

## How to Ship Batteries with Today's Evolving Regulations



*A Comprehensive Guide to Shipping Batteries*



Lithium-ion batteries power so much of our economy that any new form of regulation disrupts business for manufacturers, freight and shipping services, retailers, and Haz-Mat professionals. If you're designing a product or system that includes a battery, you don't want to be concerned with the complexities of shipping these products, but if you're not careful about your shipping strategy, you could risk fines and dangerous situations.

Batteries are categorized differently on the hazardous scale. Some are not regulated at all, such as dry cell and consumer alkaline batteries, while others are deemed "dangerous goods."

Regulations result because the dangers are real. Failures that result in fires and explosions during shipping are a true cause for concern. For example, when Lithium batteries encounter external heat sources, they can go into thermal runaway.

Individual battery cells tend to be highly reliable and contain built-in safety mechanisms, but failure likelihood increases in large-scale systems. Heat dissipation can be difficult at larger scales, which increases the chances of thermal runaway.

In August 2018, the FAA reported that there have been 225 air or airport incidents involving lithium batteries carried as cargo or baggage since 1991. For example, on June 22, 2018, a shipment was seized by U.S. Customs at the DHL JFK gateway containing 25 repaired cellphones. One of the cellphones was smoking and melted due to heat. The shipment had a lithium battery handling label (UN3481) and a statement on the air waybill stating, "Lithium-ion Batteries in compliance with Section II of PI 967."

Here is a case where labels appear to comply, but under UN3481 – PI967, there is a limit to how many batteries can be shipped in the package. According to DHL, there is a maximum number of cells and batteries permissible per package. For passengers, consumer-sized Lithium-ion batteries (up to 100 Wh per battery) and up to two-grams of Lithium in Lithium-metal batteries is permissible. When shipping larger quantities via passenger aircraft or cargo, restrictions revolve around the number of cells and batteries contained in the equipment, which will prompt further processes for shippers if exceeded

## Safety:

### Preventing Short-Circuits or Activation of Lithium Batteries While in Transport

One concern amongst those shipping Lithium batteries is short-circuiting or accidental activation while in transport. All batteries must be packed in a manner that eliminates the possibility of such occurrence. For example, packaging needs to be designed so that batteries do not encounter one another or conductive surfaces and metal objects while in transport. The regulations also require cells and batteries to be packed in fully enclosed inner packaging made of nonconductive materials that keeps terminals or connectors from being exposed.

Since transport safety is a priority when shipping batteries, Memory Protection Devices implements features such as tabs, grippers, and complete enclosures. These minor additions make sure a battery is not activated or a danger during transport.

You will encounter the strictest set of regulations on International Air Transport. Standalone lithium batteries can only be shipped in cargo aircraft. Cargo flights have their own set of restrictions. For example, these batteries can only ship at 30% charge. If companies need to ship at 100% charge, ground or sea transport is the best option.



*Unintentional activation and short circuits need to be safeguarded against while transporting Lithium cells.*



If batteries and cells are referred to as “excepted”, they meet specific criteria and have passed tests in accordance with the UN Manual of Tests and Criteria. These are batteries that are exceptions to the regulations imposed on many Lithium and Lithium-ion batteries. These may be shipped without a Class 9 classification, but size, markings, color and shipping documentations must still be in keeping with regulations.

There are instances when it is 100% acceptable to ship Lithium and Lithium-ion batteries. These are as follows:

- Lithium-ion batteries at 100watt-hours or less
- Lithium-metal batteries with two grams of lithium or less
- Individual cells come with their own set of exceptions

In this case, all that is required is a lithium battery mark with the UN number and an emergency telephone number.

When batteries exceed the exceptions listed above, they are deemed fully-regulated and require additional information:

- Class and hazard label
- Shipping papers
- Emergency contact number

Manufacturers that offer any Lithium or Lithium-ion battery for shipment, either standalone, within equipment or shipped with equipment are responsible for making sure that the batteries meet all regulations, including testing, marking, labeling, packaging, and documentation in accordance with IATA regulations. The UN Manual of Tests states that products must be re-tested if there are changes to the development of a product that could affect the outcome of tests. Changes include a 20% mass increase to the cathode, anode, or electrolyte or other material adjustments.

## Requirements

For each battery type, there are specific accompanying shipping, labelling, and packaging requirements.

All lithium batteries are considered hazardous materials, otherwise known as dangerous goods, but there are exceptions for small-sized batteries, intended to simplify the shipping of items containing such batteries by air. According to UPS, common lithium batteries under those reduced regulations are accepted only when the batteries are packed with or contained in equipment. All air shipments of Lithium-ion or Lithium-metal batteries that are not contained in equipment (UN3090 and UN3480) must be fully regulated and require a special set of documentation. For example, when shipping via UPS, a UPS Dangerous Goods contract is required.

ID Number	Shipping Name	Hazard Class
UN3090	Lithium-metal	9
UN3091	Lithium-metal contained in equipment or packed with equipment	9
UN3480	Lithium-ion	9
UN3481	Lithium-ion contained in equipment or packed with equipment	9

*For easy reference throughout this guide, the table to the left identifies the Lithium batteries that will be discussed.*

*Lithium Battery Classification for Reference.*

All Lithium-ion and Lithium-metal cells and batteries must be tested in accordance with the UN Manual of Tests and Criteria Part III Subsection 38.3 (DGR 3.9.2.6). If they have not passed, batteries must be redesigned.














## By Air

When it comes to shipping Lithium-ion or Lithium-metal batteries by air, different regulations apply depending on whether the batteries are contained inside of the equipment or packed with the equipment (loose/standalone). There are also additional marking requirements for these batteries.

All shipments of Lithium-metal batteries via air transport must be approved prior to shipping, in addition to a Dangerous Good contract, when applicable. (Obtain pre-approval via UPS.)












The chart below outlines the labelling and weight requirements for transport by air. For reference, Watt-Hour Rating is determined by using the formula Ampere-Hours x Voltage in case the Watt-Hour rating is not marked on the battery.

### Lithium-metal Battery Label Requirements – By Air

Battery Type	Label	Limit Per Package
<i>Contained in Equipment</i> For cells greater than 1 g and batteries greater than 2 g		Pax A/C [1] = 5 kg CAO [2] = 35 kg
<i>Contained in Equipment</i> For cells less than or equal to 1 g and batteries less than or equal to 2 g		Pax A/C = 5 kg CAO = 5 kg
<i>Not Contained in Equipment</i> For cells greater than 1 g and batteries greater than 2 g	 	Pax A/C = Forbidden CAO = 35 kg
<i>Not Contained in Equipment</i> For cells less than or equal to 1 g and batteries less than or equal to 2 g	  	Pax A/C = Forbidden CAO = 2.5 kg "IB" [3] must be used if package exceeds Section II limits and more than 1 package
<i>Not Contained in Equipment</i> For cells less than or equal to 1 g and batteries less than or equal to 2 g	 	(not more than 1 package) Lithium-metal content $\leq 0.3 \text{ g} = 2.5 \text{ kg}$ ; cells $> 0.3 \text{ g} \leq 1 \text{ g} = 8 \text{ cells}$ batteries $> 0.3 \text{ g} \leq 2 \text{ g} = 2 \text{ batteries}$ Pax A/C = Forbidden
<i>Packed With Equipment</i> For cells greater than 1 g and batteries greater than 2 g		Pax A/C = 5 kg CAO = 35 kg
<i>Packed With Equipment</i> For cells less than or equal to 1 g and batteries less than or equal to 2 g		Pax A/C = 5 kg CAO = 5 kg



## Lithium-metal Battery Label Requirements – By Air

Battery Type	Label	Limit Per Package
<p><i>Contained in Equipment</i> For cells greater than 20 Wh and batteries greater than 100 Wh</p>		<p>Pax A/C = 5 kg CAO = 35 kg</p>
<p><i>Contained in Equipment</i> For cells less than 20 Wh and batteries less than 100 Wh</p>		<p>Pax A/C = 5 kg CAO = 5 kg</p>
<p><i>Not Contained in Equipment</i> Maximum of 30% SoC For cells greater than 20 Wh and batteries greater than 100 Wh</p>	 	<p>Pax A/C = Forbidden CAO = 35 kg</p>
<p><i>Not Contained in Equipment</i> Maximum of 30% SoC For cells less than or equal to 20 Wh and batteries less than or equal 100 Wh</p>	 	<p>Pax A/C = Forbidden CAO = 10 kg</p>
<p>**Lithium-metal batteries, in compliance with Section II of PI968- CAO* on AWB. <b>Small Size, Low Volume</b></p>		
<p><i>Not Contained in Equipment</i> Maximum of 30% SoC For cells less than or equal to 20 Wh and batteries less than or equal 100 Wh *IB on Declaration <b>Small Size, High Volume</b></p>	 	<p>≤ 2.7 Wh = 2.5 kg; or cells &gt; 2.7 Wh ≤ 20 Wh = 8 cells or batteries &gt; 2.7 Wh ≤ 100 Wh = 2 batteries Pax A/C = Forbidden</p>
<p><i>Packed With Equipment</i> For cells greater than 20 Wh and batteries greater than 100 Wh</p>		<p>Pax A/C = 5 kg CAO = 35 kg</p>
<p><i>Packed With Equipment</i> For cells less than or equal to 20 Wh and batteries less than or equal 100 Wh</p>		<p>Pax A/C = 5 kg CAO = 5 kg</p>

PAX A/C indicates Passenger Aircraft    CAO indicates Cargo Aircraft Only



Section IB of Packing Instruction 965. Applies to Lithium-ion cells with a Watt-hour rating not exceeding 20 Wh and lithium ion batteries with a Watt-hour rating not exceeding 100 Wh packed in quantities that exceed the allowance permitted in Section II, Table 965-II.

## By Sea

Shipments by sea are regulated by the International Maritime Dangerous Goods (IMDG), which parallel the air transport regulations. The chart below outlines the different packaging, labelling, and documentation required when shipping Lithium-metal and Lithium-ion batteries by sea.



### Shipping Lithium and Lithium-ion Batteries by Sea

Battery Type	Packaging	Label	Document Needed	Package Limit
Lithium-ion/ Lithium-metal <i>Not Contained in Equipment or Shipped with Equipment</i>	Inner packages must enclose cell or battery, protect against short circuits and withstand drop test (1.2 m)		Documentation notes that package contains lithium, is flammable, should follow special procedures in case of emergency, and a telephone number	30 kg
Lithium-ion/ Lithium-metal <i>Packed with Equipment</i>	Inner packages must enclose cell or battery, protect against short circuits and withstand drop test (1.2 m)		Documentation notes that package contains lithium, is flammable, should follow special procedures in case of emergency, and a telephone number (Only needs doc if package is labelled)	30 kg
Lithium-ion/ Lithium-metal <i>Contained In Equipment</i>	Must protect against short circuits, possess no conductive materials, and include strong outer packaging	Only needs a label if there are more than 4 cells in a package or more than 2 batteries in a package	Documentation notes that package contains lithium, is flammable, should follow special procedures in case of emergency, and a telephone number	None

### By Ground

Many batteries and equipment that contain them are regulated to some extent when shipped via ground transport on highways. Shippers must refer to the most current U.S. Department of Transportation (DOT) for marking, packaging and labeling requirements.

As with all modes of transport, battery terminals must be protected against short-circuiting, completely covered, and packaged in nonconductive materials. Items must be packed to ensure there is no encounter with conductive materials. All lithium batteries must successfully pass UN safety testing.

Special regulations apply to lithium-battery shipments. Refer to 49 CFR 173.185 and 49 CFR 172.102.

Even smaller-sized Lithium batteries that were not subject to requirements now have marking and documentation requirements, including size limitations.

Markings and documentation requirements include:

- Package marking that states “Lithium-metal” or “Lithium-ion” cells or batteries
- Note that package must be handled with care and is hazardous if damaged
- An indication that special procedures must be followed if the package is damaged
- A telephone number for additional information
- For Lithium-metal batteries, there should be a statement that the package cannot board a passenger aircraft.



Only small and medium-sized Lithium-metal and Ion cells and batteries can be shipped as *partially regulated* in the U.S. via highway or rail transport.

- Lithium-metal Cells: Less than 5 grams
- Lithium-ion Cells: Less than 60 Wh
- Lithium-metal Batteries: Less than 25 grams
- Lithium-ion Cells: Less than 300 Wh

If batteries and cells do not meet these requirements, they are considered fully regulated Class 9 hazardous materials and shipper must receive pre-approval to ship. As regulations evolve, most Lithium Batteries are becoming regulated when offered for ground transport which means that many that were exempt before now require UN performance packaging, hazard labelling and additional documentation. These regulations greatly impact small consumer electronics such as laptops and medical devices.

### Requirements

For packages containing lithium cells or batteries, they must be placed in a non-metallic inner packaging that completely enclose the cells or batteries and separate the cells or batteries from contact with equipment, other devices, or conductive materials. This includes certain metals, wood, fiberboard, and plastic boxes.

Each package must display the Lithium battery mark unless it contains button cell batteries that are installed in equipment, including circuit boards, or no more than four lithium cells or two lithium batteries contained in equipment, where there are not more than two packages in the consignment.

### Ground Requirements Checklist:

UN number must be marked on the package.

Packages require the following label:



- Watt-hour (Wh) rating may not exceed 20 Wh for a Lithium-ion cell or 100 Wh for a Lithium-ion battery.
- Watt-hour rating should be marked on the outside case.
- Lithium content may not exceed 1 g for a Lithium-metal cell or 2 g for a Lithium-metal battery.
- Outer package that contains Lithium-metal cells or batteries must be marked:  
“PRIMARY LITHIUM BATTERIES— FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT.”

When transporting by highway or rail only, the Lithium content of the cell and battery may be increased to 5 g for a Lithium-metal cell or 25 g for a Lithium-metal battery and 60 Wh for a Lithium-ion cell or 300 Wh for a Lithium-ion battery.

Please see the Electronic Code of Federal Regulations for even more specific details on your packaging requirements via ground transport.



## Packaging Instructions

### Lithium Batteries

Cells and batteries must be packed in strong outer packaging that conform to standards 5.0.2.4, 5.0.2.6.1 and 5.2.12.1. Their inner packaging must completely enclose the cell or battery and they must be protected to avoid short circuits, which includes contact with conductive materials inside of the same packaging. Each package must be able to withstand a 1.2 m drop test (about four feet) without causing damage to the cells or batteries and its contents must be able to shift around without any damage or releasing the contents of the package.

Each package must also have an accompanying document such as an air waybill that states that the package contains Lithium-ion cells or batteries, must be handled with care, and poses a fire hazard if damaged. Special procedures are put into action if the package is damaged, including inspection and repacking. Documentation must also include a telephone number for additional information.

Outer packaging types include drums, jerricans, and boxes.

### Lithium-ion Batteries

Lithium-ion batteries must follow the same packaging requirements as listed for Lithium but must also include a lithium battery handling label. The equipment and the packages of lithium cells or batteries must be placed in an overpack that includes necessary markings and labels applicable marks and labels.



## Hazmat Training

Sellers must acquire Hazmat training in keeping with mode of transport. If sellers are offering only full-excepted materials, they will encounter fewer training requirements.

Employees who are involved in the processing of hazardous materials or dangerous goods shipments, as many batteries are classified, must undergo training for the specific functions they perform and the method of transport. Employees are required by federal and international laws and regulations to undergo training for all three modes so that they can properly classify their products, select the correct packaging and markings, and accurately complete shipping papers required for transport of dangerous goods by air, ground, and vessel and for an air waybill. These trainings rely heavily on the International Air Transport Association (IATA) Dangerous Goods Regulations (DGR) - 59th Edition, but IATA has released a 60<sup>th</sup> Edition, which will take effect January 1, 2019.

## Changing Regulations Mean Greater Costs

Implementing constantly in-flux regulations on batteries does not only pose the obvious challenge of new and complex processes and time-consumption. It also means increased expense for companies. Training and certification through a third party can range from hundreds to thousands of dollars per person, proper labels and packaging, and even providing a dangerous goods phone number incur many additional costs when it comes to shipping. It is critical to ensure your batteries are classified as dangerous goods to not cause additional and unnecessary charges. At the same time, it is critical to ensure you are following proper protocol to not incur any fines or cause any damage by shipping improperly.

Following the checklist on the next page will set you on the right path to achieving the correct battery shipping option in keeping with all regulations.





## Shipping Preparation Checklist

In order to ensure you're focusing on all the regulations and requirements, the following should be considered:

- ✓ Determine the type of battery you are shipping.
- ✓ Determine the country you're shipping to.
- ✓ Determine mode of transport.
- ✓ Determine if the batteries will be shipped loose, within equipment, or with equipment.
- ✓ Determine weight and dimensions.
- ✓ Determine capacity of the battery.
- ✓ Determine label requirements.
- ✓ Determine marking requirements.
- ✓ Determine package requirements

**For more information, here's a list of valuable resources:**

[FedEx: Lithium-ion Overview](#)

[FedEx: Dangerous Goods and Hazardous Materials](#)

[UPS: How to Safely Pack and Ship Batteries](#)

[DHL: Shipping Goods With or Containing Lithium Ion Batteries](#)

[IATA: International Air Transport Association](#)

**Since regulations change so often, be sure to check back on Memory Protection Devices' website for updates to this article.**



**Memory Protection Devices has Battery Holder and Contact Solutions for any Application**

