Lithium Battery Safety, Handling, and Storage

STPS-SOP-0018
Version 1

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Risk Factor: 1

This document applies to the following locations:

DEN ☐	CHC ☐	PTH ☐	McM ☐	SP ☐	PAL ☒	NBP ☒	LMG ☒

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Version History

Version #	Date	Section (if applicable)	Author/Editor	Change Details
1	Aug 2015	All	Jamee Johnson Dean Hancock	New document

The document library holds the most recent versions of all documents.

Approved by:

Peninsula Implementation Manager — date 8/12/15

Approved by:

Hazardous Materials Specialist — date 8/24/15

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Purpose

This document will serve as guideline for the safe handling, use, and storage of lithium batteries in the United States Antarctic Program (USAP).

Authorities and Mandates

This document has been created to satisfy recommendations of NSF SLEP inspectors, JMS Naval Architects and Salvage Engineers, pursuant to RVSS 9.4 and NSTM555. Recommendations in this document are based on Woods Hole Oceanographic Institution, safety document SG-10, and UNOLS lithium battery safety circular May 2012.

Pursuant to 49 CFR 173.185 all shipments of hazardous materials must comply with packaging regulations based on recommendations made by the United Nations. Fines and penalties for non-compliance can be substantial.

Risk Factor

This procedure is assigned a risk factor of 1.

Lithium batteries can be dangerous, and their handling and storage should be done with care.

Applicability

This document is applicable to USAP Peninsula support, including Palmer Station and the Research Vessels. These include the ***Nathaniel B Palmer*** (NBP) and the **Lawrence M Gould** (LMG).

Responsibilities

The following responsibilities are assigned as indicated:

Peninsula Implementation Manager

The Peninsula Implementation Manager will be responsible for primary development of this program and identification of hazardous materials that are being shipped to Palmer Station or the Research Vessels.

Hazardous Materials Specialist

The Hazardous Materials Specialist will review this document and will assist in identifying Lithium Battery hazards in the program.

Peninsula Logistics

Peninsula Logistics personnel will make sure that all shipments of Lithium Batteries include proper SDS documentation and Dangerous Goods declarations.

Marine Laboratory Technician

The Marine Lab Technician will properly store and handle batteries on the research vessels, and review safety information with grantees and Edison Chouest crew.

Palmer Assistant Lab Supervisor

The Palmer Assistant Lab Supervisor will properly store and handle batteries at Palmer Station, and review safety information with grantees and emergency teams at Palmer Station.

Electronic Technicians

Will follow safety procedures when assembling battery packs and handling batteries.

Waste Technician

Will review document, follow departmental procedures for cleaning up and disposing of hazardous waste.

Background

Lithium Cell Types

There are two types of lithium battery cells in common use:

Primary or Non-Rechargeable Metallic Lithium Cells

Primary Lithium batteries feature high energy density and long shelf life. They are generally used for smoke alarm, LED lighting and outdoor devices. However they are not rechargeable and totally different than Li-Ion batteries.

These cells are constructed with metallic lithium. The metallic lithium in a non-rechargeable primary lithium battery is a combustible alkali metal that self-ignites at 352°F, *and when exposed to water or seawater reacts exothermically and releases hydrogen.*

Secondary or Rechargeable Lithium Ion Cells

Rechargeable secondary cells utilize lithium ions that are intercalated into graphite, lithium metal oxides and or lithium salts. There is no metallic lithium in a lithium ion battery.
Lithium ion cells prefer partial discharge to deep discharge, so it's best to avoid completely discharging the battery. If the voltage of a lithium-ion cell drops below a certain level, it's ruined. Since lithium-ion chemistry does not have a "memory", you do not harm the battery pack with a partial discharge.
These batteries do age and have a maximum shelf life of three years, even when unused.
And finally, avoid using or storing rechargeable Lithium cells at elevated temperatures as heat degrades these batteries.

Because of the differences in the chemistries of the two types of Lithium batteries and the resulting differences in emergency procedures, non-

rechargeable primary Lithium batteries should be stored separately from rechargeable Lithium ion batteries.

Cell Handling Procedures

The primary hazard associated with both primary and secondary lithium batteries is short circuiting. Short circuiting allows current to follow an unintended path, potentially causing overheating, circuit damage, fire or explosion.

Hazards can be minimized by following the guidelines below:

- Always wear safety glasses when handling batteries.
- Remove jewelry items such as rings, wristwatches, pendants, etc. that could come in contact with battery terminals.
- All dented cells or batteries with dented cells should be disposed, regardless of electrolyte leakage. Denting of sides or ends of batteries increases the likelihood of developing an internal short circuit at a later time.
- Cover all metal work surfaces with an insulating material such as an anti-static mat. Work areas should be clean, dry and free of sharp objects that could puncture the insulating sleeve on each cell.
- If cells are removed from their original packages for inspection, they should be arranged to preclude shorting. Do not stack or scatter the cells. They should be placed in non-conductive carrying trays with individual compartments for each cell.
- Cells should be transported in non-conductive trays. This will reduce the chances or cells being dropped, causing shorting or other physical damage.
- All inspection tools (including calipers, rulers, etc.) should be made from or covered with a non-conductive material.
- Measure the open-circuit-voltage (OCV) of the cell. The Nominal OCV for each cell's chemistry is printed on the cell label or the manufacturer’s data sheet. An open circuit voltage of 0.0 volts may be indicative of a blown fuse. However, if no fuses are present in the circuit, 0.0 volts could be a result of complete discharge.
- After a cell has been inspected it should be returned to its original container, if possible.
- If leads or solder tabs need to be shortened, only cut one lead at a time. Cutting both leads at the same time can short the cell.
- Never touch a cell case directly with a hot soldering iron. When making battery packs, always use cells with factory solder tabs. Heat sinks should be used when soldering to the tabs and contact with the solder tabs should be limited to a few seconds.
- Cells should not be forced into battery holders or other types of housings. This could deform the bottom of the case causing an internal short circuit. Furthermore the terminal cap could be crushed putting pressure of the glass to metal seal. This could result in a cell venting. Check for proper fit before inserting the cells into any type of housing.

- Excessive force should not be used to free a cell or battery lodged inside a housing.
- Cells and/or batteries should not be exposed to high voltage AC sources or other DC power supplies that could result in subjecting the cells to unanticipated charging or forced-discharging currents. Secondary cells should be charged only according to the cell or battery manufacturer's directions, particularly with respect to maximum applied voltage.

Cell Storage

- Cells should be stored in their original containers.
- Store the cells in a well ventilated, dry area. The temperature should be as cool as possible to maximize shelf life. Observe the manufacturers minimum and maximum storage temperatures.
- Store the cells in an isolated area, away from combustible materials. Store depleted cells in an area separate from fresh cells. Allow space for complete encapsulation with class D fire extinguishing powder in the event of a fire.
- Any primary lithium battery storage should have immediate access to both a class D and ABC fire extinguisher.
- Never stack heavy objects on top of boxes containing lithium batteries to preclude crushing or puncturing the cell case. Severe damage can lead to internal short circuits resulting in a cell venting, or explosion.
- Do not allow excessive quantities of cells to accumulate in any storage area.
- On the vessels, batteries should be stored in the Hazlocker or Chem Van whenever possible. At Palmer Station batteries should be stored in the corrosives locker.
- Do not store batteries on the floor, particularly on the vessels where they may encounter seawater
- Always stow batteries carefully to avoid accidental damage, discharge, flooding, or short circuiting.

Assembling Battery Packs

Electronics Technicians or Instrument Technicians may occasionally be assembling battery packs, or manufacturing battery packs from cells. It's important to follow safety precautions when selecting and soldering batteries into assemblies.

Note Always obtain and review manufacturer's specifications for the cells being used. It is important to know the working limits of the cells selected.

- Always wear safety glasses when assembling battery packs
- All jewelry should be removed so that the cell isn't inadvertently short circuited.
- Always use the same size cells in series or parallel connections.
- Cells fabricated into a battery pack should be of the same age (lot code) and history.
- Primary and secondary cells should not be mixed together in a battery pack.

- Partially discharged cells should not be mixed with fresh cells in a battery pack.
- Cells should not be placed on electrically conductive or wet surfaces. All work surfaces should be constructed with non-conductive materials.
- Do not solder directly on the cell case. Only solder to the solder tabs welded to the case.
- Solder tabs that extend from the case and terminal cap should be insulated.
- Avoid cutting or piercing the insulating shrink wrap on the cells.
- Loose wires should not be stripped until it is time to install a connector. If not connector is used, wire ends should be insulated.
- Should wire trimming be necessary, only cut one wire at a time.
- All battery packs should be labeled with the appropriate warnings as they appear on the cell label.
- Certain potting compounds are exothermic (release heat) when they are set. It is important that the maximum temperature of the cell is not exceeded during the potting process.

Battery Shipment

All batteries must be made safe for handling prior to packing for shipment. For the US Antarctic program, it is important to follow IMDG (International Maritime Dangerous Goods) code. Shipments to and from Antarctica are likely to use multi-modal routing, including shipment by sea, land and commercial and passenger aircraft. It is important that the shipper know and declare both primary and secondary batteries contained in equipment. Shippers must provide SDS's for all shipments including lithium batteries.

The USAP logistics department, Marine Laboratory Technicians and Peninsula Implementation manager are IMDG certified, and can assist grantees and ASC personnel with selecting and packaging batteries correctly.

Note It is the responsibility of the shipper to provide proper shipping documentation, including an SDS, and to declare all hazardous materials, including lithium batteries in cargo.

Emergency Procedures

Releases from Cells (Vented, Leaked or Exploded)

The electrolyte contained within the lithium cells can cause severe irritation to the respiratory tract, eyes and skin. In addition, violent cell venting could result in a room full of hazardous air contaminants, including corrosive and flammable vapors. All precautions should be taken to limit exposure to the electrolyte vapor. Review SDS information prior to working with cells to be prepared in case of a release. The Marine Laboratory Technician or Palmer Assistant Lab Manager should prepare, distribute and file the SDS' and stoplight plans with the appropriate emergency teams.

Hazards

- Lithium batteries may emit a colorless to pale yellow gas with a sharp, pungent odor.
- The electrolyte contained in lithium cells can cause severe irritation to the respiratory tract, eyes and skin.
- Potential hazards may include the release of Thionyl Chloride, bromide, chlorine dioxide, hydrochloric acid, sulfur dioxide, sulfuryl chloride gasses, strongly acidic waste water and hydrogen produced by chemical reactions. Consult SDS and DOT 2012 Emergency Response Guide (ERG)

Emergency Actions

Employees and grantees:

- Warn others of the emergency. Pull a fire alarm or call the bridge (x200)
- Evacuate to a safe area
- Attend to any person who has been exposed to the material, if safe to do so.
- Muster if appropriate and wait for further instructions

MPC/Station Manager

- Ensure that personnel have properly evacuated and that injured personnel are attended to.
- For Marine: notify the captain of the event
- Review SDS for materials
- Assess the extent and magnitude of the release
- Determine if further evacuation is required
- Determine if the emergency response team must be mobilized

  Oversee response, neutralization and cleanup and disposal of released materials.

Handling a Hot Cell

- As soon as it has been determined that a hot cell exists, completely evacuate all personnel from the area.
- Notify the bridge and/or emergency response teams as necessary.
- If it is safe to do so, determine if in external short circuit is present and remove it as quickly as possible.
- The area should remain evacuated until the cell has cooled to room temperature.
- Using appropriate PPE (Personal Protective Equipment), and after a cell has been cooled to normal temperature, the cell should be removed from the work area. All “hot” cells should be disposed of as hazardous waste.

Note Some cell chemistries may enter a thermal runaway reaction beyond a certain temperature, thus a cell may continue to gain heat and may be a cascade to other cells.

Fire

- On the vessels, notify the bridge (x200) and shipboard firefighting will combat the fire.
- Only trained and qualified personnel should attempt to fight a lithium or lithium ion battery fire.
- Battery fires that are beyond the incipient stages may require PPE such as self-contained breathing apparatus (SCBA) and heat/fire bunker gear.
- In addition to the battery itself, packaging materials, plastics, electronic equipment and flammable solvents may be involved in a fire.

Lithium (Primary, Non-Rechargeable) Batteries

- Lithium will burn in a normal atmosphere and reacts explosively with water to form hydrogen. The presence of minute amounts of water may ignite the material and hydrogen gas. Lithium fires can also throw off highly reactive molten lithium metal particles. Cells adjacent to any burning material could overheat causing a violent explosion.
- Use an extinguishing agent that is best suited to quench the bulk of the fuel that is available. For example, if a single cell were to start burning, use a class D extinguisher to quench the fire.
- If other combustibles catch fire as a result of the lithium battery, then use the appropriate extinguishing agent to douse the secondary fires. It is important to address each type of fire with the appropriate extinguishing agent.
- When using a class D extinguisher, completely bury the burning material with the extinguishing agent.
- Class D extinguishers can be found in the hazardous materials lockers on each vessel.

Lithium Ion (Secondary, Rechargeable) Batteries

- Rechargeable, secondary cells utilize lithium ions that are intercalated into graphite, lithium metal oxides and/or lithium salts. **There is no metallic lithium in a lithium ion battery.**
- Because there is no metallic lithium in a lithium ion battery, ordinary extinguishing agents (for example, an ABC extinguisher) can be used effectively on a fire involving lithium ion batteries.

Lithium Battery Fire Extinguisher Selection

The table below provides a summary of recommendations for selecting fire extinguisher for lithium batteries, lithium ion batteries and secondary fires.

Table 1: Lithium Battery Fire Extinguisher Selection

Battery Type	Fires involving **Batteries Only**	Fire involving **Batteries and Other Materials**
Lithium Primary, Non Rechargeable	**Class D extinguishing agent.** **DO NOT USE WATER**	Use an **ABC dry chemical extinguisher** or **water** hose stream Fight the fire based on the fueling material (for example, paper, plastic, solvent, etc.)
Lithium Ion Secondary, Rechargeable	Use an **ABC dry chemical extinguisher** or water hose stream. Fight the fire based on the fueling material.	Use an **ABC dry chemical extinguisher** or **water** hose stream. Fight the fire based on the fueling material.

First Aid procedures

In case of contact with electrolyte, gases or combustion byproducts from a lithium battery or lithium ion battery release, the following first aid measures should be considered:

- Eyes: Immediately flush eyes with a direct stream of water for at least 15 minutes with eyelids held open to ensure complete irrigation of all eye and lid tissue. Get immediate medical attention
- Skin: Flush with cool water or get under a shower, remove all contaminated garments. Continue to flus for at least 15 minutes. Get medical attention, if necessary.

  Inhalation: Move to fresh air. Monitor airway, breathing and circulation. Take appropriate CPR actions, if necessary. Seek immediate medical care.

Clean up Procedures (for qualified/trained personnel)

- Don appropriate PPE (in this case a lab coat, gloves, safety glasses, respirator, SCBA, hazmat suit, depending on conditions.)
- Vent the area, if necessary
- Place leaking cell in a sealable bag and cover with a mixture of neutralizing agent (soda ash or baking soda) and absorbent material (vermiculite). Double bag the leaking cell and seal the bag.
- Absorb/neutralize any spilled electrolyte with absorbent material and neutralizing agent. Collect the contaminated absorbent into a sealable bag.
- After removing the cells and any absorbent/neutralizing materials, the area can be cleaned with water or ammonia based cleaner.
- Place all waste materials in an appropriate container, prepare a ***Hazardous Waste Identification Sheet*** (IO-FRM-0014) (HWIS), as described in ***Waste Management/Hazardous Waste SOP 1.0 Generation and***

Generator Accumulation (IO-SOP-0263). If necessary, turn materials over to Palmer Station Waste personnel.

Waste Concerns

At Palmer: Waste primary and secondary batteries will be collected, stored and disposed of by the Waste teams at Palmer Station. There are collection points for alkaline batteries in the lab areas. **Do Not** put primary or secondary lithium batteries in alkaline collection areas. Please fill out an **HWIS** and alert the Palmer waste department that there are lithium batteries waiting to be collected.

On the vessels: There are collection points for alkaline batteries on the vessels. **On the NBP** there is a container for alkaline batteries and one for lithium batteries. **Do not** mix the two collection streams. When adding materials to the lithium battery collection box, be sure that terminals are insulated so that batteries can't short circuit inside of the collection box.

On the LMG the battery collection point is in the electronics lab. This container is for alkaline batteries only. Any lithium batteries should be delivered to the Marine Laboratory Technician, who will add them to the waste stream for delivery to Palmer Station. **Do not** put lithium batteries in the alkaline battery box.

References

- UNOLS RVSS - Eighth Edition – March 2003, Chapter 9.4
- NSTM555 – Shipboard Fire Prevention and Fire Marshal Tactics, Techniques and Procedures (TTP) March, 2014
- Code of Federal Regulations (annual edition) Title 49 – Transportation, Subtitle B - Other Regulations Relating to Transportation- 49 CFR 173.185
- Woods Hole Oceanographic Institution, safety document SG-10
- UNOLS lithium battery safety circular May 2012.
- ***Hazardous Waste Identification Sheet*** (IO-FRM-0014)
- ***Waste Management/Hazardous Waste SOP 1.0 Generation and Generator Accumulation*** (IO-SOP-0263)

Records

This process currently generates no records, but the table below has been left in place for future use.

Table 2: Records

Record ID (& Owner)	Format & Location	Protection & Retrieval	Retention & Disposition
Title or description (record owner)	Electronic or hardcopy? Which software? Where is that kept?	How is it kept from the world? (Limited access folder?) How do you get a copy?	How long do you keep it? Then what happens to it? (Archived indefinitely?) (Destroyed?)

Appendices

This document currently contains no appendices.

Glossary

CPR

Cardiopulmonary Resuscitation

HWIS

Hazardous Waste Identification Sheet (IO-FRM-0014)

IMDG

International Maritime Dangerous Goods

LMG

Lawrence M Gould

NSTM555

Surface Ship Firefighting document

NBP

Nathaniel B Palmer

OCV

Open circuit voltage

PPE

Personal Protective Equipment
Anything which may be required to perform a particular job: rubber gloves (nitrile, butyl, etc.), safety goggles, and similar gear.

Primary or Non-Rechargeable Metallic Lithium Cells

These cells are constructed with metallic lithium. The metallic lithium in a non-rechargeable primary lithium battery is a combustible alkali metal that self-ignites at 352°F, and when exposed to water or seawater reacts exothermically and releases hydrogen.

RVSS

Research Vessel Safety Standards

Secondary or Rechargeable Lithium Ion Cells

Rechargeable secondary cells utilize lithium ions that are intercalated into graphite, lithium metal oxide's and or lithium salts. There is no metallic lithium in a lithium ion battery.

SCBA

Self-Contained Breathing Apparatus

UNOLS

University-National Oceanographic Laboratory System

USAP

United States Antarctic Program