

The danger of bicycle batteries

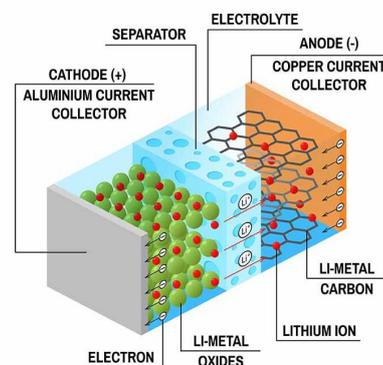
E-bikes are becoming more and more popular by young and old people. Although the electric bicycles offer a more comfortable ride, spontaneous fire of bicycle batteries causes more and more problems. For example, the Netherlands fire department needs to take action twice a week for a battery fire on average. This will only increase due to the increasing popularity of electric bicycles. A bicycle battery consists several battery cells, these are usually lithium-ion cells. Lithium-ion cells are known for their high energy density and long lifespan, nevertheless they are sensitive to deep discharge and overcharging. Although a bicycle battery is equipped with a battery management system, which must prevent discharging and overcharging too far, this system can become defective due to vibrations or mechanic impact. This can result in dangerous situations.



The battery cells in a bicycle battery are also sensitive to high temperatures, when the battery is exposed to high temperatures the separator in the cell can melt. The separator is a membrane that separates the cathode (+) and anode (-) in the cell. A melting separator will lead to an internal short circuit.



Composition bicycle battery



Cross section Lithium-battery-cell

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The battery cells in a bicycle battery consist of chemicals that contain lithium. These chemicals are unstable and decompose easily. The chemicals can start to decompose in various ways:

- Too high charging current
- Too large discharge rate
- Mechanical damage
- Environmental heat
- Manufacturing defect
- Aging



During the decomposition of these chemicals, many dangerous gases are released (including hydrogen fluoride, lithium hydroxide, hydrochloric acid) which are harmful to humans and the environment.

A lithium-ion fire is not a metal fire, but a chemical decomposition reaction, during this reaction a lot of energy is released. This creates a lot of heat, the decomposition reaction spreads further into the cell and can also cause the decomposition reaction in surrounded cells. This is also called a "thermal runaway". During a thermal runaway, the pressure and temperature in the cell will increase, causing the cell to burst open and shoot burning parts away. This allows a fire to spread quickly. A battery usually contains more than 40 cells, which together contain so much energy that they are almost impossible to extinguish. It may even take several days for the decomposition reaction to stop. The decomposition reaction can also resume later. *Example: a lithium-ion battery started smoking again and developing heat 3 weeks after it had been on fire.*



E-bike fire



Damage after fire

A bicycle battery fire is unpredictable. If, for example, a battery is damaged or contains a manufacturing defect, this is not visible on the outside. When a decomposition reaction of the chemicals in the battery starts, is not predictable.

Due to the many problems with bicycle batteries and the increasing fire damage that these batteries cause, new guidelines are under development with regard to safe and protected storage and charging of bicycle batteries. The expectation is insurance companies will soon set additional requirements with regard to safe storage and safe charging of bicycle batteries. It seems highly likely that open and exposed charging of bicycle batteries through wall sockets or integrated charging points in bicycle racks will be prohibited.

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Process steps battery fire

To successfully manage a battery fire, Lo Minck Systemen distinguishes a number of process steps:

- Detection
- Alerting
- Suppression
- Isolation
- Removal

First of all, a battery fire must be *detected* at the earliest stage possible. Since a battery fire usually starts with smoke development, smoke detection appears to be the most effective detection method.

As soon as a (starting) fire has been detected, the surrounded area must be *alerted* as quickly and effectively as possible, so action can be taken timely.

At the same time, a starting fire must be *suppressed* as effectively as possible, so a rapid spread of fire and the associated smoke are prevented.

Insulation of the fire, for example by compartmentalization, prevents a rapid spread of the fire.

Ultimately, the object must be *removed* from the room as quickly as possible.

Safe storage and charging of bicycle batteries

Because of the fire hazard of bicycle batteries, stricter regulations from both the government and insurance companies and taking into account the described process steps, Lo Minck Systems has developed two product concepts; the **Battery Charging Locker** and **VeloVolt**.

Battery Charging Locker

The construction of the Battery Charging Locker is based on a basic module with 4 individual compartments (LMS4), where bicycle batteries, and other small power consumers, such as smart phones or tablets, can be charged or stored safely. The individual compartments have an autonomous digital pin code lock.

By using several compartments, a possible Battery Charging Locker is well *isolated* and a quickly spreading fire due to blasting, burning parts is prevented. If a smoke detector is placed above the Battery Charging Locker, a possible battery fire is *detected* at an early stage and people in the immediate area are *alerted*, this way action can be taken timely to suppress the fire and remove the locker from the room. The compact configuration ensures the Battery Charging Locker can be *removed* quick and easy* from the room.

**) The compact dimensions (LMS8: 500x450x1950mm) and the limited weight (LMS8: approx. 65 kg, excl. battery weight) makes it easy to lift the Battery Charging Locker with, for example, a pallet truck or a special lifting aid and remove it from the room. This ensures a forklift truck or other heavy equipment is not necessary.*



VeloVolt

Professional users, such as bicycle shops, logistics service providers, etc., often have multiple bicycle batteries under management/ maintenance. From an efficiency point of view, these are stored and charged in big safety cabinets. This is not without risk. If one of the batteries catches fire (thermal runaway) it is difficult to extinguish such a big fire. Due to the duration of the fire or construction and assembly of the batteries, other batteries may also become involved or proceed to a thermal runaway. Such a fire can last for a long time (several hours to days). In addition to heat, toxic substances are released during this fire (including hydrogen fluoride, lithium oxide and hydrochloric acid). The affected area depends on the meteorological conditions, size of the fire and the accessibility of the EOS (Energy Storage System) for emergency services and can extend up to a few kilometres. Depending on the environment, it may be decided to evacuate local residents. This is why the focus must be placed at fighting the effects of the fire first.

For professional use and charging/storing bigger quantities bicycle batteries the VeloVolt has been developed.

The VeloVolt is a luxury version of the Battery Charging Locker and contains its own smoke detector and fire alarm system. Since the smoke detector is integrated in the storage space itself, any fire is detected even faster.

After a starting fire has been *detected*, the immediate environment is *alerted* via the fire alarm system, both by a visual (flashing light) and acoustic (sound) alarm. Optionally, the object owner is *alerted* by SMS. If VeloVolt is equipped with a fire suppression system, the fire is immediately *suppressed* after detection by activating an aerosol system. Due to the effective operation of this aerosol suppression system, the started fire is *suppressed* for approx. 2 hours*.

Moreover, due the modular configuration and the compartmentation of VeloVolt, a possible fire is well *insulated* and the spread of burning parts is prevented. Thanks to a smart ventilation system and heat-resistant seals, dangerous gases also remain in the storage room as much as possible.

The insulating is achieved because VeloVolt is provided with rockwool insulation (fire-resistant insulation up to 1,200 °C). This fire-resistant insulation makes it - in combination with the compact dimensions of VeloVolt - relatively easy to *remove* the locker from the room quickly and effectively.

*) Thanks to the compact dimensions (500x380x1650mm) and the relatively limited weight (approx. 80 kg, excl. Battery weight), VeloVolt can be relatively easily lifted and removed from the room with, for example, a pallet truck or special lifting aid. A forklift truck or other heavy equipment is therefore not necessary.

