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Lithium-ion batteries: Mitigating the risks

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Protecting against health risks around lithium-ion batteries

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The risk of fire posed by lithium-ion batteries is well documented, regularly featuring in headlines and dominating conversations around electric vehicles, battery energy storage systems and battery waste handling.

Frequency is growing too; the London Fire Brigade reported callouts to battery fires once every two days in 2023, and the running total of 'e-fires' in the capital had already outstripped the 116 recorded in 2022 by September.

The unique risks of lithium-ion fires

Thanks to a phenomenon called thermal runaway, within a lithium-ion battery any internal fault or external conditions (such as overcharging or mechanical damage) can begin an irreversible and uncontrollable self-heating state. Once a battery begins heating in a thermal runaway, it can only end one way: with extremely high temperatures, fire, smoke and vapours.

Thanks to the fast-building intensity of thermal runaway, the time between the fault or damage occurring and the release of toxic vapour during a fire can sometimes be just a few minutes, or even seconds.

Additionally, lithium-ion battery fires not only burn for much longer periods than 'normal' fires, but they can reignite hours, days, or even weeks later, and multiple times – making the risk much more complex.

While the risk to property is widely discussed in the context of lithium-ion fires, there is less conversation around what risk managers should be aware of when considering health risks in those same events.

Although contact with toxic materials is unlikely when handling lithium-ion batteries in a controlled manner, if the integrity of the battery housing is damaged, or the cell catches fire, the explosion can often be so violent that it shatters the battery. This immediately releases a dangerous shower of fragments, corrosive chemicals and poisonous vapour – highly hazardous health risks for anyone nearby.

Highly hazardous: the risk to life

Highly toxic combustion products from lithium-ion fires can result in damaging and even fatal health outcomes for those exposed to them.

Vapour clouds can form when a lithium-ion battery explodes without the gases igniting or being vented to the atmosphere. Such containment can occur in a closed storage room or a shipping container where there are no immediate ignition sources.

This vapour cloud is not like smoke; it's a mixture of toxic and explosive gases. Often it will not spread like smoke – due to differences in density it pools at ground level, proving more dangerous to those trained to stay low during a fire to avoid inhalation.

In fact, even in instances where the gases can disperse, there is still the possibility that toxic health effects may occur from brief exposure, albeit at a lower impact.

Battery substances posing serious health risks

Hydrogen fluoride: Hydrogen fluoride can exist as a colourless gas which, despite dispersing quickly in air, can still enter the body through inhalation. When hydrogen fluoride is dissolved in water, it may be known as hydrofluoric acid, a highly toxic, reactive chemical which enters the body through direct contact. Health risks include:

- Very serious and extremely painful burns from any skin contact, the extent of which can be missed at initial stages, as it can take up to 24 hours after contact before pain is experienced.
- Continued breakdown of flesh and tissue and damage to organs long after initial efforts have been made to wash it from the skin.
- Irreparable damage to the eye, even with very small quantities of diluted hydrofluoric acid.
- Fatal toxicity by inhalation.

Carbon monoxide and carbon dioxide: Ignition of lithium-ion batteries results in the release of carbon monoxide and carbon

dioxide. Both interfere with the absorption and transport of oxygen around the human body, leading to oxygen deprivation of tissues and organs. Reduced oxygen flow to the bloodstream and cells initially causes fatigue, clumsiness, breathlessness, confusion and increased heart rate. With continued or increased exposure, symptoms may worsen to include nausea, vomiting, convulsions, or coma – before progressing to death.

Cobalt: At high temperatures, cobalt is attacked by atmospheric oxygen and by water vapour, producing cobalt(II) oxide. Vomiting and abdominal pain are the results of ingestion, inhalation and/or skin contact with dusts or solutions containing cobalt.

Nickel: The toxicity of nickel metal and inorganic nickel compounds vary depending on their solubility, but short-term effects can include both irritation of the skin (on contact with dust or solutions of soluble nickel salts) and eye irritation (from exposure to nickel dust, fumes, or splashes from nickel-containing solutions). It can also enter the body via inhalation of dust, fumes or mist.

Copper: Owing to its heat and electrical conductivity as well as its resistance to corrosion, ductility and malleability, copper has many industrial applications and is widely used in electrical wiring and switches. Occupational exposure to copper is usually via inhalation (leading to a fever, headache, fatigue, cough, sore throat and tightening of the chest) and ingestion of contaminated food and liquids (causing stomach pain, nausea, vomiting and diarrhoea).

Aluminium: Aluminium powder is flammable and given an ignition source can ignite on contact with air in a dust explosion. Aluminium reacts with alcohols, and water reacts violently with oxidants, strong acids, strong bases and chlorinated hydrocarbons causing a fire and explosion hazard.

Inhalation of aluminium dust can cause irritation of the respiratory tract, whilst ingestion may result in burning in the mouth and throat and mild gastrointestinal upset and in severe cases, ulceration of the lips and mouth.

Advice for risk managers

Risk prevention strategies are essential to mitigate health risks in relation to lithium-ion batteries. In addition to undertaking a fire risk assessment, firms should develop a comprehensive procedure to prepare for emergency events, in consultation with relevant employees.

Emergency procedures should be structured so that all those working with or near lithium-ion batteries have a thorough understanding of the actions they should take, alongside any specialist clean-up of released materials.

Employees should be made aware that manual fire extinguishers do not work effectively on lithium-ion battery thermal runaway fires. Extinguishing the flames changes the threat from a fire hazard to an explosion hazard, so employees should evacuate immediately and call the Fire Brigade rather than attempting to tackle a lithium-ion battery fire themselves.

Whilst specific control measures implemented will be guided by an individual site risk assessment, in response to health and safety risks, they are likely to recommend firms to:

- Identify a suitable local exhaust ventilation of the battery charging area.
- Establish a requirement to wear suitable personal protective equipment including gloves, eye protection, boots and apron.
- Segregate the charging area: access for authorised personnel only.
- Ban metal objects in pockets which could fall onto the battery or bridge across its terminal.
- Keep sources of ignition (such as flames, sparks, electrical equipment, hot objects and mobile phones) away from batteries that are being charged, have recently been charged, or are being moved.
- Use suitable single-ended tools with insulated handles and fit temporary plastic covers over the battery terminals when handling.
- Maintain a readily-accessible and in-date supply of the antidote to exposure to hydrofluoric acid – calcium gluconate gel. Whilst suitably trained first aiders can administer the gel, in view of the severity of the effects of exposure to hydrofluoric acid and the swiftness with which it is desirable to apply the antidote, consider specifically training individuals in its application in any area where exposure may occur.
- Ensure hand washing facilities with warm water are available.

This guidance was produced in partnership with Finch Consulting. For a detailed employer guidance note on health and safety risks around lithium-ion batteries, visit the QBE Document Library: www.qbeeurope.com/document-library

Nick Fox, senior risk manager, QBE Europe

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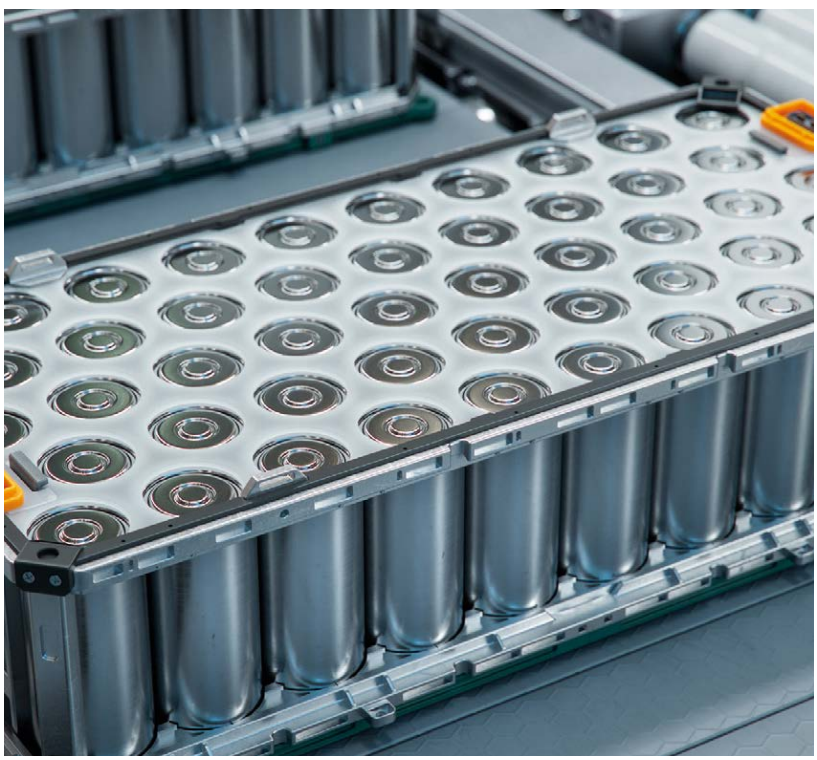

Rechargeable lithium-ion batteries were first introduced in 1991. Today, they're everywhere.

Think about how many rechargeable devices are in your home and workplace – from the fitness tracker on your wrist, cell phone and computer, to e-bikes and electric vehicles. With a growing focus on sustainability influencing many – if not all – businesses, new applications for lithium-ion batteries are being embraced, including for use in energy storage, power tools, forklifts and electric vehicles.

In normal use, lithium-ion batteries are stable and work as intended. However, these batteries are particularly sensitive to high temperatures and are inherently flammable, as well as being sensitive to cold temperatures and over-charging.

In certain circumstances – if the battery has been damaged by dropping, piercing or even heavy jolting, for example – a fault can cause a short circuit and severe overheating leading to thermal runaway: an irreversible pathway to fire.

Lithium-ion batteries can be difficult to deal with because they release a flammable and toxic vapour which helps to further fuel the fire. Fire extinguishers are available that release a water-based solution of a material called vermiculate. This seals around the damaged battery to limit further fire spread but it does not halt the thermal runaway. The thermal runaway process will continue under the vermiculate, and is waiting to accelerate again given the chance. This can reignite the fire even after hours or days or weeks of it seeming to be contained.

Any by-standers should evacuate and stay at least 10 metres away from the fire, as the explosive force of a fire and thermal runaway release can throw hot metal and burning chemicals many metres. No one should attempt to extinguish the fire unless they're trained and are using Lith-Ex extinguishers.

Ten strategies to mitigate risk

Mitigating lithium-ion fire risk can be addressed as part of emergency response plans for businesses. In addition to any contingency plans, general risk control recommendations around lithium-ion battery use and storage could include:

1. Establish a pre-defined emergency response plan to tackle damaged or overheating lithium-ion batteries. Key employees should be trained before lithium-ion batteries are permitted on site.

2. Avoid using lithium-ion batteries/battery-powered equipment in extreme heat and freezing temperatures. Do not expose the battery to condensation, excessive humidity or water. Employees should be advised to never stack heavy objects on top of batteries or devices containing batteries.

3. Charge lithium-ion battery-powered personal mobility devices or mobile plant (such as forklift trucks and powered pallet trucks) in a fire-rated non-combustible structure, or room located outside the main building or attached to the external wall. Charging inside the main building requires a minimum four metres clearance from all combustibles and charging to be interlocked with localised or premises fire detection to shut off the power to the charger bay and raise a fire alarm.

4. Ensure all charging is completed during working hours. If battery charging is undertaken out-of-hours, additional, expensive control measures are recommended, such as dedicated fire-rated cabinets or battery charging rooms, early alert off-gas detection, and localised automatic fire suppression, such as water mist protection to contain fire spread.

5. If the battery is detachable, remove it from the equipment when it is not in use for extended periods. Lithium-ion batteries not in use must be stored in a cool, dry location, in a charged state. In industrial or vehicle workshop premises, where the state of charge can be checked or changed, the batteries should be stored at 30 per cent SoC if being kept for extended periods, and certainly no more than 50 per cent. This is because the energy in a fire situation has been found to be significantly less at around 30 per cent than if the SoC is above 50 per cent, and it makes fire-fighting much easier.

6. Segregate lithium-ion batteries from other materials if bulk-stored in a warehouse, in a non-combustible, well-ventilated structure/room with sufficient clearance between the walls and the battery stacks. There should be clearance between batteries to allow air to circulate.

7. Control floor stacking of lithium-ion batteries in designated areas with limited stack heights, footprints and separation distances. Rack storage of lithium-ion batteries should not be permitted unless the building and the racks are fully sprinklered with solid metal horizontal and vertical barriers between each storage bay (use FM DS 8-9 Scheme A with horizontal and vertical solid barriers for every bay for an internationally accepted sprinklered rack storage protection standard).

8. Use a hand-held infrared temperature gun to perform thermography inspection for any battery that has, or may have sustained damage. Any deviation from the normally expected general temperature by 3°C or more on any individual lithium-ion battery package should be reported to management immediately so the pre-defined emergency response action plan can be initiated.

9. Maintain a steel bin partially filled with water (or similar arrangements) at least three metres clear of the building, in readiness for any lithium-ion batteries with elevated temperatures to be placed into by a forklift truck. Other fire containment materials such as vermiculite or sand can be used to smother the affected battery. These measures might not stop the chemical fire from continuing but they will assist with fire containment.

10. Never open, destroy or incinerate a lithium-ion battery as it may leak or rupture, and release the ingredients they contain into the environment. Any swollen, dented or otherwise damaged batteries should be recycled or disposed of by a company qualified to do so.

Risk management services for QBE customers

QBE helps businesses build resilience through risk management and insurance.

Depending upon the size and complexity of the business needs, QBE customers can access a wide range of risk management services, self-assessment questionnaires and risk management toolkits which are focused on the key causes of claims, and on generating action plans for improved outcomes – including protecting employees, reducing risk and making claims less likely.

You can find out more about how QBE helps businesses to manage risk at: www.qbeeurope.com/risk-solutions

Adrian Simmonds, interim practice leader at QBE Europe

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