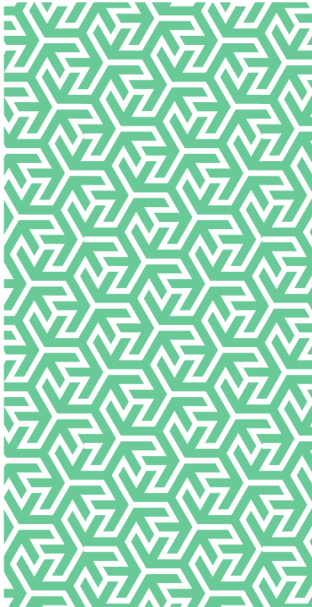




Risk control

E-Bikes and E-Scooters: The Perils of Lithium-ion Batteries



In partnership with



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Introduction

In late June 2022 the London Fire Brigade (LFB) were inclined to issue an e-bike safety warning after a serious fire that occurred in a block of flats in Shepherds Bush.

LFB fire investigators determined that the blaze was accidental and caused by the failure of an e-bike's Lithium-ion battery.

London's firefighters have reportedly seen a huge spike in fires involving e-bikes and e-scooters as they have become more popular in recent years and have issued several warnings about how ferocious the fires can be¹.

Only a few weeks later Staffordshire Fire and Rescue Service were compelled to issue a similar warning after a serious house fire resulted from an e-bike battery explosion².

Lithium-ion batteries, sometimes referred to as Li-ion cells, are widely used and can be found powering anything from mobile phones and laptops to e-bikes, e-scooters, electric vehicles and aircraft. Lithium-ion cells are also being used to provide backup power to data centres, hospitals and any other facilities that may need a reliable back-up power source.

The popularity in the use of Lithium-ion batteries in an increasing array of equipment and applications is associated with multiple benefits which they maintain over more long-standing battery technologies. They last longer, recharge faster, are more efficient, and maintain a longer lifespan.

However, Lithium-ion batteries can be very volatile due to their high energy density and many combustible components utilised in their construction. If they are overcharged, damaged or treated incorrectly they can explode and / or cause serious fires.

Lithium-ion Battery Failure

There are generally regarded to be a number of key stages to Lithium-ion battery failures³.

1 – Initiation Abuse Factor

This is the initiation abuse factor. This can be electrical, thermal or mechanical abuse that causes the battery to start to fail.

2 – Off-gas Generation

As the battery begins to fail, electrolytes break down and generate gas that is released from the cell in an off-gas event. This stage occurs immediately before thermal runaway; a situation where an increase in temperature

changes the conditions in a way that causes a further increase in temperature and is typically the last thing to happen before a fire occurs.

3 – Smoke Generation

This is an indication that the cell has reached the stage of thermal runaway and that the cell can experience rapid disassembly at any moment. The smoke is produced inside the cell and, if the cell has already experienced a vent or rupture from the off-gas event, the smoke is able to escape the battery and is detectable by smoke detectors. Following smoke generation, there is usually very little time before the cell catches fire.

4 – Fire Generation

Once smoke generation occurs, the battery is in an extremely vulnerable state and can catch fire or explode at any moment.

Common Causes of Lithium-ion Battery Failures

Some common causes of Lithium-ion battery failures include⁴:

— Manufacturing Defects

The manufacturing process for Lithium-ion batteries is extremely demanding and hard-to-detect defects can be created. The batteries have to undergo a series of processes such as charging and discharging after the assembly is completed. These processes are accompanied by physical processes such as vibration and heat generation which may exacerbate any manufacturing defects and eventually cause a short circuit.

The influx of low cost / low quality products into the Lithium-ion battery market is likely to increase the risk of fires and explosions due to an increased likelihood of manufacturing defects due to the use of cheaper materials and manufacturing processes.

— Mechanical Damage

Mechanical damage can be caused to the batteries during transportation, storage, product assembly and use. Events such as squeezing or acupuncture may lead to a short circuit in the battery and subsequent fire and / or explosion.

— Poor Storage

If Lithium-ion batteries or the products they are contained within are stored in harsh environments such as high temperatures then the risk of fire is increased.

— **Overcharge and Over-discharge**

Overcharging and discharging the lithium-ion battery during use may cause the metal crystals in the battery to become larger, which may pierce the diaphragm, causing an internal short circuit in the battery, thermal runaway and fire.

— **Incompatible Chargers**

E-bike and e-scooter chargers are designed to recharge the battery of an e-bike or e-scooter at a specific output voltage and current. It is crucial to ensure that the charger and the battery are compatible; using an incompatible charger can result in serious damage to the battery and potentially cause a fire or explosion.

— **Electrical Modifications and Conversion Kits**

The dangers can be increased through a number of risky practices, including DIY modifications being made to an e-bike's electrical systems such as the fitting of additional battery packs to enhance speed and range, or from the use of kits to convert standard bikes to e-bikes that are not adequately regulated.

Warning Signs

Signs that a Lithium-ion battery may be failing can include⁶:

— **Heat**

It's a completely normal performance characteristic for batteries to generate some heat when charging or in use. However, if a Lithium-ion battery becomes very hot to the touch, there's a significant chance that it's defective and increasingly at risk of starting a fire.

— **Swelling**

When a Lithium-ion battery is failing, swelling or degradation of its physical structure (including the appearance of lumps, bulges and leaking) may be observed.

— **Noise**

There have been reports that failing Lithium-ion batteries can make hissing or cracking sounds when failing.

— **Odour**

If a strong or unusual odour is being emitted from the battery or associated equipment, this is an indicator that the battery may be failing.

— **Smoke**

Perhaps one of the most obvious signs. If the battery or associated device is emitting smoke, then it is probable that a fire is being initiated or has already begun.

If a device is displaying any of the above warning signs then the following steps should be taken:

- Immediately turn off the device and unplug it from any power source
- Carefully move the device to a safe area away from any people, flammable materials or substances. Use protective gloves to avoid touching the device directly

If the above actions have led to a cessation in warning signs being emitted, then the following actions should be undertaken:

- Do not return the battery and appliance to use
- Contact the device manufacturer or retailer for further instructions

If the above actions have not led to a cessation in warning signs being emitted, and there is concern that thermal runaway and fire is likely or has already been initiated, then the following actions should be taken:

- Immediately contact the local Fire and Rescue Service via 999

Safety Tips

The London Fire Brigade^{6, 7} offer some essential advice for maintaining battery and charger safety:

- Batteries generate heat during their use. Allow them to cool down before attempting to re-charge
- Batteries should always be charged on hard flat surfaces where heat can dissipate
- Always follow manufacturers' instructions when charging
- Always use the original charger that was supplied with the electronic item
- If a replacement battery or charger is required, always ensure compliance with any recommendations or specifications provided by the manufacturer
- Avoid using, storing, or charging batteries at very high or low temperatures
- Protect batteries against being damaged (crushed, punctured or immersed in water)

- Take any damaged batteries or chargers out of use immediately, even on suspicion alone
- Don't leave items on charge after the charge cycle is complete. For example, don't leave items unnecessarily on charge overnight
- Never cover chargers or charging devices
- When travelling, avoid keeping all items containing lithium-ion batteries together, especially on a plane. Check with relevant flight carriers for additional information or advice
- Never block escape routes with e-bikes or e-scooters
- Store and charge e-bikes and e-scooters away from a main through route or exit
- Make sure an escape plan in place in the event of a fire. Always call 999, never try to fight the fire

It is also worthwhile considering that if larger electrical items are being charged, care has to be taken to ensure that a trip hazard has not been created by the charging cable.

London Transport Network

Due to a number of fires on the network involving e-scooters, in 2021 Transport for London (TfL) banned e-scooters from London's transport network. This means electric personal vehicles cannot be taken on any TfL service⁷.

Battery Disposal

Lithium-ion batteries are potentially dangerous and damaging to the environment. They can pose a significant fire risk. As such, they should be segregated from general waste and normal household recycling pathways.

Household waste recycling centres may offer a segregated disposal route. Alternatively, there are specialised accredited recycling companies that will safely collect and dispose of any redundant or failed Lithium-ion batteries.

If in any doubt, contact the manufacturer or supplier of the electronic device or the local authority with responsibility for waste collection.

Summary

We have witnessed a proliferation in the use of battery-powered devices and equipment in recent years.

As well as creating a significant burden on people to be constantly aware of the charge status of an increasingly

large number of items, it has also increased our exposure to risks that can be presented by Lithium-ion batteries.

When managed well, batteries are not dangerous. However, batteries can present a fire risk when over-charged, short-circuited, submerged in water or damaged.

Batteries just work, until they don't. And when they don't they are often easily replaceable. It is easy to become complacent, however, it is this complacency that we need to guard against in order to protect ourselves and the people around us.

References

1. <https://www.london-fire.gov.uk/news/2022-news/june/shepherd-s-bush-high-rise-fire-caused-by-E-bike-prompts-safety-warning-from-firefighters/>
2. <https://www.staffordshirefire.gov.uk/news/posts/firefighters-urge-public-to-remain-safe-around-lithium-ion-batteries-following-house-fire/>
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6. <https://www.london-fire.gov.uk/safety/the-home/electrical-items/batteries-and-chargers/>
7. <https://www.london-fire.gov.uk/safety/the-home/E-scooters-and-E-bikes/>

Additional Reading

1. Battery Breakdown: Why are e-scooter and e-bike batteries exploding in people's homes and what can be done about it?, Electrical Safety First, 2023, available at: <https://www.electricalsafetyfirst.org.uk/battery-breakdown/#report>

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