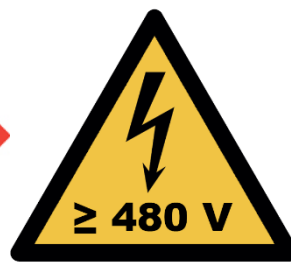
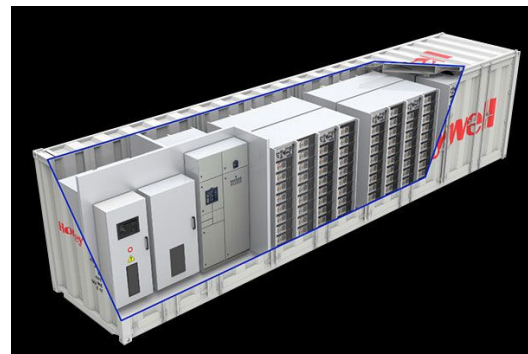
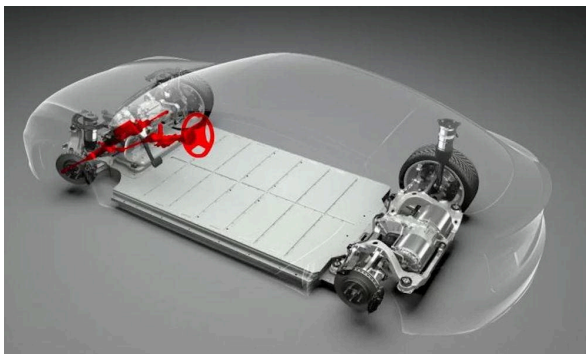


## Engineering Safety Policy (ESP)

### ESP-001: Lithium-Ion Battery Research



**IN CASE OF EMERGENCY:**

Police/Fire/EMS: (704) 687-2200

University Environmental Health and Safety: (704) 687-1111

Revision: C

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Questions? Contact the Facility and Laboratory Safety Engineer

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## Contents

1. Scope .....	3
2. Hazards .....	3
3. Administrative Policies .....	4
4. Thermal Runaway and fire prevention.....	4
5. High voltage safety.....	4
6. Handling.....	5
7. Housekeeping and storage .....	6
8. Disposal.....	6
9. Charging.....	6

## 1. Scope

This document describes the hazards of working with lithium-ion (li-ion) batteries, best practices for minimizing the risks associated with those hazards, and activities and conditions that must be avoided while working with li-ion batteries.

This document is only intended for research on li-ion batteries and their materials, and experimental assembly of li-ion batteries into packs/modules or other in-house designed and built components.

This document is not for installation and use of “off-the-shelf” li-ion batteries into consumer good as their intended purpose. E.g. computers, phones, drones, cameras, etc.

## 2. Hazards



Many li-ion batteries contain a liquid electrolyte. If this electrolyte leaks from the battery, whether from a casing rupture, or intentional disassembly, it can be harmful to humans. Proper chemical hygiene must be followed when a risk of exposure to the liquid electrolyte exists.



If improperly handled or utilized, li-ion batteries may become thermally unstable without any warning. This condition, known as “thermal runaway”, may cause off-gassing, fire, or deflagration without any advanced warning.



Li-ion batteries always have electrical energy within them. They cannot be turned “off” and are considered a live electrical source. Depending on the configuration, battery packs may easily fall into “high voltage” ( $\geq 50V$ ) category and must be handled as such.



Hot work is defined as “operations capable of producing a source of ignition”. Because of the hazards of a thermal runaway event, work involving li-ion batteries shall be considered “hot work” and subject to the associated policies.

### 3. Administrative Policies

- 3.1. If battery storage is being constructed for the purpose of powering some device, the li-ion battery cells/modules/packs that are being purchased to construct the battery **shall** be UL listed, or otherwise tested and certified by a Nationally Recognized Testing Laboratory (NRTL) as recognized by the Occupational Safety and Health Administration (OSHA).
- 3.2. After work involving li-ion batteries, **do not** leave the space unattended for at least 30min after.
- 3.3. **Do not** assemble multiple batteries into a pack that are from different manufacturers, different chemistries, and/or different form factors.

### 4. Thermal Runaway and fire prevention

- 4.1. The UNC Charlotte Environment Health and Safety office defines “hot work” as: *Any process that can be a source of ignition when flammable material is present or can be a fire hazard regardless of the presence of flammable material in the workplace.* Although EHS does not recognize work involving li-ion batteries as “hot work” the College of Engineering recognizes that li-ion batteries can be both an ignition source and fuel source in the case of thermal runaway. As such, the College of Engineering imposes the same restrictions on the work on li-ion batteries as any other hot work.
  - 4.1.1. Work **shall** only be conducted in recognized hot work areas (contact the LCOE safety engineer for a list of permitted spaces).
  - 4.1.2. Work **shall** be conducted a minimum of 35 feet away from flammable or combustible material. Otherwise work **shall** be separated from flammables or combustibles by a rated partition.
  - 4.1.3. A fire extinguisher **shall** be present in the same space as the work activity.
  - 4.1.4. Smoke and/or heat detectors, integrated with the building fire alarm system, **shall** be present in the same space as the work activity.
  - 4.1.5. Work **shall** be conducted in a space with a means of ventilation, either natural or mechanical, directly to the outside.
- 4.2. **Under no circumstances** should an experiment be performed that could reasonably be expected to cause a li-ion battery to vent, smoke, catch fire, or deflagrate, outside of a suitable enclosure vented to the outside.
- 4.3. If a li-ion battery experiences an uncontrolled thermal runaway **do not** attempt to extinguish it. Evacuate the building and sound the building fire alarm.

### 5. High voltage safety

- 5.1. **Do not** work on li-ion batteries on an electrically conductive work surface.
- 5.2. Work involving li-ion batteries **shall** follow OSHA 1910 Subpart I for Electrical Personnel Protective Equipment.

- 5.2.1. Live electrical equipment (including batteries) operating at 50 volts or more **shall** be guarded against accidental contact.
- 5.2.2. Live electrical equipment (including batteries) operating above 50 volts **shall** be evaluated for arc flash protection by University EHS.
- 5.2.3. Proper arc flash Personal Protective Equipment (PPE) meeting NFPA 2112 **shall** be worn while performing work on li-ion batteries, or electrical circuits energized by li-ion batteries at a voltage of 50V or greater.
- 5.2.4. Electrically insulating tools, or electrically insulating PPE **shall** be used when working on li-ion batteries, or circuits energized by li-ion batteries, at 50 volts or greater.
- 5.3. Battery assemblies with a voltage above 50 volts **shall not** have exposed conductors.

## 6. Handling

- 6.1. **Do not** handle li-ion batteries that have been damaged, or otherwise used outside of the manufacturer's recommendations. **Do not** underestimate the risk in handling damaged or abused li-ion batteries.
- 6.2. **Under no circumstance** should a battery that is at elevated temperature, venting, smoking, or on fire be handled by any person.
- 6.3. **Do not** disassemble a li-ion battery outside of a suitable enclosure. E.g. glove box.
- 6.4. **Do not** place batteries between any occupied space and the exit. **Do not** block any egress pathway with batteries, battery work areas, or battery charging areas.
- 6.5. The materials of construction of a li-ion battery **shall** be handled according to the Safety Data Sheet (SDS) for that particular battery. If an SDS for a particular battery is unavailable, then the SDSs for the individual materials **shall** be used.
- 6.6. Li-ion batteries that have been damaged, or otherwise used outside of manufacturer's recommendations **shall** be handled by personnel only after they have been confirmed to not be thermally unstable.
- 6.7. Personnel handling li-ion batteries that have been damaged, or otherwise used outside of manufacturer's recommendations, **shall** wear fire-resistant clothing meeting, at a minimum, NFPA 2112, NFPA 1950, or SFI 3.2a/1. Clothing worn while handling these batteries **shall** include:
  - 6.7.1. Long-sleeved shirt and pants (or coveralls)
  - 6.7.2. Gloves
  - 6.7.3. Hood
  - 6.7.4. Helmet with face shield

*Understand that the above precautions will not protect the wearer from all injury in the case of a li-ion battery deflagration. The use of fire-resistant PPE may reduce the severity of injury.*

## 7. Housekeeping and storage

- 7.1. An egress pathway with a minimum width of 36 inches **shall** be maintained, free of obstructions, between any battery working area and the exit to the space.
- 7.2. Li-ion batteries **shall** be stored according to the manufacturer's recommendations. If the manufacturer's recommendations for a specific battery do not exist, then the recommendations for the most similar product, in terms of chemistry and form factor, **shall** be followed.
- 7.3. Li-ion batteries **shall** be stored separated from other materials in such a way as to prevent accidental arcing or short circuiting.
- 7.4. Li-ion batteries that have been damaged, or otherwise used outside of manufacturer's recommendations, **shall** be stored in ventilated container, of non-combustible construction, with no other materials within.

## 8. Disposal

- 8.1. Li-ion batteries **shall not** be disposed of in regular trash or recycling.
- 8.2. Disposal of all li-ion batteries **shall** be coordinated by University EHS. To prepare batteries for disposal, each individual battery **shall** have its terminals taped, and placed in its own zipper bag (Ziploc or equivalent). The packaged batteries **shall** be buried in vermiculite (or other suitable material) inside a clean, non-combustible container.

## 9. Charging

The following procedures for charging are taken from New York City Fire Code. The 2022 edition was the most current at time of writing. The exact code sections will be quoted below.

### *309.3.3 Battery charging areas*

*...devices using a storage battery **shall** be charged in a suitable indoor room or area or outdoor location that:*

- 1. has sufficient natural or mechanical ventilation in accordance with the Mechanical Code to prevent the accumulation of any flammable or other gases that may be discharged during normal charging operations;*
- 2. has an adequate electrical supply and a sufficient number of electrical receptacles to allow the charging equipment for each device to be directly connected to a receptacle. Extension cords and power strips **shall not** be used. A minimum of 3 feet **shall** be maintained between each device during charging operations;*
- 3. has an adequate electrical supply and a sufficient number of electrical receptacles to allow the charging equipment for battery packs and other removable storage batteries to be directly connected to a receptacle. Extension cords and power strips **shall not** be used. Battery packs and other removable storage batteries shall not be stacked or charged in an enclosed cabinet (unless*

*the cabinet is specially designed and approved by the department for such purpose). Except as otherwise approved by the department, a minimum distance of 2 feet shall be maintained between each battery pack or other removable storage battery during charging operations, provided that the aggregate energy capacity of battery packs or other removable storage batteries that can be charged in a single fire area does not exceed 20 kWh. A minimum distance of 3 feet **shall** be maintained if the aggregate energy capacity exceeds 20 kWh. The aggregate energy capacity of battery packs or other removable batteries that can be charged in a single fire area shall not exceed 50 kWh;*

- 4. is not used for the storage of combustible materials, combustible waste or other hazardous materials;*
- 5. is separated by a fire barrier with a minimum one-hour fire-resistance rating from areas in which repairs or other servicing is conducted on the storage battery or other electrical components of the device.*
- 6. where six or more devices using a storage battery are being charged at a single indoor location, is dedicated for battery charging and secured from unauthorized entry; separated by a fire battier which encloses the entire space with a minimum one-hour fire-resistance rating; and protected by a fire sprinkler system and one or more smoke detectors or smoke alarms. If the building or occupancy is equipped with a fire alarm system, the smoke detector **shall** be connected to such system. If the ambient temperature of the room during battery charging operations exceeds the limitations set forth in the manufacturer's instructions or the equipment listing, the room or area shall be temperature controlled to prevent over-heating or other unsafe battery condition; and*
- 7. is provided with a portable fire extinguisher...having a minimum 4-A:20-B:C rating.*

#### *309.3.4 Storage areas.*

*Indoor storage rooms or areas or outdoor enclosures used for the storage, but not charging or repair, of devices using a storage battery **shall** comply with the requirements of 309.3.3(4), (5) and (7).*