

Factsheet

Damaged Lithium-ion Accumulator – What Do you Do?

Background

You suspect that a lithium-ion battery or a lithium-ion accumulator is damaged, or it is already swollen. What do you do?

You have transported your drone from ETH to a destination somewhere in Switzerland, where it has crashed. Can you transport the drone and the lithium-ion accumulator back to ETH in your vehicle?



Figure 1: Swollen lithium-ion accumulator (source: SSHE)

How do you recognise that a lithium-ion battery / lithium-ion accumulator is damaged?

- Damaged or substantially deformed case
- Tarnished metal parts of the battery
- Molten spots on the plastic case
- Battery heats up in a switched-off state
- Battery leaks
- Cells identified as defective by the battery management system

Note: Accumulators with a maximum weight per unit over 500 grams are considered to be especially dangerous.

How to take the correct action when you are in an ETH building or on an ETH site

- Inform the ETH Zurich 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.)
 - What?** Nature of incident (defective/swollen lithium-ion accumulator, critical condition, etc.)
 - 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
- Wait for the specialists from SSHE to call you back and follow their instructions

How to take the correct action if the damage to the lithium-ion accumulator occurs outside ETH premises (e.g. during practical work or experiments in the field)

- Assess if the lithium-ion accumulator is defective or damaged.
When assessing if a battery / lithium-ion accumulator is damaged or defective, the battery type and the previous use and misuse of the battery / lithium-ion accumulator must be taken into account.
Damaged or defective batteries / lithium-ion accumulators may include the following in particular:
 - Leaking or degassed batteries / lithium-ion accumulators
 - Batteries / lithium-ion accumulators that cannot be diagnosed prior to transport
 - Batteries/ lithium-ion accumulators that have sustained external or mechanical damage
- Assess if the lithium-ion accumulator is «non-critical» or «critical» (Table 1), i.e. is it probable that the transport can be undertaken without danger, or is this not?


Transport is expected to be safe:

- Package the accumulator according to the information in Table 1
- Mark the item to be transported according to the information in Table 1 (you can obtain marking materials in advance via sgu-gefahr-gut@ethz.ch, see the factsheet on «[Transport of Lithium-ion Accumulators](#)»)
- For return transport of the damaged lithium-ion accumulator, use the transport document «Carriage according to Special Provision 376»
- You may transport the lithium-ion accumulator in your vehicle
- After returning to ETH, notify SSHE of the incident via email to sgu-gefahr-gut@ethz.ch and arrange an appointment to hand over the defective/damaged lithium-ion accumulator to one of ETH's hazardous waste disposal facilities.

Transport is not expected to be safe:

- You must **NOT** transport the lithium-ion accumulator in your vehicle
- Notify the Emergency Desk immediately: **041 44 342 11 88**
Give your name, your telephone number and location, and state that you have a lithium-ion accumulator in a critical condition
- Follow the instructions of the Emergency Desk
- Wait for the specialists from SSHE to call you back and follow their instructions

Table 1: Transport of damaged/defective batteries by road/rail – What are the key issues?

	Damaged or defective batteries	
Packing instructions	Special Provision (SP) 376 P908	SP 376, P911
Criteria: «damaged, defective»	<p>«Non-critical» (probably no risk during transport). Batteries of this sort do not conform to the tested type as per the applicable requirements in the UN Manual of Tests and Criteria, 38.3. This refers to the following batteries, for example:</p> <ul style="list-style-type: none"> • batteries that have leaked or vented, • batteries that have sustained external or mechanical damage. <p>Note: When assessing a battery as damaged or defective, the type of battery and its previous use and misuse have to be considered.</p>	<p>«Critical» (a risk during transport seems likely). This refers to batteries that are liable to rapidly disassemble, dangerously react, and tend to formation of flames, dangerous heat generation, or dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of carriage. These may only be transported under conditions defined by the competent authority.</p>
Max. number of pieces	Not applicable	
Weight limit	If the net mass of one battery is > 30 kg, the outer packaging must only contain one single battery.	
Packaging	<ul style="list-style-type: none"> • Each battery packed individually in leak-proof/sealed inner packaging (protection against leakage, protection against short circuits). • UN-tested (packing group II), e.g. cardboard box, for all battery types. • Use filler material to secure against movement inside the outer packaging. • Only airtight packaging fitted with a venting device are permitted. • Filled with non-combustible and non-conductive thermal insulation material, Construction Product Class A1 or A2 («non-combustible», e.g. rock wool, glass wool, foam glass, vermiculite). • Sufficient absorbent material to absorb leaking electrolyte. 	<ul style="list-style-type: none"> • The packaging must be capable of meeting certain performance requirements as specified in P911 in case of rapid disassembly, dangerous reaction, and formation of flames, dangerous heat generation, or dangerous emission of toxic, corrosive or flammable gases or vapours from the batteries. • Additional performance requirements must be verified through a test stipulated by the competent authority. • A verification report must be available on request, as specified in P911. • Cells or batteries must be protected against short circuits.
Labelling of item for transport/shipping	<p>UN 3480 DAMAGED/DEFECTIVE LITHIUM-ION BATTERIES</p> <p>UN 3481 DAMAGED/DEFECTIVE LITHIUM-ION BATTERIES CONTAINED IN EQUIPMENT</p> 	
Transport documents	Yes	
Other	Instruction of participating employees according to their tasks and responsibilities	

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
- Ordinance on the Carriage of Dangerous Goods by Road (ADR/SDR)
- Packing instructions:
 - Special Provision 376
 - Packing instruction P908
 - Packing instruction P911

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Annexe: Packing instructions

Special Provision 376

Lithium-ion cells or batteries and lithium metal cells or batteries identified as being damaged or defective such that they do not conform to the type tested according to the applicable provisions of the Manual of Tests and Criteria shall comply with the requirements of this special provision.

For the purposes of this special provision, these may include, but are not limited, to

- cells or batteries identified as being defective for safety reasons,
- cells or batteries that have leaked or vented,
- cells or batteries that cannot be diagnosed prior to carriage, or
- cells or batteries that have sustained physical or mechanical damage.

NOTE: In assessing a battery as damaged or defective, the type of battery and its previous use and misuse shall be taken into account.

Cells and batteries shall be carried according to the provisions applicable to UN numbers 3090, 3091, 3480 and 3481 except Special Provision 230 and as otherwise stated in this special provision.

Cells and batteries shall be packed in accordance with packing instructions P908 of subsection 4.1.4.1 or LP904 of subsection 4.1.4.3.

Cells and batteries identified as damaged or defective which are liable to rapidly disassemble, dangerously react, produce a flame or a dangerous development of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of carriage shall be packaged in accordance with Packing Instruction P911 of subsection 4.1.4.1 and/or LP906 of subsection 4.1.4.3. Alternative packing and/or carriage conditions may be authorized by the competent authority of any ADR Contracting State, which may also recognize an approval granted by the competent authority of a country that is not an ADR Contracting State provided that this approval has been granted in accordance with the procedures applicable according to RID (Regulation concerning the International Carriage of Dangerous Goods by Rail), ADR, ADN (European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways), the IMDG (International Maritime Dangerous Goods) Code or the ICAO (International Civil Aviation Organization) Technical Instructions. In both cases, the cells and batteries are assigned to transport category 0.

Packages shall be marked «DAMAGED/DEFECTIVE LITHIUM-ION BATTERIES» or «DAMAGED/DEFECTIVE LITHIUM METAL BATTERIES», as applicable.

The transport document shall include the following statement:

«TRANSPORT IN ACCORDANCE WITH SPECIAL PROVISION 376»

If applicable, a copy of the competent authority approval shall accompany the carriage.

Packing instruction P908

This instruction applies to damaged or defective lithium-ion cells and batteries and damaged or defective lithium metal cells and batteries, including those contained in equipment, with UN nos. 3090, 3091, 3480 and 3481.

The following packaging are authorized provided that the general provisions of 4.1.1 and 4.1.3 are met:

For cells and batteries, and equipment containing cells and batteries:

Drums (1A2, 1B2, 1N2, 1H2, 1D, 1G)

Boxes (4A, 4B, 4N, 4C1, 4C2, 4D, 4F, 4G, 4H1, 4H2)

Jerricans (3A2, 3B2, 3H2)

Packaging shall conform to the packing group II performance level.

1. Each damaged or defective cell or battery or any equipment containing such cells or batteries shall be individually packed in inner packaging and placed inside an outer packaging. The inner packaging or outer packaging shall be leakproof to prevent the potential release of electrolyte.
2. Each inner packaging shall be surrounded by sufficient non-combustible and non-conductive thermal insulation material to protect against a dangerous evolution of heat.
3. Sealed packaging shall be fitted with a venting device when appropriate.
4. Appropriate measures shall be taken to minimize the effects of vibrations and shocks and to prevent movement of the cells or batteries within the package that may lead to further damage and a dangerous condition during carriage. Cushioning material that is non-combustible and non-conductive may also be used to meet this requirement.
5. Non-combustibility shall be assessed according to a standard recognized in the country where the packaging is designed or manufactured.

For leaking cells or batteries, sufficient inert absorbent material shall be added to the inner or outer packaging to absorb any release of electrolyte.

A cell or battery with a net mass of more than 30 kg shall be limited to one cell or battery per outer packaging.

Additional instruction

Cells or batteries shall be protected against short circuits.

Packing instruction P911

This instruction applies to damaged or defective cells and batteries with UN numbers 3090, 3091, 3480 and 3481 which are liable to rapidly disassemble, dangerously react, produce a flame or a dangerous development of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of carriage.

The following packaging are authorized provided that the general provisions of 4.1.1 and 4.1.3 are met:

For cells and batteries, and equipment containing cells and batteries:

Drums (1A2, 1B2, 1N2, 1H2, 1D, 1G),

Boxes (4A, 4B, 4N, 4C1, 4C2, 4D, 4F, 4G, 4H1, 4H2),

Jerricans (3A2, 3B2, 3H2).

Packaging shall conform to the packing group I performance level.

1. The packaging shall be capable of meeting the following additional performance requirements in case of rapid disassembly, dangerous reaction, production of a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours from the cells or batteries:
 - a) The outside surface temperature of the completed package shall not have a temperature of more than 100°C. A momentary spike in temperature up to 200°C is acceptable.
 - b) No flame shall occur outside the package.
 - c) No projectiles shall exit the package.
 - d) The structural integrity of the package shall be maintained.
 - e) The packaging shall have a gas management system (e.g. filter system, air circulation, containment for gas, gas-tight packaging), as appropriate.
2. The additional performance requirements for the packaging must be verified by means of a test specified by the competent authority of any RID Contracting State, which may also recognize a test specified by the competent authority of a country that is not an RID Contracting State provided that such a test was specified in accordance with the procedures applicable according to RID, ADR, ADN, the IMDG Code or the ICAO Technical Instructions.
3. A verification report shall be available on request. As a minimum requirement, the cell or battery name, the cell or battery number, the mass, type, energy content of the cells or batteries, the packaging identification and the test data according to the verification method as specified by the competent authority shall be listed in the verification report.
4. When dry ice or liquid nitrogen is used as a coolant, the requirements of section 5.5.3 shall apply. The inner packaging and outer packaging shall maintain their integrity at the temperature of the refrigerant used as well as at the temperatures and the pressures, which could result if refrigeration were lost.

Additional instruction

Cells or batteries shall be protected against short circuits.

Footnote^a

The following criteria, as relevant, may be considered to assess the performance of the packaging:

- a. The assessment shall be done under a quality management system (e.g. as described in section 2.2.9.1.7 e)) allowing for the traceability of test results, reference data and characterization models used.
- b. The list of hazards expected in case of thermal runaway for the cell or battery type in the condition it is transported (e.g. usage of an inner packaging, state of charge (SOC), use of sufficient non-combustible, electrically non-conductive and absorbent cushioning material), shall be clearly identified and quantified; the reference list of possible hazards for lithium cells or batteries (rapid disassembly, dangerous reaction, production of a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours) can be used for this purpose. The quantification of these hazards shall rely on available scientific literature.
- c. The mitigating effects of the packaging shall be identified and characterized on the basis of the nature of the protections provided and the construction material properties.

A list of technical characteristics and drawings shall be used to support this assessment: (density ($\text{kg}\cdot\text{m}^{-3}$), specific heat capacity ($\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$), heating value ($\text{kJ}\cdot\text{kg}^{-1}$), thermal conductivity ($\text{W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$), melting temperature and flammability temperature (K), heat transfer coefficient of the outer packaging ($\text{W}\cdot\text{m}^{-2}\cdot\text{K}^{-1}$) ...).

- d. The test and any supporting calculations shall assess the result of a thermal runaway of the cell or battery inside the packaging in the normal conditions of transport.
- e. In case the SOC of the cell or battery is not known, the assessment used shall be done with the highest possible SOC corresponding to the cell or battery use conditions.
- f. The surrounding conditions in which the packaging may be used and transported shall be described (including for possible consequences of gas or smoke emissions on the environment, such as ventilation or other methods) according to the gas management system of the packaging.
- g. The tests or the model calculation shall consider the worst-case scenario for the thermal runaway triggering and propagation inside the cell or battery: this scenario includes the worst possible failure in the normal transport condition, and the maximum heat and flame emissions for the possible propagation of the reaction.
- h. These scenarios shall be assessed over a period long enough to allow all the possible consequences to occur (e.g. 24 hours).