



# Lithium Batteries: Safety, Handling, and Storage

STPS-SOP-0018

Version 6, September 2022

Last Reviewed: September 2022

Risk Factor: 1

**This document applies to the following locations:**

ALX <input type="checkbox"/>	CHC <input type="checkbox"/>	DEN <input type="checkbox"/>	FLD <input type="checkbox"/>	LMG <input checked="" type="checkbox"/>	MCM <input type="checkbox"/>	NBP <input checked="" type="checkbox"/>	PAL <input checked="" type="checkbox"/>	PTH <input type="checkbox"/>	PUQ <input type="checkbox"/>	SPS <input type="checkbox"/>
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Prepared by the Antarctic Support Contractor  
for the  
National Science Foundation Office of Polar Programs

## Version History

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Version #	Date	Section (if applicable)	Point of Contact/Editor	Change Details
1	Aug 2015	All	J. Johnson D. Hancock	Initial draft and release.
2	September 2016	All	J. Johnson R. Powers	Reviewed with minor content changes. Updated formatting and cover sheet.
2	September 2017	All	L. Neidel	Annual review – No changes to content.
3	September 2018	All	Belcher	Annual review – No changes to content.
4	September 2019	All	J. Johnson D. Earl	Annual review; changed throughout to conform to the current ASC SOP template.
4	October 2020	N/A	J. Johnson D. Earl	Annual review; no changes to content.
5	August 2021	All	J. Johnson J. Baird	Changes throughout document.
6	September 2022	Responsibilities, Background, References	J. Johnson / T. Bjokne	Annual review complete – minor changes

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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 National Science Foundation (NSF) Service Life Extension Program (SLEP) inspectors, JMS Naval Architects and Salvage Engineers, pursuant to University National Oceanographic Laboratory System (UNOLS) *Research Vessel Safety Standard* (RVSS), section 9.4 and the *Naval Ships Technical Manual* (NSTM), Chapter 555. Recommendations in this document are based on Woods Hole Oceanographic Institution, safety document SG-10, and UNOLS lithium battery safety circular from May 2012.

Pursuant to Title 49 of the Code of Federal Regulations (CFR), section 173.185, *Lithium Cells and Batteries*, 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/storage should be done with care.

## Applicability

This document is applicable to USAP Peninsula support, including Palmer Station and the research vessels RVIB *Nathaniel B. Palmer* (NBP) and ARSV *Laurence 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 lithium batteries 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 USAP.

### Peninsula Logistics

Peninsula Logistics personnel will make sure that all shipments of lithium batteries include proper Safety Data Sheet (SDS) documentation and dangerous goods declarations with appropriate UN shipping numbers.

## Marine Laboratory Technician

The marine lab technician (MLT) will properly store and handle batteries on the research vessels and will review safety information with grantees and Edison Chouest Offshore (ECO) crew.

## Palmer Lab Supervisor

The Palmer lab supervisor will properly store and handle batteries at Palmer Station and review safety information with grantees and emergency teams at Palmer Station.

## Electronic Technician

Electronics technicians (ETs) will follow safety procedures when assembling battery packs and handling batteries.

## Waste Technician

The waste technician will review documents and follow departmental procedures for cleaning up and disposing of hazardous waste.

## Background

### Lithium Cell Types

Battery technology has seen very rapid development, with a proliferation of different technologies and types of batteries, in terms of construction and materials used. It is crucial to understand what type of battery you have and the corresponding SDS before you need it.

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

#### Primary or Non-Rechargeable Lithium Cells

Primary lithium batteries feature very high energy density, a long shelf life, high cost, and are non-rechargeable. They are generally used for portable consumer electronics, smoke alarms, light emitting diode (LED) lighting products, and outdoor devices. “Lithium batteries” refers to a family of different lithium-metal chemistries, comprised of many types of cathodes and electrolytes, but all with metallic lithium as the anode. Metallic lithium in a non-rechargeable primary lithium battery is a combustible alkali metal that self-ignites at 325°F and **when exposed to water or seawater, reacts exothermically and releases hydrogen, a flammable gas**. Lithium batteries are all significantly different from secondary rechargeable lithium-ion batteries.

#### Secondary or Rechargeable Lithium Ion Cells

Rechargeable secondary lithium ion cells feature high energy density, a long shelf life, lower cost than primary lithium batteries, and light-weight construction. They are generally used for smartphones, tablets, and in equipment where weight and durability are factors.

“Lithium ion” batteries refers to the overarching technology of rechargeable lithium batteries. All use lithium-ion chemistry with some form of intercalated

lithium and an electrolyte. Common categories of lithium ion batteries include lithium-ion (Li-ion), lithium-polymer (LiPo), high voltage lithium (Li-HV), and Lithium-Iron-Phosphate (LiFePO<sub>4</sub>). Most importantly, there is no metallic lithium in any of these lithium ion batteries.

Lithium ion cells prefer partial discharge to deep discharge, so it is best to avoid completely discharging the battery. If the voltage of a lithium-ion cell drops below a certain level, it is ruined. Since lithium-ion chemistry does not have a “memory,” there is no harm to the battery pack with a partial discharge.

Avoid using or storing rechargeable lithium cells at elevated temperatures as heat degrades these batteries.

## Cell Handling Procedures

One crucial 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 as per the following:
  1. Do not stack or scatter the cells.
  2. 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 of 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 directly touch a cell case 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 of 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

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**CAUTION** 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.

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Cells should be stored in their original containers or installed in equipment.

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 Class 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 vessels, batteries should be stored in the Hazlocker or Chem Van whenever possible. Palmer Station batteries should be stored in the corrosives locker.

Do not store batteries on the floor, particularly on the research vessels where they may encounter seawater.



Always stow batteries carefully to avoid accidental damage, discharge, flooding, or short circuiting

## Assembling Battery Packs

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

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**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.

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- Always wear safety glasses when assembling battery packs.
- All jewelry should be removed so that the cell is not inadvertently short circuited.
- Always use cells of the same size 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 no 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 USAP, it is important to follow International Maritime Dangerous Goods (IMDG) code, and/or International Air Transport Association (IATA) code. Shipments to and from Antarctica are likely to use multi-modal routing, including shipment by sea, land and commercial/passenger aircraft. It is important that the shipper know and declare both primary and secondary batteries contained either in equipment or separately. Shippers must provide SDSs for all shipments including lithium batteries.

All primary and secondary lithium batteries are hazardous Class 9-Miscellaneous Dangerous Goods. They can be extremely dangerous due to the potential for short-circuiting that can cause a chain reaction resulting in a huge amount of energy. They are a

prone to “thermal runaway”. A relatively small incident can lead to an uncontrollable fire. As such, they must be transported with specified packaging and shipping regulations. Lithium batteries are covered specifically by UN3480 Lithium Ion Batteries, UN3481 Lithium Ion Batteries contained in equipment, UN3090 Lithium Metal Batteries, and UN3091 Lithium Metal Batteries contained in equipment.

The USAP Transportation and Logistics (T&L) department, MLTs, and Peninsula implementation manager are IMDG and IATA certified and can assist grantees and Antarctic Support Contract (ASC) personnel with selecting and packaging batteries correctly.

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

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## Emergency Procedures

### 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 only if safe to do so.
- Muster if appropriate and wait for further instructions.

Marine projects coordinator (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.

### Health Hazards

Lithium Metal

- Inhalation or contact with vapors, substances or decomposition products may cause severe injury or death.
- May produce corrosive solutions on contact with water.
- Fire will produce irritating, corrosive, and/or toxic gases.
- Runoff from fire control or dilution water may cause environmental contamination.

Lithium Ion

- Contact with battery electrolyte may be irritating to skin, eyes and mucous membranes.
- Fire will produce irritating, corrosive, and/or toxic gases.
- Burning batteries may produce toxic hydrogen fluoride gas (see ERG GUIDE 125).
  - Fumes may cause dizziness or asphyxiation.

### 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 flush 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.

### Handling a Hot Cell

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

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**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.

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### Fire Response

On the research 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 will require self-contained breathing apparatus (SCBA) due to toxic gases from substances or decomposition products. Heat/fire bunker gear will be needed for fighting fire but WILL ONLY PROVIDE THERMAL PROTECTION, NOT CHEMICAL

PROTECTION. PPE for chemical protection could also be required when handling material.

In addition to the battery itself, packaging materials, plastics, electronic equipment and flammable solvents may be involved in a fire, making for a complex situation with need to extinguish both the battery and the secondary materials.

### Lithium (Primary, Non-Rechargeable) Batteries

Lithium metal will burn in a normal atmosphere and reacts explosively with water to form hydrogen, a flammable gas. The presence of minute amounts of water may ignite the material. Lithium fires can also throw off highly reactive molten lithium metal particles. Cells adjacent to any burning material could overheat causing a violent explosion. Beware that lithium metal can re-ignite after being extinguished.

Use a Class D extinguisher on a burning lithium battery. Completely bury the burning material with the extinguishing agent.

If other combustibles catch fire as a result of the lithium battery, use an ABC extinguisher to douse the secondary fires. It is important to address each type of fire with the appropriate extinguishing agent.

### Lithium Ion (Secondary, Rechargeable) Batteries

Because there is no metallic lithium in a lithium ion battery, ordinary extinguishing agents (Class ABC extinguisher, water, or foam) can be used effectively on a fire involving lithium ion batteries.

### Lithium Battery Fire Extinguisher Selection

Table 1 provides guidance for selecting a fire extinguisher for lithium batteries, lithium ion batteries, and secondary fires. Figure 1-3 illustrate various fire extinguishers aboard the ships.

**Table 1:** Lithium Battery Fire Extinguisher Selection

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

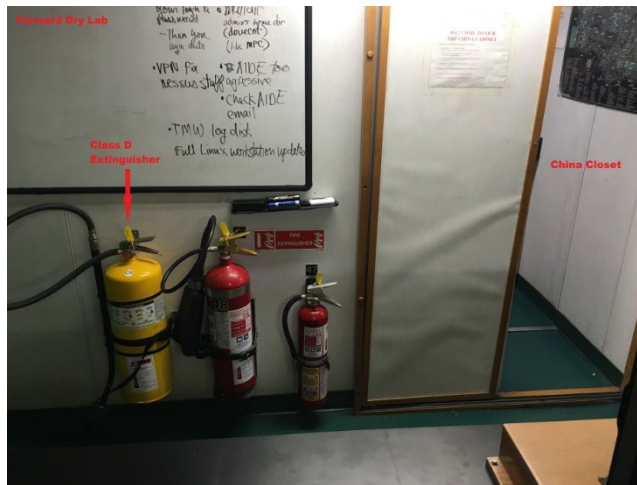


Figure 1: Class D Fire Extinguisher on NBP, in the Forward Dry Lab

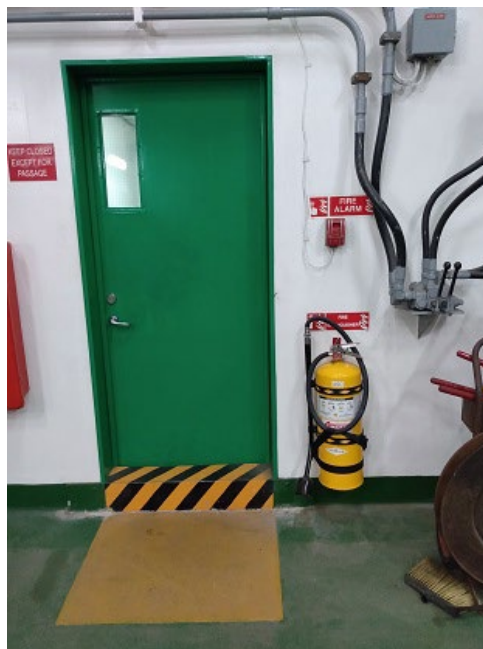


Figure 2: Class D Fire Extinguisher on NBP, in the Helo Hanger



**Figure 3:** Class D Fire Extinguisher on LMG, next to the Door to the Baltic Room

### **Spills and Damaged Cells Cleanup Procedures (for Qualified/Trained Personnel)**

Review SDS materials. If SDS is not available or you are not sure of battery type, take all precautions and wear maximum PPE.

Don appropriate PPE depending on conditions (a lab coat, gloves, safety glasses, SCBA, hazmat suit)

Vent the area. Toxic gases could be present.

Eliminate any ignition sources.

For Lithium-metal: Cover cell with dry sand or non-combustible material. Place in sealable bag. Place all in a metal container, surrounded by dry sand.

For Lithium-ion: Place compromised or leaking cell and electrolyte in a sealable bag. Cover electrolyte with a mixture of neutralizing agent (soda ash or baking soda) and absorbent material (vermiculite). Double bag the leaking cell and seal the bag. Place in a metal container surrounded by sand. 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 a metal can surrounded by clean, dry sand. Prepare a *Hazardous Waste Identification Sheet* (HWIS; OPS-FRM-0014), as described in the *ASC Hazardous Waste Manual* (OPS-MAN-0014). Turn materials over to Palmer Station Waste personnel.

## Waste Concerns

### At Palmer Station

Waste primary and secondary batteries will be collected, stored, and disposed of by Waste personnel 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 Station Waste department that there are lithium batteries waiting to be collected.

### On the NBP

On the *NBP*, **the collection point for batteries is in the china closet**. There are containers for various types of batteries. Lithium metal and lithium ion batteries have unique containers. **DO NOT** mix collection containers. All lithium batteries must have both terminals covered by non-conductive electrical tape to avoid short-circuit in the collection box. Sand for waste disposal can be found at the battery collection area and in the Chem Van.

### On the LMG

On the *LMG*, the alkaline battery collection point is in the Electronics Lab. This container is for alkaline batteries only. Any lithium batteries should be delivered to the MLT, who will add them to the waste containers for delivery to Palmer Station. *DO NOT* put lithium batteries in the alkaline battery box. Sand for waste disposal can be found in the hazards locker.

## References

### Internal Documents

*ASC Hazardous Waste Manual* (OPS-MAN-0014)

*Hazardous Waste Identification Sheet* (OPS-FRM-0014)

### External Documents

CFR Title 49 – Transportation, Subtitle B - Other Regulations Relating to Transportation- 49 CFR 173.185, *Lithium Cells and Batteries*

Department of Transportation *2020 Emergency Response Guide: Guide 138: Substances-Water Reactive (Emitting Flammable Gases- Lithium Metal Batteries; Guide 147: Lithium Ion Batteries*

NSTM555, *Shipboard Fire Prevention and Fire Marshal Tactics, Techniques and Procedures* (TTP; March, 2014) UNOLS lithium battery safety circular, May 2012.

UN Regulations: *UN UN3480 Lithium Ion Batteries, UN3481 Lithium Ion Batteries contained in equipment, UN3090 Lithium Metal Batteries, and UN3091 Lithium Metal Batteries contained in equipment*

UNOLS RVSS, Chapter 9.4 (8<sup>th</sup> Ed.), March 2003

Woods Hole Oceanographic Institution, safety document SG-10

## Records

This document generates no records.

## Glossary

Refer also to the list of approved terms at [den.usap.gov/empresources/sctnglossary.cfm](https://den.usap.gov/empresources/sctnglossary.cfm).

<b>ASC</b>	Antarctic Support Contract
<b>CPR</b>	Cardiopulmonary Resuscitation
<b>ECO</b>	Edison Chouest Offshore
<b>ET</b>	Electronics Technician
<b>HWIS</b>	<i>Hazardous Waste Identification Sheet</i> (OPS-FRM-0014)
<b>IATA</b>	International Air Transport Association
<b>IMDG</b>	International Maritime Dangerous Goods
<b>LMG</b>	<i>Laurence M. Gould</i>
<b>MLT</b>	Marine Lab Technician
<b>MPC</b>	Marine Projects Coordinator
<b>NSTM</b>	Naval Ships Technical Manual
<b>NBP</b>	<i>Nathaniel B. Palmer</i>
<b>OCV</b>	Open Circuit Voltage
<b>PPE</b>	Personal Protective Equipment Anything which may be required to perform a particular job: rubber gloves (nitrile, butyl, etc.), safety goggles, and similar gear.
<b>Primary or Non-Rechargeable Metallic Lithium Cells</b>	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.
<b>RVSS</b>	Research Vessel Safety Standards
<b>Secondary or Rechargeable Lithium Ion Cells</b>	Rechargeable secondary cells utilize lithium ions from various forms of intercalated lithium and electrolytes. There is no metallic lithium in a lithium ion battery.
<b>SCBA</b>	Self-Contained Breathing Apparatus
<b>T&amp;L</b>	Transportation and Logistics
<b>UNOLS</b>	University-National Oceanographic Laboratory System
<b>USAP</b>	United States Antarctic Program