ETH zürich

Factsheet

Lithium-ion Accumulators – Use and Store them Safely

Background

The characteristic features of lithium-ion accumulators are high energy density, low net weight and fast charging technology. They are part of our everyday lives, either in smartphones and tablets or for electromobility. And, of course, they are also omnipresent in research at ETH. The advantage of high energy density also harbours the risk of fires that can cause costly consequential damage or, in the worst-case scenario, can claim human lives.

The main safety rules

Lithium-ion accumulators must be regarded and treated as hazardous substances. Important rules of thumb for the everyday handling, storing and charging of lithium-ion accumulators are the following:

Figure 1: ZARGES box for storage and transportation of lithium-ion accumulators. Source: Heidi Hostettler

- Avoid thermal loads (heat, direct solar radiation, and cold)
- Avoid contact with moisture/humidity
- Only use chargers that are approved by the manufacturer
- Be careful during charging processes (avoid deep discharge, carry out the charging process according to the manufacturer's instructions, use fireproof underlays, and remove fire loads from the charging area)
- Monitor the charging process
- Practice battery management (document purchases and load cycles)
- Depending on number and power of the lithium-ion accumulators, use a certified safety cabinet to store and charge them (**sgu-umwelt@ethz.ch**)
- Avoid damage (e.g. due to impacts, shocks, collisions)
- Do NOT continue using lithium-ion accumulators if they are damaged or might be damaged
- Ensure correct disposal (cf. factsheet: «**Disposal of Lithium-ion Accumulators**»)
- Provide suitable extinguishing agents (**sgu-safety@ethz.ch**)
- Lithium-ion accumulators must only be stored if they have a test certificate compliant with UN 38.3
  → For prototypes and modified accumulators: carry out a risk assessment, contact SSHE (**sgu-umwelt@ethz.ch**)

What to do in case of fire

- Inform the ETH Emergency Desk immediately
  from internal phones: **888**
  from external phones: **041 44 342 11 88**
  Provide the following information:
  Where? Place where the incident occurred (building, floor, room no., lift, etc.)
  What? Nature of incident (fire involving a lithium-ion accumulator, what kind of help is required?)
  Who? Name and phone no. of the caller
  When? When the incident took place
  How many? No. of people affected
  Further information? Additional information that might be important for the intervention
- Follow the instructions of the Emergency Desk

Structure and mode of operation of a lithium-ion accumulator

There are numerous different energy storage systems using lithium in pure or bound form. In principle, a distinction is made between two types of lithium-ion cells: primary (non-rechargeable: lithium-ion batteries) and secondary (rechargeable: lithium-ion accumulators).

Depending on its power a so-called «battery pack» consists of several lithium-ion cells. Each lithium-ion cell has a positive (anode) and a negative (cathode) electrode and between them an ion-conducting electrolyte. A liquid electrolyte is used in lithium-ion accumulators. Another important component is the separator, which prevents direct contact between the poles, and thus prevents a short circuit. When discharging, lithium ions and electrons are released on the anode side. The electrons flow through the external circuit and «do electrical work». The lithium ions migrate to the cathode. The charging process runs vice versa.

The anode usually consists of graphite. In contrast, various substances are used for the cathode, such as iron, manganese, cobalt or nickel. The precise composition of the cathode material determines lifetime, charging times and performance of a lithium-ion accumulator. The electrolyte consists of an organic solvent and a conducting salt. In most cases, lithium hexafluorophosphate ($LiPF_6$) is used as conducting salt. However, various solvent mixes are used whose precise composition usually remains the manufacturer's secret. Flash points of the individual solvents used in a mix are usually between +160°C and 0°C.

Hazards when handling lithium-ion accumulators

Given today's manufacturing standards, it can be assumed that commercially available lithium-ion accumulators may be regarded as comparatively safe provided they are handled properly and in the appropriate manner. Nevertheless, lithium-ion accumulators should always be handled with due caution. The design itself entails a constant hazard because materials with high energy density and highly flammable electrolytes are brought together in a very confined space. If an uncontrolled and accelerated release of the chemically stored energy occurs as a result of technical defects or improper handling, it usually occurs in form of thermal energy, which can cause a fire. In the worst case, a chain reaction occurs that can no longer be controlled, known as «thermal runaway». In the event of a thermal runaway, the lithium-ion accumulator becomes very warm very quickly when exceeding a temperature limit. The heat triggers further reactions (e.g. the conducting salt ($LiPF_6$) may decompose under formation of hydrofluoric acid (HF)); temperatures of several hundred degrees are reached within a very short time and the lithium-ion accumulator ignites or explodes.

The temperature that leads to a thermal runaway differs from one lithium-ion accumulator to the next. The situation can already be critical at 60°C, and at 100°C or more, it becomes extremely critical. The point when the lithium-ion battery actually catches fire depends on the cause of the event. Causes can be an internal or external short circuit, and/or excessive currents when charging or discharging:

- **Internal short circuit**: a mechanical action deforms the lithium-ion accumulator; material penetrates a battery cell and triggers an internal short circuit.

- **External short circuit**: the deformation of the lithium-ion accumulator causes an external short circuit.
- **Overcharging the lithium-ion battery** beyond the maximum voltage specified in the data sheet, e.g. to extend the range for an electric car.
- Excessive currents when **charging or discharging** the lithium-ion accumulator, e.g. during fast charging.

Extinguishing agents

Lithium-ion cells produce the oxygen needed for fire themselves, so attempts to extinguish the fire with conventional methods are often unsuccessful. When selecting a suitable extinguishing agent, the power and quantity of the batteries / accumulators must be considered, as well as the operating conditions.

Extinguishing with water

Views differ on the use of water as an extinguishing agent. Since lithium reacts very readily, it is often considered inadvisable to bring it into contact with water. However, more recent studies suggest that larger quantities of water are able to contain and fight lithium fires effectively. At ETH, water is not recommended as an extinguishing agent for fires of this sort.

Fire extinguishers

After consultation with **sgu-safety@ethz.ch**.

Aerosol extinguishing technology

Aerosol extinguishing technology is used in constantly fully operational technical systems for fire suppression. Systems of this sort are compliant with standard EN 15276-10, i.e. extinguishing takes place without addition of water. The extinguishing generator interrupts the chemical combustion process within a few seconds. Systems of this sort are easy to install and require little maintenance.

Extinguishing granules

Extinguishing granules thermally isolate the battery. They function autonomously and once in contact with the battery they are active immediately. To successfully extinguish an incipient fire, the battery must be surrounded by a sufficient quantity of granules. Some granules can be used universally; they are suitable for fire-fighting but also as filler materials for storage and transport.

Safety regulations on handling and storage

Lithium-ion accumulators must be regarded as hazardous substances, and the user must carry out a risk assessment for handling them. Suitable measures are derived from the risk assessment and corresponding safety operation procedures are issued. New employees and students must be trained in correct handling. Important rules of thumb for everyday handling of lithium-ion accumulators are given in the overview at the beginning of this factsheet.

Also with regard to storage, lithium-ion batteries/accumulators must be regarded as hazardous substances. Depending on their power class (low-, medium- or high-power lithium-ion batteries/accumulators), additional specific storage conditions have to be observed (see Table 1). Low-power lithium-ion batteries/accumulators are mainly those used in computers, multimedia or small power tools. Medium-power batteries/accumulators are used in applications such as bicycles with an electrical auxiliary drive (e-bikes/pedelecs), light electric vehicles (LEVs) and larger garden appliances; however, they are also used as cells to manufacture high-power accumulators. The main areas of application for high-power accumulators are currently electromobility (automotive) and off-grid large-scale equipment.

Table 1: Storage conditions for lithium-ion batteries/accumulators depending on their power (test certificate as per UN 38.3 must be available)

Lithium-ion batteries/accumulators		
≤ 100 Wh per energy storage device (low power)	**> 100 Wh per energy storage device and ≤ 12 kg gross per energy storage device (medium power)**	**> 100 Wh per energy storage device and/or > 12 kg gross per energy storage device (high power)**
Compliance with the manufacturer's requirements (technical product datasheets)		
Protect the battery poles against short circuits		
Immediately remove damaged or defective lithium-ion accumulators from storage areas → Cf. factsheet: «**Disposal of Lithium-ion Accumulators**»		
• No specific storage conditions • Keep suitable fire extinguishers or extinguishing granules on site (**sgu-safety@ethz.ch**) *For larger quantities in contiguous storage (volumes above 7 m^3 or more than six euro pallets), the conditions for medium-power lithium-ion batteries / accumulators are applicable.*	• Storage in areas separated by fire-resistant barriers, e.g. a certified safety cabinet for storing lithium-ion accumulators or a safety cabinet for storing and charging lithium-ion accumulators, or in compliance with a safety distance (physical separation of 5 m) • No mixed storage with other fire-accelerant products • The safety cabinet must be connected to the fire alarm system via potential-free contacts, or via a decentralised alarm system (**sgu-safety@ethz.ch**) *For larger storage quantities (area occupied > 60 m^2 and / or storage heights > 3 m), the conditions for high-power lithium-ion batteries/accumulators are applicable.*	Little profound knowledge about adequate protective measures is available yet. A risk analysis must be carried out and a safety concept for «Storage» must be created. → Contact SSHE (**sgu-umwelt@ethz.ch**)

Legal basis / literature

- Chemical Risk Reduction Ordinance (ORRChem)
- Ordinance on Movements of Waste (OMW)
- DETEC (Federal Department of the Environment, Transport, Energy and Communications) Ordinance on Lists for Movements of Waste
- EPTA (European Power Tool Association) and ZVEI (German Electrical and Electronic Manufacturers' Association), factsheet: «Shipping Lithium-Ion Batteries for Cordless Power Tools and Electric Garden Equipment: Implementation of Dangerous Goods Transport Regulations», 2019

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