

Lithium Batteries: Safe to Fly?



This article has been updated in July 2025. It was initially published in January 2016.

Today, lithium batteries play a barely visible, yet essential role in both our daily life and aviation alike. Manufactured and handled correctly, lithium batteries are safe. But production failures, mishandling, or not being aware of their specific characteristics can have serious repercussions.

Lithium batteries are today's power source of choice. As we become ever more reliant on Portable Electronic Devices (PEDs) to provide at your fingertips information, entertainment and communication, then so increases the demand for more powerful, yet lighter, sources of power.

Hundreds of millions of lithium batteries or equipment with lithium batteries are carried on aircraft annually. These can be as part of passengers carry-on items, as aircraft or aircrew equipment. Lithium batteries can also be shipped as cargo. They are becoming continually more commonplace in the aircraft environment.

But the introduction of lithium batteries included some highly visible cases of cell phones, power banks or laptops self-igniting and burning. Likewise, several events have occurred on aircraft, ranging from localized and limited fires to large, uncontrolled in-flight fires resulting in hull losses and even fatalities on cargo aircraft.

The air industry has become more aware of the specific characteristics of lithium batteries, and the associated risks can now be mitigated. Procedures have been developed to address the risks for lithium batteries being part of the aircraft design, those belonging to passengers or crews carry-on items, or indeed procedures linked to the shipping of lithium batteries as cargo.

LITHIUM BATTERIES: A POWERFUL AND VERSATILE TECHNOLOGY, ASSOCIATED WITH A RISK

Lithium is the metal with the lowest density, but with the greatest electrochemical potential and energy-to-weight ratio, meaning that it has excellent energy storage capacity. These large energy density and low weight characteristics make it an ideal material to act as a power source for any application where weight is an issue, aircraft applications being a natural candidate.

Lithium: an increasing use

Experimentation with lithium batteries began in 1912 and the first lithium batteries were sold in the 1970's. In the nineties, lithium battery technology began to be widely used by a number of industries that were looking for light, powerful and durable batteries.

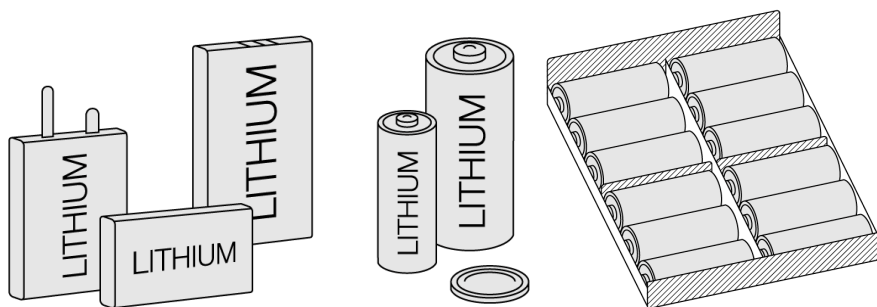
As it turns out, lithium use in batteries has been one of the major drivers of lithium demand since the rechargeable lithium-ion battery was invented in the early nineties.

Lithium batteries have progressively replaced previous technology batteries – e.g. Nickel-Cadmium, Lead-acid – and can be found in most electronic and autonomous electric systems or equipment. Development and applications are evolving with latest uses including ultra-thin (down to 0.5 mm) and flexible technologies.

The lithium battery market is extremely dynamic and expanding fast, with a growing application as the power source for a wide range of electric vehicles. In fact, no level off is foreseen in the coming years.

Different types

Lithium batteries can take many forms. They can be as tiny as single cell button batteries – for example used as power supply for watches – or multi cells (usually rechargeable) batteries that can act as high power energy sources for electric vehicles, or indeed as back-up power supply on-board aircraft (**fig.1**).



(fig.1) Types of lithium batteries: single / multi-cells

Different technologies

The term “lithium battery” actually refers to a family of batteries that can be divided into two categories:

- **Lithium-metal, non-rechargeable batteries**

These include coin or cylindrical batteries used in calculators, digital cameras and emergency (back-up) applications for example **(fig.2)**.

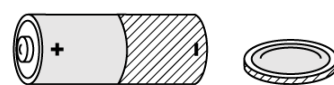
Lithium-metal batteries have a higher specific energy compared to all other batteries, as well as low weight and a long shelf and operating life.

- **Lithium-ion / lithium-polymer rechargeable batteries**

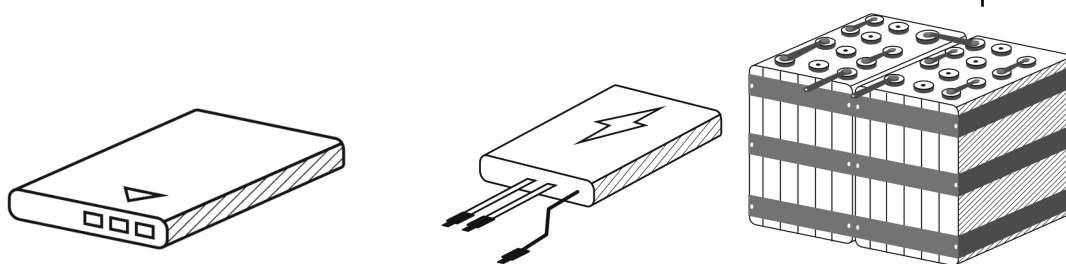
Key current applications for this type of batteries are in powering cell phones, laptops or other hand held electronic devices, as well as electric/hybrid cars and power banks **(fig.3)**.

The advantages of the lithium-ion or lithium-polymer battery are its ability to be recharged in addition to its higher energy density and lighter weight compared to nickel-cadmium and nickel-metal hybrid batteries.

(fig. 2) Non-chargeable lithium-metal batteries



(fig.3) Rechargeable lithium-ion / lithium-polymer batteries



One Main Risk: the Thermal Runaway

Although previous battery technologies were not risk-free, lithium based batteries have a larger electrochemical potential; therefore if damaged, mishandled or poorly manufactured, they can suffer stability issues and be subject to what is called a “**thermal runaway**”. This phenomenon is well recognized now, and it can be mitigated providing awareness and prevention actions are taken.

A self-ignited and highly propagative phenomenon

In case of internal degradation or damage, a battery cell rapidly releases its stored energy (potential and chemical) through a very energetic venting reaction, which in turn can generate smoke, flammable gas, heat (up to 600°C and 1500°C locally), fire,

explosion, or a spray of flammable electrolyte. The amount of energy released is directly related to the electrochemical energy stored (state of charge) and the type of battery (chemical and design).

Both the primary and secondary types of batteries are capable of self-ignition and thermal run away. And once this process is initiated, it easily can propagate because it generates sufficient heat to induce adjacent batteries into the same thermal runaway state.

Lithium batteries can be both a source of fire through self-ignition and thermal runaway, and a cause of fire by igniting surrounding flammable material.

Consequences of a thermal runaway

The phenomenon of thermal runaway in an aircraft environment can be catastrophic. At the least it can range from limited degradation of personal equipment, or minor damage to the overhead storage compartment **(fig.4)**. In the worst situation, thermal runaway in a high density package of lithium batteries can result - and has been implicated - in hull losses.



Damage to cabin overhead compartment video camera



Hull loss



Battery fire

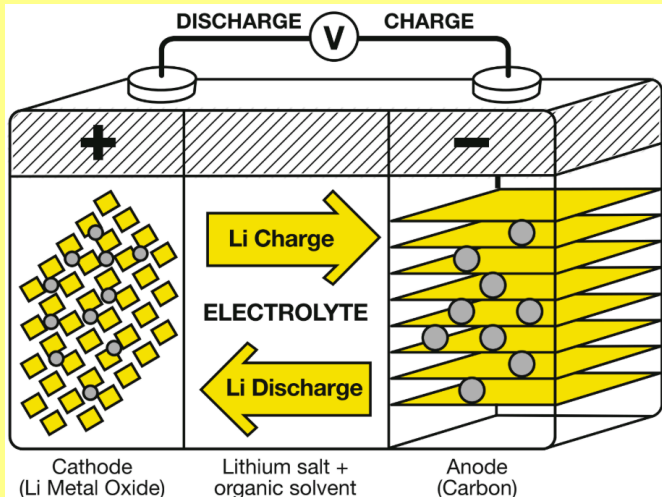
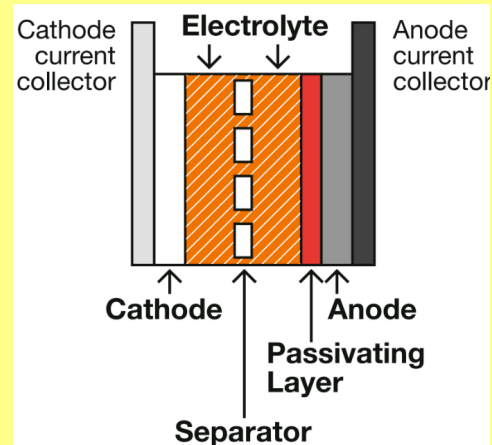
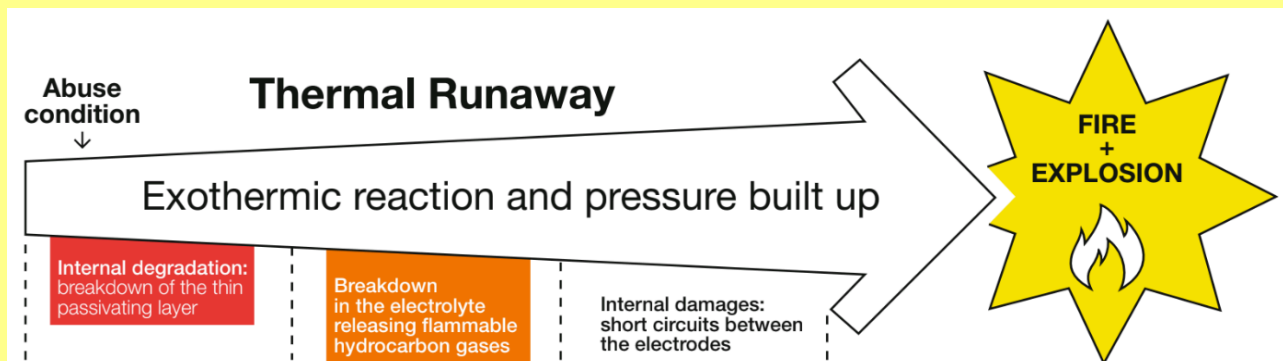
(fig.4) Consequences of lithium batteries thermal runaway

FAA tests showed that even a small number of overheating batteries emit gases that can cause explosions and fires, that cannot be suppressed by traditional fire suppression systems. In view of the possible consequences, lithium batteries are classified as hazardous materials, therefore particular care and consideration must be taken to ensure safe operations in relation to use and transport of lithium batteries (or devices containing lithium batteries) when in an aircraft environment.

INSIGHT INTO THE THERMAL RUNAWAY PHENOMENON

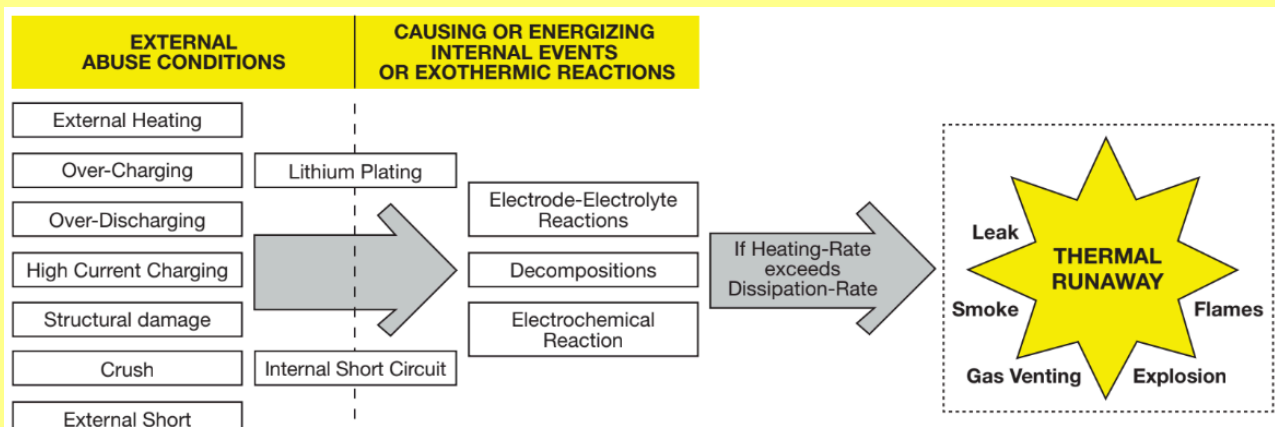
A thermal runaway consists in an uncontrolled energy release. It refers to a situation where an increase in temperature changes the conditions in a way that causes a further increase in temperature, often leading to a destructive result.

In multi-cell batteries, the thermal runaway can then propagate to the remaining cells, potentially resulting in meltdown of the cell or a build-up of internal battery pressure resulting in an explosion or uncontrolled fire of the battery.



The main factors contributing to a thermal runaway are:

- Poor design or poor integration
- Poor cell or battery manufacturing quality
- Poor safety monitoring or protection
- Poor handling / storage / packing conditions

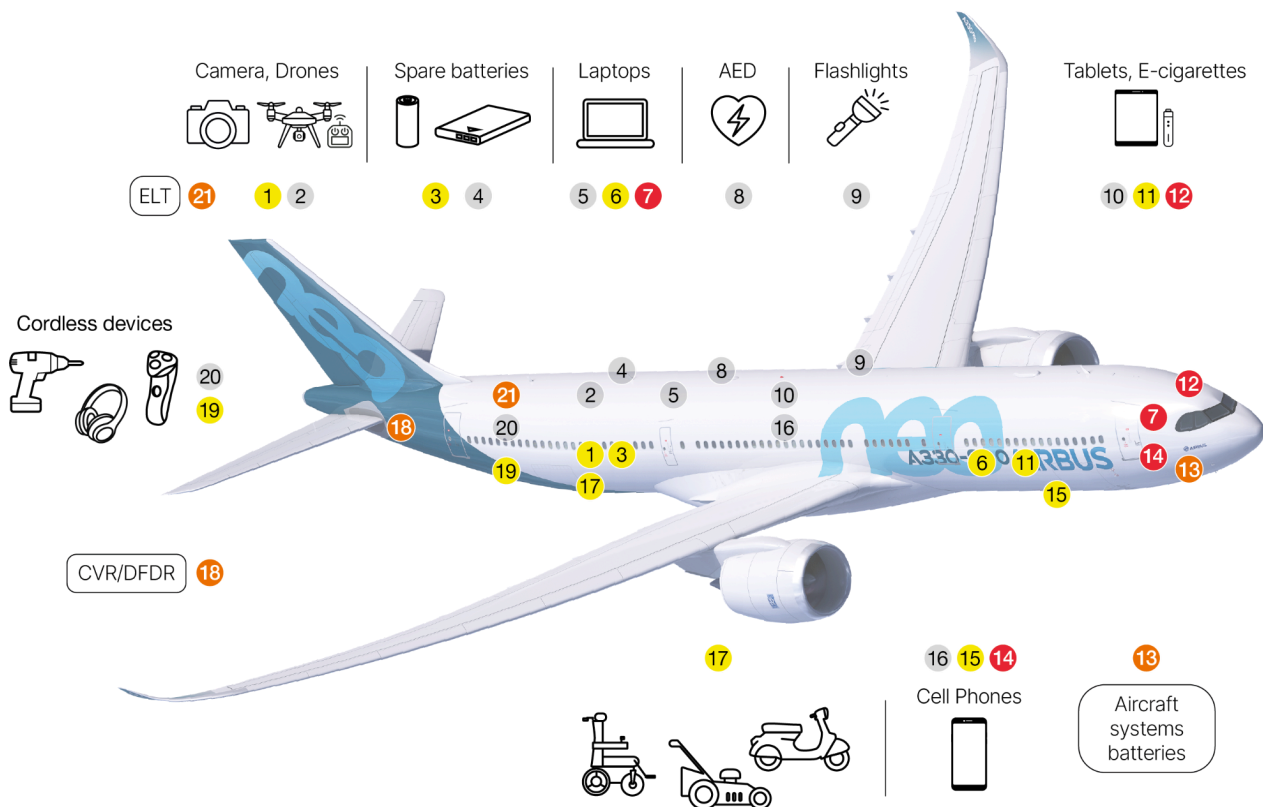


A Significant Risk Exposure

By their nature and properties, large numbers of lithium batteries can be found in many places on-board an aircraft (**fig.5**):

- In the cabin among the personal electronic devices of crews and passengers
- In the cockpit as part of tablets used for flight data support
- In the cargo holds carried as cargo or in passengers baggage
- In the aircraft design.

(fig.5) Lithium batteries on-board an aircraft



INFORMATION

Between March 3rd, 2006 and April 30th, 2025, the FAA has recorded **617 verified incidents** involving lithium batteries carried on passenger aircraft and cargo aircraft according to the FAA report on ["Lithium Battery air Incidents involving smoke, fire, or extreme heat"](#).

PERMANENTLY INSTALLED LITHIUM BATTERIES

Mitigating the risks posed by lithium batteries and preventing a thermal runaway or a fire starts with **securing the batteries that are part of the aircraft design**. In this respect, the lithium batteries embedded in the aircraft design are subject to strict development and integration requirements, complying with the highest safety standards. The intrinsic risk of this new generation of lithium based batteries is acknowledged at all levels of the aircraft design phase, as early as from the inception of the product and its systems. It is then mitigated thanks to acceptability justification based on each battery location, and a thorough review of installation, ensuring that no heat source and hazardous material or fluids are in the vicinity.

Only use Original Equipment Manufacturer (OEM) Parts

During an aircraft's service life, this risk can be mitigated by adhering to common sense precautions, such as using only the OEM parts. **The use of counterfeit or non-authorized parts increases the risk of fire and explosion.** Consequently, complying with the Airbus Parts Catalogue and exclusively using Airbus or OEM catalogue references for spare batteries is key.

Similarly, before installing spare batteries in Buyer Furnished Equipment (BFE) or in aircraft, operators should ensure the parts are genuine spare parts, that they have been stored and handled appropriately and present no mark of overheat or damage.



INFORMATION

More information about the consequences on use of non-approved batteries can be found in OIT 999.0032/03 Rev 01, OIT 999.0035/04 Rev 03 and OIT 999.0145/14.

LITHIUM BATTERIES AS A CARGO

Increased usage of lithium batteries as the power supply of choice has, not surprisingly, led to an increase in the shipping of lithium batteries as air cargo. Today, one of the main risks posed by lithium batteries is related to shipping as freight. The existing ICAO recommendations do not regulate the quantity of lithium batteries that can be shipped as cargo on any single aircraft as a cargo load. The only limitations are associated with what can be loaded into each individual package. It is also worth understanding that these same regulations are not intended to control or contain a fire within that packaging.

Research projects launched in the past years aimed at supporting the development of the new SAE AS6413 packaging standard for air cargo. The effectiveness of the packaging solutions and transport measures are validated through a series of experimental tests, representative of the operating conditions encountered by air transport. In addition, a comprehensive risk assessment method has been developed to support operators in using the solutions and measures in their daily operations (ICAO recommendations adopted by EU regulation).

What protection can the existing cargo compartment fire protection provide in the event of a lithium battery fire?

Today's cargo fire protection of an aircraft is addressed by:

- Passive protection (cargo hold linings or protection of essential systems)
- Detection
- Suppression (use of Halon) or oxygen starvation
- Preventing hazardous smoke / extinguishing agents into occupied compartments.

CATEGORIZATION OF CARGO COMPARTMENTS

Cargo compartments of the Airbus fleet are certified as class C and class E compartments according to CS 25.857. Additionally, some aircraft in service still have class D cargo compartments, but this classification was eliminated for new production in 1998.

- **Class C** compartments are required for passenger aircraft compartments not accessible during flight (lower deck) or if a fire could not be controlled from the entrance point, without entering the compartment. A class C compartment needs to be equipped with:
 - o Smoke/fire detection system
 - o Ventilation control
 - o Built-in fire suppression system
 - o Fire resistant linings (passive protection)
 - o It needs to be demonstrated that no hazardous quantity of smoke, flames or fire extinguishing agents are able to enter occupied areas.
- **Class D** compartments need to be equipped with:
 - o Ventilation control
 - o Fire resistant linings (passive protection)
 - o It needs to be demonstrated that no hazardous quantity of smoke or flames are able to enter occupied areas.
- **Class E** compartments are only allowed for freighter aircraft. They need to be equipped with:
 - o Smoke/fire detection system
 - o Ventilation control
 - o Only critical systems need to be protected from fire
 - o It needs to be demonstrated that no hazardous quantity of smoke, flames or noxious gases are able to enter occupied areas.

Investigations have shown that the cargo compartment fire protection standards described in CS 25 are not sufficient to protect the aircraft from fires involving high density shipments of lithium batteries.

"High density" describes a quantity of lithium battery accumulation that has the potential to overwhelm the cargo compartment fire protection features. In fact, the impact of different characteristics of the batteries (e.g. chemistry, state of charge, size), cargo compartments types and loading configurations make it very difficult to define a quantity limitation that could be recommended at aircraft level, for all operational situations. Tests have demonstrated that some configurations, involving only one of the regulated packaging sizes, could already have the potential to lead to significant damage to an aircraft.

Irrespective of the size of the shipment, research into the impact of both lithium-metal and lithium-ion batteries fire has demonstrated that the existing cargo compartment fire suppression functions – namely Halon 1301 (class C) or oxygen starvation (class E) – are unable to stop a thermal runaway and prevent propagation to adjacent cells. If a thermal runaway is initiated, heat and flammable gases coming from the degradation of the hydrocarbon electrolyte will be emitted. The existing fire protection cargo functions are not capable of preventing an explosion of these accumulated gases.

The passive protection standards are designed to withstand heat sources for up to 5 minutes and are not resistant against the characteristics of a lithium battery fire. The temperature, duration and intensity of such a fire will quickly overwhelm the passive protections. In addition, the quantity and continuing production of smoke produced is likely to overwhelm the passive and active smoke barriers that protect the occupied compartments.

What Regulations Say

Transportation of lithium batteries as a cargo is forbidden on passenger aircraft

In the light of the risks identified, the ICAO Dangerous Goods Panel took the position to ban the carriage of lithium batteries of all types as cargo on passenger aircraft from April 2016.

Maximum state of charge of transported batteries

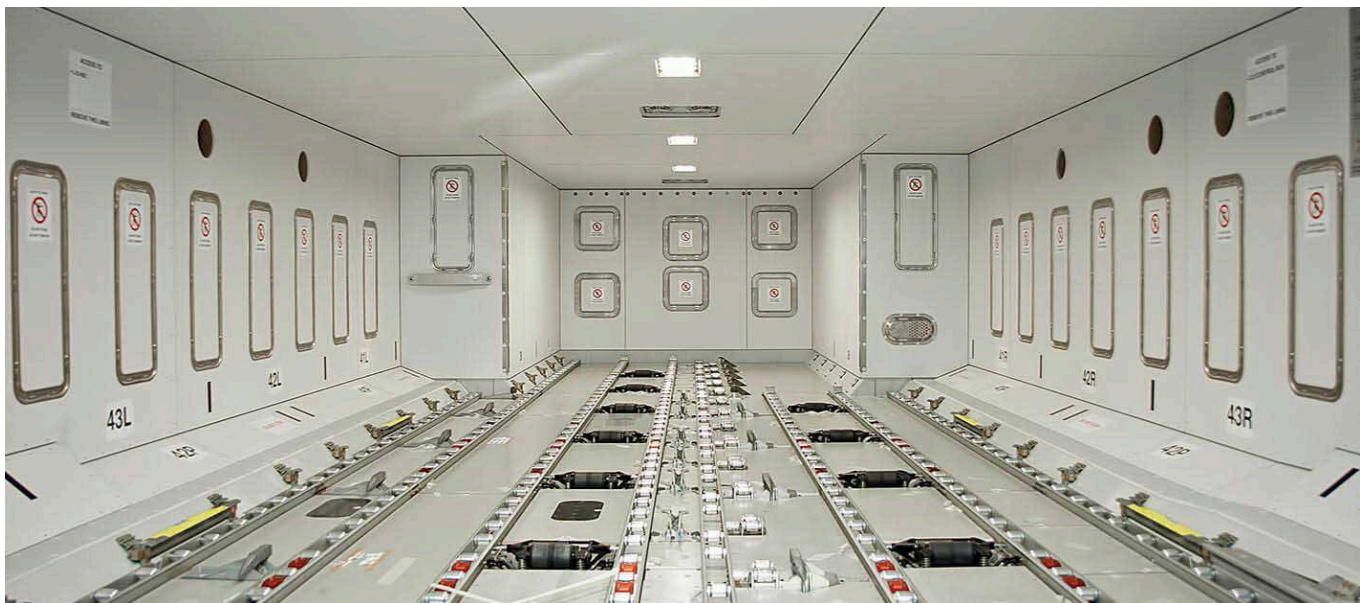
The ICAO Dangerous Goods Panel (DGP) recommends not exceeding a 30% State of Charge (SoC) limit as an interim measure aiming to reduce the risk of fire propagation to adjacent batteries and thereby improve aviation safety.

Packaging and shipping

ICAO is also focussing on establishing appropriate packaging and shipping requirements to ensure safer shipment of lithium-ion batteries. Airbus is also involved in the Civil Aviation Safety Team (CAST) investigating overall approaches from the battery itself to a combination of packaging / container and the aircraft itself.

The importance of correct transport and shipping of lithium batteries therefore becomes key, and the involvement of the shipper and operator is crucial.

On request of ICAO, SAE has established a standardization working group - SAE G-27, which develops a Performance-Based Package Standard for lithium-ion Cylindrical Cells as a Cargo on Aircraft - AS6413.



What Shippers and Operators Can Do: Risk Assessment and Best Practices

1. Check the latest industry available information and guidance

Air transport of lithium batteries is controlled by international and local regulations. If transporting lithium batteries, operators need to first check the latest instructions for the safe transport of dangerous goods by air, be they provided through Airworthiness Authorities or local regulations, and/or the ICAO.

2. Perform a risk assessment

In the end, the responsibility for the safe carriage of dangerous goods (including lithium batteries) lies with the shipper and operator. It is recommended that if carriage of dangerous goods is pursued, then a safety risk assessment of cargo operations should be performed to determine if battery shipments can be handled safely.

With respect to lithium batteries, guidelines for the assessment should consider factors such as:

- The quantity and density of lithium battery shipment
- The type of lithium batteries to be shipped
- Who the supplier/shipper of lithium batteries is and their quality control
- The identification and notification of all shipments of lithium batteries (also Section II lithium batteries)
- Accepting only lithium battery shipments that comply with applicable regulations (ICAO and/or local regulations)
- Overall capability of the aircraft and its systems
- Segregation possibilities of lithium batteries from other flammable/explosive dangerous goods.

3. Ensure safe packaging and shipping

Local and/or international regulations provide the applicable set of rules that need to be complied with when transporting lithium batteries. Attention should be given to:

- **Training and awareness of employees** regarding:
 - o The aircraft limitations against a lithium battery fire and existing mitigation means.
 - o Regulations, handling procedures, the dangers of mishandling, and methods to identify lithium battery shipments.
- **Packaging:**
 - o Clearly identify shipments of lithium batteries by information on airway bills and other documents.
 - o Make sure that the packaging is correctly labelled and identified as dangerous goods according to ICAO technical instructions.
 - o Do not ship damaged packages.
- **Cargo loading:** segregate any lithium battery shipments from other dangerous goods that present a fire hazard (flammable and explosive goods).



INFORMATION

More information on the carriage of lithium-ion batteries is provided in Airbus ISI 00.00.00182 dated 27 August 2024.

Industry Guidance, such as the IATA "Lithium Batteries Risk Mitigation Guidance for Operators" also provides useful information for mitigating the risk on the carriage of lithium batteries.



LITHIUM BATTERIES IN THE CABIN

Whilst recent discussions have shifted the focus towards the carriage of large quantities of lithium batteries as cargo, due to their proliferation and use in many applications, operators need to also be aware of the risk of carrying lithium batteries in passenger baggage – both checked in, off loaded cabin baggage and also carry-on cabin baggage.

The widespread use of lithium batteries means that hundreds of Portable Electronic Devices (PED) are likely to be carried on a large aircraft, either in hold baggage or as carry-on. Prevention is therefore essential to raise passengers' awareness of the risks associated with carrying lithium batteries.

Raising passengers awareness before boarding

Recommendations have been developed with respect to what can or cannot be carried in passenger baggage. IATA regulated and recommended general requirements with regards to carrying and managing what is carried in passenger baggage is that:

- Batteries carried should have been appropriately tested (e.g. should be manufactured by the original manufacturer).
- PEDs containing lithium batteries should be carried in carry-on baggage.
- Spare batteries (i.e. those not contained in a PED), regardless of size, MUST be in carry-on baggage. They are forbidden in checked baggage and should be appropriately protected against short circuit, e.g. by leaving the batteries in its original retail packaging.
- Consider the quantity carried by individuals. Whilst there is no limit on the number of PEDs or spare batteries, below a specified size (normally 100 Watt-hour) that a passenger or crew member may carry, but they must be for personal use.

The key however is making both the ground personnel and the passenger themselves aware of the risks presented by the incorrect carriage of lithium batteries, and making sure that they know the regulations. To increase the awareness of the travelling public, posters and lithium battery pamphlets can be a useful option and are widely used by air carriers and authorities around the world alike. As an example, the FAA has issued Safety Alerts for Operators (SAFO) number 15010, which deals with "Carriage of Spare lithium Batteries in Carry-on and Checked Baggage".

In May 2025, EASA released a Safety Information Bulletin SIB No. 2025-03 that

provides a set of recommendations for passenger aircraft operators, aerodrome operators and ground handling service providers on actions that should be taken to make passengers aware of the restrictions and conditions applicable to carriage of lithium batteries and PEDs powered by lithium batteries in passenger aircraft.

Raising passenger awareness on-board the aircraft

A key aspect to mitigating the risk is making the owner, namely the passenger, aware of the risks inherent to lithium batteries being used in an aircraft environment. Make sure passengers are aware of what is allowed in the terms of lithium batteries in carry-on baggage, and the requirement for correct storage, but also the impact of a PED getting trapped in the movable seat mechanism.

Due to their small size, PEDs can easily be trapped in seat mechanisms. The subsequent crushing of PEDs during adjustment of the seat can lead to overheating and thermal runaway.

Making passengers aware of this inherent risk can help reduce this scenario. For example, including a note in the pre-flight briefing to ensure that in case a PED is lost, then the seat is not moved until the component is retrieved is an option. Likewise, making cabin and flight crew aware of this potential failure mode is key to quick and efficient action when addressing a fire caused by a PED.



INFORMATION

- EASA Safety Information Bulletin [SIB No.: 2025-03, Passenger and Crew Awareness on the Risks of Lithium Batteries](#)
- IATA has issued more information on the risk mitigations for operators on carriage of lithium batteries. Visit their website for more information and guidance on different situations, making sure the last approved versions are used.
<https://www.iata.org/en/publications/newsletters/iata-knowledge-hub/what-to-know-about-how-to-ship-lithium-batteries/>

Mitigating the risks posed by lithium batteries: summary

Lithium battery thermal runaways can be caused by design / manufacturing quality / integration shortcomings or by inadequate compliance with a number of basic rules. The following principles should be adhered to in order to minimize the risk of lithium battery fires and explosions:

- Ensure that lithium cells/batteries shipped comply with international standards.
- Ensure that loads conform with ICAO / IATA labelling, packaging and handling recommendations.
- Ensure compliance to the Airbus Parts Catalogue when replacing aircraft batteries.
- Ensure that ground, flight and cabin crews are trained and passengers are aware of lithium batteries specificities.



INFORMATION

For more information on how to handle a lithium battery fire in the cockpit or the cabin, refer to the "[Lithium Battery Fire in the Cabin or in the Cockpit](#)" article published in July 2025.

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Lithium batteries have existed for more than 20 years now and are widely used in all daily applications. This technology is extremely efficient and its range of applications is constantly expanding. Whilst fortunately events involving lithium batteries are rare, and even rarer when occurring in flight, the risk of fire still exists. The specificities of lithium batteries need therefore to be considered in all aspects of aircraft applications and managed correctly.

It is essential to consistently review and adhere to the latest procedures and regulations. ICAO and IATA, along with FAA and EASA, frequently update their documentation and websites to support customers, operators, and stakeholders in staying informed about the evolving challenges related to the air transport of lithium batteries.

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