and employers on the professional training standards adequate for our maritime professionals.maritime standards.

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The Council

The Maritime Professional Council of the UK is made up of senior individuals and representatives from the member organisations, who meet periodically.

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The Member Organisations

The MPC comprises of these 11...

Cameron Maritime Resources

CHIRP Maritime

Institute of Marine Engineering, Science & Technology

InterManager

Maritime Volunteer Service

The Honourable Company of Master Mariners

The International Institute of Marine Surveying

The Nautical Institute

The Professional Charter Association

Trinity House

Trinity Maritime

Executive Summary

In a new guide, "Lithium-ion Battery Fires: What We Know So Far", the Maritime Professional Council of the UK (MPC) warns of the rising risks and dangers of lithium-ion battery fires to ships, boats and their crews.

The maritime industry faces increasing incidents of lithium-ion battery fires, particularly with the growing use of electric vehicles (EVs) and a myriad of devices powered by these batteries. Lithium-ion batteries have a high energy density, making them efficient but also prone to catastrophic failures if mishandled.

The guide makes five key points regarding safety issues and implications:

1. Thermal runaway risks: understanding thermal runaway is critical as it leads to uncontrollable fires.
2. Firefighting challenges: traditional firefighting methods may be ineffective against lithium-ion battery fires due to their unique characteristics.
3. Regulatory gaps: current regulations do not sufficiently address lithium-ion battery safety, highlighting the need for updated guidelines.
4. Training deficiencies: crew members often lack training specific to lithium-ion battery risks, increasing vulnerability to incidents.
5. Collaborative solutions: cooperation among stakeholders, including ship operators, maritime regulators, and emergency responders, is vital for enhancing safety measures.

Reports indicate that battery-related fires are a significant and rising cause of marine insurance claims, with an increase in incidents linked to lithium-ion technology.

Meanwhile insights from professionals in the maritime and fire safety sectors emphasize the need for comprehensive approaches to battery management and fire prevention.

Many incidents stem from inadequate safety protocols and a lack of understanding among crew members and vessel operators about how to handle lithium-ion batteries safely.

The dangers include thermal runaway, which can cause fires and explosions, and the release of toxic gases during combustion.

The guide includes detailed analyses of past incidents to illustrate the potential dangers and the importance of understanding lithium-ion battery behaviour during fires.

Several reported incidents illustrate the consequences of lithium-ion battery fires on vessels including car carriers and container ships, leading to significant financial losses and safety hazards.

The dangers are not confined to sea-going vessels but reported examples include explosions on a canal boat in the UK and a fire on a yacht due to inoperable battery management systems.

Current regulations are insufficient to address the unique challenges posed by lithium-ion batteries in maritime environments. Enhanced training for crew members on fire safety and emergency response is crucial to mitigate risks.

The maritime industry must collaborate with manufacturers, regulatory bodies, and emergency services to develop comprehensive safety protocols and training programs. Adoption of best practices, such as thorough inspections and maintenance of battery systems, is essential for preventing fires.

The guide's authors stress: "The growing prevalence of lithium-ion batteries in the maritime sector necessitates a proactive approach to safety and risk management."

They conclude that effective strategies must include ongoing education, robust safety regulations, and collaborative efforts to ensure the safe transport and usage of lithium-ion batteries. Immediate action, the report warns is required to address the challenges posed by lithium-ion batteries to prevent future incidents and protect lives and property in the maritime industry.

Welcome and introduction

by Mike Schwarz, CEO, International Institute of Marine Surveying

On behalf of the Maritime Professional Council of the United Kingdom (MPC), I'd like to welcome you to the second edition of *"Lithium-ion battery fires: What we know so far".*

Lithium-ion battery technology is a fast moving landscape. Much has been written in recent times about lithium-ion battery fires by many organisations following a spate of catastrophic events in the marine industry affecting both large ships, as well as small pleasure craft powered by this technology. And disasters are not confined to the maritime sector with an increasing number of high profile land based incidents occurring. Our motivation to release this publication was borne out of the many shocking lithium-ion battery incidents and accidents that have been observed by the MPC Council member organisations in the course of their work.

Although collated and prepared by my colleague, Frances Birkett, and me in the UK, this publication is intended for a worldwide audience. We are grateful for the many existing resources, reports and case studies we have been able to tap into as part of the production of this guide. Part of the challenge is knowing when to draw a line, stop, and share what we know. By that I mean there are an ever increasing number of high profile lithium-ion battery fires hitting the news headlines on a regular basis – and not just in the marine sector – which are now reaching the attention of the public as awareness of this phenomenon grows.

In this publication we seek not to delve too deeply into the science behind the chemistry of lithium-ion batteries. That said, understanding the chemistry and the type of battery involved in the event of a fire can be essential for those who are faced with fighting it, but that is not always easy to determine.

Our aim is not to stymie, or rail against the advancement of using this emerging technology, which to be frank surrounds us all in our everyday lives from electric vehicles to mobile phones, and from eScooters to eBikes, laptops and wearables. And, for balance, it is important to mention that there is no statistical evidence to suggest that there are more lithium-ion battery fires than conventional ones. But when a lithium-ion battery blows and explodes, the intensity of the resulting conflagration makes it hard to contain and almost impossible to extinguish, for at this time there remains no effective and reliable means of putting out the fire. In some of the examples we will share, the vessels have been ablaze for days. More often than not the loss is total, resulting in mounting insurance claims, which are now burdening the P&I Clubs as they grapple with this situation.

Regards, **Mike Schwarz,** *IIMS Chief Executive Officer*

About the authors

Mike Schwarz
Chief Executive Officer,
International Institute
of Marine Surveying

In recent years, Mike has become increasingly concerned about the increase of li-ion battery fires. As a consequence, he has written several articles and has spoken on this subject at various conferences. He remains deeply committed to alerting the industry and others about this technology.

Frances Birkett
Marketing &
Publishing Executive,
International Institute
of Marine Surveying

As part of her role curating a yearly calendar of marine accidents, Frances has been exposed to many of the li-ion incidents and accidents as they have occurred and she has developed a keen interest in this subject matter.

Feedback and comments are most welcome to the MPC Council Secretary by email to ***council@mpc.org.uk***.

Although great care has been taken in compiling this publication, neither the authors nor representatives of the member organisations of the Maritime Professional Council of the UK can be held liable in the event of any factual errors or omissions, nor for any opinions that have been expressed.

Lithium batteries

Sustainability is a hot topic. As the maritime industry continues to address the challenges of pollution and greenhouse gases, the use of lithium marine batteries has grown. Li-ion batteries tend to last longer and are more efficient than lead-acid battery systems. They also have a reputation for being safer and more reliable.

However, the safety considerations surrounding li-ion batteries cannot be ignored. But what is known about them? The different chemistry and characteristics available need to be understood to comprehend the benefits and risks involved – and to ensure safe application and installation of this energy source.

What is a lithium battery?

A lithium battery is rechargeable and comes in a range of battery chemistries and formats. They're popular due to their high energy density, low weight and long lifespan. They are made of an anode, a cathode and a lithium salt electrolyte.

Common battery chemistry types:

- Lithium iron phosphate (LFP)
- Lithium cobalt oxide (LCO)
- Lithium titanate (LTO)
- Lithium nickel manganese cobalt oxide (NMC)
- Lithium manganese oxide (LMO)
- Lithium nickel cobalt aluminium oxide (NCA)

So, what is a LiPo battery?

A lithium-polymer (LiPo) battery uses a solid or gel-like polymer electrolyte instead of liquid lithium-salt electrolyte found in traditional li-ion batteries. This means that a porous separator isn't needed, allowing for flexible packaging that can conform to various shapes and sizes. They tend to be packed inside a pouch casing. While they are unable to store as much energy as a li-ion battery, they can charge faster.

Types of lithium cell forms

	Cylindrical	Pouch	Prismatic
Characteristics	Widely used and the oldest format used in li-on batteries. Shaped like an AA battery but bigger.	Soft, flexible and flat shaped, these lithium batteries are designed to fit within a solid housing or case.	This type of battery is characterised by its block-like casing, allowing it to be stackable.
Can be found in	• Power tools • Portable power banks • Laptops • E-bikes • Medical instruments • EVs	• Smartphones and tablets • Wearable technology • E-bikes • Medical equipment • Drones and UAVs • EVs	• Smartphones and tablets • Laptops • Solar energy storage • Industrial robotics • Grid-scale energy storage systems • EVs
Pros	Cheaper and easier to manufacture with excellent thermal management. Very durable. No cell swelling.	Lightweight and can be designed to fit into small spaces. High energy density and low-cost casing.	Mechanical strength and space savers due to their shape. Can be stacked together for this reason. Very durable due to casing and high energy efficiency.
Cons	Inefficient use of space as cylindrical shape leads to gaps. Limited individual capacity.	Expensive to develop and produce. They are also fragile and can swell as they are prone to physical damage. Design of the battery needs to accommodate for cell swelling – which can be as much as 10% after 500 cycles.	Expensive to manufacture and proper ventilation is needed to prevent heat buildup. Vulnerable to cell swelling and mechanical stress/punctures.

Marine lithium batteries

Characteristics

The three main types of marine lithium batteries that you will come across include LiPo, NMC and LFP batteries.

	LiPo	NMC	LFP
Can be found in	▪ Smartphones ▪ Laptops/tablets ▪ Power banks ▪ Hobby drones ▪ RC vehicles ▪ E-cigarettes/vapes ▪ Wearable technology	▪ EVs ▪ Power tools	▪ EVs ▪ Solar/energy storage systems ▪ Boats
Risk of thermal runaway or fire	Less stable than NMC and LFP. Thermal runaway can happen when battery temperature reaches around 150°C Can burn if: ▪ overcharged/discharged ▪ physically damaged ▪ gets too hot	When battery temperature gets to 150-200°C, e.g. if the battery is: ▪ damaged ▪ overcharged, or ▪ shorts Can self-ignite Max temperature 600-700°C	When battery temperature gets to 250-350°C Low risk of thermal runaway or self-ignition Max temperature Under 200°C

What is thermal runaway?

As defined by the IMO Future Fuels and Technology project (FFT Project): "Thermal runaway is a catastrophic overheating of the battery, causing a fire that generates toxic gases and risk of explosion. The fire can propagate between batteries and adjacent materials/structures. In a marine environment, this obviously causes great danger to the crew, the ship and any passengers on board."

Thermal runaway can occur in several different ways. This includes:

- mechanical damage
- overcharging
- excessive temperatures
- short circuiting
- rapid charging

What does off gassing mean?

When a li-ion battery goes into thermal runaway, it can release flammable and toxic gases. These off gasses may contain:

- Oxygen (O)
- Carbon monoxide (CO)
- Hydrogen Fluoride (HF)
- Methane (CH4)
- Carbon Dioxide (CO2)
- Hydrogen (H2)
- Hydrogen cyanide (HCN)

They can appear smoke-like, but these vapour clouds can ignite and lead to explosions. Coming into contact with water, such as during firefighting efforts or within the marine environment, these gasses can produce chlorine gasses or hydrofluoric acid.

You can read more via this academic paper at **https://bit.ly/3KX9wUE**

Concerns

EVs are 20 times less likely to catch fire than petrol and diesel cars
- Data from the Swedish Civil Contingencies Agency (MSB)

Science backs it up. Electric vehicles (EVs) fires are less likely than conventional internal combustion engine vehicle fires. But that's not why you should worry about lithium-ion battery fires. The industry's real concern lies with the dangers involved with a li-ion battery fire and our ability to deal with them once they've started. As you'll read in later sections within this publication, li-ion battery fires can be far more deadly than a conventional fire for several reasons.

Research is still in its relative infancy when it comes to lithium-ion battery fires. This in turn affects the effectiveness of fire safety techniques and procedures, as well as firefighting and fire prevention training.

Lithium-ion battery fires can be catastrophic, and even if no one is killed or injured in a fire, the damage done can come to a tremendous financial loss.

Read further to see the risks of lithium-ion batteries within the marine environment.

Lithium batteries don't commit suicide. They're murdered

(Headline wording attributed to Professor Paul Christensen)

Cylindrical cell

Pouch cell

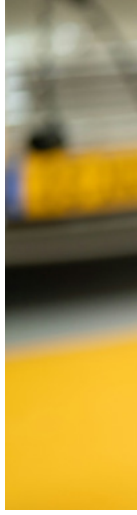
Image from BSLBATT Lithium

Prismatic cell

Lithium-ion (LiBs) batteries are increasingly used in the marine industry. Their advantages are many: compact and cheap, with higher energy density, they can help to cut down sharply on fossil fuel use. Problems are rare, but when things go wrong the results have a high impact and take up emergency resources for a considerable time which has spawned the phrase: Lithium batteries don't commit suicide. They're murdered.

Lithium cells come in three types or form factors:

- The cylindrical cell, such as the lithium 18/6/50. This is shaped like an AA battery and can be used alone or linked in series. It is usually used for smaller devices such as power tools but can be linked up to power larger things like Tesla cars.
- The soft flexible Pouch cell often the size of an A4 sheet of paper but can be smaller: it can be shaped to fit within a housing and was originally developed for Electric Vehicles (EVs).
- The Prismatic cell with a plastic case. This is about the shape and size of a 6 cigarette pack stacked in pairs side by side. Victron LPF marine batteries use this cell type. LFP cells produce higher volumes of hydrogen gases and take longer to ignite the vapour cloud increasing the risk of VCE pack stacked in pairs side by side. Victron LPF marine batteries use this cell type. LFP cells produce higher volumes of hydrogen gases and take longer to ignite the vapour cloud increasing the risk of VCE.



When LiBs fail

LiBs can store a large amount of energy in very small space and can be cycled many times over their lifetime with very little loss of capacity. However, if the stored energy is released all at once it can be very destructive.

It’s not smoke... and apply common sense

When LiBs go into thermal runaway a number of things can happen. The first is the battery may simply explode. Throwing hot shrapnel around. This has happened with light electric vehicles {LEVs), scooters, bikes, water hover boards, jet skis, etc. If it doesn’t explode, you may hear pressure caps popping and hissing of gas escaping with a chemical smell. You might briefly see a black cloud as the carbon particles are blasted out. The flammable gas escapes at high pressure and can ignite producing jet or rocket like flames at 1,000 C. If ignition is delayed the gases vent off creating an explosive atmosphere with an LEL of 11% to 16% with a risk of VCE (Vapour Cloud Explosion). This vapour contains hydrogen, hydrogen cyanide, hydrogen fluoride, hydrogen sulphide, carbon monoxide, CO2 and visible droplets of the solvent mistaken for smoke or steam. Hydrogen fluoride turns into hydrofluoric acid on contact with water or sweat on skin. The DTLH (Danger to Life and Health) level is well below the LEL.

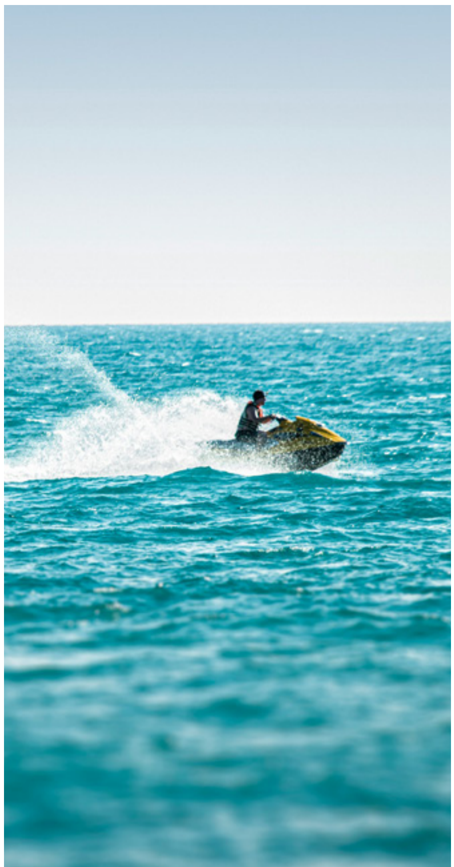
The volume of gas boiled off is huge. In the region of 300 to 5000 litres per kWh of battery capacity. There are also two vapour clouds. One is lighter than air, and the other denser than air. At the moment it’s not known how to predict which will dominate.

Marine Safety Regulations

The current European guidelines, published by P&I clubs, IACS and state authorities for the use of builders and vessel operators are a good starting point. But this is a fast-moving technology though. And the guidelines reveal large gaps in the industry’s understanding of TR and its behaviour beyond the theoretical cell or module testing level and how that practically translates into failures in a large installation in a propulsion system battery room, UPS, super yacht water toys or power tools. The focus is on fire because it’s familiar and easy to understand but, but TR is not a fire, its heat, although fire can be a result. And suppression of active fire is good and buys useful time to remove people or other fire hazards from the area, but in the case of LIBs it flips the risk from fire to VCE. With old-style battery technology, fire suppressants such as water or powder would safely resolve a dangerous situation. LiBs are different. The TR and TP continue as we currently can’t stop it directly as explained above, and it can lead to VCE with all its risks to life and property.

Marcus Jones

Read the article in full at **https://bit.ly/46vp36J**



Carrying electric vehicles and lithium-ion batteries at sea and the fire risks

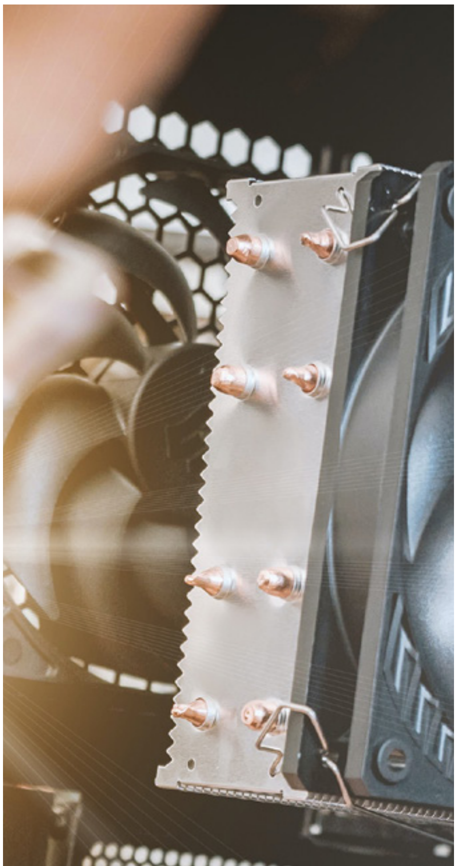
In its Shipping and Safety Review 2023, Allianz Global Corporate & Specialty reported that the second top cause of loss of vessels in 2022 was fire or explosion. There were 209 ship fires reported during 2022, the highest in a decade and 17% more than in 2021. Of those fires, 13 occurred on car carriers. Fire was also reportedly the most expensive cause of marine insurance claims furthering the point that electric vehicles and lithium-ion batteries at sea at potent fire risks.

According to the Allianz report, a combination of causes is increasing the risk of fires at sea. Decarbonization, while a positive global development, has led to new types of cargo such as electric vehicles (EVs) and the prevalence of lithium-ion (Li-ion) batteries which pose a growing risk for container shipping and car carriers. The Li-ion market is expected to grow by over 30% annually over the next decade. Nearly 10% of global car sales were electric in 2021, four times the market share in 2019.

In March 2023, the European Maritime Safety Agency (EMSA) published its CARGOSAFE study, which assesses the risks associated with fires on container ships and evaluates prevention, detection, firefighting, and containment measures. The study indicated that the main cargo types identified as responsible for a large share of cargo fire accidents included Li-ion batteries.

Furthermore, the cause of many cargo fires can be attributed to mis-declared dangerous goods. By way of example, in August 2021, a container loaded with discarded Li-ion batteries, intended to be loaded on board a container ship bound for China, caught fire whilst being transported to the port. The bill of lading listed "computer parts," not Li-ion batteries. The Cargo Incident Notification System (CINS) indicates that nearly 25% of all serious incidents onboard container ships can be attributed to mis-declared cargo.

Read the full article at **https://bit.ly/46L33DA**



Are lithium-ion batteries safe on yachts – and other vessels?

There are believed to have been nearly 70 yacht fires in 2023 alone involving large and superyachts. As more new information on this subject comes to light on a regular basis, I simply have to come back to it time and time again and share what we know. It is a massive and worrying subject and one that is consuming the finest technical minds in the marine world right now.

I attended an event hosted by Shoosmiths, a firm of maritime lawyers. The event took the form of a panel discussion involving five experts from different parts of the marine industry and was entitled "Are lithium-ion batteries safe on yachts?" It drew a sizeable audience of about 120 delegates to the event in person, way beyond their expectations and included marine surveyors, yacht management companies, regulators, underwriters, boat brokers and boat builders. As the event unfolded, I would describe the mood of the audience as engaged but concerned. In some cases, many seemed unaware of the immense threat posed by lithium-ion battery fires and all in the room were anxious for guidance. Guidance, however, was in short supply.

One marina manager when asked what their policy is for berth holders to mitigate a lithium-ion battery fire disaster in one of their facilities said it is still too early for them, and they are "only in the embryonic stages of developing a policy". That frankly sums it up!

There seemed to be a consensus that lithium-ion batteries if installed in a new build boat or ship and meeting all the latest requirements on keeping them in sealed metal containers, are no more inherently dangerous than conventional fossil fuelled vessels. Indeed, the evidence would seem to support that; and insurers confirmed they have no issues insuring an electric boat powered by lithium-ion battery propulsion. The picture is less clear for batteries that are retrofitted into older vessels. But the panel discussion focused heavily, perhaps surprisingly, on the other less thought about aspects such as the charging of devices powered by lithium-ion batteries onboard, particularly overnight, including mobile phones, laptops, tablets and superyacht toys, for this is where the major issues lie. Leaving them to charge unattended overnight is potentially dangerous as overcharging can cause thermal runaway resulting in a catastrophic fire. This applies equally to an onboard setting as it does to a land-based home one. There have sadly already been examples. I will never do this again; nor should you, and I would encourage you to pass on this information. Please tell anyone you meet not to do it either.

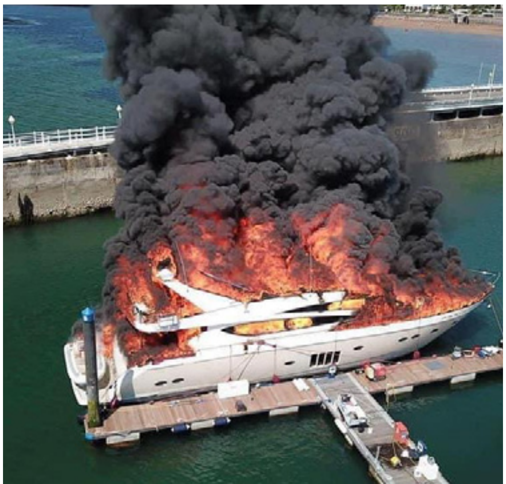
One of the panel also spoke passionately about the importance of using the right charger for each device and not some cheaper imitation replacement from an unknown supplier, which presents a further unnecessary risk. The advice is to use the correct charging mechanism always and read the instructions.

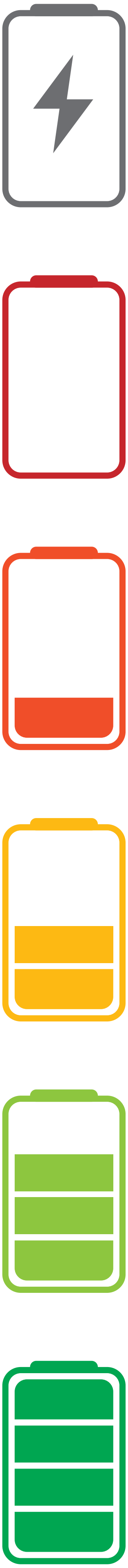
There was an acceptance and understanding that firefighting systems are not yet developed sufficiently to extinguish a lithium-ion battery fire in most cases. Simply chucking the burning object overboard, whilst a highly dangerous thing to do and not recommended, will bring some peace of mind, but won't put out the fire! Early warning detectors of an imminent thermal runaway event are under development and will be available soon. But then we learned about the lethal mass of unignited toxic gases which hang around at low levels that could easily go undetected and ignite or simply kill.

Mike Schwarz

Read the full article at **https://bit.ly/46INnR9**

Image credit: Stevie-Iona Vaughan/Facebook





Managing the growing risk of lithium-ion battery fires

The global energy transition has led to an acceleration of new and innovative technologies designed to support decarbonization efforts across the global supply chain. The maritime industry plays a fundamental part in this effort, not simply by addressing its own impact on global CO2 emissions, but also by facilitating the availability and transportation of new and innovative technologies that are designed to mitigate carbon emissions. But not all of this is safe as there is a growing risk of Lithium-ion battery fires.

For instance, the shipping industry is playing a critical role in accelerating the green automotive market, particularly the global transportation of electric vehicles (EVs) and large battery hybrids. According to Statista, the EV market is projected to grow by nearly 10% each year and account for over 17 million vehicles by 2028. However, this development also brings with it significant safety implications that don't just impact the vessel, but also the health and wellbeing of crew members onboard – specifically in relation to the significant increase in fire risks presented by the lithium-ion (Li-ion) batteries used in EVs. Li-ion batteries are the preferred technology for EVs due to their high energy density and efficiency. However, such batteries are inherently volatile and can catch fire or explode under certain conditions. The characteristics of fires caused by li-ion batteries are complex, and the shipping industry is making continuous efforts to understand effective ways to mitigate them. When incidents do occur, the threat to crew, vessels, cargo, and the environment is profound.

The main characterization of a lithium battery fire is the creation of an extremely hot thermal runaway, a primary risk where the battery's internal temperature rapidly increases, leading to a fire or explosion. A li-ion battery fire will sustain itself, meaning that rather than lasting minutes or hours, a fire can continue for days. Such an event can be triggered by physical damage, manufacturing defects, as well as exposure to extreme temperatures.
Despite the nature of the risk being the same, the implications of transporting EVs via both car carriers as well as in containers are different, and each comes with its own individual sets of risks. It is a legal requirement that EVs are declared as dangerous goods (DG) when transported in containers. However, the current DG regulations contain no specific restrictions related to stowage and segregation. This lack of stowage and segregation restrictions means that EVs on container ships can be stored near cargoes or operations where fires could originate, or near cargoes with corrosive properties. Furthermore, there are currently no declaration requirements for EVs being transported on vehicle carriers (PCC's, Ro-Paxes, etc). Although these vessels are designed with additional fire safety measures, this lack of information makes it difficult to plan where EVs should be loaded to reduce exposure to any fire risks. It also makes it difficult to contain fires that EVs could be exposed to.

The continued growth of the EV market, coupled with the seeming increase in regularity of fire incidents onboard, means that the industry must act quickly and decisively to mitigate the growing risk. However, shipping companies cannot manage the fire risk of li-ion batteries alone. This is a complex, interconnected issue that requires collaboration between multiple stakeholders throughout supply chains, starting with equipment manufacturers and in developing associated regulations.

Rising EV volumes are reshaping the risk profile of managing hazardous cargoes, and this is going to increase as the market grows. Ultimately, the key to taking control of such a potentially volatile presence on board is proactive defence and risk mitigation. Through effective crew training, ship owners and operators are able to establish a robust line of defence against li-ion battery fires on their vessels. This requires a reassessment in current approaches both in terms of fire detection, firefighting equipment, and in firefighting strategy. Managing fires caused by li-ion batteries requires a 'Fixed Fire Extinguishing System First' defensive strategy focused on early detection and containment.

Read the full article at **https://bit.ly/3Wf0u7W**

Toys and lithium-ion powered devices can cause devastating marine fires

by Mike Schwarz, CEO, International Institute of Marine Surveying

In this article, I do not plan to address the specific issues of lithium-ion (li-ion) battery fires on electric powered boats or ships, nor will I discuss the electric vehicles that have caught fire in high profile, well reported incidents at sea in recent years, whilst being transported onboard car carrying ships.

Neither is it my aim to scare people in what I hope is a well thought out article, that articulates and reflects where we are at in our current complex relationship with li-ion as a significant power source. There are millions of li-ion powered devices in existence throughout the world, and the vast majority perform their function without drama or malfunctioning. But there is growing evidence to show that li-ion batteries, for all their good points, present some significant challenges when things go wrong, especially in the maritime sector.

For balance, it is important to state that statistically there is no evidence to suggest that a li-ion battery conflagration is more likely to occur than a conventional fire, but the reality is that when one does, the results are usually rapid and explosive often leading to a total loss. The rapidly spreading inferno represents immediate danger to crew, passengers and the vessel itself, as well as neighbouring boats and even harbour infrastructure. Unlike a fire in an electric vehicle on the road, where the driver has an opportunity to pull over and escape, that luxury is not afforded to those at sea should a similar emergency situation occur.

In recent years, the number of fires aboard vessels has risen dramatically. While there are many potential causes, li-ion batteries have been directly proven to be the cause of a number of these incidents.

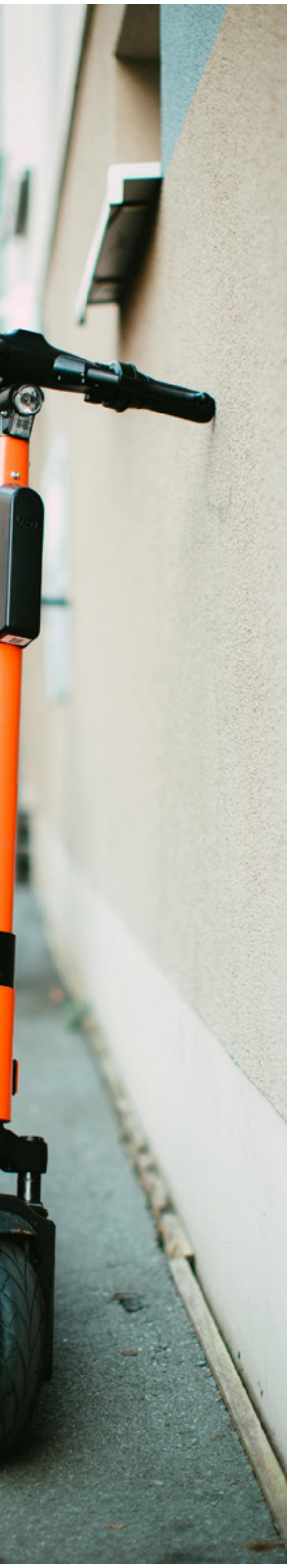
Li-ion batteries are commonplace and the plethora of high-end water toys and electric devices are causing catastrophic fires on boats, often due to overheating while charging, or damage in storage that has agitated the batteries. Some examples include e-scooters, e-bikes, drones, electric surfboards, seabobs, phones, tablets and so on.

Each of us personally could have up to half a dozen li-ion batteries in close proximity - a watch perhaps, laptop, mobile phone, handheld UHF radio, flashlights, other wearable tech, and even vapes - are just a few examples. The power of li-ion batteries and their convenience come with risks that we need to be aware of so we can take mitigating action when and if required.

Lithium is a highly reactive alkaline metal and the chemistry behind li-ion batteries is complex. This makes it ideal for storing large amounts of energy in battery form but also makes it potentially explosive when something goes wrong. The key is in the construction of the cells which make up the particular battery type. When in use, electrons flow between the cathode and the anode through a perforated separator. If this membrane breaks down, either through poor manufacture, old age or mishandling, a short circuit can occur. Then the cell quickly heats up, the electrolyte expands and a toxic, flammable gas is vented, sometimes explosively. In bigger batteries with multiple cells, the heat starts to damage neighbouring cells, which then also malfunction. This process is called thermal runaway and once triggered, it is near on impossible to stop. When the cell is breached, highly reactive lithium simply adds fuel to the fire.

Thermal runaway is a dangerous, self-sustaining chain reaction where internal heat exceeds heat dissipation, leading to excessive temperatures. It causes rapid, uncontrollable temperature rises, releasing toxic and flammable gases - known as off gassing - and often resulting in fire or explosion. The toxic gases are a rarified mix of substances, and if inhaled, could kill.

Fire suppression systems and extinguishers are not yet effective enough to guarantee to put out a li-ion fire once it has taken hold, and worryingly, there is an ongoing risk that the device could reignite hours, days, or even some weeks later after the event.



Protection is key and there are some simple yet essential things that can be done

In most cases, regulators remain behind the curve as far as li-ion battery technology is concerned. However, there are industry guidelines emerging as more becomes known. The US Coast Guard Safety Alert 14-25, for example, covers those hazards that are linked to li-ion batteries and urges the importance of proper inspection regimes and crew training.

Additionally, there are practical, common sense steps that should be taken. Make sure that li-ion batteries are certified to UL, CE or IEC standards. At all costs, avoid cheaper products, such as chargers, and stick to the manufacturer's specifications always.

Mixing battery types must be avoided. Compatibility between batteries, devices and chargers must be verified to avoid electrical mismatches that could cause overheating or failure. For shipboard use, all procurement should be documented in inventory logs to ensure traceability and accountability.

Storage considerations

Li-ion batteries do not like excessive heat or cold and must be stored in cool, dry, well-ventilated areas. Li-ion fireproof containers and special bags should be used where possible and kept well away from flammable materials. Crew should avoid stacking batteries, which can cause short circuits and fires, and ensure that personal devices and power banks are stored separately from combustible items.

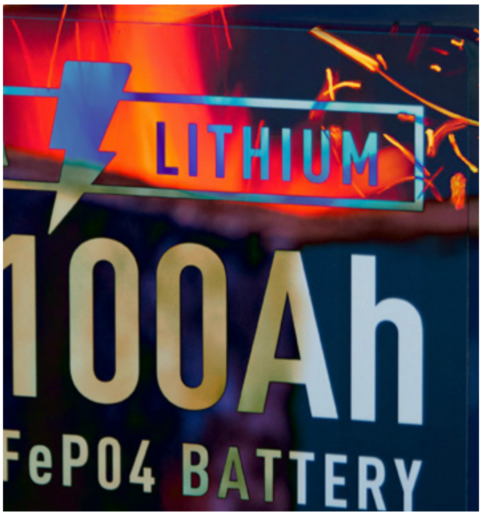
Some practical safety tips and advice

- Any li-ion battery propulsion installation should have been installed by a competent person. Does it meet the ISO 23625:2025 Small craft - Lithium-ion batteries standard published in 2025?
- It is recommended that devices should never be left on charge overnight unattended. Even when charging in the daytime, it is good practice to be able to have line of sight to your device on charge.
- Checking batteries regularly is a good and sensible practice. Look for any signs of swelling, corrosion or weeping. If you see something that looks wrong, be vigilant as the device could misbehave without warning. Isolate it in a secure place if it is safe to do so.
- Never accept a charger offered by someone else because you have left yours behind. You cannot vouch for its authenticity.
- Buy replacement batteries or chargers from trusted suppliers, and always choose a genuine, branded product.
- Never cover chargers and make sure they are charged in a well-ventilated area.
- Always charge in cool, open areas and avoid charging in direct sunlight or hot environments.
- Never charge a li-ion battery device in a place where you would need an escape route in the event of a fire - the speed and rapid spreading of any fire could block your way out.
- If you see white vapour that may look like smoke coming from a battery then get out, stay out and call the fire service immediately.

In conclusion

Having some knowledge about li-ion battery technology and its associated risks can surely only be a good thing. You are encouraged to share some of what is now known about li-ion battery fires with your own professional and personal networks.

Navigating the Risks: Lithium-Ion Batteries, Electric Vehicles, and Fire Safety in the Maritime Industry



by Karley Smith and Yvonne Tung, Brookes Bell

INTRODUCTION

Lithium-ion (Li-ion) batteries are an everyday essential item embedded in everyday life, found throughout the world and in almost every household or workplace in one form or another. We can find them in portable devices such as mobile phones, laptops, tablets, power banks and cordless vacuums, all the way through to electric vehicles (EVs) - scooters, buses, cars and bikes.

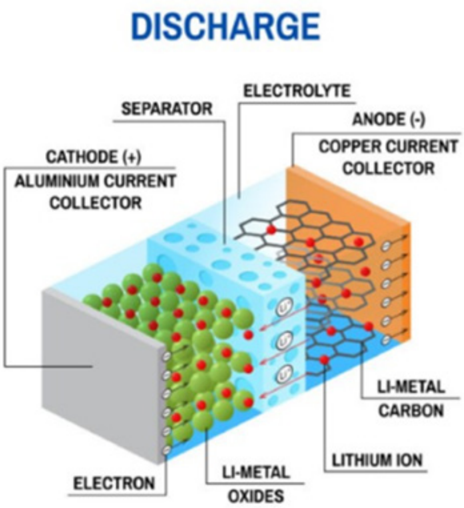
However, their widespread use has led to a surge in fire incidents, particularly involving EVs. Recent media reports and insurance data highlight a 17% increase in Li-ion battery-related fires in New Zealand alone[1].

As the maritime industry embraces the global shift toward electrification, the integration of Li-ion batteries and EVs onboard vessels presents both opportunities and significant fire safety challenges. This article explores the science behind Li-ion batteries, the risks they pose, and the implications for maritime operations, drawing on recent incidents and emerging mitigation strategies.

UNDERSTANDING THE BATTERY: CONSTRUCTION AND CHEMISTRY

Li-ion batteries consist of:

- **Electrodes** (anode and cathode) – where Li-ions are stored during battery charging and discharge and where the electric current enters and leaves the battery.
- **Electrolyte** – organic solution that the Li-ions pass through but electronically insulating. This is the flammable component of a typical battery.
- **Separator** – A porous membrane that physically separates the electrodes from one another and allows Li-ions through.



During discharge, Li-ions flow from the negative electrode (anode) to the positive electrode (cathode). When the cell is charging, the ions flow in the opposite direction, from cathode to anode.

EV battery packs are complex assemblies of connected cells known as modules, enclosed in protective casings with integrated cooling systems and Battery Management Systems (BMS). The battery pack is typically integrated into the chassis of an EV.

1 https://www.iag.co.nz/newsroom/news-releases/ami-reveals-increase-in-battery-related-fires

The battery pack enclosure not only protects the batteries from external damage and ingress of dirt or debris, but it can temporarily contain a fire in the enclosure, providing time for fire extinguishing and preventing propagation to other cars. However, for such Li-ion battery fires, the encasing also makes firefighting more difficult by preventing direct access to the battery pack itself.

The BMS monitors voltage, current, resistance and temperature of the battery, which are all vital to allowing the battery to function at its optimum potential. It is also critical for balancing the cells, which means ensuring that every single cell within each module of the battery pack charges and discharges at the same level. Cell balancing is critical to prevent over-charging or over-discharging of any single cell within the pack. Over-charging or over-discharging batteries can lead to battery failure.

The BMS also monitors the State of Charge and State of Health.

FIRE RISK AND THERMAL RUNAWAY

Li-ion batteries can fail due to:

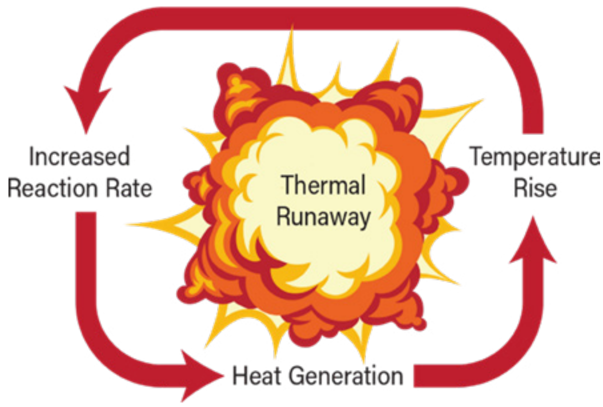
- Manufacturing defects.
- Battery management software faults.
- Internal/external short circuits.
- End of life.
- Battery abuse:
  - **Mechanical damage** – This is external damage, such as dropping from a height, indentation, or punctures, etc., which can result in damage to the internal components, rendering the battery unstable.
  - **Electrical abuse** – Over-charging or over-discharging the battery. This can occur due to manufacturing faults in battery cells and ineffective monitoring of the voltage by the BMS.
  - **Thermal abuse** – Subjecting the batteries to extreme temperatures (both high and low), or its local temperature is too high which could be due to poor battery design or manufacture, or the BMS not regulating the temperature properly.

Each type of battery abuse described can lead to battery failure. Mechanical abuse can cause the separator to break, causing a short circuit by contact between the two electrodes, whilst electrical abuse can lead to formation of dendrites (branches of lithium) which can pierce the separator, again resulting in short circuit. Thermal abuse at high temperatures can lead to electrolyte breakdown.

The battery failure can lead to a phenomenon known as 'thermal runaway.' Thermal runaway is the term used to describe when a reaction becomes self-accelerating; this occurrence is not exclusive to batteries. In the context of batteries, battery failure can result in exothermic (heat generating) reactions taking place, the heat generated from these reactions allow for more reactions to take place, creating a positive feedback loop. Eventually, the reaction reaches an uncontrollable, self-sustaining and self-accelerating state, i.e., thermal runaway.

The time taken to reach thermal runaway can be very fast, giving little time to react, and with devastating consequences.

A 1kWh battery can emit up to 6,000 litres of toxic and flammable vapour. This flammable gas mixture can contain gases including hydrogen, carbon monoxide, and hydrogen fluoride.



MARITIME INCIDENTS INVOLVING LI-ION BATTERIES

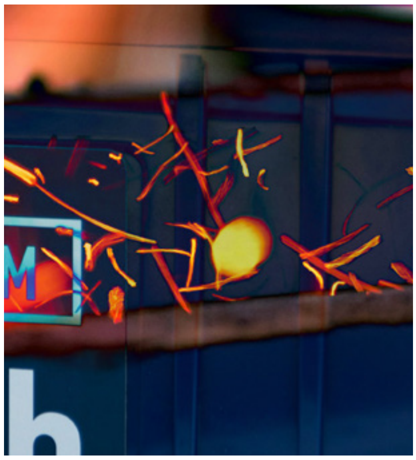
Whilst root causes are often difficult to determine due to extensive damage, several high-profile ship fires have been linked to Li-ion batteries, including:

- **S-TRUST (USA, 2022)** – Charging of Li-ion batteries on the bridge.
- **FELICITY ACE (Atlantic, 2022)** – Carrying new EVs and ICE on board.
- **FREMANTLE HIGHWAY (Netherlands, 2023)** – Carrying new EVs and ICE on board.
- **MORNING MIDAS (North Pacific, 2025)** – Carrying new EVs and ICE on board.

Additionally, the number of Superyacht fires are on the rise. Superyachts generally carry an array of 'toys' onboard, typically battery powered. These can include e-scooters, e-bikes, sea bobs, drones and now electric jet skis are being introduced into the market.

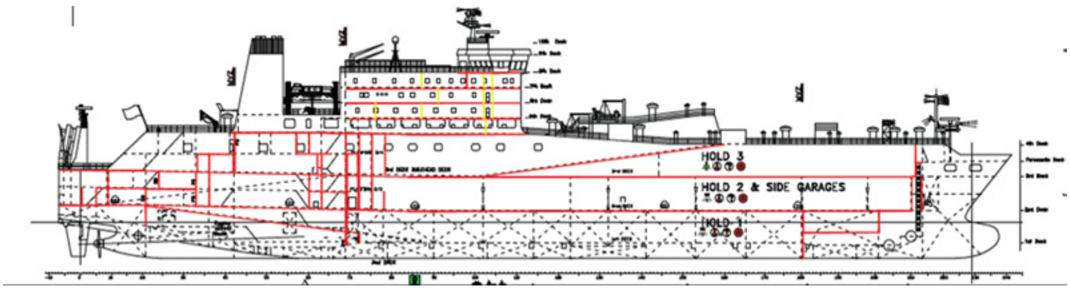
CHALLENGES FOR FIREFIGHTING ON DIFFERENT TYPES OF VESSELS

Firefighting on different vessel types can present different problems. Below are some of the difficulties that can be encountered when fighting a fire on these ship types.



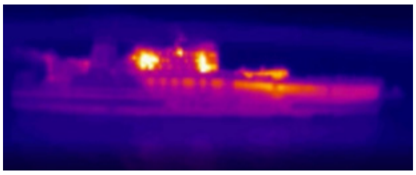
RO-RO AND PCTC VESSELS

Ro-Ro and PCTC ships lack transverse bulkheads which means large open spaces on each deck that allow a fire to spread quickly longitudinally as there are no subdivisions to contain the fire. The lack of subdivision also makes fire suppression more difficult. This is illustrated in the GA Plan for this vessel type, an example of which is shown below.



There is the added uncertainty of what vehicle types are stowed on deck. Locating the origin and source of the fire can be difficult in the stow, as well as recognising if the vehicle is electric, hybrid or ICE. Currently, there is no requirement for identifiers to be placed on the cars to distinguish between electric, hybrid, or ICE vehicles.

Essentially the subdivision of the watertight compartments makes it like an oven, which is illustrated in the thermal image. Whilst this was not an EV fire, it demonstrates how fire can spread longitudinally in these vessel types.



Additionally, excessive amounts of water cannot be used for firefighting, as too much water on an open deck could lead to free surface effect and stability issues.

Due to the tightly packed cargo stow, there can also be physical challenges for seafarers fighting these fires as there is very limited access between vehicles. The minimal space between vehicle rows also means that it is difficult for wearing a breathing apparatus (BA) set.

In an emergency, a typical muster on a vessel takes between 8-12 minutes. The crew then need to get kitted up and access the fire for firefighting. A normal BA set has around 20 minutes of air, and it could take a fire team 5-10 minutes to reach the required car; the fire team must also factor in having enough time to safely get back out. Taking into account the time taken to enter and leave the compartment the crew is likely to have a very short period to fire fight.

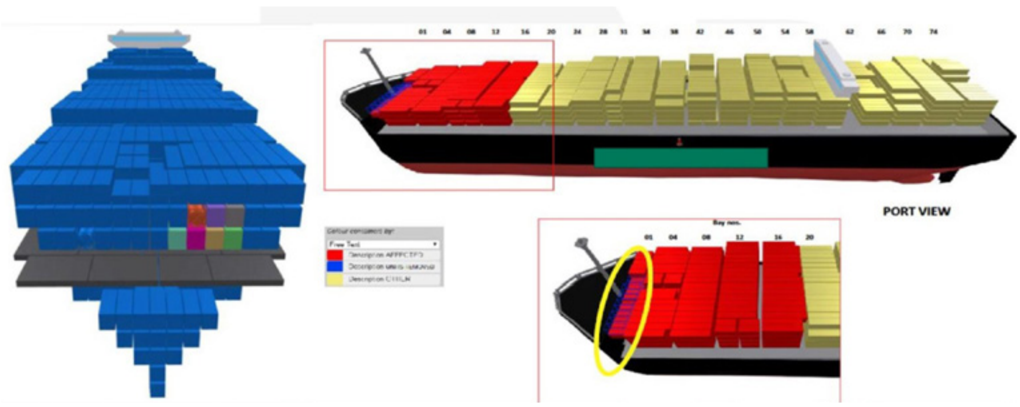
The recommended firefighting method for a Li-ion battery fire is the use of a fire blanket weighing 20-40kg. Practically, this will not be easy for a fire team to handle and use in a tight stow, particularly whilst wearing BA.

To summarise, the problems faced include:

- Large open decks with minimal subdivision.
- Limited access and headroom.
- Close-packed stowage of mixed cargo.
- Difficulty identifying EVs vs ICE vehicles.
- Fire blanket (25-40kg) and BA limitations.

CONTAINER SHIPS

Container ships present their own challenges. Large quantities of small parcels of cargo are carried in security sealed and contained units. Containers are stowed both above deck and in the holds, which can give difficulty in locating the origin and source of the fire.



Stowage of containers (with EVs inside) in the hold can be beneficial as the space could be flooded with CO_2, but fighting a fire within a specific container could be difficult.

Stowage on deck can be beneficial as the container can be situated away from the accommodation but could still be difficult to access.

Stowage in the upper tier locations on deck can present challenges in the event of a fire, unless the ship is fitted with hi-rise monitors/nozzles to apply large quantities of water direct to the burning container.

Due to the nature of the stow, it can be difficult to access specific containers. Mis-declared cargo is also an issue that can affect firefighting and emergency situations.

ADDITIONAL FIREFIGHTING CONSIDERATIONS

As previously discussed, the batteries are located in the chassis of the vehicle. Approaching can therefore be difficult for any firefighting team as their pathway can be blocked by flames.

In addition, significantly more water is required for fighting an EV fire compared to a combustion engine vehicle. For example, 30,000 gallons of water over 4 hours are estimated to be required for an EV fire, instead of 500-1,000 gallons over 30 minutes for a combustion engine car. Large quantities of water are not suitable for use on ships, particularly on large open surfaces as previously discussed.

EV fires also generate much higher temperatures than an ICE fire with a sustained flame, which can be difficult to 'knock-down.' Re-ignition can also occur, in some cases, a considerable time after the fire has been extinguished.

Methods for fighting a fire involving Li-ion batteries remain under review, with new technologies being researched and developed. There is currently no definitive answer for how best to tackle an EV fire.

LESSONS FROM RECENT INCIDENTS

Brookes Bell have attended fire incidents and casualties that have involved both the carriage of Li-ion batteries and EVs. Following these attendances, additional challenges came to light which may not be fully appreciated by the wider industry, and particularly the seafarers at the front line.

Firstly, as a consequence of thermal runaway, there is a possibility of flammable gases collecting in enclosed head spaces that the ship's crew may not be aware of. On a recent case we attended, there was evidence of a vapour cloud explosion beneath the top canopy deck, lifting it 2.5 metres across 100 metres length. As a result, the crew were unable to access the lifeboats on this deck. Additionally, the fire and foam mains also ran the length of this deck and had been buckled following the explosion.

MV Fremantle Highway in July 2023.

Following the fire, many of the car carcasses were unrecognisable. Aluminium has a melting point of 660°C; however, car manufacturers have reported that tests involving EV fires can reach temperatures in excess of 2,000°C. As a result of the extreme temperatures, heat can also transfer downwards, not only upwards, burning container floors or melting aluminium structures which have the potential to block bilges and scuppers. The photographs show the stalagmites created by molten aluminium on a recent attendance.

Ship designs may also need to be reconsidered. Based on our experience, access into certain spaces may not be suitable to safely exit in an emergency involving EVs. For instance, open stairwells will pass through car decks, meaning that crew would have to move through a fire zone that could potentially be filled with toxic gases and vapours.

On this note, should further investigation also be given into Personal Protective Equipment (PPE) for ship's crew? If crew are on deck awaiting rescue or whilst accessing the lifeboats, should a full-face mask be worn, such as the PPE that are being used by personnel attending in the aftermath of responding to a Li-ion fire? Face masks could be held on the bridge or within the accommodation of ships for personnel to use in the event of evacuation from a ship that is on fire.

As well as the toxic and flammable gases emitted during thermal runaway, the dust and other matter created by the fire can also be toxic and harmful.

Another challenge is the potential that the firefighting water could short circuit batteries in stowage. During our attendance, when moving cars that had been flooded with firefighting water, a short circuit took place as the car was being removed from the vessel.

BATTERY ENERGY STORAGE SYSTEMS (BESS)

More vessels are starting to ship BESS or 'Megapacks' which can present additional risks. This type of cargo is typically high value with a high energy density.

Stowage needs to be considered carefully. Tight stowage complicates isolation during incidents, as access can be restricted and the fire can propagate between units. However, if not stowed as a block stow, the units need to be sufficiently secured individually for a sea passage.

Additionally, manufacturer guidance may not always be compatible with maritime conditions. The stowage and securing guidance for Megapacks (Tesla) for instance, states that there should be no more than 5 degrees tilt. This cannot be guaranteed on a vessel at sea.

Risk Mitigation Strategies and Future Directions

TECHNOLOGICAL INNOVATIONS

Li-ion battery research is still a growing research area. With new designs and innovation, the industry is always looking at ways to improve battery quality, safety and performance and durability. With this, numerous modifications are currently being researched; some examples are provided below:

- Electrolyte modifications (e.g., solid-state, non-flammable electrolytes).
- Modification of other battery components (e.g., separator, electrode coatings).
- Battery pack level innovations (improved cooling and pressure relief systems).

VESSEL DESIGN

Vessel design is also currently being reconsidered. Purpose built vessels for shipping EVs and Li-ion batteries are in discussion. One potential design is to increase the number of subdivisions and compartments, as there is more chance to isolate a potential fire or incident within these smaller compartments.

FIRE DETECTION

Additionally, fire detection systems are being adapted and modified. For instance, the Li-ion Tamer detects catastrophic battery failures early.

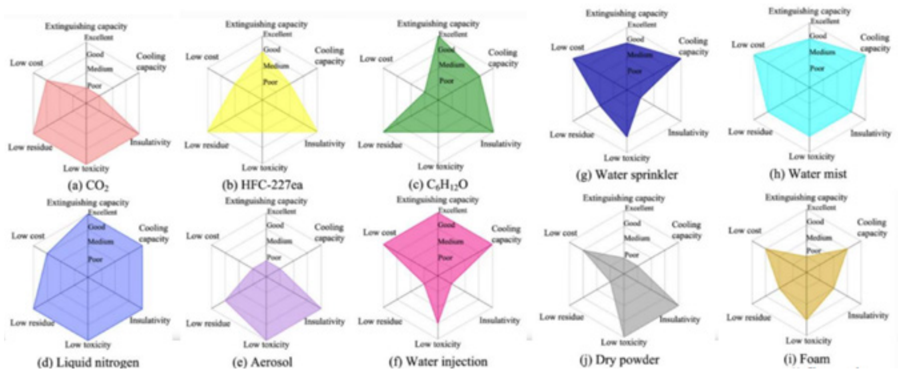
The Li-ion Tamer is a plug-and-play rack system that improves safety by sensing the off-gassing that precedes thermal runaway battery failures much earlier than smoke, or traditional gas detection systems would. Li-ion Tamers work at the second stage of battery failure: the interval between off-gas generation and smoke to stop thermal runaway before it gets started.

The most effective firefighting medium for Li-ion fires is still being investigated. The figure below[2] shows a range of fire fighting agents and how effective they are against Li-ion batteries. Generally, firefighting mediums work by isolating, smothering, cooling, or chemically suppressing fires. One factor to consider for Li-ion battery fires is the re-ignition aspect; even after cooling to room temperature, the probability of re-ignition still exists. The potential environmental impacts of the firefighting agent post-fire must also be considered.

RESEARCH

Various working groups and organisations are looking into options for tackling EV fires. Industry groups are developing documents designed to assist industry and ships' crews in how to deal with Li-ion fires, with several white papers being produced. Technology is constantly evolving; and continuous monitoring of developments is required.

Fighting Li-ion batteries – fire fighting agents



Conclusion

The maritime industry must adapt rapidly to the evolving risks posed by Li-ion batteries and EVs. Through a combination of scientific innovation, vessel design, and operational preparedness, we can navigate these challenges and ensure safer seas.

2 DOI: 10.1007/s10694-022-01278-3

What to expect from the insurer's and underwriter's perspective

Here is an example of the minimum expected requirements from a vessel owner seeking to insure their small craft as a new-build or retrofit project.

- ☑ Confirm the make, model, and type of any installed lithium batteries.
- ☑ Confirm that the batteries are specifically marine grade and are specified by their manufacturers as being suitable for use in a marine environment.
- ☑ Confirm their storage, securing, ventilation, temperature control measures, any battery management system (BMS) and charging methods.
- ☑ In addition to the above the insurer/underwriter will need confirmation that the system was professionally installed - perhaps by who and their qualifications.
- ☑ If the system was not professionally installed, then the insurer/underwriter would usually require that it be professionally inspected and formally signed off.
- ☑ To what standard was the system installed might be a consideration? Preferably ISO 23625 Small craft - Lithium-ion batteries, published in 2025.
- ☑ If a lithium-ion system was installed at the factory as part of a professional new build, this is acknowledged and only confirmation that the system was professionally installed is required.
- ☑ A lithium-ion battery system that is retrofitted will be treated differently from those installed in a new build vessel. If a system has been retrofitted, then the above information will be requested, receipt acknowledged, and will need to be approved by insurers/underwriters prior to confirmation that the lithium-ion battery system is covered on the policy.

Small Lithium-ion battery fires on ships: Hidden sparks, big risks

By Trever Fernandes, Senior Loss Prevention Executive, NorthStandard

This article examines the hazards posed by small lithium-ion batteries and how they can be devastating in confined shipboard environments. From handheld radios, cell phones, and power banks to vapes and flashlights, lithium-ion batteries are everywhere onboard vessels. Compact and powerful, they're essential, but when mishandled, they can turn into ticking time bombs.

While the maritime industry has rightly focused on the dangers of lithium-Ion battery fires on car carriers and container vessels, the hazards posed by small lithium-ion batteries are often overlooked and can be just as devastating in confined shipboard environments.

What Makes Them Dangerous?

The biggest threat is thermal runaway, a chain reaction triggered by overheating, damage, or internal faults. Once it starts, it's nearly impossible to stop. These fires burn hot, release toxic gases, and can explode with force, especially dangerous in confined spaces like crew cabins, the bridge, or storage lockers.

Real Fires, Real Lessons

Bridge Blaze on Tanker: A handheld radio battery overheated and ignited, burning down the bridge navigation and communication equipment causing US$3 million in damage.
Cabin Combustion: Rechargeable power bank, vapes, and cell phones left charging overnight have sparked fires in crew quarters often due to unsupervised charging or poor storage.

Power Bank Peril: A crew member's power bank exploded during charging in a locker, igniting nearby clothing and causing smoke inhalation injuries.
These aren't rare events; they're warnings to all of us.

Smart Safety Practices for Small Li- Ion Batteries Onboard

Responsible Purchase (Vessel & Personal Use)
Responsible purchase is the first line of defence against lithium-ion battery incidents onboard. Batteries should be sourced from reputable manufacturers with proven safety records. It is essential to verify certifications such as UL, CE, or IEC standards to ensure compliance with international safety benchmarks. Bulk purchases from unknown or unverified suppliers should be avoided, as they may introduce substandard or counterfeit products. Compatibility between batteries, devices, and chargers must be confirmed to prevent electrical mismatches that could lead to overheating or failure. For vessel use, purchasing procurement should be documented in inventory logs to maintain traceability and accountability.

Storage & Handling

Proper storage and handling of lithium-ion batteries is critical to minimizing fire risks. Batteries should be kept in cool, dry, and well-ventilated spaces. Fireproof containers are recommended. Batteries should never be casually stored in drawers or near flammable materials. Stacking batteries or placing them near metal objects should be avoided to prevent accidental short circuits. For long-term storage, maintaining a charge level between 30-50% helps reduce chemical stress and prolong battery life. Personal devices and power banks should be stored separately from flammable materials to further reduce risk.

Charging

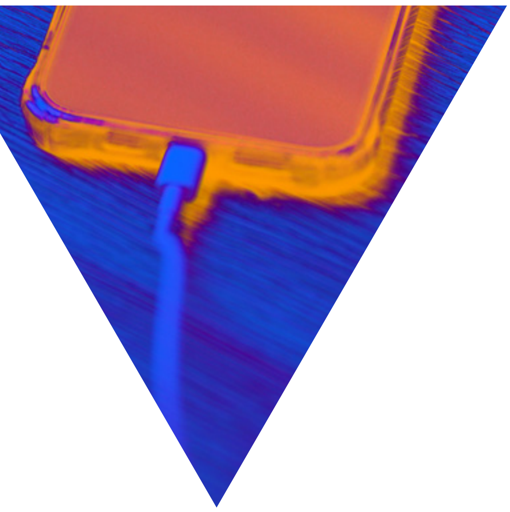
Charging practices must be strictly controlled. Only approved chargers should be used, and personal devices must never be charged unattended, especially overnight. Overcharging and deep discharging should be avoided, as both can accelerate battery degradation and increase the risk of thermal runaway.

Inspection & Maintenance

Routine inspection and maintenance are essential for identifying early signs of battery failure. Batteries should be checked regularly for swelling, leaks, or corrosion. Damaged batteries must be isolated and reported immediately. A Battery Management System (BMS) should be used to document compliance and ensure safety standards are met. Personal devices and accessories should be inspected periodically to detect wear or damage that could compromise safety.

Emergency Preparedness

Emergency preparedness is vital. Areas where batteries are stored or charged should be equipped with Class D fire extinguishers, fire blankets, and appropriate personal protective equipment (PPE). Crew members must be trained to respond to thermal runaway incidents, and battery fire scenarios should be included in regular drills and Safety Management System (SMS) procedures.



Disposal & Documentation

Lithium-ion batteries must be disposed of as hazardous waste in accordance with MARPOL Annex V. Disposal activities should be logged in the Garbage Record Book, and end-of-life batteries must be handed over to certified recyclers to ensure safe and environmentally responsible handling.

Crew Awareness & Training

Crew awareness and training is essential. Regular safety sessions should be conducted onboard, and safety posters or warnings should be displayed in crew areas and cabins. All crew members must be familiar with standard operating procedures (SOPs) and emergency response steps. Personal electronics and power banks should be included in pre-joining safety briefings to ensure new crew are aware of the risks and procedures from day one.

Final Thought

Small batteries, big consequences. As their use grows onboard, from UHF radio batteries to phones and power banks, so must our vigilance. With smart handling, proper training, and strict SMS protocol on procedures and compliance, we can keep these silent sparks from becoming shipboard infernos.

Case studies

Canal boat explodes and bursts into flames in Northamptonshire, UK

In early August 2025, a narrowboat on the UK canal network exploded violently as a result of a li-ion battery installation being charged overnight. This is the first known accident of its kind on the canal network. Reports suggested that debris was strewn 40ft across the canal and witnesses said the explosion was very loud and shook their boats. Fortunately, there was nobody onboard at the time and there were no injuries consequently.

Had anyone been on board at the time, it is hard to imagine they would have survived such a blast and walked away. This incident has sent a shock wave through the boating community, well, those who have heard about it, for it was reported only through a local paper and the obligatory social media of course. But it was not deemed of sufficient importance to make national news headlines. Strangely, even the specialist UK canal boat media seems to have ignored the story too. Why? Surely at the very least the public should be made aware so they can make their own choices and informed decisions. The local fire brigade attended but could not put the fire out. The boat reportedly sank, only for it to resurface and for the fire to reignite - a conundrum that is common with li-ion batteries.

Captain Pat, based at a large suburban fire department in Michigan - a mechanical engineer with a background in R&D, holding multiple patents on electric vehicle technology - remarkably picked up this story and produced a thought-provoking video on what happened. He is an illuminating character and something of an expert in the field of li-ion battery fires, although he possesses scant knowledge about boats.

Pat's YouTube channel where he goes into detailed analysis on a series of li-ion incidents - not all marine related - is worth exploring further.

Head to **https://www.youtube.com/@StacheDTraining**

Mike Schwarz

NTSB report says lithium-ion battery bank cause of yacht fire

The US National Transportation Safety Board (NTSB) has said in a report that inoperable battery management systems were the probable cause of a fire on yacht Flagship last year.

On April 28, 2024, at 1031 local time, a fire started on board the uncrewed yacht Flagship while it was docked at an enclosed bay of a shipyard on the Miami River in Miami, Florida. The Flagship was declared a total loss, valued at $5 million.

Since the vessel's arrival in the US, the BMSs for the battery banks of the 24-volt system and the three 48-volt battery systems were inoperable; they did not safely monitor and maintain the charge level of the batteries. This problem with the BMSs was not immediately resolved. In the interim, the vessel manufacturer, shipyard personnel, an electrician, and the vessel owner's representative developed a new procedure to increase the charging speed of the lithium-ion batteries by bypassing the BMS of each battery bank. A wire was attached to bypass each BMS so the batteries could be manually charged at a faster pace by an external charger. As a result, the charge level within the vessel battery banks was not automatically maintained by the BMSs, and, due to an unidentified electrical drain within the vessel, the batteries became fully discharged (0% charge) on several occasions for extended periods. In addition, routinely charging the batteries using a portable battery charger could have resulted in overcharging, since the external battery charger was not connected to and monitored by a BMS and the battery charge level was instead monitored by personnel at the shipyard. Therefore, the practice of externally charging the lithium-ion batteries without resolving the BMS issues resulted in fluctuations in the level of charge on the battery bank.

The National Transportation Safety Board determines that the probable cause of the fire on the yacht Flagship was the thermal runaway and explosion of the 24-volt lithium-ion battery bank due to the inoperable battery management systems, resulting in the practice of manually charging the lithium-ion batteries with a portable battery charger, which compromised the safe monitoring of the vessel's lithium-ion battery systems.

Read the full article at **https://bit.ly/46rHKIm**

Norwegian Safety Investigation Authority: Report on the lithium-ion battery fire on board 'MS Brim'

Overview
It is highly likely that seawater ingressed through the ventilation outlet in the tunnel as a result of waves slamming against the tunnel top and then leaked through the ventilation fan and down onto the batteries. This caused short-circuits and electric arcs and subsequent outbreak of fire. The hybrid vessel 'MS Brim' was passing through the outer Oslofjord, when the fire alarm went off and the fire alarm panel indicated fire in both the starboard battery room and the starboard engine room.

The Norwegian Safety Investigation Authority (NSIA) made a number of safety recommendations to the Norwegian Maritime Authority.

Extinguishing efforts and control of the vessel continued for several days before the vessel was considered safe enough to board.
The NSIA's investigation has shown that the positioning of the ventilation outlet in the tunnel was unfavourable and that measures to prevent water ingress were insufficient. Neither the shipyard, nor DNV or the Norwegian Maritime Authority (NMA) identified the fan as a leakage point with regard to ingress of seawater.

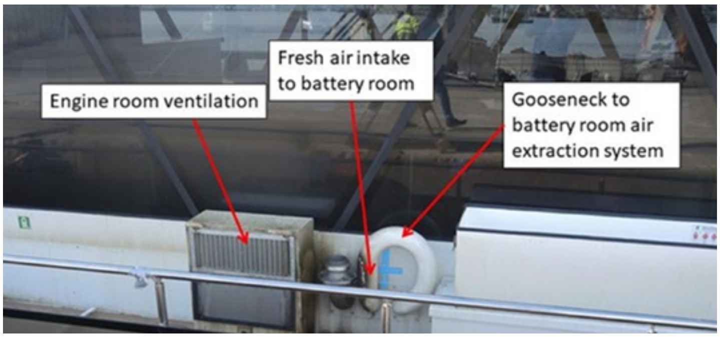


Photo credit NSIA

The fire on board most likely arose as a result of seawater entering the ventilation system and coming into contact with the high-voltage components of the battery system, causing short-circuiting, electric arcs and fire.

The investigation has also shown that the low IP rating enabled seawater and sea air to enter battery modules. Late release of the fire suppression agent meant that it had little suppressive effect and did not prevent the fire from developing but had a cooling effect for a short period. The report has also shown that a clear extinguishing strategy that would limit the scope of damage in the event of lithium-ion battery fires was lacking.

The investigation identified several areas where the risks associated with the use of lithium-ion batteries were not sufficiently identified or addressed in the design. At that time, DNV's classification rules for battery safety did not sufficiently address the risks associated with the use of lithium-ion batteries on board vessels. Based on current rules and regulations, the same error may be made again. Consequently, the NSIA submitted a total of seven safety recommendations as a result of the investigation.

1. Safety recommendation MARINE No 2022/03T
On 11 March 2021, a fire arose in the starboard battery room of the passenger vessel 'Brim' in the outer Oslofjord. The investigation has shown that there were several weaknesses associated with the propagation test used to identify the battery's likelihood of cell-to-cell propagation and that the test failed to identify the possibility of side wall rupture. DNV's rules, based on the IEC 62619 standard, provide for a free choice between the approved methods of propagation testing. The method chosen was not appropriate for the battery type in question.

The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority issues requirements for appropriate test methods that reflect the risks associated with the design of different battery types to be chosen for conducting propagation tests.

2. Safety recommendation MARINE No 2022/04T
The Norwegian Safety Investigation Authority cannot see that the load line requirements are adapted so as to prevent small amounts of seawater from entering a battery room and ensure battery safety. The investigation has shown that the positioning of the ventilation outlet in the tunnel was unfavourable and that measures to prevent water ingress were insufficient. The ventilation should have functioned as a safety barrier by extracting explosive gases in the event of an incident, but instead it contributed to sea air or seawater entering the battery room, resulting in short circuiting / electric arcs and fire.

The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority ensures that battery safety regulations be developed so that ventilation arrangements do not contribute to batteries and high-voltage components being exposed to humid sea air or seawater.

3. Safety recommendation MARINE No 2022/05T

The investigation has found that the bulkhead between the engine room and the battery room was not smokeproof. Toxic gases spread to adjacent rooms. This was not detected in connection with approval of the drawings, construction follow-up or inspections. There is a need for better quality assurance of the execution of fire insulation of battery rooms through additional measures that ensure that gas and smoke do not penetrate the fire division, as defined in Regulations No 1099 of 1 July 2014 on fire protection on ships.

The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority introduces additional measures to verify that installations are smokeproof and ensure fire integrity.

4. Safety recommendation MARINE No 2022/06T

The Norwegian Safety Investigation Authority cannot see that the risk assessment reflected the real risk of fire in the battery packs, as neither the weaknesses of the ventilation system nor those of the battery system were sufficiently identified. A risk assessment should address all relevant risks identified by various disciplines, that together present a risk to the vessel. Taken together, this will potentially uncover weaknesses in the vessel design and identify risks associated with the use of lithium-ion batteries.

The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority issues requirements for risk assessments relating to the use of lithium-ion batteries, and that they should contain all relevant risks identified by different disciplines, the sum of which represents the vessel's fire risk.

5. Safety recommendation MARINE No 2022/07T

The Norwegian Maritime Authority does not have separate regulations relating to battery safety but relies on classification rules. There were shortcomings in the battery safety regulations for the class. Furthermore, the classification societies may have different requirements for battery safety, which can result in different vessels having different standards of battery safety. Different supervisory bodies may be involved in the supervision of vessels and marine equipment, which was also the case for this vessel. In the Norwegian Safety Investigation Authority's opinion, this represents a safety risk that requires better coordination between the different agencies.
The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority, as the administrative authority, cooperates with Directorate for Civil Protection on stipulating a requirement that all Norwegian vessels, regardless of classification, must be built to a defined standard that ensures battery safety.

6. Safety recommendation MARINE No 2022/08T

The investigation has shown that Novec had little effect on the development of the fire, and that there are currently no effective suppression agents available capable of preventing fire and propagation in lithium-ion batteries.

The Norwegian Safety Investigation Authority recommends that the Norwegian Maritime Authority introduces compensatory measures to address the safety of passengers and crew in the event of a lithium-ion battery fire.

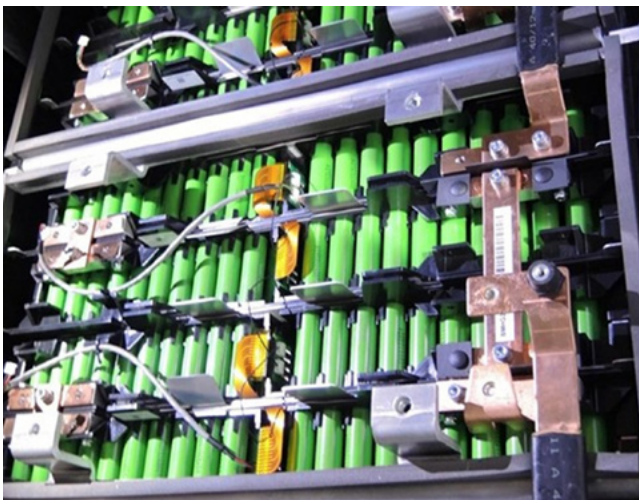
7. Safety recommendation MARINE No 2022/09T

The investigation has identified a need to raise the knowledge and expertise of the parties involved in first-line emergency response in connection with fires in lithium-ion battery systems on board vessels.

The Norwegian Safety Investigation Authority recommends that the Directorate for Civil Protection strengthens the knowledge and expertise of the parties involved in the first-line response to accidents involving a fire on board a vessel carrying lithium-ion batteries.

Read the MS Brim report at **https://bit.ly/42kXtGG**

Battery module with battery cells, from the port battery room. Photo credit: NSIA



Panama Maritime Authority: Report on the investigation of fire on M/V Felicity Ace

Below you will read a lightly revised version of report no: R-013-2022-DIAM - edited for clarity and brevity.

Summary
The Felicity Ace was engaged on a voyage from Emden, Germany to Davisville, USA, and was loaded with a total of 3,965 vehicles

During the beginning of the voyage, the ship encountered gale force winds. On the 16 February 2021, while the third officer and the Captain were on the bridge, the smoke detection system was activated indicating smoke detected on deck no 1 between holds 3 and 4.

The third officer called the AB on duty engaged on the safety round by VHF requesting him to verify the alarm visually. The AB arrived on deck number 1 through the aft starboard stairway. When the AB opened the fire door, a lot of smoke and flames near the port side were seen. The AB called the third officer back on VHF informing them about the fire while trying to pick up a fire extinguisher. The AB was unable to approach the flames and went back to the stairway closing the fire door.

The fire team was quickly set and instructed to proceed while the remaining crew were mustering. The fire team quickly arrived at the fire seen describing the area as inaccessible due to heavy smoke and lack of visibility within the deck. In the meantime, the Master called engine room to activate the high expansion foam fixed system. The First engineer proceeded to the steering gear room, where the foam system was fitted and started the pumps while the system was confirmed to be on and liquid foam being pumped into the fixed fire line.

During operation of the fixed system, it was observed from the indication lights of the control panel that the foam fans, which were supposed to start automatically, did not appear to operate. As the fixed firefighting system did not operate as it was supposed to do and so there was no means of controlling the fire, which was spreading, the Captain decided to abandon the ship.

The ship was abandoned, and the salvage company took the ship which was reported to have sank on 01 March 2022 at 09.11hrs. The ship was a total loss.

Conclusions

- Car carriers are currently not prepared for extinguishing fires on electrical/hybrid vehicles since shipping of such vehicles is relatively new and currently growing.
- There were no specific equipment nor procedures for fire extinguishing on electrical/hybrid vehicles on car carriers.
- Advance firefighting course under STCW VI/3 is generic and does not cover specific type of ship such as car carrier.
- Visibility was good as shown in photo below hence fire teams could have entered and fought the fire to avoid fire spreading from car to car.

Boundary cooling of Felicity Ace.
Source: Panama Maritime Authority

Photo of deck no. 1 on fire taken by a crew member.

- Despite being certified under STCW VI/3, crew have no specific training for extinguishing fires on electrical vehicles and no confidence due to inexperience with firefighting on enclosed spaces such as cargo decks.
- Fire patrol was being carried out by two ABs instead of one OOW and one AB as required on the SMS Ch. 4.09.
- The charging battery level of vehicles is unknown by crew.
- According to the crew evidence, the fire started on an electric Porsche Taycan.
- The reasons why the vehicle ignited is unknown but likely to be due to a defective battery cell due to high temperature, damage during assembling of the vehicle or a crack on insulation between the anode and the cathode causing a large short circuit.
- Lithium-ion batteries tend to be the main cause of electrical vehicle fires as stated on probable ignition source and literature gathered suggesting Porsche Taycan tend to have a problem with batteries causing fires.
- It is unknown why the foam fan failed to start but since the electrical motor was fitted at the deck level near the fire it is likely it failed due to damage to electrical cables from flames or heat.
- The operator was asked for any known reason why the vessel sunk while under salvage, but operator confirmed that the cause of sinking is unknown.
- Fire hoses were fitted inside the cargo deck and in view of visibility being deteriorated fire teams did not attempt to use them.
- Boundary cooling was only considered on weather deck hence ineffective,
- Extraction or suction of smoke was not considered by the Master at early stages of the fire to clear the deck of smoke to allow fire teams in.
- The fixed high expansion foam system installed is considered to be effective on electrical vehicles.

Recommendations

To Owners:
- Distribute a safety notice throughout the fleet describing the accident and including the accident in the following scheduled safety trainings.
- Comprehensive review SMS manuals in regard to danger of cargo adding electrical vehicles (SMS Ch. 9, Section 4, Par 4.02)
- Comprehensive review SMS manuals in regard to firefighting (SMS Ch. 5, Par 4.03)
- Review the internal investigation of the accident to establish the contributing factors and identify measures to be considered to avoid a similar accident. (ISM)
- Consider external expertise to evaluate risks and more advance training of crew.
- Evaluate transferring extinguishers, hoses or nozzle lances inside the stairway to make it more accessible avoiding entering cargo deck.
- Add specific instructions for hold inspection on vehicle cars referring to fire patrol in SMS Ch. 4.09.

To Panama Maritime Administration:
- Propose to Segumar the issue and distribution of a safety warning bulletin addressed to operators and vessels of the dangers of carrying electrical vehicles.
- Prepare safety guidelines for carrying electrical/hybrid vehicles.
- Propose additional fire training for specific type of ship to be employed as part of STCW requirements. (STCW VI/3)
- Request onboard Panamanian registered ships certificate of approval for firefighting outfits as requested by EU registered ships on Directive 2014/90/EU

To KASHIWA Co. Ltd:
- Investigate failure of fans and further evaluate effectiveness of system on cargo decks when loaded with electrical/hybrid vehicles. 10.13
- System was fitted on construction numbers 5306, 5307, 5308 hence inform other sister ships and ensure system is properly operational.

To Shipper/Charterer:
- Carry out risk assessment on battery condition standards needed for sea transport and prolonged vehicle switched off mode and issue clear fire prevention and extinguishing protocols on electrical vehicles.

Read the full report:
https://bit.ly/4qiE0B1

Firefighting

Then the big question is, how do you put a li-ion battery fire out? It is a very good question because for the most part, nobody knows for sure.

There are many dangers to consider when tackling a li-ion battery fire. Especially as modern firefighting methods have evolved over hundreds of years – techniques that don't take into account the issues that li-ion battery fires present today.

In an article, Brookes Bell said an EV fire might require 136,000 litres of water over four hours to extinguish, compared to just 10,000-17,000 litres over 30 minutes for a traditional combustion engine vehicle. It added firefighters also face the risk of electrocution from the batteries – especially when large volumes of water are used.

Li-ion battery fires can also generate oxygen meaning the effectiveness of firefighting suppression systems is limited. Off gasses create further hazards as they are not only flammable but are toxic, which adds to the risks firefighters face in tackling these kinds of blazes. Li-ion battery fires also have the potential to re-ignite hours, days and even weeks later.
Apart from water, foam or CO2 extinguishing systems, fire blankets can be used. But they can be difficult to use in an enclosed and restricted areas such as on board a ship.

Research is still being carried out to find to safely and effectively handle li-ion battery fires. The best thing to do is to prevent these fires in the first place.

Lithium-ion batteries: a growing risk for yacht fires?

Increased usage of lithium-ion batteries aboard yachts and superyachts presents significant risk for the maritime industry and it is compounded by the rapid evolution of technology with which regulatory oversight struggles to keep apace. But now we must ask: Are Lithium-ion batteries a growing risk for yacht fires?

On 9 January 2025, a fire broke out on board the m/y Naisca IV while moored near Marseille. Initial indications are that the fire, which ultimately destroyed the Naisca IV and caused damage to two neighbouring yachts, originated from a lithium-ion battery. While efforts were made to mitigate environmental harm, the extent of the loss remains uncertain.

In this case, the extent to which fire safety protocols were followed remains unclear. However, this incident underscores the importance of (i) strict adherence to fire safety standards; (ii) insurance coverage; and (iii) ongoing training for captains and crew to understand the risks involved with lithium chemistries and cell balancing issues.

As the yachting industry grapples with the challenges posted by lithium-ion batteries, the need for enhanced regulation and proactive risk management has never been more evident.

Read the full article at **https://bit.ly/4mFathK**

NTSB alerts land-based firefighters to risks of vessel fires

The U.S. National Transportation Safety Board (NTSB) issued a safety alert urging greater awareness and training for land-based firefighters who may be called to fight fires aboard vessels in local ports.

The safety alert follows several NTSB investigations into deaths and injuries to firefighters.

The NTSB found land-based firefighters often lack the necessary training and familiarity with vessel layouts and fire protection systems to effectively fight in-port vessel fires. They also may be unaware of how to use the structural fire protection built into most commercial vessels.

NTSB recommends fire departments that serve ports improve the safety of their firefighters when responding to vessel fires by:

- Developing training plans to ensure all firefighters understand how to fight vessel fires, including the resources needed, the best tactics, strategies and methods for communicating while on a vessel and with vessel crew, and vessel layouts
- Identifying supplemental training areas and developing a training plan and operational procedures in reference to National Fire Protection Association publication 1405: Guide for Land-Based Fire Departments that Respond to Marine Vessel Fires, and NFPA 1010: Standard on Professional Qualifications for Firefighters (formerly NFPA 1005: Standards for Professional Qualifications for Marine Fire Fighting for Land- Based Fire Fighters)
- Working in advance with local ports to organize vessel familiarization tours and to coordinate vessel firefighting response preparedness and training in conjunction with the drills and exercises required for certain vessels
- Coordinating with the U.S. Coast Guard on standard operating procedures during emergencies
- Learning from the circumstances of other in-port vessel fires to improve contingency planning

Read the full safety alert: **http://bit.ly/42u7Hol**

Firefighters conduct exterior boundary cooling on the Höegh Xiamen on June 5, 2021, the day after the fire was discovered.

Source: Jacksonville Fire and Rescue Department.

Lithium-ion fire prevention

Fires dominated 2025 major losses, according to Cefor, the Nordic Association of Marine Insurers. In its 2025 Mid-year Hull Report it said four claims exceeding 20 million USD were reported by 30 June—far more than the ten-year average of 1.5 claims per six months. All four claims were fires.

Here, we've gathered a range of articles on what should be a high priority for anyone within the maritime world: fire prevention.

An expert's guide to lithium-ion battery fire prevention

Mark Halverson, Executive Manager State Fire Safety Section, Queensland Fire Department shares some essential lithium-ion battery safety advice and guidance to give a better understanding of the risks associated with this technology.

Lithium-ion battery powered devices don't pose an increased risk if devices are maintained in good working condition and people follow some basic rules. From a fire service perspective, the vast majority of lithium-ion battery fires we've seen have been caused by human error.

Many of these simple rules that should be followed are almost all related to battery charging. Ensure that the charger you use to charge your particular device is the specific charger that's recommended by the manufacturer. If you buy a quality product from a reputable retailer, you can be confident that the correct charger will be supplied with that product. However, if you buy a discount replacement charger online you need to be very aware where that product is coming from.

The above also applies to borrowing chargers from friends or family. Just because a charger can physically connect into the charging port of a device or the lithium-ion battery pack, doesn't mean that it is the correct charger for that device. So always check the manufacturer's recommendations.

Never charge a lithium-ion battery when a device is hot. Always give the battery time to cool after use rather than connecting it to a charger immediately. Similarly, never charge a lithium-ion battery powered tool or device in direct sunlight, such as on the deck of your boat.

Another key factor is water ingress. Never charge a battery anywhere where water could potentially penetrate. Salt water in particular is an important risk to be aware of for any lithium- ion-powered tool or device that is taken onboard a boat.

Don't put a lithium-ion powered tool on charge and leave it unattended on your boat. Certainly never charge a lithium-ion battery onboard overnight while people are sleeping in their cabins.

The nature of lithium-ion technology and chemistry means fires can escalate very rapidly. What might appear in the first instance to be overheating, a crackling noise, usual odour or changes to the shape of the battery, could quickly escalate into a serious fire or in extreme circumstances even an explosion.

Always maintain oversight while charging lithium-ion batteries so you can spot any of these warning signs within the early stages. If you do see any of these warning signs immediately disconnect the charger from the power if it is safe to do so. If there's any sign of smoke, evacuate and call the emergency services.

Put simply: the fire extinguishers onboard the boat or within a home are typically not effective in fighting lithium-ion battery fires. In the future, extinguishers for lithium-ion battery fires may be developed, but current extinguishers are typically not effective.

Read the full article at **https://bit.ly/3IAiIxE**

Batteries should be inspected for deterioration

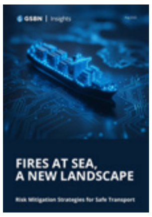
The Nautical Institute has drawn lessons learned from an incident where an integrated lithium-ion battery bank on a passenger vessel caught fire. It was found that loosely crimped lugs overheated and initiated the fire. No one was injured and the vessel sustained minimal damage, but this casualty highlights the safety hazards posed by Li-ion batteries.

The resulting investigation found, among other things, that all Li-ion installations used for propulsion, control and electrical power must undergo an engineering plan review and be fitted with supporting safety systems. Additionally, these systems should 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.

Lessons learned

- 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.
- Crew members responsible for battery operation and maintenance should be trained in the manufacturer's guidelines and operational procedures and familiar with the functioning of the battery management system.

Crew should 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 considered when conducting other drills.



Preventing the next lithium fire at sea: A data-driven blueprint for safer transportation

With new data and technological innovation, the maritime industry must re-evaluate cargo handling protocols and develop more resilient fire mitigation strategies to address growing risks at sea, argues Alicia Lee, Chief Operating Officer at GSBN. On a summer morning in June 2025, a carrier vessel called the Morning Midas caught fire in the middle of the Pacific Ocean. The entire crew on board had to abandon ship to escape flames. The Morning Midas, along with the electric vehicles it was carrying that started the blaze, now rests at the bottom of the ocean.

Experts attribute the rise of shipboard fires to the growing volume of dangerous goods being transported and traded globally – for example, lithium-ion batteries, which are the key components in electric vehicles. According to McKinsey's Battery 2030 Report, global demand for lithium-ion batteries is projected to skyrocket in the coming decade. Estimates indicate a surge from approximately 700 GWh in 2022 to around 4.7 TWh by 2030. This trend has significantly heightened the risk of fire incidents across maritime supply chains and there needs to be methods to preventing the next lithium fire at sea.

Lithium batteries, if damaged, overcharged, or exposed to high temperatures, can release toxic, flammable and explosive gases. These conditions can also trigger "thermal runway", a rapid, self-sustaining fire that may lead to violent explosions.

While carriers and industry experts are aware of the crucial role played by temperature related protocols in preventing battery fires, there is currently no universal protocol in place for carriers to action. With new data and technological innovation, the maritime industry must re-evaluate cargo handling protocols and develop more resilient fire mitigation strategies to address growing risks at sea.

The global trade industry also deals with gaps in information exchange when transporting goods. Paper-based declarations remain vulnerable to fraud and misdeclaration, and verifying such documents is often slow and unreliable. The fragmented landscape and the lack of interoperability across digital systems — where protocols vary by company, port of entry, and destination—create inefficiencies and increases operational risk.

Ultimately, we need robust digital first solutions that minimise error and establish universal protocols. These systems should give manufacturers, shippers, and terminals the confidence that cargo will be handled safely and that vessels won't be compromised by preventable risks.

Read the story in full and download the whitepaper at **https://bit.ly/48FZbq1**

Transportation of electric vessels containing lithium batteries

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) has issued this safety advisory notice to inform the public and raise awareness of the risks involved in Transportation of electric vessels containing lithium batteries that may have been damaged due to submersion in waters during extreme weather events. When transported in commerce, EVs containing these damaged batteries may present particularly significant hazards to the public, including property damage, injury, and even death. Our intention with this notice is to prevent those things from happening.

Furthermore, PHMSA wishes to remind potential shippers of EVs - including vehicle owners, salvage companies, and vehicle transport companies - that they have a responsibility to assess EVs for potential damage to their installed lithium batteries and to observe the specific requirements in the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) for both the transportation of EVs containing lithium batteries, and for the transportation of damaged and/or defective lithium batteries in commerce.

PHMSA's mission is to protect people and the environment by advancing the safe transportation of hazardous material in commerce. To achieve this mission, PHMSA works with its modal partner agencies to establish national policy, s and enforce regulations (published in the HMR), educate stakeholders, and conduct research to prevent hazardous materials incidents. Additionally, federal hazardous material law authorizes the Secretary of Transportation (the Secretary to "prescribe regulations for the safe transportation, include security, of hazardous materials in intrastate, interstate, a foreign commerce" 49 U.S.C. 5103(b)(1).

The Secretary has delegated this authority to PHMSA in 49 CFR 1.97(b). PHMSA's regulations (i.e., the HMR) are designed to achieve three primary goals:

1. Ensure that hazardous materials are packaged and handled safely and securely during transportation. This document contains guidance provided to help the regulated community understand how to comply with regulations, but its contents are not substantive rules themselves and do not create legally enforceable rights, assign duties, or impose new obligations not otherwise contained in the existing regulations and standards.

2. Effectively communicate the hazards of the materials being transported to transportation workers and emergency responders.

3. Minimize the consequences of an accident or incident should one occur.

Saltwater is especially harmful to lithium batteries as residual salt within the battery or battery components can form conductive bridges that can lead to short circuit and self-heating of the battery, resulting in fires. The time frame in which a damaged battery can ignite varies, from days to weeks, and EV battery fires can be extremely time – and resource- intensive for responders. In addition, responders face safety risks related to the emission of toxic and flammable gases from damaged lithium batteries, and the unpredictability of thermal runaway and reignition. As such, lithium batteries from EVs that have experienced flooding or other exposure to the elements in a manner other than designed are at significant risk of damage, resulting in elevated potential for producing a dangerous evolution of heat, fire, or short circuit.

Read the full article at **https://bit.ly/3KMxPVd**

CINS issues guidance on shipping lithium-ion cells in containers

The International Safe Containerised Cargo Organisation (CINS) has published safety guidelines for shipping lithium-ion cells in containers. Lithium-ion cells are the primary elements of a battery and can exist in various forms. Commonly used in portable electronics and electric vehicles, their defining characteristic is the ability to accumulate, store and release electrical energy through the movement of lithium ions between a positive and a negative electrode.

According to CINS, lithium-ion cells must be handled with care, as they pose several risks if damaged, improperly charged, or exposed to extreme conditions. Proper safety features and handling protocols are critical to mitigating these risks.

Hazardous properties of lithium-Ion cells

Lithium-ion cells are classed as dangerous goods because of several hazardous properties listed below. Strict adherence to safety standards during handling and transport are required.

- Fire hazard: Flammable electrolytes can ignite if damaged or overheated, triggering thermal runaway reactions that lead to fires or explosions.
- Chemical reactivity: Reactive materials may explode or catch fire if punctured or short-circuited.
- Toxic emissions: Fires release harmful gases such as hydrogen fluoride (HF), which are toxic and corrosive.
- Explosion risk: Internal pressure buildup can cause rupture or explosive vapor clouds. – Electrical hazard: Short circuits or mishandling can lead to burns, sparks, or fires.
- Environmental risk: Improper disposal can contaminate soil and water, causing environmental harm.

Key risks during transportation

- Packing not consigned in compliance with the IMDG Code.
- Packing into containers other than in accordance with the CTU Code.
- High temperature inside container(s) during transport.

Read the full article at **https://bit.ly/42L3gWc**

U.S.C.G. releases lithium battery guide for shippers

The United States Coast Guard has published a helpful compliance resource, Lithium Battery Guide for Shippers.

The publication aims to assist shippers to safely package lithium cells and batteries for transport by all modes, including vessel shipments, with new regulatory requirements based on cell or battery configuration as well as Watt-hour (Wh) rating.

As described in the guide, the transport of lithium cells and batteries via vessel can be subject to both the domestic regulations and the International Code for the International Maritime Dangerous Goods (IMDG) that may require additional actions. Both publications should be consulted based on shipment route.

Read the full article at **https://bit.ly/3VDyBGv**

Further suggested reading

Current legislation and regulation are still in early stages within the maritime industry. What works for land-based incidents, doesn't work for maritime ones.

Technical resources

BU-205: Types of Lithium-ion
Lithium-ion is named for its active materials; the words are either written in full or shortened by their chemical symbols. A series of letters and numbers strung together can be hard to remember and even harder to pronounce, and battery chemistries are also identified in abbreviated letters.

For example, lithium cobalt oxide, one of the most common li-ions, has the chemical symbols LiCoO2 and the abbreviation LCO. For reasons of simplicity, the short form li-cobalt can also be used for this battery. Cobalt is the main active material that gives this battery character. Other li-ion chemistries are given similar short-form names. This article lists six of the most common li-ions.

Read the full article at **https://bit.ly/4mDDzxN**

How Lithium Batteries Work: Understanding the Power Behind the Energy Revolution
Lithium-ion batteries have become the cornerstone of modern energy storage, powering everything from smartphones and laptops to electric vehicles (EVs) and solar energy systems. Their efficiency, high energy density, and long lifespan have made them the preferred choice for a wide variety of applications. But what makes lithium batteries so special? How do they store and release energy? In this post, we will break down the working principles of lithium-ion batteries, explaining the science behind their operation in simple terms.

Read the full article at **https://bit.ly/4lPnGpt**

Lithium-ion battery cell formation: status and future directions towards a knowledge-based process design
The battery cell formation is one of the most critical process steps in li-ion battery (LIB) cell production, because it affects the key battery performance metrics, e.g. rate capability, lifetime and safety, is time-consuming and contributes significantly to energy consumption during cell production and overall cell cost.

As LIBs usually exceed the electrochemical [stability] window of the electrolyte, formation is required to activate and stabilise the electrochemical reactions. Enhanced battery technologies are poised to further expand voltage windows and harness conversion or metal electrodes to elevate energy density, thereby magnifying the significance of cell formation in the battery realm. Despite its critical importance, even the understanding of the formation process of conventional LIBs is still incomplete due to numerous influencing factors. Complex internal processes and the associated high experimental and simulation effort make it difficult to gain a thorough understanding of the process and hence to optimise it.

This review paper provides a systematic overview of the formation process and its influencing factors. It is emphasized that material and cell design and the formation process are not independent but must interlock with each other. Promising experimental and simulative methods to gain the required understanding of the interplay for a truly knowledge-based design of the formation process are highlighted. In the concluding discussion research gaps are identified and a perspective for development of tailored cell formation processes for current and future battery technologies is outlined.

Download the article at **https://bit.ly/4nyskrS**

How lithium-ion batteries work
Like any other battery, a rechargeable li-ion battery is made of one or more power-generating compartments called cells. Each cell has essentially three components: a positive electrode (connected to the battery's positive or + terminal), a negative electrode (connected to the negative or - terminal), and a chemical called an electrolyte in between them. The positive electrode is typically made from a chemical compound called lithium-cobalt oxide (LiCoO2—often pronounced "lyco O2") or, in newer batteries, from lithium iron phosphate (LiFePO4). The negative electrode is generally made from carbon (graphite) and the electrolyte varies from one type of battery to another—but isn't too important in understanding the basic idea of how the battery works.

Read the full article at **https://bit.ly/46IdfNc**

Recommended marine related lithium-ion battery reading

Lithium-ion battery explosion on a vessel
According to AMSA an explosion occurred on a charter fishing vessel whilst berthed. The investigation identified that the ignition source was a li-ion battery that was not holding charge connected to a battery charger in a way that bypassed the battery management safety system. The vessel was beyond repair following the explosion.

Read the full article at **https://bit.ly/4pKMtMQ**

Addressing the challenges of lithium-ion battery fires on board ships: A collaborative approach
In recent years, the increasing use of li-ion batteries, particularly in electric vehicles (EVs), has introduced complex challenges for fire safety in maritime environments.

The most recent incident involves the fire on the cargo ship Morning Midas, which occurred on 3 June 2025. It was carrying approximately 3,000 new vehicles, including around 70 fully electric and 681 hybrid vehicles, travelling from Yantai, China, to Mexico. The fire originated on the deck where the EVs were stored, rapidly disabling the vessel about 300 miles southwest of Adak Island. Despite evacuation and firefighting efforts, the fire continued, causing significant damage to the ship's structure. On 23 June, amidst rough weather and water ingress, Morning Midas sank to a depth of about 16,400 ft (5,000 m), roughly 450 miles southwest of Adak.

Read the full article at **https://bit.ly/488rYDt**

Ocean carriers playing catch up in reducing risk of lithium-ion fires on ships
As if shippers needed even more risk associated with their containerized supply chains beyond pandemics, droughts and attacks on vessels, yet another can be added to the list: fires on ships started by lithium-ion batteries.

Historically speaking, li-ion batteries have very quickly become ubiquitous in society and onboard ships, whether as cargo, in crews' personal devices or as part of the ship's equipment. Yet the shipping industry, while acknowledging the batteries are here to stay and can't be banned as cargo, is lagging behind in coming to terms with risks that remain poorly understood.

Read the full article at **https://bit.ly/46ulAoY**

Lithium battery fires now the biggest cause of insurance claims on ships
Fires caused by lithium batteries are causing astronomical losses for ship insurers. Fires and explosions were the most expensive cause of marine claims in 2021 accounting for 18% of $9.2 billion in total losses, according to global ship insurer Allianz Global Corporate & Specialty (AGCS). And it warns the problem will only get worse with the use of lithium batteries, especially in cars, expected to soar in the coming years.

Read the full article at **https://bit.ly/4nVU49t**

Surge in vessel fires linked to lithium-ion batteries sparks safety concerns

Fires onboard vessels are a major safety issue for the maritime industry. A significant rise in the number of vessel fires over the last decade is concerning for maritime safety. Insurance experts from HDI Global SE are watching the increasing use of highly combustible li-ion batteries, a "hot topic" in the insurance industry.

Read the full article at **https://bit.ly/4gNsglB**

Striking risk-reward balance for shipping lithium-ion batteries

While the advancement of technology in electric vehicles and other lithium-ion powered goods facilitates energy transition from fossil fuels, the fire risks associated with such products need proactive management, writes Dr. William Moore, global loss prevention director, The American Club.

Read the full article at **http://bit.ly/4mKFy3J**

A series of fires on recreational vessels have been linked to lithium-ion battery-powered devices

A series of fires on recreational vessels around the world have been linked to li-ion battery-powered devices, tools, and toys stored on board. Responding to this emerging safety issue for boat owners, Nautilus Marine Insurance has interviewed a panel of independent experts for an article within the latest issue of Nautilus Marine Magazine to share their technical advice.

Read the full article at **https://bit.ly/4mIAMnd**

Much to learn about fighting lithium-ion battery fires at sea

Shipowners and maritime industry leaders, insurers and consultants are working on response plans and training to make ship crews aware of the potential fire hazards of carrying electric vehicles fitted with li-ion batteries.

Read the full article at **https://bit.ly/4nW5V7E**

Maritime companies now refusing to ship EVs, citing fire risks from large Li-ion batteries

Several ship fires started by electric vehicles onboard have made shipping companies reconsider their policies. Alaska Marine Lines is the latest to ban EVs and PHEVs onboard ships. The company cited increased fire risk associated with "shipping large lithium-ion batteries on vessels at sea."

Read the full article at **https://bit.ly/48MkKoO**

Deadly yacht fire believed to be caused by lithium-ion batteries

Li-ion batteries are believed to be the cause of a deadly yacht fire aboard a 70-foot Viking that occurred on July 26 at a Florida Keys marina. The fire claimed the life of 51-year-old Linda Vella of St. Petersburg, Florida, and critically injured her husband Michael Kenneth Robson, 58, and son Anthony Joseph Vella, 21.

Read the full article at **https://bit.ly/3VHC5b6**

U.S. Coast Guard issues lithium-ion battery warning after passenger vessel fire

A recent fire aboard an inspected passenger vessel has prompted the U.S. Coast Guard to issue a comprehensive safety alert regarding li-ion battery installations on vessels. The incident, which occurred when loosely crimped lugs overheated in an integrated li-ion battery bank, resulted in minimal damage and no injuries but highlighted significant safety concerns inherent to these power systems.

Read the full article at **https://bit.ly/4nqXbq6**

No, lithium batteries don’t burn boats

“What I would agree to is that a large percentage of fires on boats are caused by poorly designed and installed electrical systems, and that includes those installed by the “professionals.”

Read the full article at **https://bit.ly/4pMbGGN**

Uncontrollable lithium battery fires at sea

An increasing use of li-ion batteries leads to an increased risk for fire. In a report made by the European Union, scientists conclude that a li-ion battery fire on board of a ship can be more deadly than a sinking ship.

Read the full article at **https://bit.ly/4ntL9N1**

Lithium-ion battery safety on boats - Installed lithium-ion batteries

If you’re thinking of switching your domestic, starter or power batteries to li-ion, here are some tips. The following advice is based upon guidance provided by industry experts.

Read the full article at **https://bit.ly/471lDbY**

Taking care of lithium batteries to avoid fire on board a yacht

Following a number of reported lithium battery fires in the past several months, yacht crew have been asking for a more in-depth look at how to minimise the risks, and what to do should you experience a fire. With so much technology running on lithium batteries, now more than ever, yacht owners and crew need to understand the best practices.

Read the full article at **https://bit.ly/46Ls3um**

How lithium-ion battery hazards are changing yacht insurance

Li-ion batteries’ role in yachting is growing. They offer superyachts a lightweight, efficient solution for powering everything from personal watercraft and tenders to e-bikes, phones, tablets, tools, toys, and appliances onboard. However, the surge in adoption comes at a potentially steep cost: a rise in catastrophic fires on luxury vessels, with substantial insurance implications, according to Scott Stamper, Managing Director National Marine Practice, for US- based insurance brokerage Risk Strategies.

Read the full article at **https://bit.ly/471lGoa**

Consequences of incidents involving battery powered vessels

Li-ion batteries can be considered as inert when functioning normally and do not pose the same risk of pollution as the fuel oils in traditional combustion engine propelled vessels. However, if damaged, li-ion batteries have the potential to undergo thermal runaway, generate large vapor clouds, and result in vapor cloud explosions.

Read the full article at **http://bit.ly/470J59b**

Recommended general lithium-ion battery reading

National Fire Protection Association
Lithium-ion batteries are increasingly found in devices and systems that the public and first responders use or interact with daily. While these batteries provide an effective and efficient source of power, the likelihood of them overheating, catching on fire, and even leading to explosions increases when they are damaged or improperly used, charged, or stored. NFPA offers several resources that provide information to promote safer use of lithium-ion batteries across a wide range of applications.

Read the full article at **https://bit.ly/3VHDluM**

What is thermal runaway in batteries?
Thermal runaway is a chain reaction within a battery cell that can be very difficult to stop once it has started. It occurs when the temperature inside a battery reaches the point that causes a chemical reaction to occur inside the battery. This chemical reaction produces even more heat, which drives the temperature higher, causing further chemical reactions that create more heat.

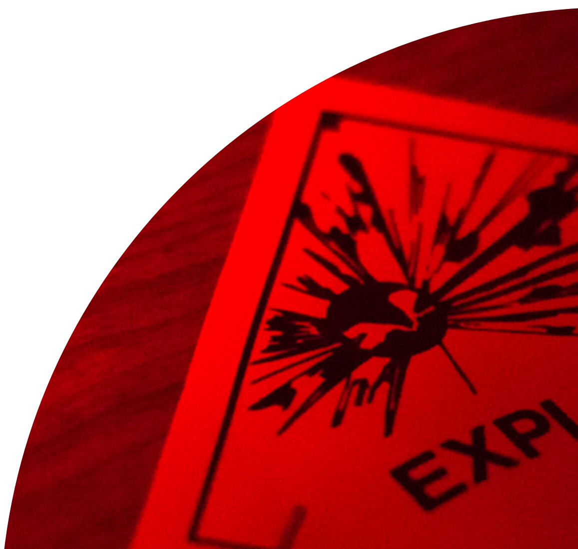
Read the full article at **https://bit.ly/481HIYW**

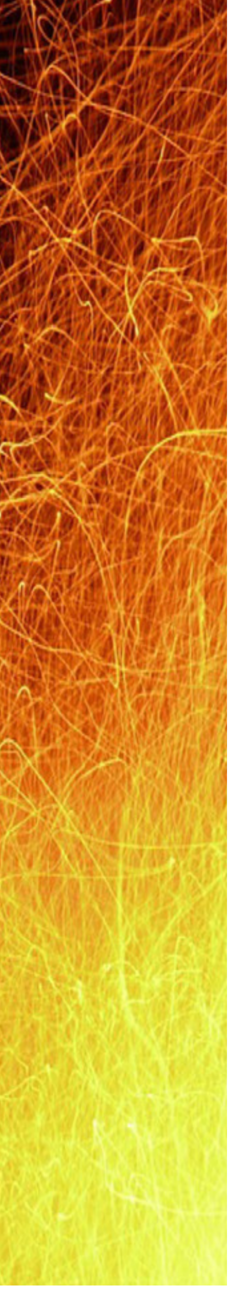
What is thermal runaway? Common causes and how to prevent it
Lithium-ion battery fires are often self-sufficient and continue to burn without access to additional oxygen. This renders firefighting systems that rely on oxygen deprivation less effective. They may also continue to generate high amounts of heat following fire-extinction and are at risk of re-ignition. BOAT International - 'Spate of fires results in new yacht toy and tender guidelines.

Read the full article at **https://bit.ly/4mIrgjQ**

Lithium-ion battery safety
Li-ion batteries have become extremely common. They are found in virtually every rechargeable/electronic device, from personal devices (Bluetooth headphones, vape pens, cell phones, computers) to transportation (e-scooters/ebikes, electric vehicles, airplanes) to stationary home/commercial Battery Energy Storage Systems (BESS, e.g., Tesla Energy Wall or Megapack), and many other applications. If these batteries suffer a catastrophic failure, they can create extreme heat, result in a fire or explosion, and produce toxic gases.

Read the full article at **https://bit.ly/42jX7QG**





Dispose of lithium-ion batteries safely to prevent fires

Natural Resources Wales (NRW) and the Fire and Rescue Services in Wales are urging people across the country to dispose of li-ion batteries safely, following several fires believed to have been caused by incorrectly discarded batteries.

Read the full article at **https://bit.ly/42jX9bg**.

Battery bin plea as fire numbers increase

A senior West Yorkshire fire officer has warned about disposing batteries in household bins amid what the force described as a "growing national crisis". Li-ion batteries, commonly found in everyday items such as vapes, mobile phones and power tools, are increasingly causing fires when discarded incorrectly, West Yorkshire Fire and Rescue Service (WYFRS) said.

Read the full article at **https://bit.ly/3VHpPap**

Lithium-ion battery fires: Myth vs. Reality

There were at least 25,000 incidents of fire or overheating in li-ion batteries over a recent five-year period, according to the U.S. Consumer Product Safety Commission. Within large-scale li-ion battery energy storage systems, there have been 40 known fires in recent years, according to research from Newcastle University.

Read the full article at **https://bit.ly/4nVrd5e**

Safety reminder regarding lithium-ion batteries aboard boats

Fire services are reporting a growing number of fast-spreading fires caused by damaged or failing li-ion batteries. The Boat Safety Scheme (BSS) is also receiving increasing reports of boat-related incidents, from near misses to onboard fires and serious losses, linked to li-ion powered devices.
Read the full article at **https://bit.ly/4ntWGMg**

What can cause a lithium-ion battery explosion?

Li-ion battery explosions are extremely rare, but when they do happen, they are very dangerous because li-ion fires release toxic gases and are difficult to extinguish.

Read the full article at **https://bit.ly/4nRYa2r**

Lithium-ion battery fires: A growing concern

In recent years, they have become a major part of our everyday lives – rechargeable li-ion batteries are used to power many devices, from your smartphones and laptops to e-bikes and e-scooters, and many more. Li-ion batteries come with beneficial features which make them ideal for the devices we use the most.

Read the full article at **https://bit.ly/48CNNLx**

Safety tips for lithium-ion batteries

Li-ion batteries are used in various devices, commonly powering cell phones, laptops, tablets, power tools, electric cars, and e-micromobility devices such as e-bikes and e-scooters. Li-ion batteries store a large amount of energy and can pose a threat if not treated properly.

Given the nascent industry and lack of federal standards for e-micromobility products, a number of the batteries in these devices are or become defective and can overheat, catch fire, or explode. In 2023 alone, there were 268 fires caused by lithium-ion batteries, many of which were used to power e-bikes.

Read the full article at **https://bit.ly/46P38WV**

How to mitigate the risk of a lithium-ion battery fire

Insurance companies such as Zurich and Aviva have become much more aware of Lithium-Ion battery fire risks and report a significant uplift in related claims over the last 3 years.

Read the full article at **https://bit.ly/4pKOGI2**

The hidden danger:
Lithium-ion battery fires in the UK – A growing crisis

The number of fires linked to li-ion batteries in the UK increased by 46 per cent in 2023, compared with the previous year, according to research from business insurer QBE. Even more concerning, UK fire brigades are now responding to more than three li-ion battery fires each day.

Read the full article at **https://bit.ly/46Jj50D**

Industry Certification and Standards

Maritime & Coastguard Agency MGN 550 (M+F) Amendment 1: Electrical installations - guidance for safe design, installation and operation of li-ion batteries

This MGN provides best practice marine guidance to facilitate safe and environmentally friendly battery solutions for vessels utilising li-ion batteries.

The intent of this Marine Guidance Note (MGN) is to provide the marine industry with best practice guidance to facilitate safe and environmentally friendly battery solutions for vessels utilising li-ion marine batteries as part of an energy source, hybrid power system or as the sole source of propulsion power. Topics include:

- Introduction
- Battery System Design
- Battery Replacement
- Battery Management System
- Battery Space and Storage
- Ventilation
- Cooling Systems
- Operation and Handling
- Fire Detection and Fire Fighting
- Disassembly and Recycling

1. Introduction/background

1.1 The need to reduce emissions is driving battery use within the marine industry. Battery technology is rapidly evolving, enabling the production of more efficient batteries for the use of energy, hybrid and sole propulsion on board vessels.

1.2 Li-ion battery technologies have become a viable energy storage option, due to greatly improved energy density. However, these do not come without risks.

1.3 Thermal runaway is one of the main concerns in relation to li-ion batteries; where an increase in temperature can cause venting of gases and/or chemicals with corrosive and flammable vapours, cascading from a cellular level through a module, leading to a fire or explosion. Li-ion batteries are high-energy devices and should be considered as hazardous, at all times, including during transportation.

1.4 This guidance does not supersede any other guidance or statutory instruction; sound engineering practice and manufacturer guidance should be considered when developing designs for battery power systems. The contents of this guidance will not cover every eventuality, and each case should be considered separately.

1.5 The design of a battery system within a vessel should anticipate future changes. These changes might relate to the operational tasking of the vessel, modifications to the electrical equipment and upgrades to the battery. It should be highlighted that any modification which changes the requirements upon an existing battery system should be thoroughly assessed against the original requirements of the battery and its current state of health and action taken appropriately to ensure safe use and operation.

1.6 The use of hazard identification and risk assessment techniques should be performed to understand the potential safety issues for personnel, the environment, the vessel and the vessel's operations. Suitable mitigations or safeguards should be implemented to reduce risks to an acceptable level.

1.7 A risk assessment of all components and systems should be carried out and be submitted to the vessel's Certifying Authority or Recognised Organisation. The risk assessment should consider the components of the batteries and connected systems both individually and as an entire operating unit, and should be carried out either as part of, or in addition to, any other risk assessment required. Risk Assessments should be regularly reviewed as part of the Safety Management System.

1.8 Li-ion batteries and associated components intended for powering a vessel should comply with a recognised standard meeting the approval of the Administration (see Annex 1 of this MGN). Where li-ion batteries are to be used for propulsion, the design and capacity of the electrical energy storage system should be appropriate for the intended operation of the vessel, including capacity for an energy reserve, such as higher power demand in adverse weather or for emergency operations.

1.9 An intention to test li-ion batteries should be notified to the Certifying Authority or Recognised Organisation and Administration with reasonable notice, and the Certifying Authority or Recognised Organisation may require that a surveyor witness the battery tests.

1.10 The Administration may appoint an MCA surveyor, or other designated person, to witness tests.

Read the MGN at **https://bit.ly/46RXjrX**

ISO 23625:2025 Small craft — Lithium-ion batteries
This document specifies requirements and recommendations for the selection and installation of li-ion batteries for boats, as well as requirements for the safety information provided by the manufacturer.

This document is applicable to li-ion batteries and battery systems with a capacity greater than 500 Wh used on small craft for providing power for general electrical loads and/or to electric propulsion systems. It is primarily intended for manufacturers and battery installers.

More details at **https://bit.ly/4mHQz5K**

UL (Underwriters Laboratories) Standards
UL standards are widely recognized across North America and many other regions and set rigorous safety standards for li-ion batteries that focus on fire resistance, thermal stability, and electrical performance. They have specific standards that ensure the safety of li-ion cells in consumer electronics (UL 1642), apply to battery pack durability (UL 2054), apply to EV battery safety (UL 2580), and apply to portable lithium batteries (UL 62133-2).

More details at **https://www.ul.com/**

IEC (International Electrotechnical Commission) Standards
IEC plays a critical role in setting international benchmarks. They ensure a global safety standard for rechargeable batteries (IEC 62133-2), industrial energy storage batteries (IEC 62619), EV batteries (IEC 62660), and automatic controls for battery safety systems (IEC 60730).

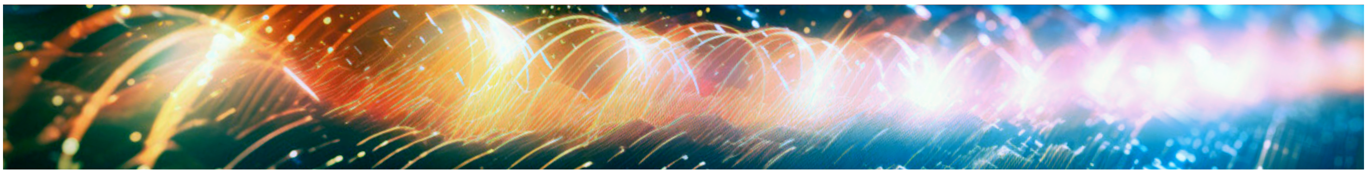
More details at **https://webstore.iec.ch/en/**

SAE (Society of Automotive Engineers) Standards
SAE provides important guidelines for lithium batteries in transportation industries. This includes safety requirements for EV battery systems (SAE J2929), abuse testing procedures for high-voltage batteries (SAE J2464), and performance testing methods (SAE J1798).

More details at **https://www.sae.org/standards**

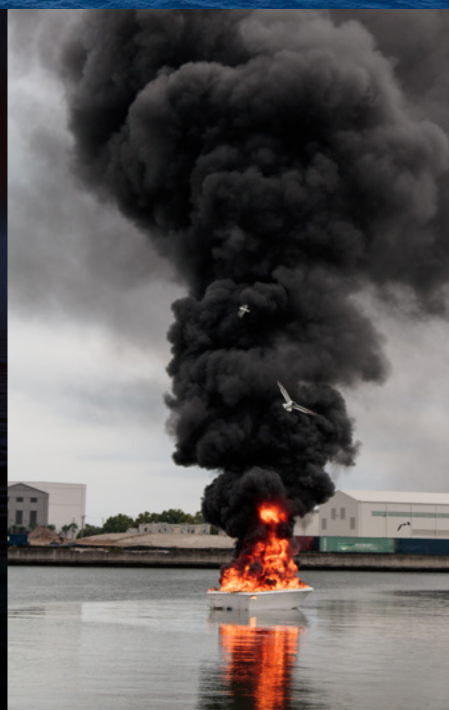
UN/DOT (United Nations and Department of Transportation) Regulations
Given the risks associated with lithium battery transport, UN/DOT regulations ensure safe shipping and handling. They require batteries to undergo rigorous testing for shock, vibration, and pressure (UN 38.3), regulate lithium battery air and ground transportation (49 CFR 173.185), and govern air transport of lithium batteries under the International Air Transport Association (IATA DGR).

More details at **https://www.phmsa.dot.gov/lithiumbatteries**







MPC
THE MARITIME PROFESSIONAL COUNCIL OF THE UK

Promoting excellence in professional maritime standards

The purpose of the **Maritime Professional Council of the UK** is:

- To promote the professionalism and esteem within the British Merchant Navy and to those organisations directly concerned with the sector.
- To provide a central point from which professional opinion on maritime matters can be offered to the Maritime Community, Industry, Government and the Media.
- To provide independent expert advice and guidance based on our combined professional knowledge and experience unhindered by any financial or commercial interests.
- To provide guidance to regulators and employers on the professional training standards adequate for our maritime professionals.maritime standards.

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