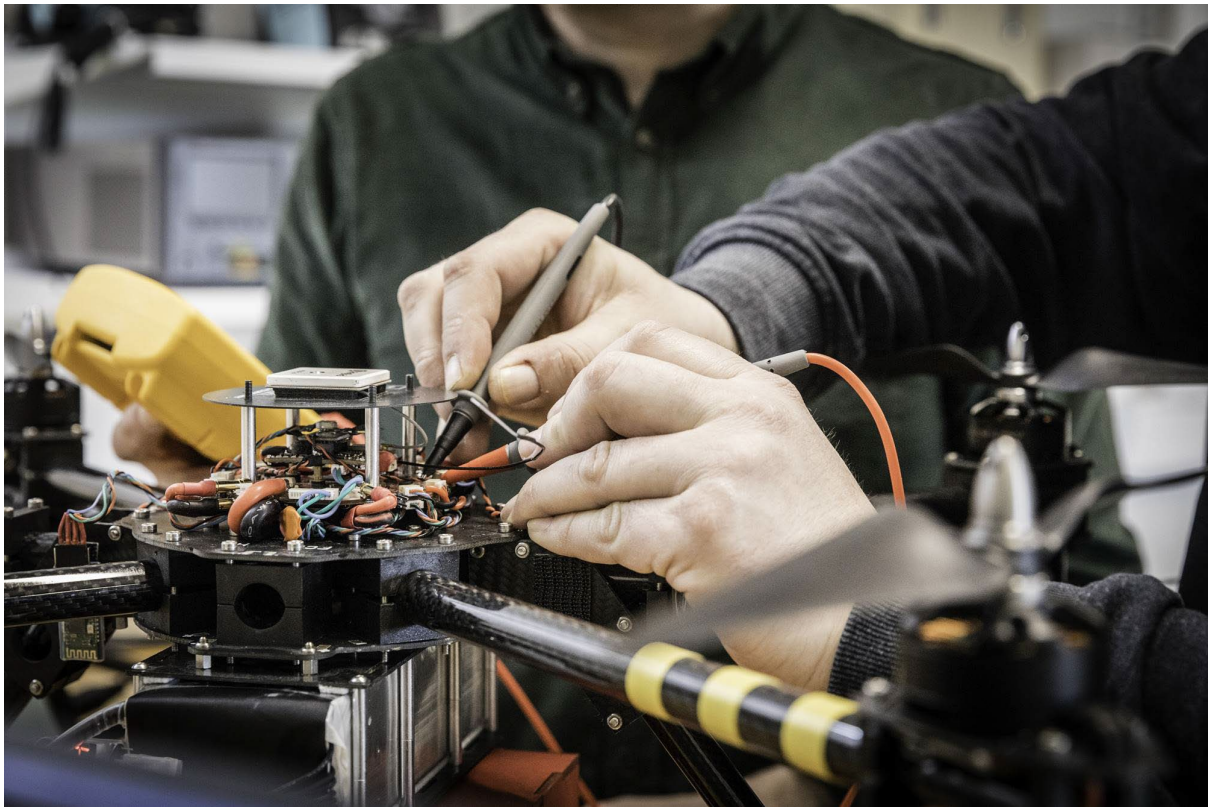
SDU
Faculty of Engineering

TEK Battery Safety Guidelines



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1. Introduction, Purpose, and Target Groups

Note: If you do not find answers to your questions in the following text, please refer to Appendix 1, where you can see where you can find advice and guidance at TEK.

The purpose of this document is to provide an overall introduction to battery safety in connection with activities at the Faculty of Engineering at SDU, as well as specific instructions for the safe handling and storage throughout the battery's lifespan. This document serves as an internal guideline, which is one of the components to ensure that our work can be carried out in a fully healthy and safe manner.

The guideline primarily applies to batteries used in connection with research and educational activities.

Additionally, there are references to where you can find more inspiration or assistance to ensure safe handling of batteries in your work.

The main focus is on lithium batteries, but there are also guidelines that apply to other types of batteries and accumulators.

The document is intended for both staff and students at the Faculty of Engineering at SDU.

The document is not exhaustive and cannot replace risk assessment and safety instructions for specific processes and equipment.

Furthermore, the manufacturer's/manual's instructions must always be followed.

Please note that there are special requirements and regulations in certain specific areas, such as for energy storage units we manufacture ourselves, equipment for military purposes, or equipment for use in space.

2. Roles and Responsibilities

Everyone has a responsibility to collaborate on maintaining a healthy and safe work environment.

Those who use equipment/processes have a particular responsibility for these; this applies to the entire process from planning through requisition, use, and disposal. The requisitioner is responsible for obtaining permission from the laboratory manager and conducting a prior risk assessment, ensuring that the required documentation is available. See section 6.3 on risk assessments.

The room/laboratory manager, or person responsible for field work (henceforward called “lab manager”), is obligated to monitor safety in the lab/workshop and point out any "errors and deficiencies."

The lab manager must ensure that:

- Risk assessments and safety instructions are done.
- A routine is agreed upon for who gives safety instructions; remember repetition, e.g., annually or per semester.
- An inventory list is kept of the number, type, and size of batteries. Refer to the overview on Teams in the folder General → Lithium and Other Batteries at TEK.xlsx[1].
- Ensure a fixed interval for battery inventory counts.

[1] All multi-cell batteries, as well as medium and high-performance batteries, must be registered; as well as where there is considered to be a particular risk, e.g., in the case of large quantities of batteries.

- Batteries/battery systems are checked at regular intervals. See section 6.6.
- There are provisions for safe charging and storage, including, for example, Kevlar bags, various containers, battery cabinets, etc.; this may be in another room or an outdoor container.
- Users know how to handle and dispose of end-of-life or damaged batteries.

Note: The room manager does not necessarily have to carry out the tasks but must monitor safety conditions and ensure that rules and requirements are followed. Contact the Health & Safety committee or management for support if needed.

The safety organisation plays a facilitating role. The role does not include being a specialist on all safety matters but rather helping to identify problem areas, share knowledge, and provide guidance where possible.

Management must monitor safety work and is always responsible for ensuring that work is planned and organized so that it's fully safe and healthy.

3. General Battery Safety at TEK

The guidelines that follow generally apply to all battery types, with the primary focus on rechargeable batteries with medium or high capacity/performance, where the risk is greatest.

Much equipment is supplied by the manufacturer with a built-in rechargeable battery with a safety system (Battery Management System/BMS), and an original charger is included. Examples include laptops, mobile phones, tablets, and some light laboratory equipment.

No special safety precautions are immediately required for this type of battery-powered equipment, but the instructions in the manual must be followed. One of the biggest risks with this type of equipment is when the original charger is not used, or if the battery or equipment is dropped, causing damage to the battery.

Larger batteries, such as those for robots, e-bikes, more powerful tools, etc., have much higher capacity/performance and require special safety precautions.

For all battery-powered equipment, the following applies[2]:

- The equipment must be CE-marked.
- Follow the instructions in the manual.
- Use only original batteries without damage.
- Use only original or approved chargers/cables (CE-marked and of the correct type). Contact the supplier or SDU IT (for IT equipment) or the room manager (for laboratory equipment) if in doubt.
- Do not damage or modify the equipment. Be aware of any damage to the equipment or battery, such as from impact, pinching, extreme temperatures, liquid exposure, etc.; have it inspected if in doubt.
- Check that the cord and plug are not damaged.
- Do not charge near flammable materials, and never in or near escape routes. See more in section 6.5 on charging, especially batteries with medium or high capacity/performance.

[2] Source: Guidelines from the Danish Safety Technology Authority (in Danish): www.sik.dk.

- Ensure that the charger and battery/equipment can cool naturally; do not cover them during charging.
- Charge in a manner that allows you to respond if something unforeseen happens (heat, smoke, fumes, unusual noises from the battery or charger), and if possible in a room with a smoke detector.
- Avoid overcharging or deep discharging, which can lead to thermal runaway and fire. Do not charge batteries that have not been in use for a long time. If you use the original CE-marked equipment, you are well-protected against overcharging. Deep discharging typically occurs with (equipment with) batteries that are no longer used and therefore not charged. Dispose of such batteries/equipment or monitor the battery's state of charge; see section 6.4.
- Non-integrated rechargeable (lithium) batteries must be stored in suitable fireproof containers or cabinets. See section 6.4.
- Avoid exposing batteries to moisture (including condensation), especially during storage, as far as possible.
- Batteries should be charged at room temperature whenever possible; cold batteries should be brought to temperature before charging.
- Generally, avoid heating batteries from sources such as sunlight, heat sources, electrical equipment, etc.
- Never use damaged batteries! This includes batteries that are swollen, leaking fluid, or have other visible damage/deformation. Do not use old, unused batteries either. Such batteries must be disposed of; see section 8 and Appendix 4.
- Always dispose of batteries and/or equipment with built-in batteries according to applicable regulations; see section 8 and Appendix 4.
- Be aware of safety rules for battery transportation; see section 6.7.
- Batteries for which you do not know the specifications or safety information must not be used.

In connection with equipment we use in our research, development, teaching, etc., we often use battery systems, usually rechargeable, which we handle, charge, in some cases replace, and in some cases work directly on, build, and modify. The battery systems are used, for example, in drones, robots, race cars, etc. It is especially this type of equipment and processes that the following sections address.

Connecting batteries, etc., falls under the standard "EN50110-1 Operation of Electrical Installations" and should be handled accordingly, as this standard applies down to 0 Volts.

*Note: When working with batteries, you must also **follow the "Electrical Safety at TEK" guidelines**, which you can download here: https://sdunet.dk/da/tek/safety.*

4. Table of Battery Types and Basic Safety Instructions

Low Performance	**Medium Performance**	**High Performance**
Computers, multi-media, small electrical units, small electrical tools	Electric bikes, electric scooters, large garden tools	Cars, network-dependent equipment, industrial power banks, battery storage systems
Lithium Metal storage:		
≤ 1 g Li per cell ≤ 2 g Li per battery	>2 g Li per battery ≤ 12 g gross per battery	>2 g Li per battery > 12 g gross
Lithium Ion storage:		
<20 Wh per cell < 100 Wh per battery	>100 Wh per battery < 12 kg gross	>100 Wh per battery And/or > 12 kg gross
Specific security rules:		
• None When storing larger quantities (more than 7 m^3 or more than 6 Euro pallets), the rules for batteries with medium performance apply.	• Storage in separate fireproof areas or in compliance • with safety distances (at least 2 as per DBI). • No storage together with combustible materials. • Area monitoring with ABA or interconnected fire alarms.	Measures in collaboration with the insurance company. – • Storage in separate areas specifically designed for battery storage. The area must not be arranged with combustible materials. • Maintain distance between multiple battery storage areas. • Quantity limitation.

Source: Excerpt from the table in the COWI fire safety note: Handling of Lithium Batteries, prepared for SDU, January 2021. See detailed definitions and guidelines in the following sections.

5. Definitions and Battery Types

Batteries come in many different types and sizes. At a basic level, there is a distinction between:

- Non-rechargeable/primary batteries
- Rechargeable/secondary batteries

The size varies from button cells to large battery packs for electric vehicles. Battery voltage ranges from 1.5V up to about 5-600Vdc. Lithium-ion batteries are often used in connection with drones, mobile robots, and electric vehicles. Battery packs/systems for supplying emergency power systems and electric vehicles are often composed of smaller batteries/packs up to 25Vdc.

5.1 Description of the Most Commonly Used Primary Battery Types at TEK

We still use a considerable number of primary batteries at TEK, both in office areas as well as in laboratories and workshops. The most well-known are AA, AAA, and 9V batteries, as well as non-rechargeable (alkaline/lithium) button cells. These have low capacity and risk, but you should still be

careful not to drop or damage the battery and avoid using batteries that have visible damage or are leaking.

Also, be very mindful that button cells should be wrapped in non-conductive foil/tape before disposal, as they can otherwise cause short circuits and fires.

See also section 8 on disposal.

5.2 Description of the Most Commonly Used Rechargeable (Secondary) Battery Types at TEK

At TEK, several rechargeable batteries are used, such as:

- Lithium Ion-batteries
- Lithium Iron Phosphate batteries
- Lead-acid batteries
- Button cells
- Nickel Metal Hydride (Ni-MH) or Nickel Cadmium (Ni-Cd)


Lithium battery packs

Fuse

Inline fuse holder

Rechargeable button cell batteries

Rechargeable AA and AAA batteries

Lithium iron phosphate battery with BMS

18650 cell and battery

Definition regarding capacity/performance (lithium batteries):

- Low performance/low capacity ≤ 100Wh: Mobile phones, tablets, laptops, small electric tools, etc.
- Medium performance > 100Wh < 12 kg/battery: Electric bikes, power tools, large electric tools, etc.
- High performance > 100Wh > 12 kg/battery: Electric vehicles, mobile robots, UPS systems, industrial power banks, battery storage, network-dependent equipment, etc.

6. Safe Handling and Use of Batteries

The most important rule is that you should always know what you are working with. Read the manual, safety data sheet, and/or packaging information about the batteries and equipment you are using and adhere to the specified guidelines. For example, you must be sure whether it is a primary or rechargeable battery, as attempting to charge a primary battery can be dangerous. Always follow the safety advice in section 3.

Battery voltage is typically not very high (typically 15-16Vdc), but batteries are often capable of delivering a very high short-circuit current, which can cause sparks and overheating of both the connected electronics and the battery pack itself. Therefore, the battery pack and connected equipment must be protected with an appropriately sized fuse whenever possible.

Pay special attention to the risk of "thermal runaway" – high and rapid heat generation in the battery, which can lead to a fire. The three most common handling or storage errors that lead to battery fires are:

1. Electrical:
    a. Overcharging of cells due to too high (final) charging voltage - incorrect charger/setting
    b. Overheating due to too high charging current - incorrect charger/setting
    c. Charging with incorrect polarity - incorrect charger/cables/usage
    d. Charging multi-cell battery packs without a BMS – can cause overcharging of one or more cells due to imbalance in the battery pack
    e. Charging batteries that have been damaged or have become defective due to previous overcharging/undercharging
    f. Short-circuiting due to incorrect handling/connection to the wrong type of charger/load, etc.
    g. Excessive current draw during use
2. Mechanical: Damage to the battery, e.g., from tools or impacts on the battery
3. Thermal: Typically, external heat exposure, or the battery cannot dissipate heat, e.g., due to covering/wrapping.

See also the following subsections.

6.1 Procurement and General Requirements for Rechargeable Batteries/Battery Systems

You can do much to reduce risks during the procurement phase.

Note: Be aware that you have a greater responsibility and fewer rights concerning battery defects (including safety and documentation) if you purchase directly from abroad (this also applies to online purchases). When you purchase directly from abroad, you are the importer.

Do not buy more batteries/cells for "stock" than necessary. Less stock means less risk.

Be very mindful of quality and reliability when acquiring both equipment and batteries.

Ask the supplier for a safety data sheet for the batteries/equipment. It is often called an MSDS, which stands for Material Safety Data Sheet.[3]

Batteries, like other electrical equipment and machines, must be CE-marked, and they must comply with the relevant battery standard (for lithium batteries: EN 62619 and UN 38.3).

As a general rule, all batteries/battery systems must be equipped with a Battery Management System (BMS), which, among other things, protects against overcharging, which can cause short-circuits leading to fires. If it is necessary to use batteries without a BMS, these must be charged via an external BMS whenever possible. Pay particular attention to additional safety measures in your risk assessment and safety instructions regarding the specific battery system (see section 6.3 below).

For rechargeable batteries and other large batteries and battery systems, instructions and safety information must be provided in Danish and in a language that the users understand, typically English if there are international users.[4]

Also, ensure that the **labelling** with important information on the battery/system is in a language that the users can easily understand; the labelling may need to be refreshed to remain legible. However, the CE marking must never be replaced by anyone other than the organization responsible for the CE marking. Labelling requirements for batteries will be tightened from August 18, 2026, particularly concerning "special collection" (in connection with disposal) and QR codes.[5]

Make sure you have a procedure for receiving batteries/battery systems/equipment with batteries so that you know how to inspect, handle, and store them safely immediately upon receipt. When ordering large or many batteries (over 100 Wh / 12 kg), a special plan must be made to minimize risk. For example, is there a risk of mechanical damage during handling (e.g., with a forklift)? Do you know where the equipment will be stored? See section 6.3 on risk assessment.

Note: Always check the equipment/batteries for defects and damage immediately upon receipt. Is the packaging intact, and do the batteries/equipment appear undamaged?

Are individual cells packaged in protective plastic?

Are the batteries correctly labelled:

- CE marking; including manufacturer information

[3] Source: https://www.isikkerhed.dk/raadgivning/batterier/

[4] The requirement for CE-marking came into force 18 August 2023, and there will be a period when there are still un-marked batteries in the market.
https://www.tuvsud.com/en-us/resource-centre/blogs/mobility-and-automotive/understanding-the-new-eu-battery-regulation;
https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32023R1542; see particularly Articles 18, 38, 41, 42, 74.

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32023R1542; see particularly Article 13.

- UN 3481 batteries installed in equipment (lithium)
- UN 3480 battery cell (lithium)

Also check according to the accompanying manual/product declaration for both equipment and battery and follow the checklist in section 6.6.

6.2 Handling and Use of Safety Equipment

Batteries must be handled according to the manufacturer's instructions and with caution. Avoid impacts, shocks, etc.

If batteries are handled incorrectly and suffer mechanical damage, they can pose a significant safety risk.

Exposed poles (e.g., screw/bolt terminals, connector pins, and open cable ends) pose a risk of short-circuiting and should therefore always be protected against contact (e.g., covered with insulating tape or foil). Be aware that tape alone is not sufficient for a high-voltage battery pack (>60 V DC) (see standard EN50110-1 and check whether a safety course is required; see section 9).

When assembling high-performance battery systems, the batteries must be secured individually, and insulating covers, insulating gloves, and safety glasses must be used. Suitable insulated tools should also be used.

Always be aware of the risk of sparks when connecting the battery: Are there flammable materials or atmosphere where you are working with the battery (including, for example, dust, fumes, gases)?

Sparking can be avoided by controlled potential equalization:

- Where possible, via series impedance
- Otherwise, via parallel equalization

A simple solution is "anti-spark connectors", which have built-in series impedance.

Find out who can advise you and get more information on electrical safety in the guide *Electrical Safety at TEK*, which you can find here: https://sdunet.dk/en/enheder/fakulteter/teknik/arbejdsmiljoe-og-personaleforhold/safety.

6.3 Documentation and Risk Assessments

In connection with each process and equipment, a specific risk assessment must be prepared, which must also include safety instructions and an emergency plan for incidents involving batteries in the specific process. Use TEK's template for the risk assessment (can be downloaded at the MS Teams-site with Lab Safety Files[6]).

Note: The person preparing the risk assessment must be trained at the level covered by the risk assessment. For example, you must have at least an electrical safety course EN50110 (equivalent to "L-AUS") when conducting risk assessments in the low-voltage area.

The risk assessment, along with safety instructions and emergency plans, as well as manuals and data sheets, must be easily accessible to all users at or from the workplace (legally required). Manuals/data sheets must be available in Danish and a language that users understand, typically English. Written instructions must always be followed up with verbal instructions, and one must

[6] Contact TEK Senior Consultant for Health & Safety, Susanne Arnsted, if you do not have access to the Teams site or have questions about the template.

ensure that the instructions are understood. The instructions must be repeated at appropriate intervals, e.g., at the start of each semester or once a year, depending on complexity and risk level.

6.4 Storage

When storing medium- and high-performance rechargeable batteries and larger battery systems/packs, all relevant batteries must be labelled* with the following information:

- Unique number/name
- The lab where the battery is assigned
- Storage location in the lab
- Date of first use and, if applicable, date of disposal
- Log or date of the last and next inspection
- Comment field: Any special observations during charging/usage
- When possible, link/URL to battery specifications/manual
- When possible, reference to suitable chargers in the lab, with a link to the specification/manual of the charger

**If there is not enough space for the information on the battery, there should be a reference to where the information can be found, which must be stored at the battery's storage location.*

It is also recommended that this information be noted in the battery inventory list, as mentioned in section 2 above.

Batteries must be stored at the correct state of charge when not in use, in approved containers/cabinets (usually specified in the battery's manual). If the state of charge is not specified, 30% is recommended (minimum 20% and maximum 50%; for NiMH batteries, however, storage at a higher state of charge, preferably 100%, is recommended). Routine checks must ensure that the battery does not undergo deep discharge, which can cause internal damage to the cells, potentially leading to short circuits and/or thermal runaway during charging, with a risk of fire. The lab manager must ensure this is done, but they are not necessarily responsible for carrying it out (see section 2 above).

Batteries should be stored at room temperature to avoid "thermal runaway" due to overheating from external heat sources. Ensure not to place (equipment with) batteries near heat sources, processes that generate heat, or in direct sunlight. To prevent heat buildup from the battery and equipment, do not cover batteries or equipment.

Storage must be at an appropriate distance from other flammable materials/liquids and escape routes.

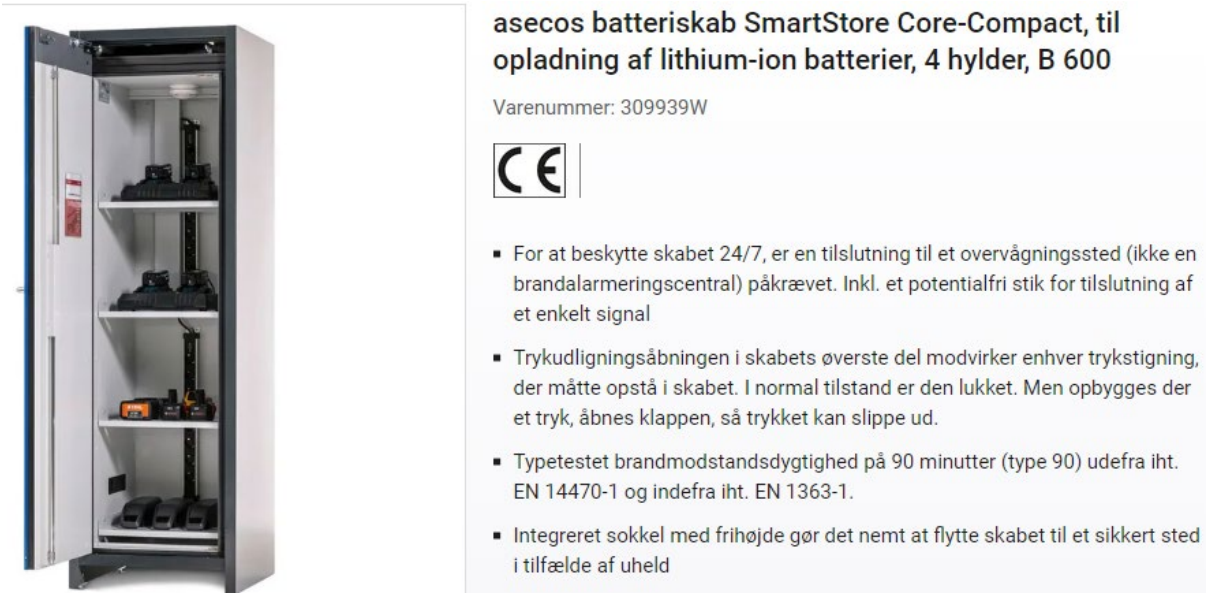
If you need to store non-integrated batteries with a total capacity of more than 10 kWh, you must contact Technical Services: 8888@sdu.dk and the TEK Building Committee[7].

Storage of lithium batteries/systems totalling 2,000+ kWh must be on the ground floor or basement level with level and safe access to the outdoors or in an outdoor container. The storage location must be approved by Technical Services and the TEK Building Committee.

Rechargeable batteries that are not permanently installed in equipment should, as a general rule, be stored and charged in battery cabinets with a fire resistance of at least 90 minutes from the inside,

[7] Find the members of TEK Building Committee here: https://sdunet.dk/en/enheder/fakulteter/teknik/praktisk-info-og-faciliteter/ombygninger-installationer-og-pladsudnyttelse

in accordance with EN 1363-1; for example, of this type (several suppliers are available, such as: https://safegroup.dk/):



Source: https://www.denios.dk/

Note: Be mindful of the capacity/performance you require: Type, size, and quantity of batteries. The supplier can advise on your specific needs.

Remember that the cabinet must be CE-marked, and a manual in Danish and English (if the users are international) must be provided as a minimum.

Contact Technical Services before purchasing a battery cabinet to ensure correct placement and connection, either directly at 8888@sdu.dk or via the TEK Building Committee: https://sdunet.dk/en/enheder/fakulteter/teknik/praktisk-info-og-faciliteter/ombygninger-installationer-og-pladsudnyttelse.

Note: Cabinets may only be installed according to the manufacturer's instructions and after approval of the location by SDU Technical Services.

6.4.1 Embedded Batteries in Equipment

As a general rule, the risk is considered significantly lower with purchased CE-marked equipment that has embedded batteries with a Battery Management System (BMS).

However, caution must still be exercised, and safety precautions must be taken, especially during charging, and it must be carefully considered where the equipment is best stored and charged.

The most important thing is to always follow the instructions in the manual. If there is no manual for the finished product with an embedded battery, follow the entire guideline for non-embedded batteries, and treat the entire product as if it were a battery pack.

See more in section 6.5 and appendices 2 and 3.

6.5 Charging

Some basic rules for safe battery charging are:

- Always follow the instructions in the manual.

- Batteries must be charged with appropriate chargers to ensure correct charging and avoid "Thermal Runaway" and, consequently, the risk of fire.
- Charging must take place in a room/area designed for charging with non-conductive/non-flammable materials. Charging must be monitored or carried out in a secure environment (e.g., battery cabinet or container). See section 6.4 above.
- Familiarize yourself with the battery specifications and never exceed them.
- Use a suitable charger/charging process according to the specifications (and remember that equipment must be CE marked).
- Special cases: If batteries or chargers are acquired without adequate documentation, it is the responsibility of the purchaser/receiver/any cell constructor to ensure such documentation is available.

Note: Avoid these mistakes, which can lead to battery fires (see also section 6 above):

1. **Electrical:**

   a. Overcharging of cells due to too high (final) charging voltage - incorrect charger/setting

   b. Overheating due to too high charging current - incorrect charger/setting

   c. Charging with incorrect polarity - incorrect charger/cables/usage

   d. Charging multi-cell battery packs without a BMS – can cause overcharging of one or more cells due to imbalance in the battery pack

   e. Charging batteries that are damaged or have become defective due to previous overcharging/undercharging

   f. Short-circuiting due to incorrect handling/connection to the wrong type of charger/load, etc.

   g. Excessive current draw during use

2. **Mechanical:** Damage to the battery, e.g., from tools or impacts on the battery
3. **Thermal:** Typically external heat exposure, or the battery cannot dissipate heat, e.g., due to covering/wrapping

6.6 Inspection of Batteries/Battery Systems and Accessories

If a battery or charger is damaged, there is a significant risk of personal injury, short-circuiting, and fire. Therefore, it is essential that rechargeable batteries and accessories are regularly inspected.

In your risk assessment, you must decide how often batteries and related equipment must be inspected. Always follow the instructions in the manuals as a minimum. If no inspection interval is specified, you must check the batteries at least every three months to avoid deep discharge.

Battery and accessory inspections can advantageously be carried out simultaneously with inventory checks (see section 2).

During inspection, the following points must be checked as a minimum, plus any other points mentioned in the manual/data sheet:

1. **Visual Inspection:**

- Visible damage to cells/casings and/or connections.
- For lithium batteries in pouches: Is the battery swollen?
- Are there any signs of leakage or liquid?

- Damage to plugs and cables (can possibly be repaired, and if not, must be replaced).
- Loose wires and/or damage to insulation.
- Is there a label on the battery with the agreed information (see section 6.4)? Remember to update the date – and update the battery inventory list (see section 2).
- Also check connectors. Damage to connectors can lead to short circuits or reduced performance and heat generation during use.
- For embedded batteries, check if there is damage to the equipment that the battery is embedded in, as part of the general inspection of electrical equipment.

2. State of Charge:

- Measurement of state of charge/cell balance.
- If the battery is deemed okay, bring it to the optimal state of charge for continued storage, or up to 100% if it is to be used immediately. Follow the manual's recommendations; otherwise, see section 6.4 for recommended state of charge during storage.

If the material has defects, repair it if possible (only cables/plugs where meaningful), otherwise dispose of the defective material according to applicable guidelines, see section 8 and Appendix 4.

Update the battery inventory/log list after completing the inspection.

6.7 Transportation of Batteries

It can be difficult to determine whether a battery must be shipped as dangerous goods and under which UN number. Therefore, the first step should always be to ask the manufacturer or importer for this information. Most manufacturers have a safety data sheet for their batteries. It is often called an MSDS, which stands for Material Safety Data Sheet. The MSDS will usually indicate whether the item is considered dangerous goods and under which UN number.[8]

With the correct information from the supplier, the task becomes relatively straightforward.

- Batteries installed in equipment or packaged in suitable packaging can generally be transported to the workplace without special requirements, as long as each battery is max. 110 Wh. However, this only applies if you are the user ("craftsman's rule").
- See section 9 regarding training requirements for transporting batteries.
- Most lithium batteries and battery cells must be manufactured and tested according to UN 38.3. Check the manufacturer's documentation.
- Batteries with medium or high performance/capacity (see sections 4 and 5 above) must be transported as dangerous goods and packed and labelled as such.
  Labelling:
  - Must be labelled as "dangerous goods," hazard label 9.
  - UN number and battery type must be on the warning label, e.g., "Lithium-Ion Batteries – UN 3480."
  - Remember to also add the phone number of the person responsible for the shipment.
  - The four UN numbers for lithium batteries are:
    - UN 3090 Lithium metal batteries (including cells), shipped loose
    - UN 3091 Lithium metal batteries (including cells), shipped installed or with equipment

[8] Source: https://www.isikkerhed.dk/raadgivning/batterier/. Here you can also find information on various battery types (in Danish).

- UN 3480 Lithium-ion batteries (including cells), shipped loose
- UN 3481 Lithium-ion batteries (including cells), shipped installed or with equipment

- Batteries must be transported in suitable containers/cases with inserts that protect the batteries from shocks and impacts.

Once the batteries are classified and assigned a UN number, depending on the mode of transport, you can refer to the ADR, IMDG, or IATA lists to see the requirements for transportation and how the batteries/equipment must be packed.

There is transport packaging available on the market specifically designed for this purpose (UN number). Guidance from the supplier or carrier is usually the easiest and fastest way to ensure correct packaging and transport.

Examples of transport packaging:

Example of labelling – both labels must be attached:

Note: Defective batteries may only be transported outside SDU's premises by specially trained personnel.

Contact Technical Services (8888@sdu.dk), who are responsible for hazardous waste collection at SDU, if the defective batteries cannot be safely brought to the disposal areas immediately, see Appendix 4.

7. Critical Incidents/Emergency Procedures

In the event of critical incidents, always follow TEK's guidelines and emergency plan. See "What to do in case of an acute accident?" points 1-3 at the top of this page: https://sdunet.dk/da/tek/safety. **Note: Remember that you are obligated to** familiarize yourself with emergency procedures; there is no time to find the information and understand it when an incident has already occurred. Also, remember that it is legally required to conduct a risk assessment of all work processes with special

risks; emergency procedures in the event of a critical incident must be included in this risk assessment.

See more in section 6.3.

For emergency procedures in case of electric shock and accident reporting, see the “Electrical Safety at TEK” guide, which you can find here: https://sdunet.dk/da/tek/safety.

You should only attempt to fight or limit a fire if you can do so without endangering yourself or others:

If there is a fire, or smoke from batteries without fire, it is crucial to avoid inhaling the smoke, as it is highly toxic. **As a general rule, you should not attempt to fight a fire involving lithium batteries personally. Start by calling 112 and evacuating the affected area.**

If the fire has started in a battery cabinet or battery room, do NOT open the cabinet or the door to the battery room.

Press a fire alert button if possible; where there is no fire alert button: always call 112 to summon the firefighting service (also, for example, in case of smoke from a relatively small battery). Follow the general Alarm Instructions in the SDU Emergency Plan: https://www.sdu.dk/en/om-sdu/fakulteterne/teknik/ledelse_administration/beredskab.

People who have inhaled smoke must be brought into fresh air immediately and you must seek medical attention; call 112 if there is an acute effect or if you are in doubt. It is important to provide information about the source of the smoke, e.g., which battery type, chemicals, or other materials are involved.

"Most lithium-ion batteries will generate gases, including toxic and flammable gas if thermal runaway occurs. For example, carbon dioxide (CO2), nitrogen oxides (NOx), hydrogen cyanide (HCN), hydrogen chloride (HCl), carbon monoxide (CO), and hydrogen fluoride (HF) may be produced. However, CO, NO2, and HCl are the primary gases released when thermal runaway occurs in a lithium-ion battery. CO has been found to be the primary gas for the longest time during the (fire) incident. [Gully et al., 2019]".

Also, be very aware of the risk of explosion and ejection of fragments from the fire.

Note: There may be residual voltage/energy ("stranded energy") in a battery after a fire. The equipment/battery must therefore be handled and stored under the assumption that there is a risk of electric shock and/or the risk of re-ignition of the fire up to days after the fire has been extinguished.

Note: Cleanup after a battery fire must be carried out ONLY by specially trained personnel (e.g., external emergency service). Users must not handle material or open battery cabinets/rooms after a fire.

8. Disposal[9]

All users of batteries, accumulators, and equipment with batteries are required to handle end-of-life units according to the applicable rules and regulations. SDU Technical Services ensure, through

[9]See also: ”Affaldsbekendtgørelsen” (Danish) chapter 7 onwards; esp. chapter 9 (§ 60 about batteries and electronics): https://www.retsinformation.dk/eli/lta/2024/573.

SDU's waste management system, that the guidelines are followed in connection with the final disposal.

Users are required to familiarize themselves with how the waste must be sorted and where it must be delivered at SDU. You can find more information here: https://sdunet.dk/en/servicesider/teknisk-service/affald. See also the guide on battery and equipment disposal below and in Appendix 4.

In case of doubt, contact Technical Services at 8888@sdu.dk.

Note the special provisions of the Battery Directive, particularly § 20, if you are building or importing batteries yourself.[10]

8.1 Disposal of Loose Batteries and Battery Cells

Just for your information: Used non-rechargeable batteries (e.g., 9V, AA, and AAA batteries in lab and office environments) must be placed in white containers which must be labelled correctly regarding content and placed together with other environmental waste. Contact your local waste manager[11] if there is a lack of containers for collecting end-of-life batteries.

Disposal of large batteries and emptying of smaller battery bins can be done in drum containers for used batteries, which are located in SDU's waste rooms; see Appendix 4 for their location at TEK.

For the disposal of large batteries that cannot be discharged or generally cannot be disposed of in the usual way (e.g., leaking batteries), contact Technical Services at 8888@sdu.dk.

If damaged batteries react, for example, by expanding, they should be discharged as carefully as possible (e.g., the battery can be placed in a fireproof battery bucket with sand during discharge, and the discharge is carried out at low current, e.g., 1/10 capacity). Then the battery is disposed of like other end-of-life batteries. See also section 8.3.

In case of smoke from or fire involving batteries, see section 7 on emergency procedures.

Exposed poles pose a risk of short-circuiting and must therefore always be protected from contact (e.g., covered with insulating tape or foil). This also applies to, for example, lithium button cells.

Batteries must, if possible, only be disposed of in a fully discharged state, i.e., as close to 0 volts as possible. *See also Appendix 4.*

[10] Statutory Order on batteries and accumulators and waste batteries and accumulators, https://producentansvar.dk/wp-content/uploads/2021/08/uk-bat-statutory-order-no-1186-dec-2009.pdf (a translation of: https://www.retsinformation.dk/eli/lta/2015/1453).

[11] Find your waste manager here: https://sdunet.dk/en/servicesider/teknisk-service/affald/farligt-affald

8.2 Disposal of Equipment with Embedded Batteries

Follow the instructions in the equipment manual for disposal.

If in doubt, ask the manufacturer. In the absence of instructions, batteries must, if possible, be removed from the equipment and disposed of like other batteries, see section 8.1.

If the battery or accumulator cannot be easily removed from the equipment, it is important to plan how this can be done safely to avoid accidents and, at worst, personal injury. Follow the manual and call qualified professionals if necessary.

In case of doubt regarding the disposal, contact Technical Services at 8888@sdu.dk.

8.3 Damaged Batteries – Handling and Safe Disposal

See Appendix 4 for a list of where you can dispose of both used and damaged batteries at TEK.

The general rule for large batteries is.

- End-of-life batteries, with or without faults/damage, that have been discharged must be placed in a drum container with a clamping lid in a waste room.
- Damaged batteries that cannot be discharged or for other reasons pose a particular risk must be placed in a drum container with a clamping lid, and Technical Services must be contacted for disposal.

For questions or if the battery is too large for the drum, contact Technical Services: 8888@sdu.dk.

Note: If the battery is smoking, leave the room and call 112. Otherwise, see section 8.1 about disposal.

9. Education and Training

Users must be instructed in laboratory safety related to working on battery systems: Protection with fuses, use of laboratory wires, equipment, measurement, and covering setups.

Several employees at TEK have attended a battery safety course held for TEK by the Danish Technological Institute in November 2023. The Institute must continuously assess whether there is a need to send more employees to a targeted battery safety course to ensure ongoing comprehensive safety instruction for all users. The local occupational Health & Safety group should be involved in the assessment.

In addition, supplementary electrical safety training EN50110 (e.g., L-AUS) is provided in connection with work on high-performance battery systems such as electric vehicles, mobile robots, Formula Student, UPS systems, Smart Grid, and generally whenever the total battery capacity exceeds 250 Wh.

Please note that special training, ADR, is required if you transport:

- Batteries with a capacity of over 100 Wh (lithium-ion batteries)
  AND
- You are not the user yourself – meaning you transport for others, are a technician, etc.

Special training is also required to transport defective batteries. See section 6.7.

Appendices and References

Appendix 1: Electrical Safety When Working with Batteries

Find more information about electrical safety in the "Electrical Safety at TEK" guide, which you can find here: https://sdunet.dk/da/tek/safety.

In section 13.c of the guide, you can see where at TEK you can find help and advice.

Appendix 2: Setup of Areas for Storage and Charging of (Equipment with) Large Batteries and Large Quantities of Batteries[12]

- A thorough risk assessment and emergency instruction must be conducted for rooms with large battery storage (both charging and storage of non-end-of-life and/or end-of-life batteries). The instruction must be visibly accessible to all users. In rooms with restricted access, such as workshops and laboratories, as well as battery and charging rooms at faculties/institutes, users must also receive verbal instruction. See Section 2 above on Roles and Responsibilities.
- Rooms with large quantities of batteries and/or charging of large batteries must be placed with level access to the outdoors.
- As a rule, we must keep storage to the necessary minimum to reduce risk. If the following limits are exceeded, special measures dictated by the Emergency Services are required; this applies to both indoor and outdoor storage. Contact Technical Services: 8888@sdu.dk and the TEK Building Committee:[13]
    - 2 MWh for functional batteries without defects and damage
    - 1 MWh for damaged batteries
- Ensure good access routes, also for emergency vehicles. Pay attention to access all the way from the outdoor emergency route to the material.
- Escape routes and emergency openings must be kept clear at all times.
- Signs must be placed on doors to rooms/cabinets/containers with large quantities of lithium batteries; they must state: "Lithium Batteries" and be designed as a safety sign. Signs can be requested from Technical Services via email 8888@sdu.dk; see also: https://sdunet.dk/en/servicesider/teknisk-service/inventar-og-udstyr/folie-og-skiltning.
- Signage must indicate "No open flames."
- There must be fire/smoke detection in the area, and preferably sprinkling if possible.
- Charging cables must be stored and placed to avoid damage from mechanical impact.
- Necessary ventilation and possibly cooling must be provided, and equipment/batteries must be placed so that cooling is not obstructed.
- Chargers and batteries must be placed on non-flammable surfaces or in battery cabinets/ fireproof cabinets. This also applies if a charger is mounted on a wall: the backing should also be made of non-flammable material.
- Surfaces on walls and ceilings within at least two meters of the charging/storage area must be clad in materials rated K1 10 / B-s1, d0; this corresponds to gypsum walls and ceilings.

[12] Source: https://www.brs.dk/da/virksomhed-institution/brandfarlige-virksomheder-og-oplag/krav-til-virksomheder-der-ikke-er-omfattet-af-bek/storre-oplag-af-litiumionbatterier/: *Vejledning om brandsikring af større oplag af litiumionbatterier samt BESS*, maj 2023; s. 26.

[13] See who is in the TEK Building Committee here: https://sdunet.dk/en/enheder/fakulteter/teknik/praktisk-info-og-faciliteter/ombygninger-installationer-og-pladsudnyttelse.

There must be no storage of materials within this area, with special attention that no flammable materials are present.

- The room's and building's other uses must be taken into account in a risk assessment, which is part of the decision on where large quantities of batteries can be stored.
- **Note**: Both indoor and outdoor large quantities of batteries must always be approved by Technical Services and the TEK Building Committee; see section 6.4.

Also, be aware of the Danish Emergency Management Agency's guideline on maintaining a minimum distance of 10 meters to neighbouring properties as well as road and path centrelines when storing in a container or outdoors.[14]

Appendix 3: Overview of Installed Battery Cabinets and Registered Storage at TEK

Appendix 3.1 Odense

Solution: Outdoor container
Location: Odense, east of TEK building 42
Contents: Batteries for SDU Vikings/Formula Student (cars)
Contact: Martin Houman Thygesen, IME

Solution: Battery cabinet with 4 shelves
Maximum effect (single-phase) [kW]: 3.68 / Maximum effect (three-phase) [kW]: 11.04
Location: Odense, TEK building 42, Ø27-508a
Contents: Drone batteries, lithium
Contact: Emad Samuel Malki Ebeid, IME

Appendix 3.2 Sønderborg

Drone Lab:
Solution: Battery cabinet with 5 shelves
Maximum power (single-phase) [kW]: 3.68 / Maximum power (three-phase) [kW]: 11.04
Location: Alsion D0.03
Contents: Drone batteries, lithium Polymer (NMC) without BMS
Contact: Søren Gejl Ilstrup Madsen, IME/CIM

BatteriLab:
Solution: Battery cabinet with 5 shelves
Maximum power (single-phase) [kW]: 3.68 / Maximum power (three-phase) [kW]: 11.04
Location: Alsion CIE 0.06
Expected Contents: Box batteries with BMS LiFePo4, Battery prototypes (research) LiFePo4
Contact: Henrik Andersen, IME/CIE

Appendix 3.3 Nordfyn – HCA Airport

Solution: Fireproof battery room with battery cabinet
Location: HCA Airport, Beldringe, room 1-16b-00
Contents: Drone batteries, lithium
Contact: Jussi Hermansen, MMMI

[14] Source: https://www.brs.dk/da/virksomhed-institution/brandfarlige-virksomheder-og-oplag/krav-til-virksomheder-der-ikke-er-omfattet-af-bek/storre-oplag-af-litiumionbatterier/: *Vejledning om brandsikring af større oplag af litiumionbatterier samt BESS*, s. 42.

Appendix 3.4 Munkebo, Lindø (LSP)

Limited storage of non-installed batteries, which are stored in ESD bags on shelves.
Installed lithium and lead-acid batteries.
The upcoming new facilities will be established with a separate battery room (spring/summer 2025).
Contact: Louise Møller or Christian Schlette, MMMI.

Appendix 4: Overview of Facilities for Battery Disposal at TEK

Indoor areas for end-of-life batteries and batteries with defects/damage are set up according to the guidelines in Appendix 2.

For handling and disposal of used and damaged batteries, see section 8 above. The general rule for large batteries is:

- End-of-life batteries, with or without faults/damage, that are discharged must be placed in a drum container with a clamping lid in the waste rooms.
- Damaged batteries that cannot be discharged or for other reasons pose a particular risk must be placed in a drum container with a clamping lid, and Technical Services must be contacted for disposal, 8888@sdu.dk.

You can find containers for disposing of end-of-life batteries in the waste rooms at TEK; see the following sections.

REMEMBER: Exposed poles pose a risk of short-circuiting and must therefore always be protected from contact (e.g., covered with insulating tape or foil). This also applies to, for example, lithium button cells.

Appendix 4.1 Odense

Outdoor round Waste Shed C (Ø35-600-1); located east of TEK building 42.
Large batteries that do not fit in the battery bins can also be placed here.

Waste room in TEK building 42:
Ø28-607c-1
(on the ground floor at the southern end of the building).

Mærsk-2, building 47:
Dream Lab area:
Ø21-608-00

Appendix 4.2 Sønderborg

Waste room 1 in the basement, level 0, Block B: B0.05.

Waste room 2, level 2, Block B: H2.04B.

Appendix 4.3 Nordfyn – HCA Airport

Drum container in fireproof battery room, room 1-16b-00.
When the container is about half full, place it in the waste container (chemistry container) outdoors.
A new drum must be acquired via TrueTrade.

Appendix 4.4 Lindø – The Harbour (LSP)

Users must bring their own end-of-life batteries back to the Odense campus for disposal. If the battery is damaged or otherwise poses a particular risk, you must not transport it yourself. Contact Technical Services at 8888@sdu.dk to have it picked up.

Appendix 5: Various References and Sources

The Battery Directive
https://eur-lex.europa.eu/eli/reg/2023/1542/oj

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006L0066-20180704

Danish Producer Responsibility, Legislation on batteries and end-of-life batteries:
https://producentansvar.dk/en/products-and-responsibility/legislation/batteries-legislation/

Regulation on batteries and accumulators and end-of-life batteries and accumulators (Danish):
https://www.retsinformation.dk/eli/lta/2015/1453

Order on import and sale as well as export of batteries and accumulators (Danish):
https://www.retsinformation.dk/eli/lta/2015/870

The Danish Emergency Management Agency: https://www.brs.dk/en/

The Danish Safety Technology Authority: https://www.sik.dk/en

The Waste Management Order (Danish): https://www.retsinformation.dk/eli/lta/2024/573

The Environmental Protection Act, §§ 9.u and onwards (Danish):
https://www.retsinformation.dk/eli/lta/2024/928

ADR Convention (Danish):

- *https://www.brs.dk/da/virksomhed-institution/transport-af-farligt-gods/regler-og-myndigheder/adr-konventionen/*
- *https://fstyr.dk/Media/638185390852001759/Konvention%20om%20International%20Transport%20af%20Farligt%20Gods%20ad%20Vej%20ADR%202023.pdf*

Miscellaneous (Danish):
https://safegroup.dk/blog/7-gode-raad-der-minimerer-brandfaren-ved-litium-ion-batterier