Unimutual Risk Management Services
University Emerging Risk Issue Notice 72

Issue: E-bike battery catches fire whilst being recharged

Recently, a member reported an intense fire in an office/lab where an electric bike battery was being recharged. E-bikes are an increasingly popular form of low-cost, emission-free transport amongst university staff and students for travel to, from, and around campuses. However, as this incident suggests – and based on a plethora of other battery charging incidents – e-bikes are not a risk-free proposition, and therefore perfectly fit the profile of a tertiary education sector emerging risk.

What happened?

A student purchased a second-hand e-bike through a popular internet trading platform. The bike was supplied with a battery charger – but no user manual or model information for either the bike or the battery. At approximately 1000hrs, the Lithium Ion battery was removed from the bike and connected to the charger on the floor of the lab, adjacent the bike. At 1300hrs, the student left to have lunch, returning around 1400hrs to find the lab on fire. Attempts were made to extinguish the fire using a hand-held extinguisher, but the blaze was too well established. The heat generated by the fire was so intense that it melted the plastic air conditioning unit three meters above the seat of the fire. Fortunately, addressable smoke detectors alerted the Fire Brigade who responded and extinguished the fire before it spread to adjacent offices. The origin of the fire was identified as the battery and recharger, and the cause as the battery overheating and combusting.

Types of Batteries

Lead acid batteries have a very low energy-to-weight ratio and a low energy-to-volume ratio, but their ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles – but their bulk and weight make them less attractive for use in e-bikes.

Lithium-ion (Li Ion) batteries, on the other hand – the subject of this emerging risk report – are commonly used in e-bikes, and are one of the most popular types of rechargeable batteries for portable electronics, with a high energy density, tiny memory effect, and low self-discharge. Their light weight makes them attractive as a power source for e-bikes, but they are not 100% fire safe. Some Li Ion batteries are more dangerous than others, depending on the chemistry; whether or not they have a management system; and the nature of the casing in which the battery is contained. A metal casing presents a lesser fire risk than a plastic casing.

A lithium iron phosphate (LFP) battery, also known as a lithium ferrophosphate battery, is a specific type of lithium-ion battery that is capable of charging and discharging at high speeds. It is a rechargeable battery that has $LiFePO_4$ as its cathode material, and superior power density, low discharge rates, a flat discharge curve, less heating, a higher number of charge cycles, and is considered safer than Li Ion batteries.

Lithium-Ion Battery Charging

The attraction of a lithium-ion battery for use in an e-bike is that lithium is the least dense metallic element, which means that weight-for-weight it can pack more power than other types of batteries. But lithium is also a highly reactive substance; it belongs to the alkali metal group, which contains sodium and potassium – both highly reactive. Like all batteries, lithium ones consist of two electrodes separated by an electrolyte. Typically, in a lithium cell the electrolyte is a solution of lithium salts and organic solvents. When the battery is charged, lithium ions are driven from the electrolyte into a carbon anode. When the battery is discharged they flow back, creating a balancing flow of electrons in a circuit that powers the device. Short circuits can arise if there is a fault or damage to the extremely thin separators that keep the elements of the battery apart. This can trigger what is known as a "thermal runaway" where the battery overheats and can burst into flame.

Lithium ion batteries prefer to be charged slowly: the smaller the battery in amp hours, the slower the charge. Charging too quickly or overcharging can cause the battery to overheat and catch fire.

Early Lessons from This Event

Lithium Ion batteries do catch fire, generally due to overheating (caused by damage to the battery), overcharging, and/or charging the battery too quickly at an inappropriate amperage. Li Ion batteries produce a fire that repeatedly flares up as each battery cell in turn ruptures and releases its contents. The result is the release of flammable electrolyte from the battery, and of molten burning lithium. The fire may be a progressive burn-off, or one that is explosive in nature – resulting in jetted shrapnel, molten metal, burning electrolytes, and other matter. Lithium-ion batteries can also catch fire when dendrites, tiny lithium particles that form fibers, accumulate inside the battery. This causes short-circuiting, which then causes the battery to overheat and combust.

The heat from these fires is intense and they can be difficult to extinguish. Lithium Ion batteries have high power-to-density ratios that allow them to store large amounts of energy. When a Lithium Ion battery catches fire, it is the stored energy, along with materials in the battery, that make it difficult suppress or extinguish. Placing water on burning lithium may increase the intensity of the fire and the fire can only be extinguished when the lithium is totally consumed. Every battery uses a different electrolyte solution, but many contain Fluorine, which readily combines with the hydrogen found in water to make Hydrogen Fluoride. This is a highly toxic gas that can cause blindness and respiratory failure, and in aqueous form (Hydrofluoric Acid) is highly corrosive and can be absorbed through the skin.

Lithium-ion batteries are, in theory, a class-A fire risk and can be extinguished with plain water. However, care should be taken – particularly if the battery contains lithium metal, as this can cause the dangerous side effects described above. The other two extinguisher options are Dry Chemical extinguishers (Class ABE) and Class D extinguishers, which contain a copper extinguishing agent specially developed for fighting lithium and lithium alloy fires. The copper compound smothers the fire and provides an excellent heat sink for dissipating heat. Copper powder has been found to be superior to all other known fire extinguisher agents for lithium.

Smoke detection in the office/lab helped prevent more widespread damage. An addressable smoke detection system activated the Fire Indicator Panel, which notified the local fire brigade who attended within 15 minutes. As a result, damage was limited to the room in which the battery was being charged.

Recommendations

1. Ensure that your e-bike and battery come with a user manual and a suitably-rated battery charger. Always follow the instructions in the manual.

2. Use a "smart charger" and charge your battery slowly. It is advisable to only charge your battery to around 80% and to never allow it to fully discharge.

3. Where possible, charge your battery outside or in a fire proof bag or other fire proof or resistant container. If this is not possible, then charge the battery in the middle of the room (with smoke detection) away from combustible material and ideally on a metal trolley so you can move it safely outside if it does catch fire.

4. Have the right type of portable fire extinguisher readily available.

5. If the e-bike usage rate on campus warrants it, consider investing in a dedicated e-bike charging station.

6. Consider using a lithium ferrophosphate battery as they present a lower fire risk.

7. Supervise the battery charging process if you are charging the battery indoors.

8. Develop a policy for the on-campus charging of e-bike batteries.

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