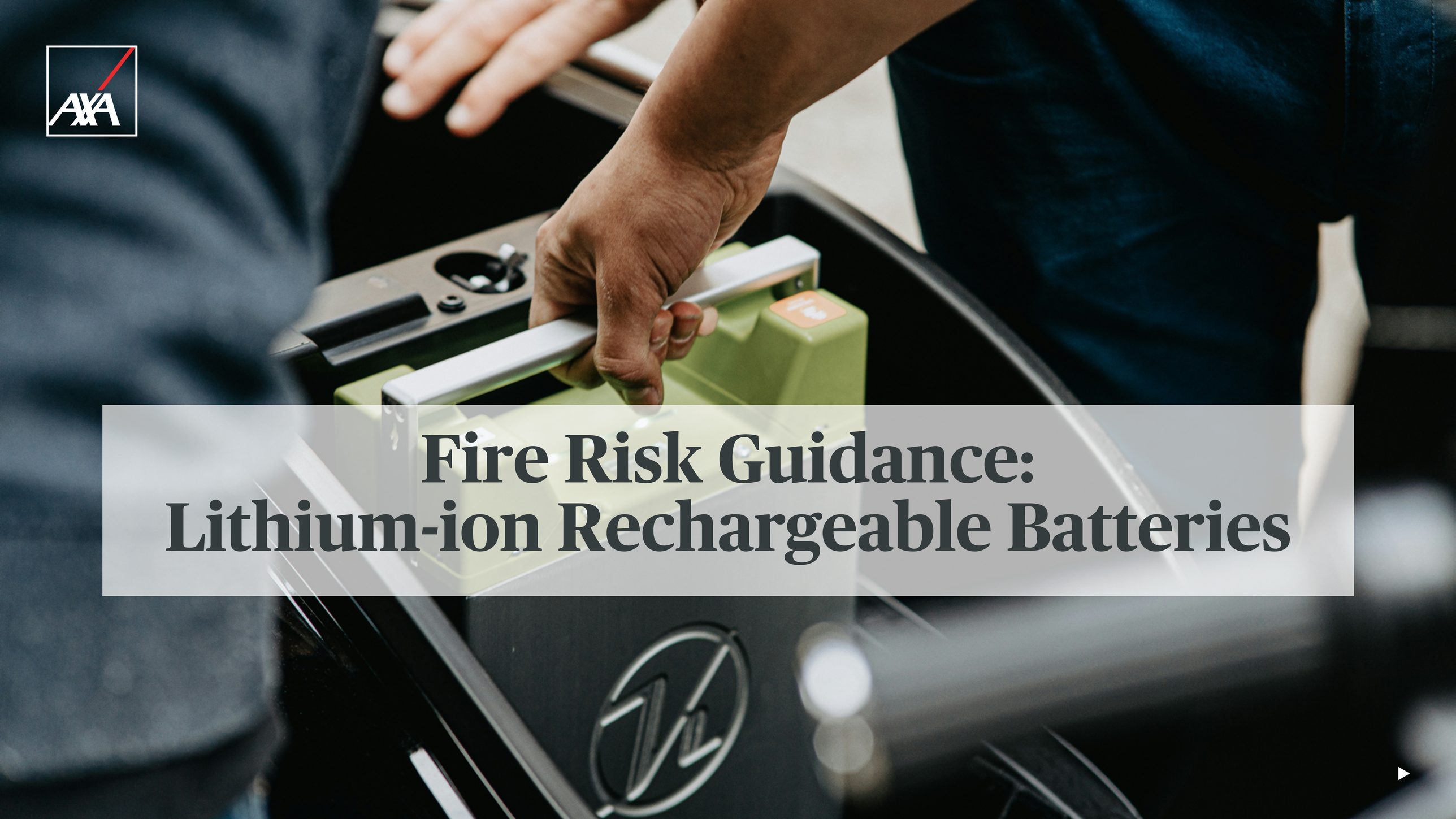
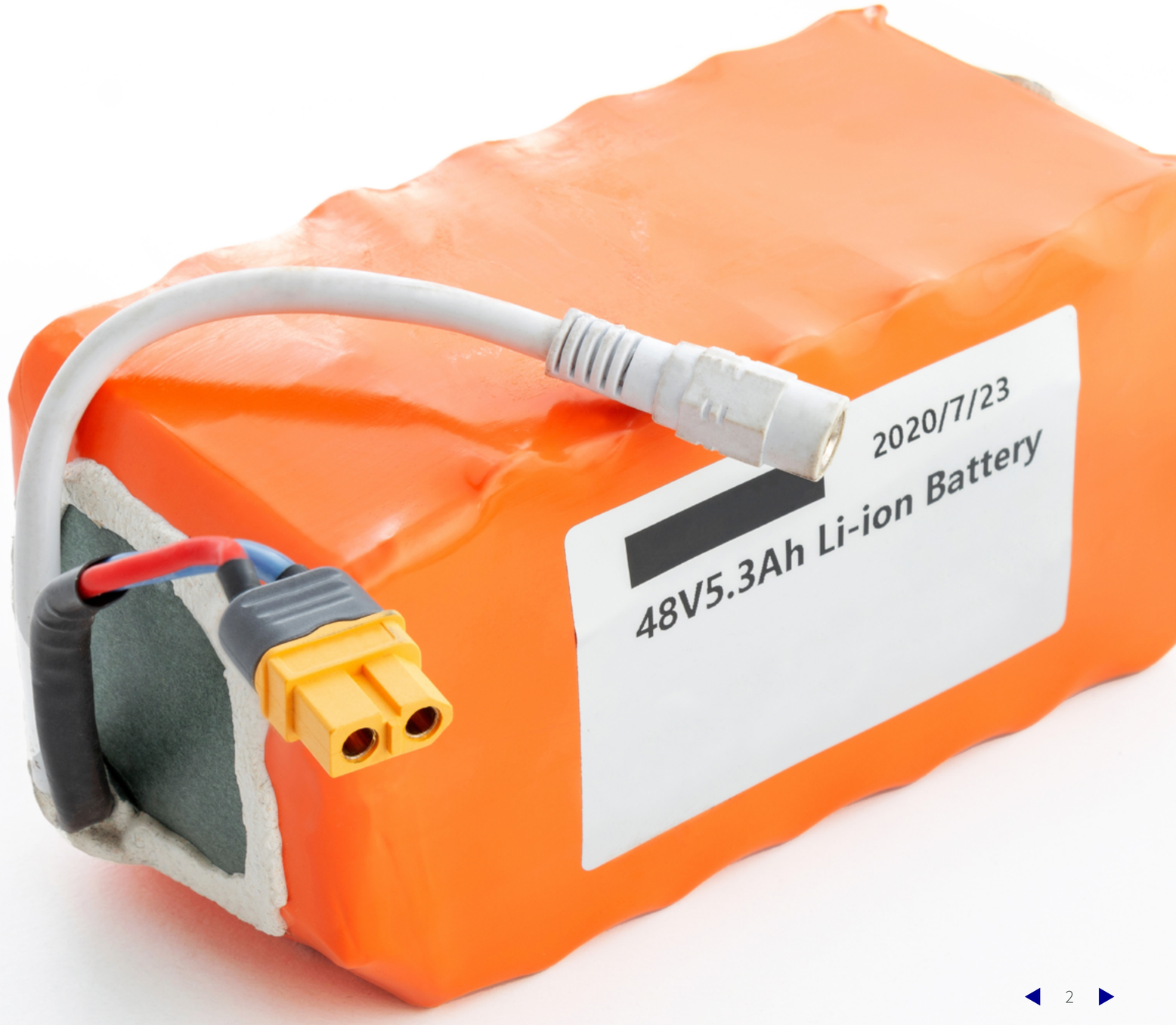


Fire Risk Guidance: Lithium-ion Rechargeable Batteries

Contents



Introduction

The use of Lithium-ion (Li-ion) rechargeable batteries in both domestic, industrial and commercial settings has grown since their introduction in the early 1990's.

Widely used in an increasing range of applications from small electronic devices such as mobile phones, cameras, laptops/ tablets, DIY and commercial power or garden tools, e-scooters, and e-bikes etc. up to large modules powering forklift trucks, electric vehicles (EV) and hybrid vehicles.

Li-ion batteries have also been successfully used to power a single seat propellor driven research and speed record-breaking airplane developed by Rolls-Royce – The Spirit of Innovation. They're now in use in CAA certified light recreational aircraft.

In addition, the drive to move to a more sustainable environment has driven their increased use in Battery Energy Storage System (BESS) applications. These are connected to alternative energy sources such as photovoltaic (PV) solar panels, wind turbines in both domestic housing and commercial or industrial premises. They enable the electrical energy generated to be stored for use later or to smooth out a fluctuating or intermittent energy generation.

It's likely that we'll see more of BESS systems in the future as the trend to install alternative energy sources continues to meet Environmental, Social and Governance (ESG) commitments.

BESS systems range in size depending on power output requirements from as little as 1kw for domestic use up to many Mw for commercial and industrial applications.

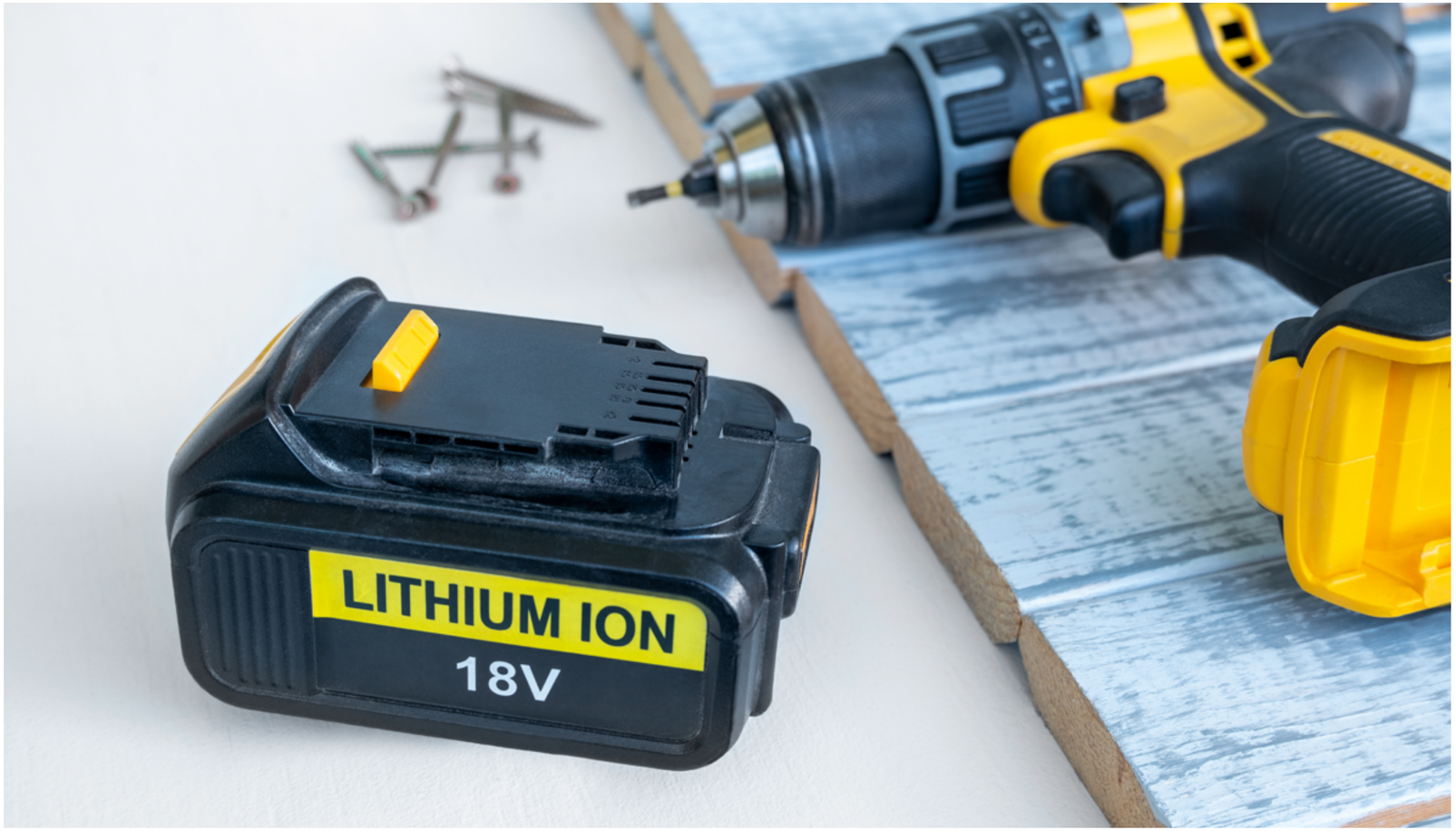
A BESS will comprise the following elements either fully integrated in the unit/facility or provided separately:

- Individual battery cells arranged in modules.
- Battery Management System (BMS) to monitor the condition of the battery cells and other operating parameters such as charge state and temperature to ensure safety.
- An inverter or power conversion system to convert direct current (DC) to alternating current (AC) – this may be integrated in the BESS or a separate unit in smaller applications.
- Energy Management System (EMS) – to manage and monitor the power flow efficiently.

Small BESS systems are compact self-contained power packs wall mounted either internally or externally. The larger multi cell modules/packs together with their associated battery management systems (BMS) and remote monitoring software are typically housed in steel containers.

Li-ion battery failure & fire risks

Hundreds of thousands of Li-ion batteries are in use daily without incident but when they ‘fail’, it can be catastrophic causing a severe fire inception hazard due to their chemical composition which includes a flammable electrolyte.



Li-ion batteries are formed from multiple cells and the batteries can be further interconnected depending on the size and nature of the electrical rating required. Failure of a cell can be caused by several reasons detailed on the right, and if this occurs the heat released will affect neighbouring cells resulting in thermal runaway. This is a condition whereby the cell generates more heat than it can effectively dissipate which can result in a chain reaction to neighbouring cells in the battery. Thermal runaway will lead to fire or explosion with venting of flammable and toxic gas that is difficult to extinguish and will rapidly involve any adjacent batteries or combustible items.

Contamination from fire water run off plus the liberation of harmful gases and smoke will create additional environmental contamination challenges.

The cause of Li-ion battery failure can be grouped as follows and the battery doesn't have to be fully charged for an incident to occur:

- **Electrical** – this includes use of incompatible chargers, overcharging, overdischarging, electrical surge, external short-circuits of terminals or cables etc.
- **Mechanical Damage** – physical damage caused by dropping, puncturing, bending, crushing, vehicle collision or other external forces. Batteries can ignite several days or weeks after the initial damage has occurred.
- **Faults** – internal defects during manufacturing, internal short-circuits, Battery Management System (BMS) failure.
- **External Heat** – exposure to an external heat source such as storage close to heaters, open flame or from an accidental fire.

When a Li-ion battery fails, it typically goes through the following stages per the Fire Industry Association (FIA) 'Guidance on Li-ion Battery Fires' document:

- Temperature increase – can result in swelling and rupture of the battery case
- Venting or off-gassing of flammable and toxic vapours
- Flare
- Steady Burn
- Flash Fireball
- Explosion

Case Study

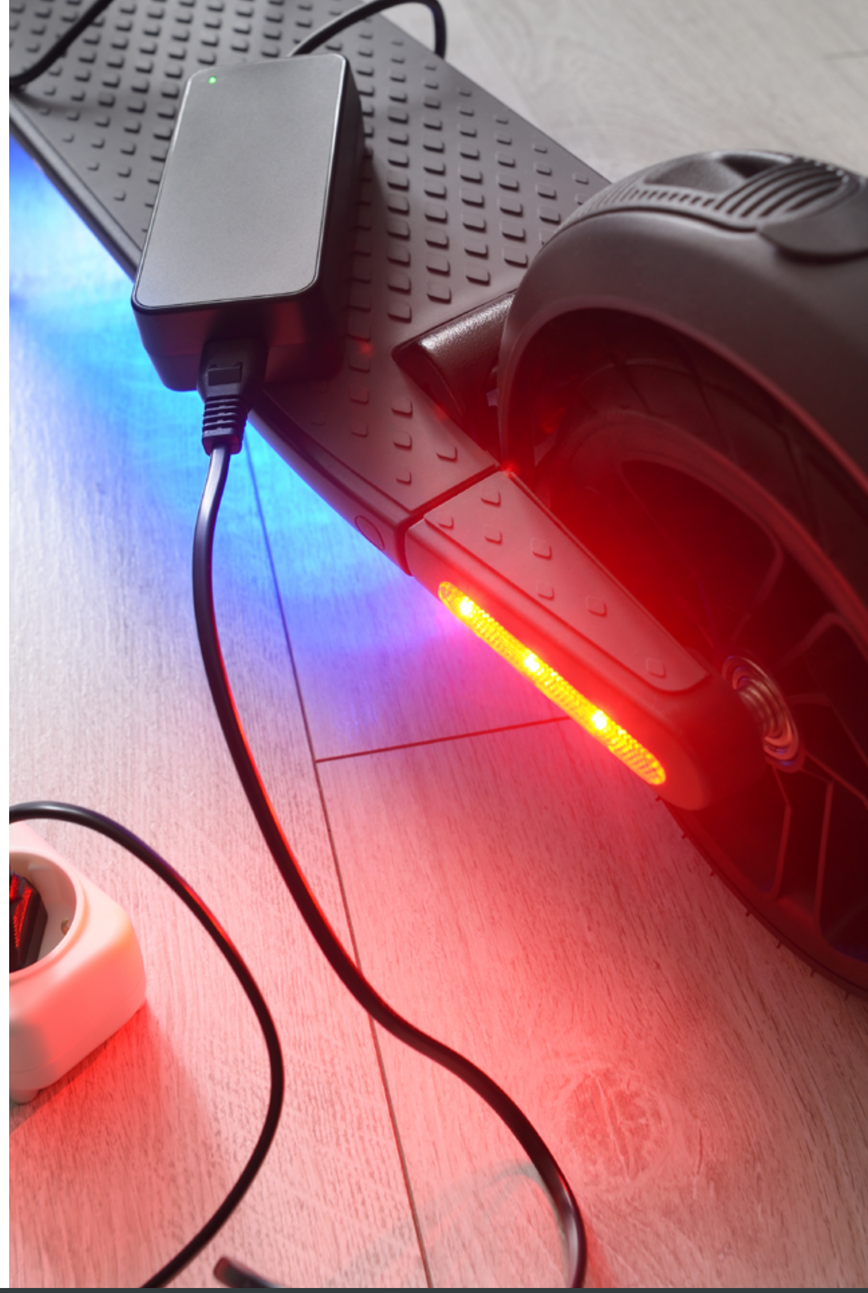
Flat Fire

A third floor flat in a six storey building was destroyed by the fire. One man was rescued from the building by firefighters using a fire escape hood due to the toxicity of the fire. Around 30 people were evacuated from the building by the Metropolitan Police Service.

The fire is believed to have been accidental and caused by the catastrophic failure of a lithium battery pack for an e-bike that was on charge. Occupants of the flat where the fire started are believed to be takeaway delivery drivers, who used both electronic bikes and scooters for their employment and a number of Li-ion batteries were either stored or on charge.

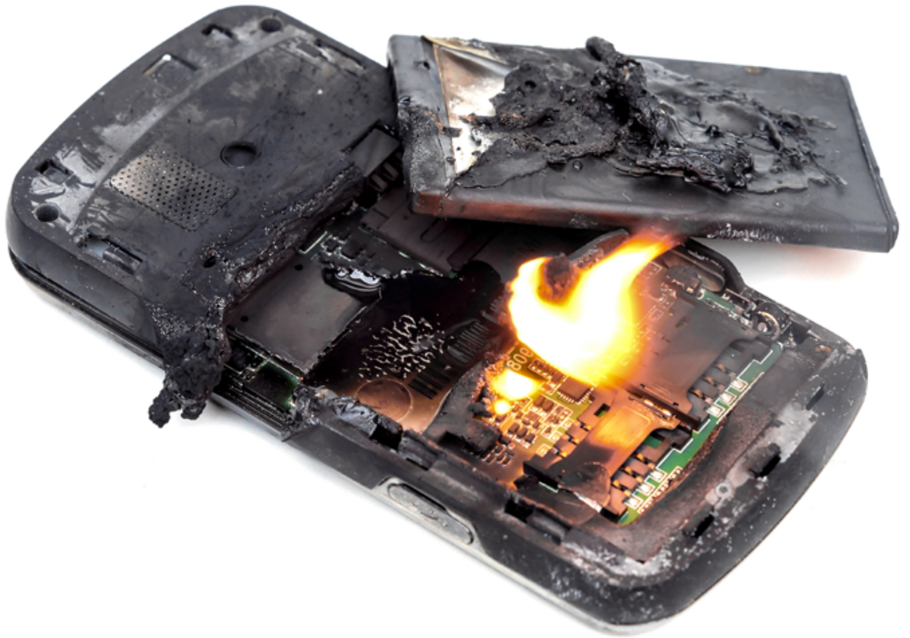
A London Fire Brigade spokesperson said:

“When charging your e-bike or e-scooter or the batteries for them, make sure you are using the correct charger. Mismatching the charger increases the risk of fire. It’s also important not to overcharge and to unplug the charger once it’s completed charging. Never charge an e-bike or e-scooter unattended or whilst you’re sleeping and don’t charge it on an escape route, such as in a hallway. Instead, charge or store the device outdoors or in a shed. If this is not possible, make sure the device is in a room where you can shut a door and contain a fire.”



Risk management considerations

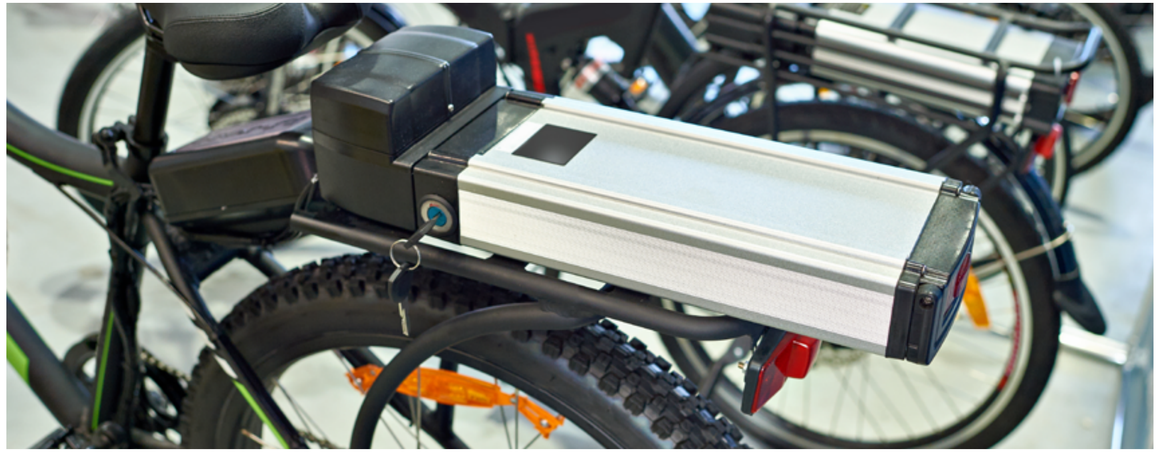
Due to their nature, Li-ion batteries can pose a challenging fire risk particularly if they fail into thermal runaway as the resultant fire is difficult to extinguish. Research is ongoing about methods to achieve adequate protection and, at best, suppression rather than extinguishing may be the only result to mitigate spread beyond the immediate seat of fire.

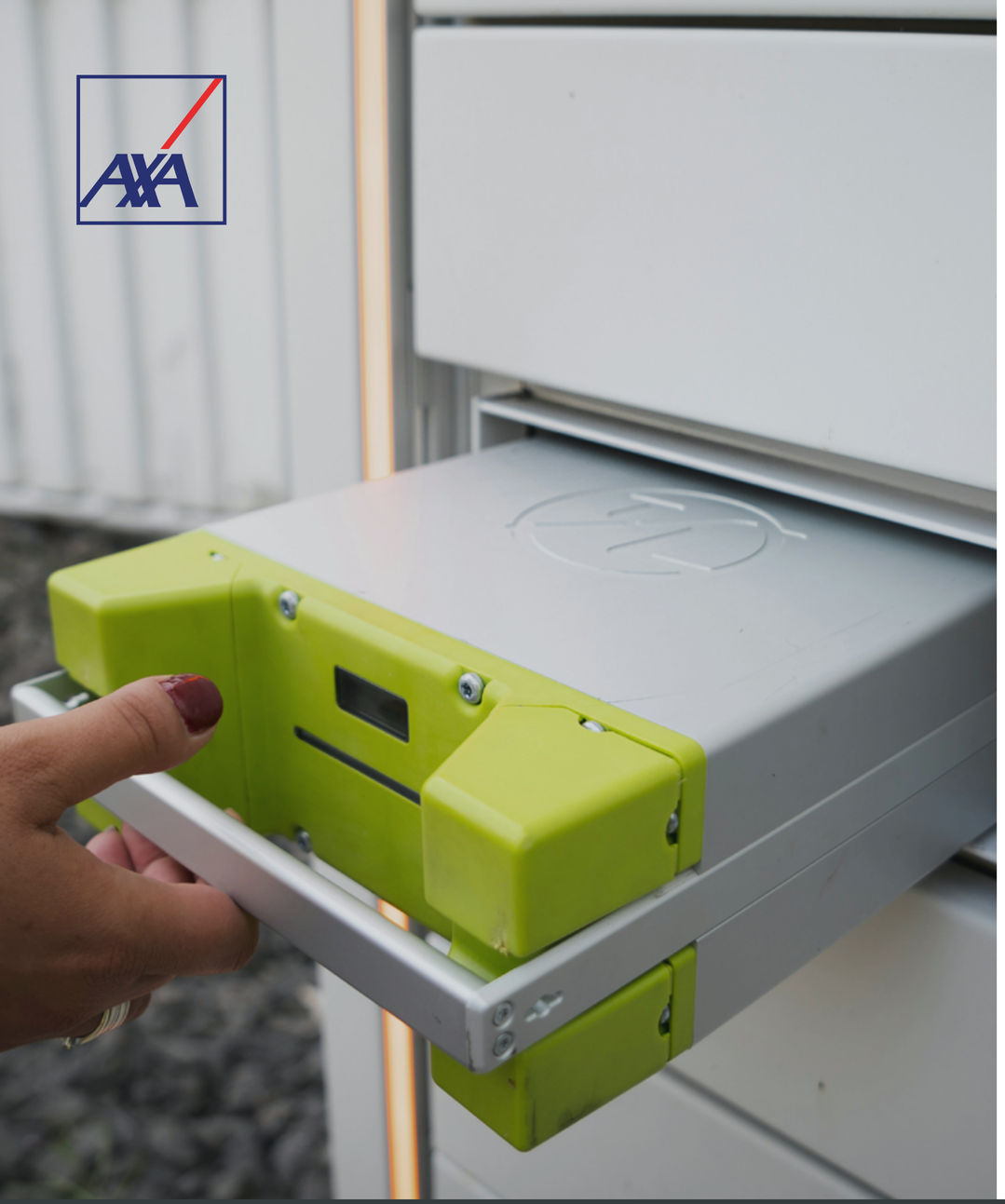


Li-ion batteries are present in virtually all locations to varying degrees and it's important appropriate and proportionate controls are implemented to control or mitigate the potential fire risk they may present. The following risk control measures should be reviewed and applied where necessary and in addition early engagement with AXA Business Resilience Managers will enable the latest protection advice to be considered.

- The site Fire Risk Assessment should be updated to cater for the presence of Li-ion battery fire risks and any recommendations from this should be actioned. The FRA should also consider whether a more focussed assessment under the Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) needs to be undertaken.
- Emergency procedures should be updated to reflect the presence, quantity, and type of Li-ion batteries on site. Particular attention should be paid to effectively dealing with damaged or faulty batteries (see below). Liaison with the local Fire and Rescue Service should be considered where large number of Li-ion batteries are present.
- Training should be provided to staff on appropriate measures to minimize the fire risks associated with Li-ion batteries, including inspection prior to equipment use and safe handling and storage to look for damage or faults.
- Li-ion batteries should be handled, used, charged, and stored in accordance with the Original Equipment Manufacturers (OEM) guidelines. Charging should be undertaken using a suitable OEM or compatible charger designed to safely charge the specific battery cells or battery packs in use.
- Equipment using Li-ion batteries should be subject to routine inspection, test, and maintenance in accordance with the OEM recommendations.
- Storage configuration including packaging, method (i.e., racks, shelves), height, segregation and compartmentation needs to be considered to assess the severity of the hazard and potential for fire spread.
- Consider the general fire protection at premises – Automatic Fire Detection, Sprinklers etc. Where sprinkler protection exists or is being considered, this should be referred to AXA so our sprinkler engineers can advise on the latest design codes and effectiveness of protection.
- As part of the Fire Risk Assessment, consider provision of suitable portable fire extinguishers (Lith-Ex) for use with Li-ion batteries and where provided, staff must be trained in their use due to the toxic nature of smoke and gases liberated.
- In residential premises, the charging of e-scooters and e-bikes should be avoided where possible. If this isn't possible, they shouldn't be charged in communal areas designated as escape routes.

- Consideration should be given to providing a dedicated area for storage or charging. This may be a detached building preferably 10m from the main building or within a dedicated internal compartment with a 90 minute fire rating. For small batteries, the use of a proprietary 90 minute fire rated cabinet may be considered. Where necessary consult AXA Business Resilience Managers for further advice.
- Where damaged or waste batteries are taken in under the Waste Batteries and Accumulators Regulations 2015, they should be stored appropriately prior to collection by a suitably licenced contractor in a non-combustible lidded container and removed to an external location preferably 10m from the building. Where an external location isn't available, they should be stored within a fire rated storage container or specific room – the recommended fire resistance of either should be 90 minutes. Battery terminals should be protected to prevent short circuits.
- Review the management controls for dealing with known faulty or damaged batteries – identified batteries should be removed prior to collection per the bullet point above.
- The frequency of collection of recycled or faulty/damaged batteries by licensed contractors should be reviewed to avoid accumulation on site.
- Electric Vehicles (EV's) – are motor garage staff trained in maintenance and repair of EV and hybrid vehicles.
- Crash damaged EV vehicles should be stored in the open preferably minimum 15m from buildings – **see reference document**.
- Battery Energy Storage Systems (BESS) – these vary considerably dependent on power rating from small wall mounted systems to larger systems in dedicated steel containers. In commercial or industrial applications BESS systems located internally should preferably be in dedicated room giving 120 minute fire resistance. If in an external steel container this should preferably be situated 10m from the building. Further advice can be obtained from AXA Business Resilience Managers for your specific application. For Domestic applications, further guidance is available in PAS 63100:2024 available to download from BSi.
- BESS systems – if in a dedicated container structure or compartment, consideration should be given to 'off-gassing' early warning detection and/or suppression system. Further information can be provided by AXA Business Resilience Managers.





Reference documents:

Fire Industry Association (FIA) Guidance on Li-ion Battery Fires

RISCAuthority – RC61 Secondary Batteries – fire and associated hazards

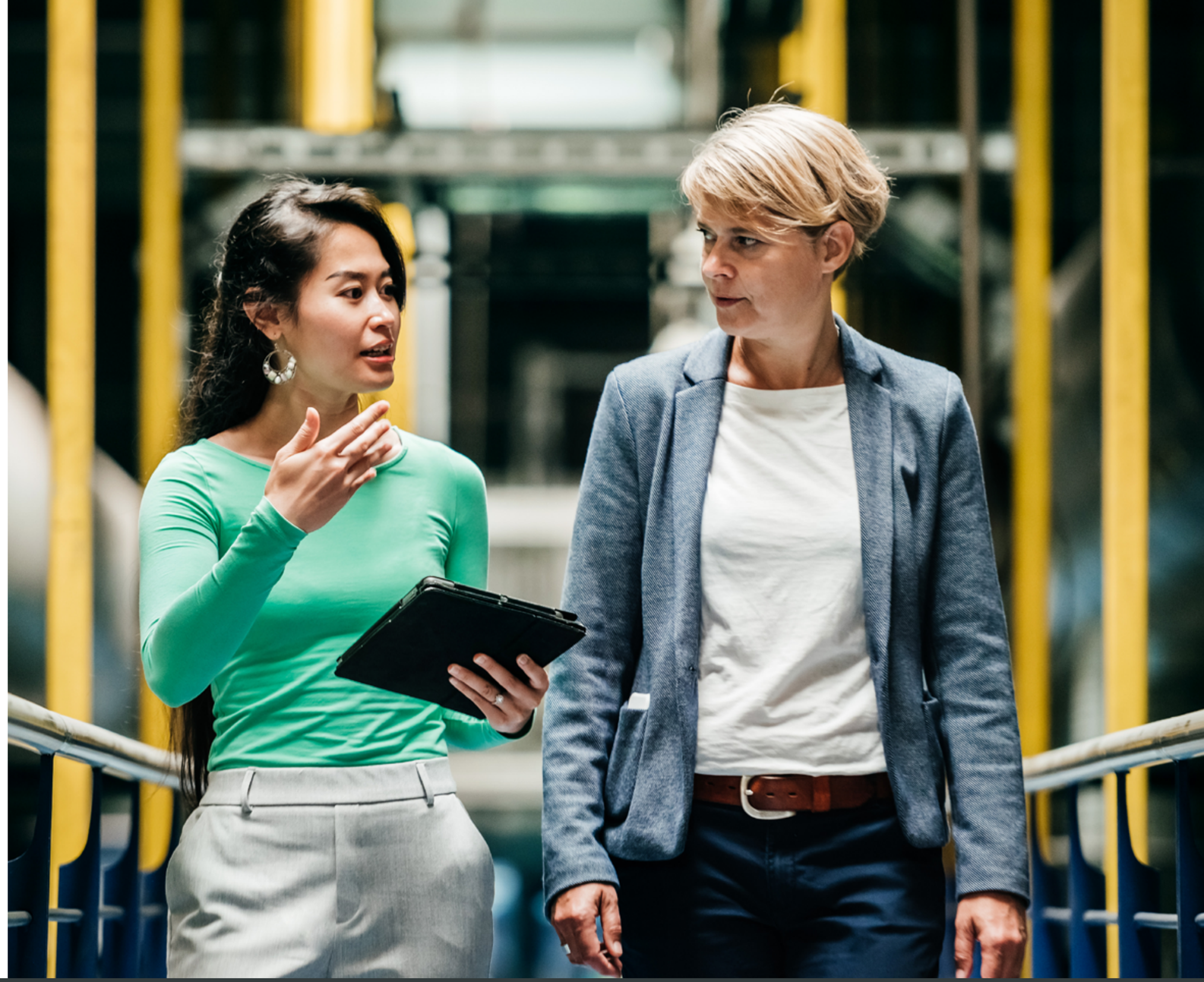
RISCAuthority – RE1 Battery Energy Storage Systems

RISCAuthority – RE2 Lithium-ion Battery Use and Storage

PAS63100 – Protection against fire of battery energy storage systems

Get in touch.

If you have any questions about this document, please get in touch with your usual AXA contact or your insurance broker.



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