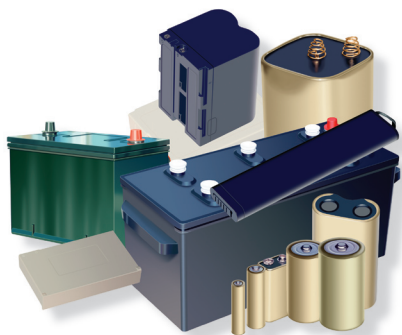


# SHIPPING BATTERIES SAFELY

# BY AIR

What You Need To Know



U.S. Department  
of Transportation  
Pipeline and  
Hazardous Materials  
Safety Administration



This guide is written to help you ship batteries safely by air. It is not a substitute for the Hazardous Materials Regulations (HMR; 49 CFR Parts 100-185). Every effort has been made to provide a simplified guide consistent with the HMR. However, if there is any instance in which this guide is inconsistent with the HMR, the regulations themselves are the final authority for proper shipping procedures. If you have questions about a specific shipment, please call our Hazardous Materials Info-line at 1-800-467-4922.

# Contents

Why Are Batteries Regulated in Transportation?	6
Lithium Batteries	10
Is Your Lithium Battery Small, Medium, or Large?	12
Examples of Lithium Batteries	13
What requirements apply to shippers of “Small” Lithium Batteries?	14
What requirements apply to shippers of “Medium” and “Large” Lithium Batteries?	16
Wet Batteries	18
Nonspillable Batteries	20
Dry Batteries (Excluding Lithium)	22
Battery-powered Vehicles and Equipment	24
Batteries Contained in or Packed with Equipment	26

# Why Are Batteries Regulated in Transportation?

Batteries are woven into the fabric of modern American life. They power portable computers, phones, and audio devices. They make possible motorized wheelchairs and cordless tools. We have come to depend on batteries for an increasingly mobile lifestyle. Today's batteries contain more power than ever, making possible a steadily growing number of higher-powered devices on the market. But with that increased power comes greater risk and the need to manage the risk. Shippers can play an important role in reducing this risk and preventing incidents including fires aboard aircraft.

Batteries present both chemical (e.g., corrosive or flammable electrolytes) and electrical hazards. Dangers associated with batteries include chemical burn, fire, and electrical shock. Batteries can be dangerous if not safely packaged and handled when transported. Misused, mishandled, improperly packaged, improperly stored, overcharged, or defective batteries can short circuit, overheat, and sometimes cause a fire. In addition, some of the chemicals in batteries can pose hazards if they are released.

In general, the risks posed by batteries are a function of battery size and chemistry. Certain battery types are of greater concern when transported. For example, unlike standard alkaline batteries, most lithium batteries manufactured today contain a flammable electrolyte and have a higher energy density. They can overheat and ignite under certain conditions and, once ignited, can be difficult to extinguish. In addition, although an infrequent event, a lithium battery is susceptible to thermal runaway, a chain reaction leading to a violent release of its stored energy. Lead-acid and lead-alkali batteries present a hazard in transportation if the corrosive electrolyte leaks from a damaged or defective battery.

The Hazardous Materials Regulations (HMR; 49 CFR parts 100-185) include provisions for packaging, hazard communication (package marking, labeling, and shipping papers), and handling batteries and battery-powered devices. The purpose of these regulations is to protect the safety of people and property when batteries and battery-powered devices are being shipped. If the applicable minimum regulatory requirements are not followed, these shipments may contribute to fires, injuries, or other incidents during transport. Failure to comply with the applicable regulations may result in a fine or even jail time.

This document provides guidance on methods of safely transporting batteries and battery-powered equipment in compliance with the regulations. There is generalized guidance on proper packaging and handling methods and also greater detail where necessary for a better understanding of the requirements of the HMR. This guide also provides a framework for compliance with international regulations for those shippers transporting batteries and battery-powered devices internationally. Most of the requirements in the HMR are the same as international regulations and standards. However, there are some different requirements and/or different dates for compliance. For international shipment of batteries and battery-powered equipment by air, we recommend shippers consult the International Civil Aviation Organization (ICAO) Technical Instructions for current and up-to-date requirements. Publications and regulations issued by ICAO can be found at [www.icao.int](http://www.icao.int). For both domestic and international shipments, we also recommend checking with your air carrier for any additional requirements that it may impose.



PHMSA prepared this guide with the help of FAA, and with input from experts in the battery, airline, and shipping industries, to assist you in safely packaging batteries for transport by air. Whether you are shipping a single battery, a palletized load of batteries, or a battery-powered device, the safety of your package, and of the people who handle it along the way, depends on compliance with these regulations.



### Battery incident?

Certain types of incidents must be reported to PHMSA. Incidents involving batteries and battery powered devices including those that result in a fire, violent rupture, explosion, or dangerous evolution of heat must be reported. In addition to the written incident report, immediate telephonic reporting is required for incidents involving batteries and battery-powered devices in air transportation.



You are an crucial part of aviation safety. It is essential that you preserve the batteries and/or electronic equipment involved in an incident. We ask you to contact DOT so that any evidence from a battery incident can be transferred to the appropriate authorities for analysis and evaluation.

For further information:

See §§ 171.15 and 171.16

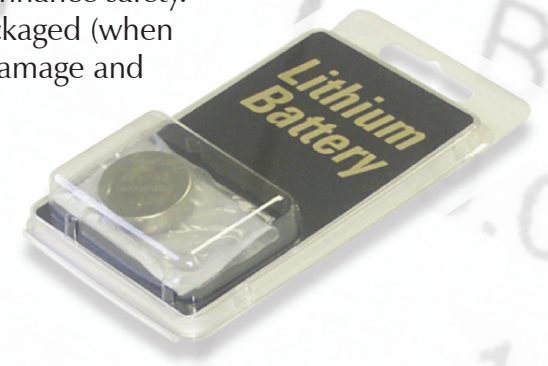
PHMSA's web site at <http://www.phmsa.dot.gov/hazmat/incident-report>

The Hazardous Materials Information Center at 1-800-467-4922

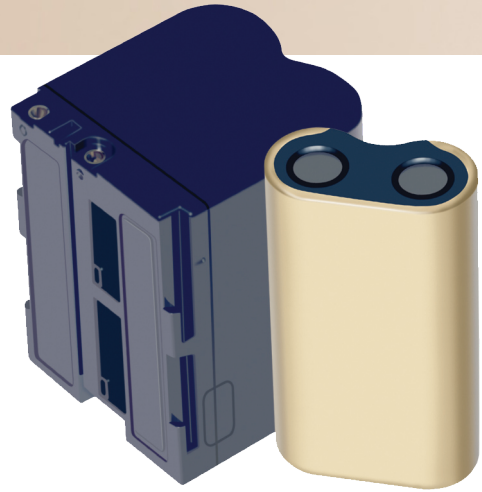
### Batteries and battery-powered devices can be a safety risk when transported by air.

Batteries may spark, overheat or even catch fire if they short-circuit. A short circuit can happen any time something which conducts electricity touches both terminals on a battery. For example, a tool, a set of keys, or wiring could bridge the terminals, creating a short circuit. Additionally, damaged batteries may lead to short-circuiting or contribute to a fire through release of stored energy or may release hazardous contents such as corrosive battery fluid. Packaging batteries to protect terminals, especially from metallic objects, reduces risk in transportation and increases safety. Implementing measures to prevent inadvertent activation of battery powered equipment also contributes to increased safety. Proper packaging is one of the most critical measures that a shipper can take to prevent incidents and enhance safety. Batteries should be individually packaged (when practical) or separated to prevent damage and short circuiting.

Enclose batteries in plastic blister wrap, pasteboard, or other inner packaging that will protect each battery from making contact with another battery or any item that is capable of causing a short-circuit.



# Lithium Batteries



## What's different about lithium batteries?

Rechargeable lithium batteries (also called lithium ion (Li-ion), or secondary lithium batteries), and non-rechargeable lithium batteries (also called lithium metal, or primary lithium batteries), provide more energy and a longer operating life than other battery chemistries. They have the potential to generate a significant amount of heat or catch fire if damaged or improperly packaged, cared for, or constructed than do other batteries. In recognition of these facts, the U.S. and international regulations (i.e., ICAO TI) pertaining to the transportation of lithium cells and batteries have changed significantly in recent years.

Note: The ICAO TI have different shipping names when describing lithium batteries. We recommend that shippers consult the ICAO TI when shipping internationally.

You can safely and easily ship most consumer-type lithium batteries, both rechargeable and non-rechargeable varieties, if certain precautions are taken to prevent short circuits, overheating, and inadvertent operations. These batteries include camera batteries, notebook computer batteries, and cell phone batteries.



## DO NOT SHIP DAMAGED, DEFECTIVE, OR RECALLED BATTERIES BY AIRCRAFT.

Damaged or defective lithium batteries or devices containing lithium batteries (including those being returned to the manufacturer as part of a safety recall) are forbidden for transportation by aircraft. Such batteries have the potential of producing a dangerous evolution of heat, fire, or short circuit. If your battery or batteries are part of a recall or are damaged, you need to take extra care when preparing these batteries for shipment. Recommended practices for preparing recalled batteries for transportation are set forth in "DOT Guidance for the Safe Transportation of Recalled Lithium Batteries," available for download at <http://safetravel.dot.gov/downloads.html>.

Non-rechargeable (i.e., metal/primary) lithium batteries **MAY NOT** be transported as cargo aboard passenger aircraft and packages containing those batteries must be marked\*:

**"PRIMARY LITHIUM BATTERIES—FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT"**

or

**"LITHIUM METAL BATTERIES—FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT"**

\*Letters must be at least 6mm high for packages with a gross weight of 30 kg or less and 12 mm high for packages with a gross weight of over 30 kg.

## IS YOUR LITHIUM BATTERY SMALL, MEDIUM, OR LARGE?

The regulations for shipping lithium batteries are based on the size of the battery or cell to be shipped (a battery is made up of one or more connected cells). These size categories depend on the lithium metal or alloy (Li) content of a non-rechargeable battery or cell, or the equivalent lithium content (ELC)\* for rechargeable lithium batteries or cells.

		Cells		Batteries	
		Non-Rechargeable	Rechargeable	Non-Rechargeable	Rechargeable
Battery and Cell Category Definitions	Small (no more than)	1.0 g Li	1.5 g ELC	2.0 g Li	8 g ELC
	Medium (between)	1.0 g and 5 g Li	1.5 g and 5 g ELC	2.0 g and 25 g Li	8 g and 25 g ELC
	Large (more than)	5 g Li	5 g ELC	25 g Li	25 g ELC

\*ELC (g) = rated capacity (Ah) X 0.3; assumes a battery or cell with a rated voltage of 3.7v.

Determining the lithium content or equivalent lithium content of a battery or cell can be complex, so examples are also listed, as are watt-hour equivalencies. If the information for determining watt-hour rating (Wh)\*, lithium content, or ELC is not on your battery or in the information provided with the battery, contact the manufacturer, distributor, or Hazardous Materials Information Center (HMIC)\*\* for more information.

## Examples of Lithium Batteries

**Small lithium batteries and cells** include cell phone batteries, camera batteries, and internal batteries for notebook computers. The eight gram equivalent lithium content at the top of the “small” range of rechargeable batteries provides about 100 watt-hours of power.



**Medium lithium batteries and cells** include larger batteries and cells a consumer might purchase, but not without noticing their larger size — examples include some extended life batteries for notebook computers, and batteries used by audiovisual professionals for video and lighting equipment.



**Large lithium batteries and cells** are primarily those used in industry. A large rechargeable battery provides over 300 watt-hours of power (over 25 g of equivalent lithium content). Large batteries may be found in some electric and hybrid vehicles, as well as some mobility devices and scooters.



\*Wh = (mAh ÷ 1,000) × Volts.

\*\*The Hazardous Materials Information Center can be reached at 1-800-467-4922.

## WHAT REQUIREMENTS APPLY TO “SMALL” LITHIUM BATTERIES?

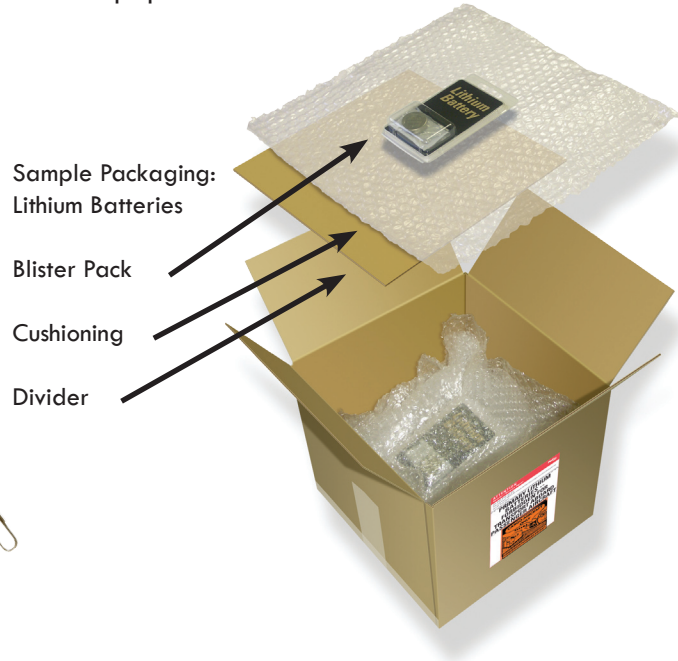
A shipper is responsible for ensuring that the batteries and cells offered for transportation have passed the tests found in the UN Manual of Tests and Criteria (after October 1, 2009). Check with the battery manufacturer or distributor to determine if a battery design has passed these tests.

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 outer packaging or be contained in equipment.

### Improper Packaging:

#### DO NOT package batteries:

- Loose
- With metal objects such as tools or keys



- Packaging requirements for “small” lithium batteries are found in the HMR in § 172.102, Special Provision 188.
- Provisions for airline passengers are found in § 175.10(a)(17).

Primary (non-rechargeable) lithium batteries and cells are forbidden for transport aboard passenger carrying aircraft as cargo. Secondary (rechargeable) small lithium batteries and cells are authorized aboard passenger carrying aircraft when properly packaged and identified (where applicable).



### A package containing “small” lithium batteries or cells must be:\*

- Marked to indicate that it contains lithium batteries and that special procedures should be followed in the event the package is damaged;
- Accompanied by a document indicating that the package contains lithium batteries and special procedures should be followed in the event that the package is damaged;
- Capable of withstanding a 1.2 meter drop test in any orientation without damage to cells or batteries contained in the package, without shifting of the contents that would allow short circuits and without release of package contents; and
- No more than 30 kg (66 pounds).

*\*See § 172.102, Special Provision 188, for batteries or cells contained in or packed with equipment.*



## WHAT REQUIREMENTS APPLY TO “MEDIUM” AND “LARGE” LITHIUM BATTERIES?

When transported by aircraft or vessel, “medium” lithium batteries and cells are subject to the same requirements as “large” lithium batteries.



For requirements and exceptions for “medium” batteries shipped by highway or rail, see §§ 173.185 and 172.102, Special Provision 189.

The shipper must confirm that the manufacturer has performed all the tests and the batteries/cells have passed the tests found in the UN Manual of Tests and Criteria prior to offering for transportation.

Batteries or cells must be separated so as to prevent short circuits and must be packed in a strong outer packaging or be contained in equipment.

### **Aircraft Quantity Limits for Medium and Large Lithium Batteries:**

Primary (non-rechargeable) lithium batteries and cells are forbidden for transport aboard passenger carrying aircraft. Secondary (rechargeable) lithium batteries and cells are authorized aboard passenger carrying aircraft in packages that do not exceed a gross weight of 5 kg (11 pounds).



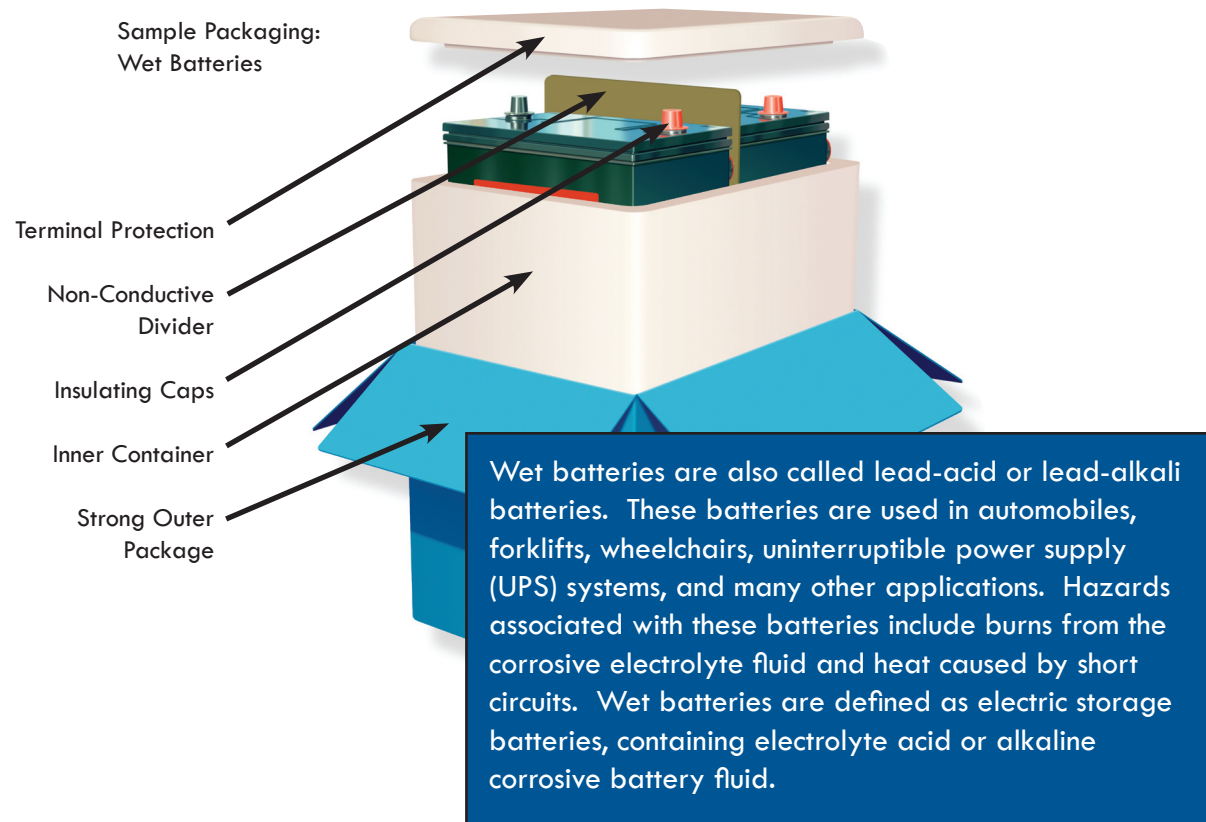
“Medium” and “Large” lithium batteries and cells must:

- Pass the design type tests in the UN Manual of Tests and Criteria.
- Be packaged in UN Specification combination packagings.

Shipments of “Medium” and “Large” lithium batteries and cells must be:

- Marked and labeled in accordance with the HMR as Class 9.
- Accompanied by a hazardous materials shipping paper prepared in accordance with the HMR describing the batteries.
- When transported by aircraft: accompanied by a shipping paper, emergency response information, notification of pilot-in-command, and must meet general packaging requirements and the requirements in § 173.27.

# Wet Batteries



- **UN2794 – Batteries, wet, filled with acid, electric storage.**
- **UN2795 – Batteries, wet, filled with alkali, electric storage.**

- Wet battery requirements are found in § 173.159.



In general, wet batteries may not be packed with other materials (exceptions are provided for battery acid/alkali fluid, dry cell batteries, and mechanical equipment such as battery chargers). When transported by aircraft, the packaging for wet batteries must incorporate an acid- or alkali-proof liner, or include an additional packaging of sufficient strength, and be adequately sealed to prevent leakage of electrolyte fluid from the packaging in the event of a leak from a battery.

Batteries must be securely packed to prevent:

- Dangerous evolution of heat\*,
- Damage to the terminals, and
- Short circuits - by any of the following methods:
  - Fully enclosing each battery or device in inner packagings;
  - Separating batteries to prevent contact; or
  - Covering exposed terminals with protective caps.

\*A “dangerous evolution of heat” is an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of the packaging, melting of packaging, scorching of packaging, or other evidence.

# Nonspillable Batteries



**A nonspillable battery** is a battery that is capable of passing the vibration and pressure differential tests as provided by § 173.159. Nonspillable batteries must be marked:  
**“NONSPILLABLE” or “NONSPILLABLE BATTERY”**

- **UN2800 – Batteries, wet, non-spillable, electric storage**



**A nonspillable wet electric storage battery is not subject to the HMR when the battery:**

- meets pressure differential and vibration testing standards found in § 173.159;
- (and its outer packaging) are plainly and durably marked, “NONSPILLABLE” or “NONSPILLABLE BATTERY”;
- is protected against short circuits (e.g., by the use of non-conductive caps that entirely cover the terminals);
- contains no unabsorbed (i.e., free-flowing) liquid (at 55 °C (131 °F)); and
- is designed so that electrolyte will not flow if the case ruptures or cracks (at 55 °C (131 °F)).

# Dry Batteries

(Excluding Lithium)



These are sealed batteries that are normally used in flashlights or small appliances. Examples include alkaline, nickel metal hydride, nickel cadmium, and carbon zinc batteries (e.g., AA, AAA, D-Cell, C-Cell, etc). These batteries include both non-rechargeable types (sometimes called alkaline batteries) and rechargeable types (nickel metal hydride and nickel cadmium).

Note: Some AA, AAA, and 9-volt batteries are made using lithium chemistries. Dry batteries do not include lithium batteries.

- Section 172.102, Special Provision 130 provides detailed requirements for packaging and protecting dry batteries (including examples).

## • Dry Batteries

Unless covered by an entry found in § 172.101, Hazardous Materials Table, in the HMR such as “UN3028, Batteries, dry, containing potassium hydroxide solid, electric, storage,” dry batteries are not subject to other requirements in the HMR when they are properly packaged and protected as specified in § 172.102, Special Provision 130.

Batteries must be securely packed to prevent:

- Dangerous evolution of heat\*,
- Damage to the terminals, and
- Short circuits - by any of the following methods:
  - Fully enclosing each battery or device in inner packagings;
  - Separating batteries to prevent contact; or
  - Covering exposed terminals with protective caps.



When you transport batteries by air with an electrical potential greater than 9 Volts, you must:

- Package a device containing the battery in a way that restricts access to activation switch, install a switch cap or lock, determine that the device has a sufficiently recessed switch, or use other suitable methods to prevent accidental activation of a device.
- Mark each package “non restricted” or provide a transport document with the words “non restricted” entered on it.

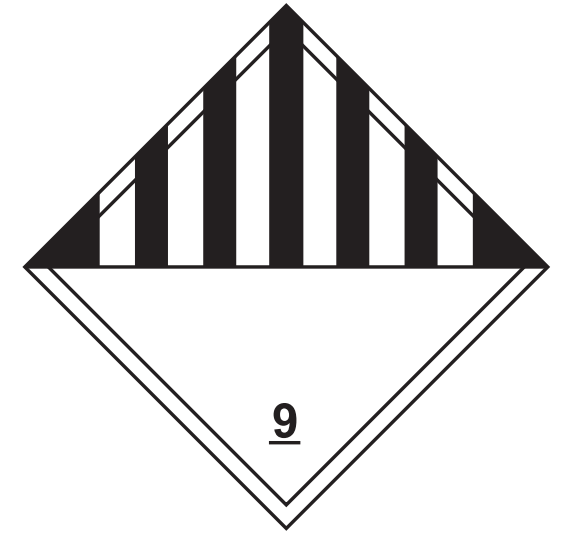
\*A “dangerous evolution of heat” is an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of the packaging, melting of packaging, scorching of packaging, or other evidence.

# Battery-Powered Vehicles and Equipment



The HMR include a number of provisions applicable to batteries installed in vehicles, machinery, or other types of equipment. Section 173.220 includes requirements for shipment of internal combustion engines, self-propelled vehicles, mechanical equipment containing internal combustion engines, and battery-powered vehicles or equipment.

- **Battery-powered vehicle or Battery-powered equipment**



Section 173.220 provides regulatory exceptions for battery-powered vehicles, machinery, and equipment provided they meet certain minimal requirements:

- Batteries must be securely installed.
  - Wet batteries must be fastened in an upright position.
  - Batteries must be protected against short circuits (e.g., by the use of non-conductive caps that entirely cover the terminals) and leakage, or removed and packaged separately.
  - When transported by aircraft: shipping papers, emergency response information, notification of pilot-in-command, general packaging requirements, and compliance with § 173.27 are required.
  - Lithium batteries contained in battery-powered vehicles are subject to most of the restrictions applicable to lithium batteries (see §§ 172.102 Special Provision 134 and A101, and 173.220(d)).
- 
- **Battery-powered wheelchairs and other mobility aids are eligible for exceptions from some regulatory requirements on passenger aircraft under certain conditions. These conditions can be found in § 175.10 of the HMR.**

# Batteries Contained in or Packed with Equipment



Many of the requirements discussed in this guide are accompanied by the statement “except when contained in or packed with equipment.” This section describes what is required for batteries contained in or packed with equipment. Battery-powered equipment can be shipped safely if certain precautions are taken to prevent short circuits, overheating, and inadvertent operations.

- Batteries, wet, non-spillable, electric storage
- Batteries, wet, filled with acid, electric storage
- Batteries, wet, filled with alkali, electric storage
- Life-saving appliances, not self inflating
- Lithium batteries packed with equipment
- Lithium batteries contained in equipment
- Dry Batteries



All batteries, wet, dry, nonspillable, and lithium, must be securely packaged with the equipment in such a way that prevents the dangerous evolution of heat and protects against short circuits, or the batteries must be properly installed in the equipment. Properly cushion items to prevent shifting.

The equipment must be designed, packaged, and be in proper condition so that no dangerous evolution of heat, fumes, gases, or fire will result. Leave devices in the “off” position. The device may not operate on its own or short circuit the battery in it. This can be achieved by engaging a trigger lock or disabling the power button/switch. Batteries may not be recharged during transportation.

Batteries packed in equipment may not exceed certain weight limits:

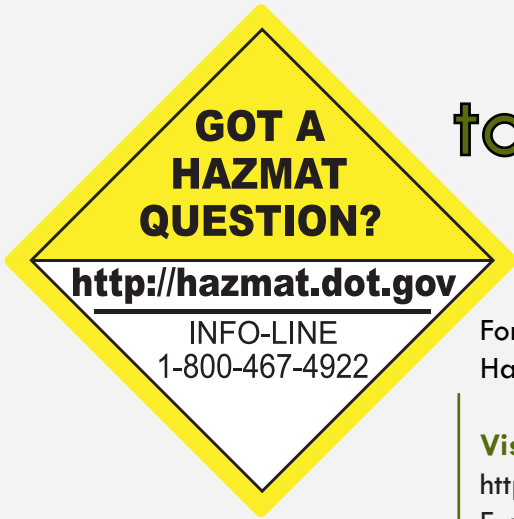
Lithium batteries in equipment: 5kg net (passenger air/rail), 35kg net (cargo air)

Lithium batteries packed with equipment: 5kg net (passenger air/rail), 35kg gross (cargo air)

Wet batteries: 30kg gross (passenger air/rail), no limit by cargo air

Dry batteries and Nonspillable batteries: no limit

- Important sections pertaining to batteries installed in and packaged with equipment: §§ 172.102, (Special Provisions 134, 157, 188, 189, A101, A103, and A104), 173.185(b) and (c), and 173.220(d).



# Where to Learn More

For information about other  
Hazmat Publications:

**Visit our web site:**

<http://www.phmsa.dot.gov/hazmat>

E-mail: [infocntr@dot.gov](mailto:infocntr@dot.gov)

**Fax:** (202) 366-7342

**E-mail:** [training@dot.gov](mailto:training@dot.gov)

**Phone:** (202) 366-4900

**Write:**

U.S. Department of Transportation

**Pipeline and Hazardous Materials**

**Safety Administration**

1200 New Jersey Avenue, SE, PHH-50

Washington, DC 20590-0001

