



Rising Star of the Year 2024

Winning Submission

Charlie Evans

Where there is smoke...

Lithium ion-batteries are thought of as a safe technology, but questions remain over the part they play in fires involving port equipment. **Charlie Evans** reports

Using lithium-ion batteries as a power source is not a new phenomenon. The technology was developed in the 1970s and the first battery of its kind was sold commercially in 1991. Evolution has been fast-paced and now many everyday items that we need to function in our lives are powered by lithium-ion batteries. Personal devices such as mobile phones, tablets, laptops, and electronic toothbrushes all contain these batteries due to being rechargeable.

Most port equipment was previously diesel-powered but manufacturers have accelerated their use of lithium-ion batteries due to the benefits they can bring - they are 50-60% lighter and last ten times longer than the lead-acid alternative. The rechargeable aspect also improves the efficiency of terminals as equipment can be used for longer and more often, meaning operations can be carried out at a quicker pace.

The push towards decarbonisation has also helped increase the demand for lithium-ion batteries as they emit no harmful gases. However, while it is accepted that lithium-ion batteries are safe, some risks remain, particularly fires, that can become very serious if the battery is impacted in any way.

Research from market consultant IDTechEX showed that, for general applications, when an electric vehicle (EV) fire occurred, 33% of the time it was while the vehicle was parked and 26% was when the vehicle was charging, most likely because of overcharging. Lithium-ion batteries are extremely sensitive to high temperatures and overcharging will increase the internal temperature of the battery, potentially leading to overheating and a much more intense fire than an internal combustion engine.

Opportunity and risk are intertwined, and manufacturers certainly see the former in the value of lithium-ion batteries. ZPMC produces electric straddle carriers but the dangers of combustion do not seem to faze the Chinese manufacturer.

Gu Jing, sales and marketing manager for ZPMC's overseas key account department, told **CM**: "For the safety of the batteries, we are not very concerned about it because in our opinion, the battery industry, at least in China, is quite mature.

"We have a lot of electrical cars, and it's quite popular to use [a lithium-ion] battery now in cars, and in straddle carriers it is quite similar, but the battery is larger."

This sentiment is not shared by Peter Kania, Konecranes sales director of business line straddle carrier and port solutions. He stated: "We use lithium-ion batteries on our hybrid straddle carriers as well as on our fully battery-driven straddle carriers. We are constantly studying and improving how lithium-ion battery technology can be best used in our products. Everybody is learning fast, Konecranes included."

The Finnish company Konecranes has a significant part of its product portfolio – straddle carriers, rubber-tyred gantry (RTG) cranes and automated guided vehicles (AGVs) - powered by lithium-ion batteries and understands the risk factors associated with them. A lithium-ion battery fire is very hot and prone to reignition, so Konecranes has developed a 'flushing system' to cool down the batteries if a fire breaks out.

Kania explained: "It is very difficult to extinguish a burning lithium-ion battery. You start by cooling it down, and we do this by flushing water into the batteries and out, which cools the batteries down as much as possible, as fast as possible. This flushing system is standard on all of our straddle carriers using lithium-ion batteries, both hybrid and battery."

Jeffrey Stokes, director of product and technology management at Konecranes Lift Trucks, said: "At Konecranes we build safety into all layers of our company, most of all in the products we offer our customers. We were early adopters of lithium-ion battery technology in our industry because our customers wanted it twenty years ago.

"Today we offer many lithium-ion-driven products. It could be said that lithium-ion battery technology is an outlying technology, because all industries are learning about it and so are we. So are the national regulatory bodies, who are trying to keep up as they always do with any outlying technology."

When it comes to the risk of fire for Konecranes lift trucks powered by lithium-ion batteries, the company notes that fire is a risk for diesel trucks as well. Konecranes offers a Thermal Management System and Battery Management System (BMS) for its battery-driven trucks. The BMS monitors the battery temperature and keeps it around 25°C to give longer battery life and better efficiency.

One company that has developed a solution to try to counteract fires is Fogmaker. The system is a high-pressure water-based mist system that releases a fire suppression liquid as atomised droplets in the protected compartment of the equipment. There is a long emptying time of around 35-60 seconds which ensures a long cooling period to prevent possible reignition.



Gustav Stigsohn, Fogmaker product owner, told **CM**: "When water is transformed into vapour, the volume increases 1,700 times. This means that one litre of liquid will become 1,700 litres of water vapour. This volume expansion pushes out the air and oxygen into the compartment and helps suffocate the fire."

The liquid also contains surfactants that will form a layer on top of hydrocarbon liquids, such as diesel, hydraulic oil, and engine oil, which prevents gases from the fuels mixing with the air and forming a combustible mixture.

According to Stigsohn, lithium-ion fires are difficult to suppress for two main reasons. Firstly, it is hard to reach, as battery packs are sealed and there can be multiple barriers between the fire suppression nozzle and the fire. Secondly, the fire is hot and rapid, making it challenging for any type of fire suppression agent to work.

For a solution that effectively extinguishes a fire in a lithium-ion battery to be developed, greater cooperation is needed between the fire suppression manufacturers and battery manufacturers. While the risk of fires remains, the safety standards of port equipment will be questioned as to whether they are strong enough to protect workers.

Stigsohn said: "The number of guidelines and standards for fire suppression systems for machines and vehicles has really developed over the last 10 years.

"However, for port equipment I still believe there is work to be done. The material handling industry is a worldwide industry and I believe international standards and guidelines could be beneficial to make fire suppression systems more available."

This is echoed by Anders Gulliksson, Dafo Vehicle's technical manager. He told **CM**: "The speed of electrification and the demand for electrification in different areas has gone so fast the regulatory authorities are dragging behind.

"Then it comes up to companies like us to at least try to share, in waiting for regulatory standards, we can only share our knowledge and our experience with our customers to hopefully help them building the safest possible system."

The Swedish manufacturer's SafEV system aims to detect

fires in lithium-ion batteries early to prevent a full-scale blaze from happening or toxic gases being emitted. The cooling agent Forrex is applied to stop or delay a hazardous situation without the fire developing further.

Tommy Carnebo, Dafo Vehicle training manager and EV specialist, told **CM**: "We did some testing and some research, and we saw that these batteries start to produce smoke before they start to burn and that's where we see the window where you can address the situation before the situation occurs.

"If you can address where there is smoke from batteries, then you can do something before the thermal runaway starts because when the thermal runaway starts, then it's a slightly, so to speak, bigger challenge."

Dafo Vehicle views lithium-ion batteries as a safe technology but with new technology, there is always a need to continuously adapt systems to improve safety. The company operates a training programme for people who work with batteries to know what to do if a battery malfunctions and how they react.

There is also another programme for those who work in ports, for people who stand and point where things should go to machine operators, and on how to deal with a damaged vehicle at a terminal.

Carnebo said: "Ports have a pretty good knowledge of fire suppression systems, detection systems and information on how to deal with the challenge with combustion engines on different machines.

"When it comes to batteries, they have more or less nothing because they totally, 100%, rely on what the battery manufacturer says."

Both Dafo Vehicle and Fogmaker have been asked by the Port Equipment Manufacturing Association (PEMA) to write a paper on fire suppression for port equipment, with representatives from Bromma, Liebherr and ZPMC also part of the project. The target is to have this ready by April 2024.

Carnebo said: "We are constantly moving, and we are very proud of our work because we think that we have a solution that can help make batteries safer and better for society."

Opposite Page:
Fogmaker is a high-pressure water-based mist system

This Page:
Left: Konecranes hybrid straddle carrier
Right: Dafo Vehicle has a training programme on how to deal with damaged EVs

... there is fire

As lithium-ion batteries are transported around the world, there are increased fire risks for the ships that carry them. **Charlie Evans** reports

As the ambition to decarbonise both the cargo and passenger transport sectors draws closer to reality, lithium-ion batteries are becoming a necessity and need to be carried around the world to meet demand. These batteries can be carried on board ships as cargo or as part of the equipment for the electric vehicles (EVs) that they power. Although they are safely transported daily, there will always be risks of fires in both situations, particularly if the battery is defective or damaged in any way.

Containers are increasingly being used to transport improperly stored, packaged, and handled lithium-ion batteries, which are potentially hazardous and combustible. These cargoes are in turn being carried by large vessels, where a fire would be even more dangerous and potentially result in greater losses of cargo and the ship itself.

In February 2022, a fire on a *Felicity Ace* car carrier broke out which eventually led to the vessel and its cargo of 4,000 vehicles being sunk in the Atlantic Ocean. It was thought that lithium-ion batteries powering luxury electric vehicles (EVs) being carried on the ship were responsible for the fire.

Whether lithium-ion batteries make fires more likely remains unknown but fires that originate from this source present more dangerous situations than a combustion engine blaze. The blaze from these fires is much more harmful because a vapour cloud of toxic gases as well as smoke is released. Hydrogen fluoride is produced which can burn the skin and, if inhaled, causes a serious threat to life.

The main cause for concern in lithium-ion battery fires is thermal runaway, a rapid self-heating fire that can cause explosions. When a sealed lithium-ion battery overheats and explodes, the flammable electrolyte is exposed to air and oxygen, and the heat from the electrical fault usually starts a fire. The reaction causes the battery's temperature to rise quickly and the explosion itself can reach temperatures of around 400°C.

Jim Campbell, COO at CakeBoxx Technologies, an American container manufacturer, told **CM**: “This inherent risk poses many challenges for transport and storage. Currently, there is limited capability to sense the thermal runaway condition and few options for suppressing thermal runaway or the subsequent fire that may occur.

“Further, there is little protection from surrounding batteries or cargo. The result of a thermal runaway event can be catastrophic for the battery, the cargo, the ship itself, and, of course, the crew or anyone in close proximity.”

To improve the safety of transporting lithium-ion batteries, CakeBoxx recently formed a technical alliance with Serco to try to solve the issue of thermal runaway and the main challenges of these fires. The collaboration involves creating

a product that incorporates advanced fire detection and suppression mechanisms tailored for containers to be able to detect fires earlier and before catastrophic failure.

Campbell explained: “We intend to take a systems engineering approach to create an integrated system to address all three challenges. A great deal of research continues into technologies in these areas.

“We will partner with and leverage that expertise to complete and test a comprehensive design incorporating those technologies, utilising Serco's great marine engineering expertise and CakeBoxx's outstanding specialised cargo container design capabilities.”

Despite the uncertainty created by not being able to fully address these fires, the lithium-ion battery market is expected to grow by 30% from 2022 to 2030. Nevertheless, thermal runaway adds an extra layer of severity to a lithium-ion fire and due to the rate of reaction, it is very difficult to stop the damage.

As such, safety measures in everyday life have been implemented, with electric scooters banned from the London transport network due to the potential consequences a fire underground may have. Similar issues remain on vessels as a fire could occur in the middle of the ocean, like with the *Felicity Ace* car carrier, and there would be no help available.

Captain Randall Lund, Allianz senior marine risk consultant, told **CM**: “Most ships lack the suitable fire protection, firefighting capabilities, and detection systems to tackle such fires at sea, which has been made more difficult by the dramatic increase in ship size.”

Fire is one of the biggest causes of general average claims on container vessels and one of the main causes of total losses across all vessel types, with 64 ships lost in the past five years alone across all incidents, not just involving batteries.

Lund said: “With upwards of 20,000 containers on board some vessels, the risk of a fire originating from a container increases, while detecting and fighting a fire at sea is particularly difficult for a crew of just 20 to 30 people.

“A container fire can easily take hold and overwhelm the ability of the crew to deal with the situation, leading to the abandonment of the vessel, and potentially its total loss.”

Cargo insurance offers comprehensive insurance for all stages of the distribution chain, including goods in transit, storage risks, global programmes, and project cargo for specialist shipments. Marine hull and liability insurance gives coverage for all types of blue and brown-water shipping, as well as shipyards and building risks, plus mega yachts, and pleasure craft.

Lund explained: “For Allianz as hull insurer, the quality of



crew is an essential element of risk assessment. We take into account crew retention rates, crew training schemes and data from platforms which collect information in detail – such as findings from Port State Controls – that could possibly raise questions with crew management and treatment.

“We must also always remember that merchant vessels are manned by professional merchant mariners, not professional fire fighters, although basic shipboard firefighting and prevention is a requirement for those going to sea.”

Most crews undertake Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) courses to know what to do in the event of a fire on a vessel. The regulations require seafarers to do a two-day firefighting course at an approved establishment, where exercises will be conducted on how to use fire extinguishers and donning smoke hoods.

Engineers and dock workers complete a one-week firefighting course at the beginning of their careers but only update it with a one-day course every five years. The training remains basic and crew members should not be expected to be able to react in the same way a firefighter would. There has been little progress to better equip seafarers for when these situations arise, but companies are trying to shine a light on the issues.

In November 2022, TT Club, alongside UK P&I Club and Brookes Bell, issued a white paper to highlight the ongoing safety threat posed by the transportation of lithium-ion batteries. The document considered the science of lithium-ion batteries and transport regulations, as well as fire risks and emergency response.

Mike Yarwood, TT Club managing director loss prevention, told **CM**: “We recognised there were a number of incidents happening that were touted to be involving lithium-ion batteries. The initial aim of that white paper was to understand the scientific level of what lithium-ion batteries were, what were their critical components, and why they burst into flames.

“It was very much a focus on raising awareness and asking some pertinent questions around classification, what the risks and fire response should be and leaving no stone unturned around the carriage handling storage of these items.”

The white paper recommended improving and updating safety methods, monitoring systems and equipment, including automatic fire detection alarm systems (AFA), hand-held thermal imagery equipment and appropriate personal protective equipment (PPE), such as fire suits, longer duration,



and lighter self-contained breathing apparatus (SCBA).

A review of statutory regulations, including STCW, and standards was also suggested, pushing for urgent changes to ensure all stakeholders in the supply chain are trained in potential hazards and consequences and prepared to respond appropriately.

Clearly, large quantities of lithium-ion batteries are transported safely every day on vessels, or the fire safety problem would be an existential issue. Yet, when fires do occur on ships in isolated locations, they are by their very nature challenging to suppress, and combined with the potential impact of thermal runaway and the inability to effectively train crew members, they can be fatal. As the uptake of lithium-ion batteries throughout the global transport sector grows, it is imperative that fire safety is prioritised.

Opposite Page:

Top: Three Tesla electric vehicles

charging

Middle: CakeBoxx

and Serco's product

will incorporate

fire detection

and suppression

mechanisms

Bottom: The *Felicity*

Ace car carrier