The Hassle of Li-ion Batteries for Miniature Applications

and Why Silver-Zinc is an Easy Solution

INTRODUCTION

As a society, we rely on our electronic devices and therefore batteries more than ever before. Small electronic devices, depending on their function, can improve communication, enhance quality of life, contribute to physical well-being, and generally provide entertainment, safety and security. However, the lithium-ion (Li-ion) batteries powering these devices have some major shortcomings; the most critical being safety. Li-ion has been a prominent topic in recent news because when Li-ion batteries fail, they can do so in a dramatic fashion—the cells have the propensity to burst into flames.

And as batteries have gotten both smaller and more powerful, Li-ion devices have proliferated, and safety incidents have been happening more frequently. Concerns about the safety of Li-ion batteries are well documented. In 2017, the Federal Aviation Administration reported that a fire from a lithium-ion battery grounds a flight every 10 days on average in the U.S.[1] Due to this risk of thermal runaway, the batteries are subject to onerous but necessary testing and regulations that are meant to assure the safety of those working with, transporting and using the batteries.

DID YOU KNOW?

There is a more convenient microbattery technology available for hearable and wearable devices. **ZPower's silver-zinc battery chemistry has a history of being a reliable, safe alternative to Li-ion cells.**

[1]https://www.consumerreports.org/product-safety/whats-behind-the-increase-in-lithium-ion-battery-fires-on-planes/

SAFETY TESTS AND STANDARDS REQUIRED FOR TRANSPORTATION

If a company intends to ship Li-ion batteries by air **they must certify that their batteries have passed UN Transportation Testing—UN/DOT 38.3.**

Together, the United Nations and Department of Transportation guidelines define test requirements for the safe packaging and shipment of lithium metal and Li-ion batteries. Safety test criteria are defined in the "Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, Part III, Section 38.3."[2]

AIR TRANSPORTATION AND SHIPPING RESTRICTIONS

In addition to the safety tests that all Li-ion batteries must pass prior to air transport, they are subject to several restrictions placed on them based on the way the battery is shipped. The restrictions are governed by a number of UN regulations (specifically UN3480 and UN3481), as well as rules set out by various transport bodies, including the International Air Transport Association (IATA).

Li-ion rechargeable batteries are classified as hazardous, with multiple requirements and restrictions on packaging, shipping and handling. Prior to shipping, personnel need to be trained and often are required to obtain a Class 9 hazardous goods certification that shows they are trained on how to properly package and ship Li-ion batteries.[3]

UN Transportation Testing
UN/DOT 38.3

T1 – Altitude Simulation
T2 – Thermal Test
T3 – Vibration
T4 – Shock
T5 – External Short Circuit
T6 – Impact
T7 – Overcharge
T8 – Forced Discharge

[2]http://www.intertek.com/energy-storage/un-transportation-testing
[3]https://www. lion.com/catalog/courses/hazmat/hmt-shipping-lithium-batteries

SHIPPING REGULATIONS ACCORDING TO UN3480 AND UN3481

There are a number of factors that come into play when trying to ascertain which packaging and shipping method to use when transporting lithium-ion batteries.

Shipping is governed by a number of UN regulations (specifically UN3480, UN 3481 and UN3090), and rules set out by the IATA.

Shipping Bulk Li-ion Microbatteries

If Li-ion microbatteries are shipped in bulk without being contained in or accompanied by a device, they must:

- Be shipped at ≤30% state of charge (SoC)
- Be sent on cargo aircraft only
- Be limited to 1 package—maximum 2.5kg per package. If the package exceeds this weight, or there is more than 1 package, the shipment is considered Class 9 Dangerous Goods and requires the Li-ion Class 9 label (**Figure 1**).
- Be affixed with a label for Li-ion batteries and a cargo aircraft only label (**Figure 2** and **Figure 3**).

Shipping Li-ion Microbatteries Packed with Equipment

The Li-ion battery label (**Figure 4**) is required and packages can be shipped on passenger or cargo aircraft if it is ≤ 5 kg.

Shipping Li-ion Microbatteries Contained in Equipment

No labels are required, and packages can be shipped on passenger or cargo aircraft if the package contains ≤ 2 batteries or ≤ 4 cells, and ≤ 2 packages.

If there are more than four cells or two batteries and more than two packages, they must be labeled with a Li-ion battery label (**Figure 4**). This adds a greater logistical burden on manufacturers that are trying to bulk ship their products or devices with Li-ion batteries to a single location. However, following these guidelines may not be enough to get the packages to the destination. Each carrier has their own internal specifications that must be taken into account in order to ship Li-ion batteries. A similar issue arises with regard to international shipping, where customs may require additional information to process the shipment.

Figure 1.
Class 9 Dangerous Goods Li-ion battery label.

Figure 2.
Li-ion battery label for shipping loose cells under UN3480-PI965 Section II.

Figure 3.
Label indicating a shipment can only be carried on a cargo aircraft (CAO) following UN3480-PI965 Section II.

Figure 4.
Li-ion battery label for shipping either batteries packed with or in equipment under UN3481-PI966 or PI967.

PACKAGING REQUIREMENTS

One of the major risks associated with the transport of batteries and battery-powered equipment is short-circuiting as a result of the battery terminals coming into contact with other batteries, metal objects or conductive surfaces. Packaged batteries or cells must be separated in a way to prevent short circuits and damage to terminals. They must be packed in a strong rigid outer packaging—unless contained in equipment that provides equivalent protection.

HOW SHIPPING REGULATIONS INCREASE THE COST AND HASSLE OF LI-ION BATTERIES

≤ 30% State of Charge Cost Considerations
Bulk air shipments of bare Li-ion cells must be shipped under 30% SoC. This raises a problem regarding the self-discharge rates during storage and transportation that may cause the battery to enter a deep-discharge state, which can damage batteries and decrease their capacity to the point of being non-recoverable.

If companies are not diligent about battery inventory aging, device manufacturers may be left with an unreliable battery inventory. Several companies are beginning to create specialized, climate-controlled cabinets and enclosures for batteries to be placed in when in warehouses in order to minimize this effect.

Repair and Customer Service Complexity
When a device powered by Li-ion batteries is not working due to a battery problem and is returned for repair, the device cannot be shipped by air under any circumstance—only ground or sea, as Class 9 dangerous goods.

The challenge for consumers and retailers is determining whether the cause of a nonfunctioning device is a defective Li-ion battery, which is usually sealed in the device. If the cause for a non-functioning device is unknown and the batteries cannot be diagnosed prior to transport, the device cannot be shipped by air.

Practically speaking, this means that a retailer or consumer can only ship back a non-functioning Li-ion-powered device by Class 9 ground or sea transportation, if they cannot diagnose the problem prior to shipping. This becomes an extremely complex issue when the equipment manufacturer is located overseas, or the failing device is a medical device that the patient cannot do without for the period of time required for ground or sea transportation.

DID YOU KNOW?

When a Li-ion-powered device needs returning for repair because of a battery issue, **it cannot by shipped by air—under any circumstances.**

CONSUMER TRAVEL RESTRICTIONS

Consumers are also limited to what they can bring on an airliner when they travel. There can be no spare (uninstalled) batteries for their devices in checked bags. Spare Li-ion and lithium metal batteries must be carried in carry-on baggage only. When a carry-on bag is checked at the gate or at planeside, all spare lithium batteries must be removed from the bag and kept with the passenger in the aircraft cabin. There is usually no limit on number of spare batteries that can be carried on, but lithium-ion (rechargeable) batteries are limited to a rating of 100 watt hours (Wh) per battery.

The reason spare batteries must be packed in carry-on baggage only is to ensure that **if they were to catch fire, it would easily be seen and dealt with quickly.**

If batteries catch fire in the cargo hold, there would be a much higher chance of propagation and spreading. This covers spare lithium metal and spare rechargeable Li-ion batteries for personal electronics such as cameras, cell phones, laptop computers, tablets, watches, calculators, hearing aids, etc. This also includes external battery chargers (portable rechargers) containing a Li-ion battery.

DID YOU KNOW?

A Li-ion battery fire grounds a flight every 10 days on average, according to the FAA.

Even in carry-on baggage, batteries must be protected from damage. Battery terminals (usually the ends) must be protected from short circuit (i.e., the terminals must not come into contact with terminals from another battery or any other item made of metal). Methods for doing this include leaving the batteries in their retail packaging, covering battery terminals with tape, using a battery case, using a battery sleeve in a camera bag or putting them snugly in a plastic bag or protective pouch. **These restrictions are outlined in the federal regulations for transportation by aircraft: 49 CFR 175.10(a)(18).**[4]

[4]https://www.ecfr.gov/cgi-bin/rieveECFR?gp=1&SID=bba5ad06518b529c94e1d67a3270196b&ty=HTML&h=L&r=SECTION&n=49y2.1.1.3.12.1.25.5

RECHARGEABLE SILVER-ZINC—THE SAFE ALTERNATIVE

Silver-zinc rechargeable batteries were introduced to the hearing industry by ZPower in 2013 and have been adopted by global hearing aid manufacturers for their FDA Class I and Class II hearing aids. More recently, they have been adopted for ear-worn hearables by consumer electronic companies. Silver-zinc is one of the oldest battery chemistries, first reported by Volta in 1800 and widely used by the military and space industries. NASA successfully deployed rechargeable silver-zinc batteries without any incidents in launch systems beginning with the Mercury manned space flight missions. The military has used silver-zinc batteries in missiles, torpedoes and submarines for more than 50 years.

One advantage of silver-zinc is that it uses a water-based, non-flammable electrolyte. The stability of the silver-zinc battery materials and the complete non-flammability of the silver-zinc electrolyte make it an intrinsically safe battery technology. Additionally, when compared to other rechargeable battery chemistries, silver-zinc has considerably higher energy density in smaller sizes.

DID YOU KNOW?

NASA successfully deployed rechargeable silver-zinc batteries **without any incidents in launch systems beginning with the Mercury manned space flight missions.**

TRANSPORTING PRODUCTS WITH SILVER-ZINC RECHARGEABLE BATTERIES

ZPower's silver-zinc battery technology has much less regulatory complexity than the similar lithium-ion cell. **Unlike lithium-ion cells which must pass UN safety testing to be shipped, silver-zinc has none of these restrictions on shipping.**

Silver-zinc batteries are shipped under the dry battery clause, essentially the same as the normal alkaline AA battery. They are not subject to Class 9 hazardous goods regulations and do not have strict packaging regulations that limit the number of cells or devices that can be shipped per consignment.[5] They are not subject to SoC shipping regulations, consumer travel restrictions, and devices containing silver-zinc batteries can easily be shipped back to the manufacturer for replacement or repair.

[5]US DOT Ref. No. 07-0152 29 Oct 2007

CONCLUSION

The regulations placed on the packaging and transportation of Li-ion batteries cause increases in both cost and supply chain complexity. Regulations are in place at every step of the process of packaging and shipping from the manufacturer to the consumer. While some manufacturers have a thorough background in shipping these devices, many manufacturers, distributors and most consumers aren't aware that the same regulations apply when shipping their devices. This is where expensive and compounding fines and restrictions can occur for both manufacturers and consumers.

Luckily, there's a better alternative.
When you need a reliable and safe battery chemistry that also helps reduce logistical complexities and supply chain delays, ZPower's silver-zinc is an easy solution.

DID YOU KNOW?

Silver-zinc batteries **are not restricted from any mode of transportation.**