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1 *Cell residues after a safety test on a battery pack made of 18650 cells.*
2 *Electrolyte release and fire during a thermal abuse test of a lithium ion cell.*

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SAFETY INVESTIGATIONS ON LITHIUM-ION BATTERIES (LIBS) FOR MILITARY APPLICATIONS

Lithium-ion batteries (LIBs) are becoming increasingly important for various applications in the Bundeswehr. They are characterized by their high energy density, but have a certain hazard potential. Practical safety tests make it possible to evaluate their behavior in the event of a malfunction fault and under operating conditions, enabling safe deployment.

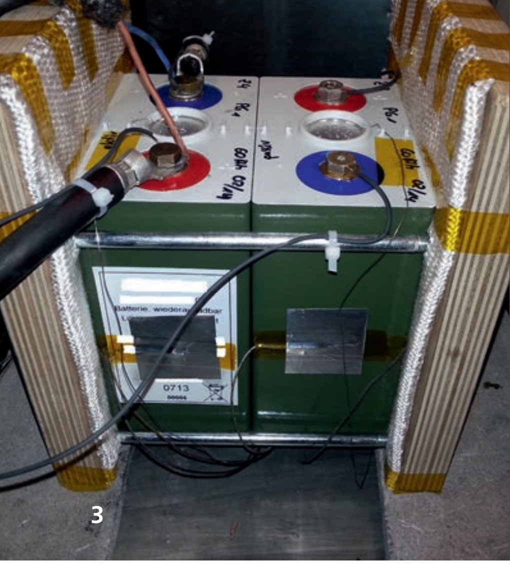
Fraunhofer ICT, together with WTD 41, Department of Electrochemical Energy Storage (GF 230), conducts safety investigations and tests on various types of lithium-ion cells and batteries (LIBs) for military applications.

LIBs have become indispensable for military use and will increasingly replace other rechargeable systems (lead-acid, Ni/Cd) in the coming years. The biggest advantage is their high energy density, which cannot be achieved by any other available battery system. However, LIBs can pose a much higher risk to both people and machines.

Together with WTD 41, Fraunhofer ICT has been working intensively in recent years on identifying key hazards and countermeasures.

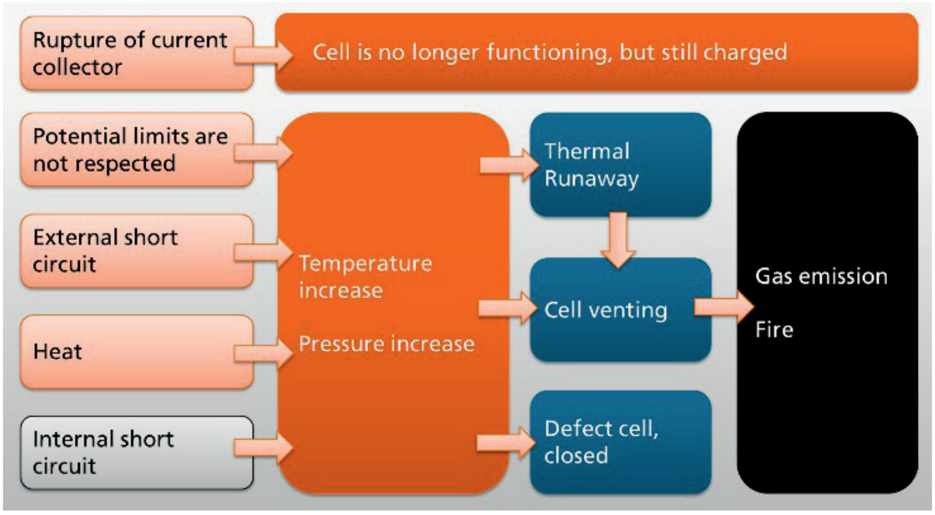
In the case of LIBs, specific energy density and intrinsic safety are inversely proportional to each other. The Bundeswehr uses only high-quality systems, so there have been no significant safety-related incidents during operation to date. Only bullet impact and safety tests show the potential danger of this battery technology. In the event of a malfunction, the energy stored in the cell can be released abruptly as fire (thermal runaway, TR). Under certain circumstances, a TR can spread rapidly from one cell to all other cells of a battery in a chain reaction (propagation).

We carry out practice-relevant safety tests on all currently used and also on possible future LIBs of the Bundeswehr.



These tests include thermal ramps, overloading, overdischarge, external short-circuits, mechanical force, etc., that covering the special deployment scenarios in a military application. It has been shown that LIBs based on the cathode materials NCA (Ni-Co-Al-Oxide) and NMC (Ni-Mn-Co-Oxide) are the most critical. In this case, a TR forms early upon misuse and propagation occurs. Cells with LiFePO4 as cathode material (LFP) show significantly higher intrinsic safety. A TR can also occur, but propagation is much less likely. In the case of underwater applications, for example, this is of the utmost importance, as no escape is possible in the event of a malfunction. However, it is also important in land applications as, for example, a shell splinter can put an entire weapon system out of operation, or destroy it.

In addition, it is important to examine the composition of possible released substances, as toxic, corrosive and flammable components such as carbon monoxide, hydrogen fluoride, hydrogen and hydrocarbons may also be present. These results are particularly important for applications with limited installation space.
In addition, production-related faults or faults in the electronic circuits cannot be completely excluded. Consequently, we also investigate constructive measures to mitigate the effects of a TR and to prevent propagation.



Possible causes of failure of lithium-ion cells.

These include:
- the development of so-called "intrinsically safe" cells that use complex methods to prevent a possible TR inside the cell
- isolation of individual cells
- the use of heat-absorbing materials
- constructive measures for the targeted dissipation of the reaction heat in the event of a TR

Above all, a solution with an intrinsically safe LIB would eliminate the need for complex measures to ensure the safety of a battery module. This technology is still in its infancy, but we are closely monitoring and evaluating it.

3 *Propagation test by overcharging two charged LFP cells (before the test).*
4 *Propagation test by overcharging two charged LFP cells (after the test). The passive cell (left) does not catch fire itself during the thermal runaway of the neighboring overcharged cell.*
5 *Cell-internal short-circuit.*