



Lithium batteries: safe to fly?

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.



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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 (e.g. Portable IFE, defibrillators) or aircrew equipment (such as Electronic Flight Bags). They can be shipped as cargo in battery form or within other purchased items to support the demand for "just in time deliveries", or indeed as power supply for aircraft equipment. Lithium batteries are becoming continually more common place in the aircraft environment.

But the introduction of Lithium batteries included some highly visible cases of cell phones 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 fatalities.

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 COMMON 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.

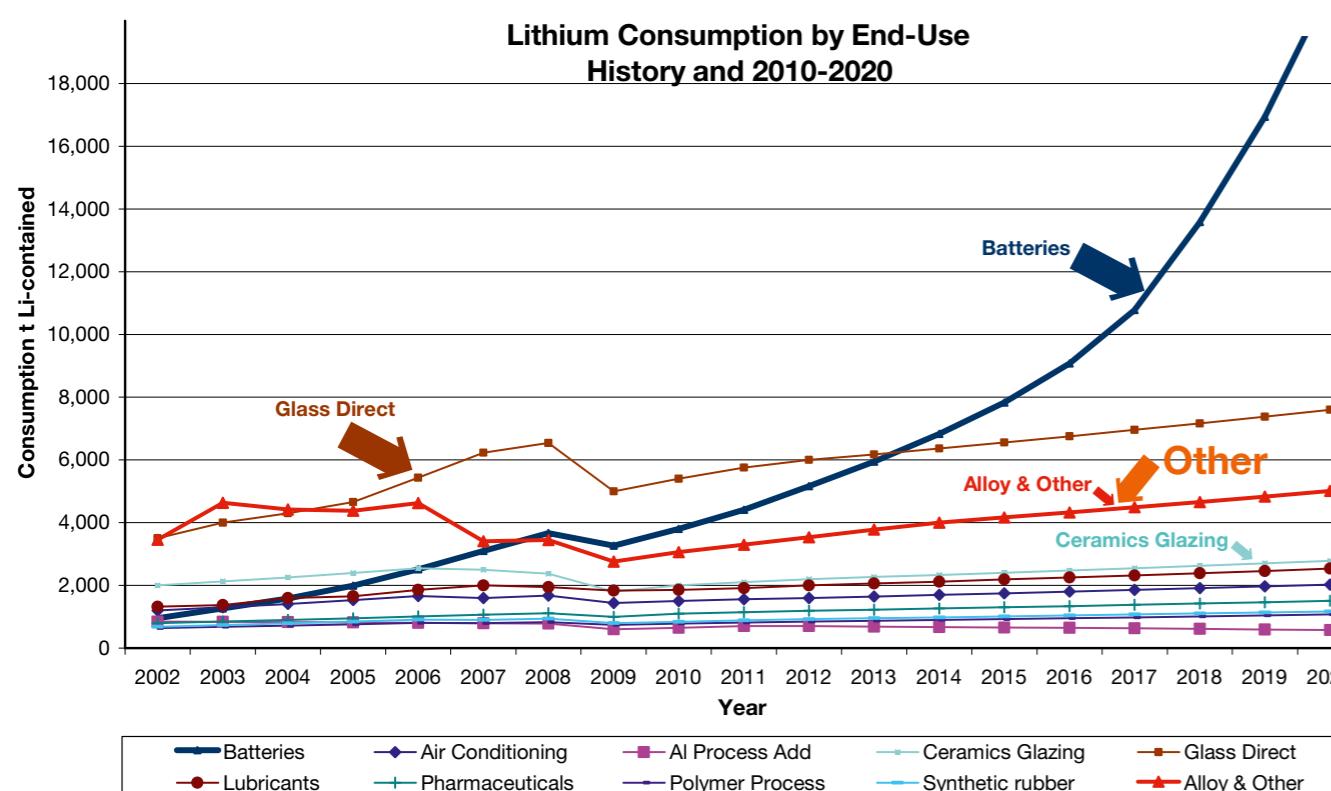
While the technology used and the

intrinsic risk is the same for all applications, different solutions and procedures exist to mitigate this common risk depending on where and how the Lithium battery is used (i.e. part of the aircraft design, transported as cargo or in passengers and crews luggage and PED). This section will highlight the benefits of this new technology irrespective of its use in applications, and describe the associated risk of "thermal runaway".

Lithium batteries: safe to fly?

(fig.1)

Forecast Lithium demand by application (Source: TRU Group)



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,

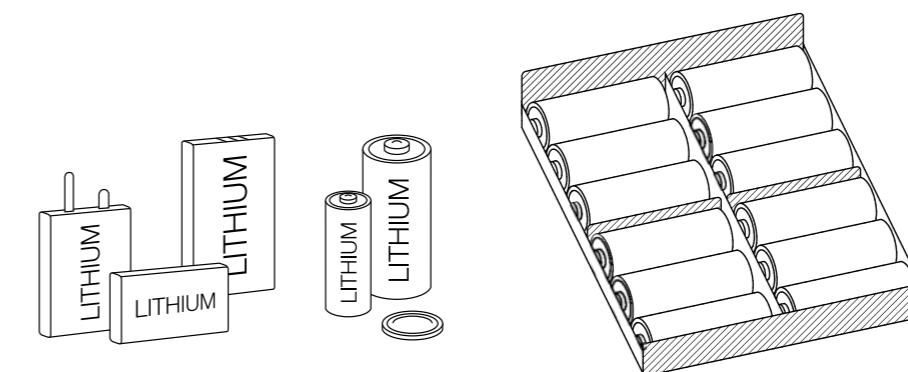
powerful and durable batteries. As it turns out, Lithium use in batteries has been one of the major drivers of Lithium demand since the rechargeable Lithium-ion battery was invented in the early nineties (fig.1).

Different types of Lithium batteries, different applications

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.3).



(fig.3)
Types of Lithium batteries: single/multi cells

Different technologies

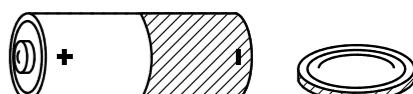
The term "Lithium battery" actually refers to a family of batteries that can be divided into two categories:

» Primary: Lithium-metal, non-rechargeable batteries

These include coin or cylindrical batteries used in calculators, digital cameras and emergency (back-up) applications for example (fig.4).

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.

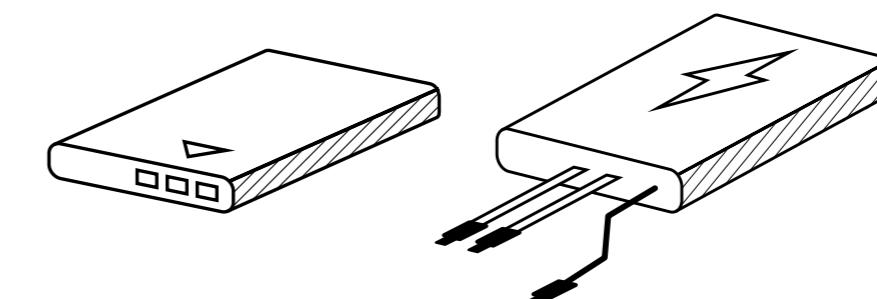
(fig.4)
Lithium-metal batteries



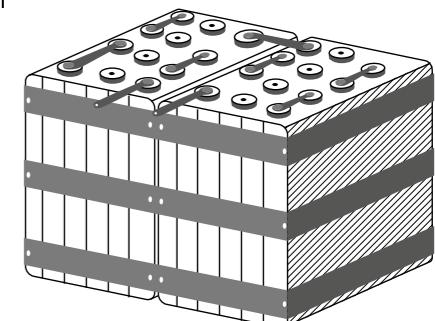
» Secondary: Lithium-ion / Lithium-polymer rechargeable batteries

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 stores (fig.5).

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.

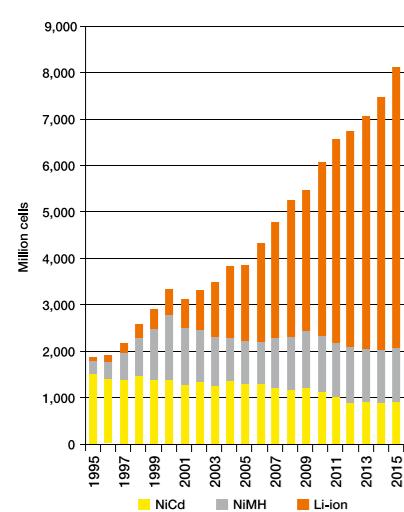


(fig.5)
Lithium-ion / Lithium-polymer batteries



(fig.2)

Worldwide batteries production (Source: Christophe PILLOT, Avicenne Energy)



Today, Lithium batteries are progressively replacing previous technology batteries – e.g. Nickel-Cadmium, Lead-acid – and can be found in most of electronic and autonomous electric systems or equipment. Development and applications are evolving with latest uses including ultrathin (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. In 2014, 5.5 billion Lithium-ion batteries were produced (fig.2).

Lithium batteries: safe to fly?

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.

One main intrinsic risk to tackle: the thermal runaway

As with every new technology, Lithium batteries offer a number of advantages, but they also come with limitations. Although previous batteries 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

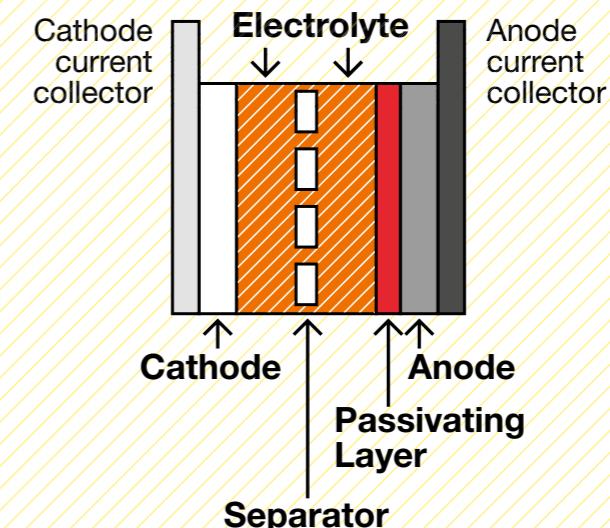
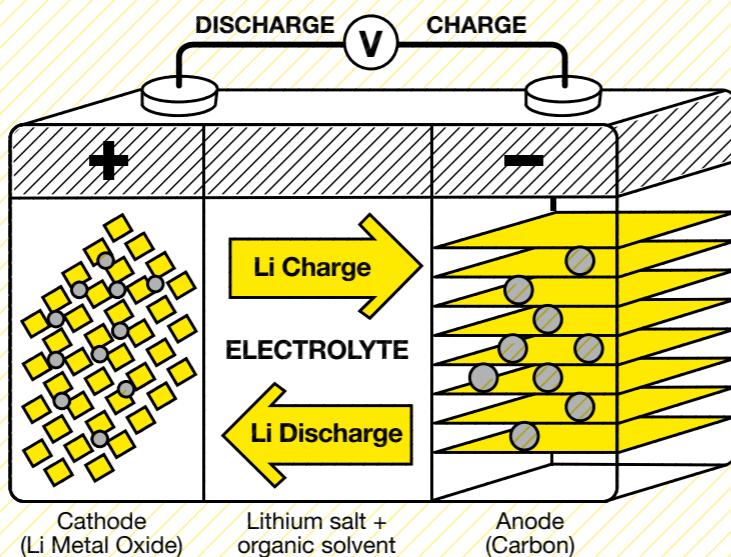
In case of internal degradation or damage, a battery cell rapidly releases its stored energy (potential and chemical) through a very energetic venting reaction, which in turn can generate smoke, flammable gas, heat (up to 600°C and 1000°C locally), fire, explosion, or a spray of flammable electrolyte. The amount of energy released is directly related to the electrochemical energy stored and the type of battery (chemic and design).

Both the primary and secondary types of batteries are capable of self-ignition and thermal runaway. 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.

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.



Abuse condition
↓

Thermal Runaway

Exothermic reaction and pressure built up

Internal degradation: breakdown of the thin passivating layer

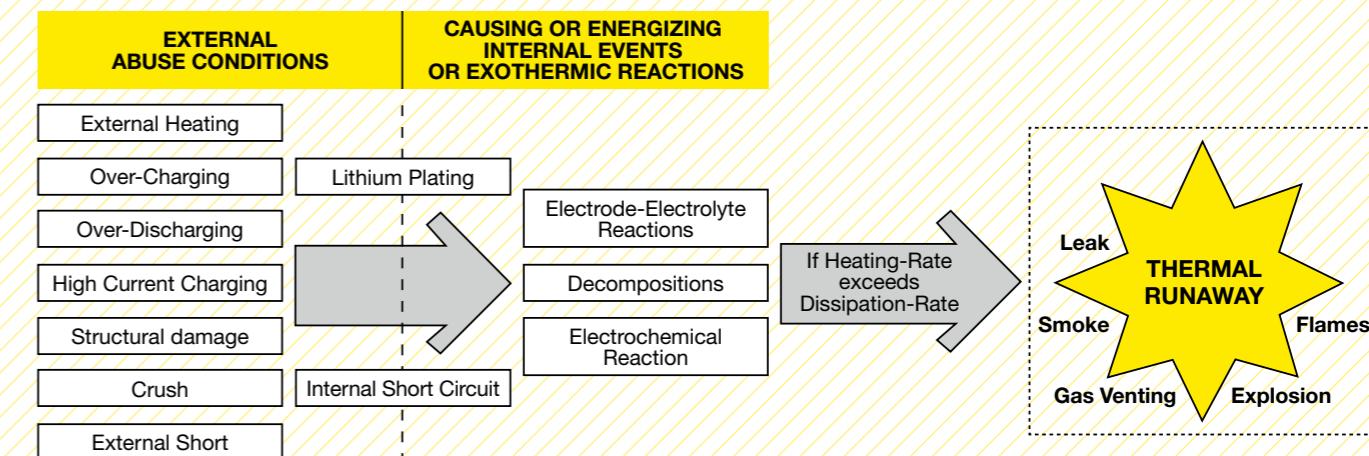
Breakdown in the electrolyte releasing flammable hydrocarbon gases

Internal damages: short circuits between the electrodes



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

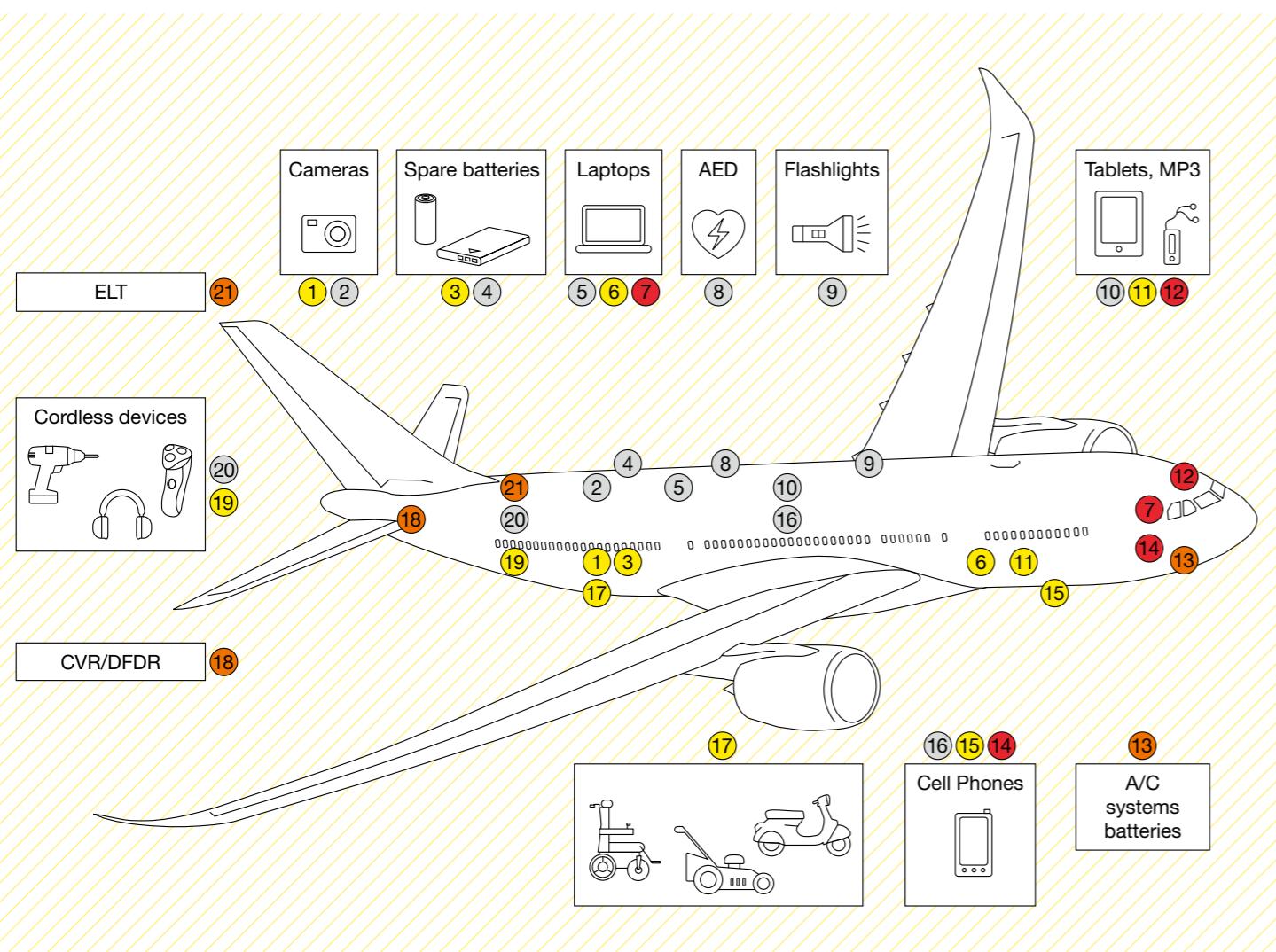


Lithium batteries: safe to fly?

In-service experience

By their nature and properties, large numbers of Lithium batteries can be found in many places on-board an aircraft (fig.6):

(fig.6)
Lithium batteries on-board an aircraft



Since March 20th, 1991, the FAA has recorded 158 incidents involving batteries carried as cargo or baggage according to their report on "Batteries & Battery-Power Devices – Aviation Cargo and Passenger Incidents Involving Smoke, Fire, Extreme Heat or Explosion" dated 30 June 2015. 81 of these events related to Lithium batteries.

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. In the case worst situation, thermal runaway in high density package of Lithium batteries can result - and has been implicated - in hull losses (fig.7).

- 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 cabin among the personal effects of crews and passengers
- In the aircraft design.



FAA tests show that even a small number of overheating batteries emit gases that can cause explosions and fires that cannot be prevented 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. ■

Lithium batteries are classified as hazardous materials.



Damage to cabin overhead compartment video camera

Hull loss

Battery fire

HOW TO MITIGATE THE RISKS POSED BY LITHIUM BATTERIES

Although investigation into reported events highlighted that some Lithium batteries fires were due to internal short circuits relating to design, manufacturing or integration shortcomings, many – if not most – fires were caused by abuse by the user. This may be deliberate or negligent abuse or physical damage due to mishandling, but quite often it is unconscious abuse. Also, while strict regulations for transporting Lithium batteries as cargo exist, several incidents have been related to Lithium batteries being in the cabin. For this reason, a good awareness on risks posed by Lithium batteries of both airlines personnel and their passengers is crucial.

Lithium batteries: safe to fly?

“ The Lithium batteries embedded in the aircraft design are subject to strict development and integration requirements, complying with the highest safety standards. ”

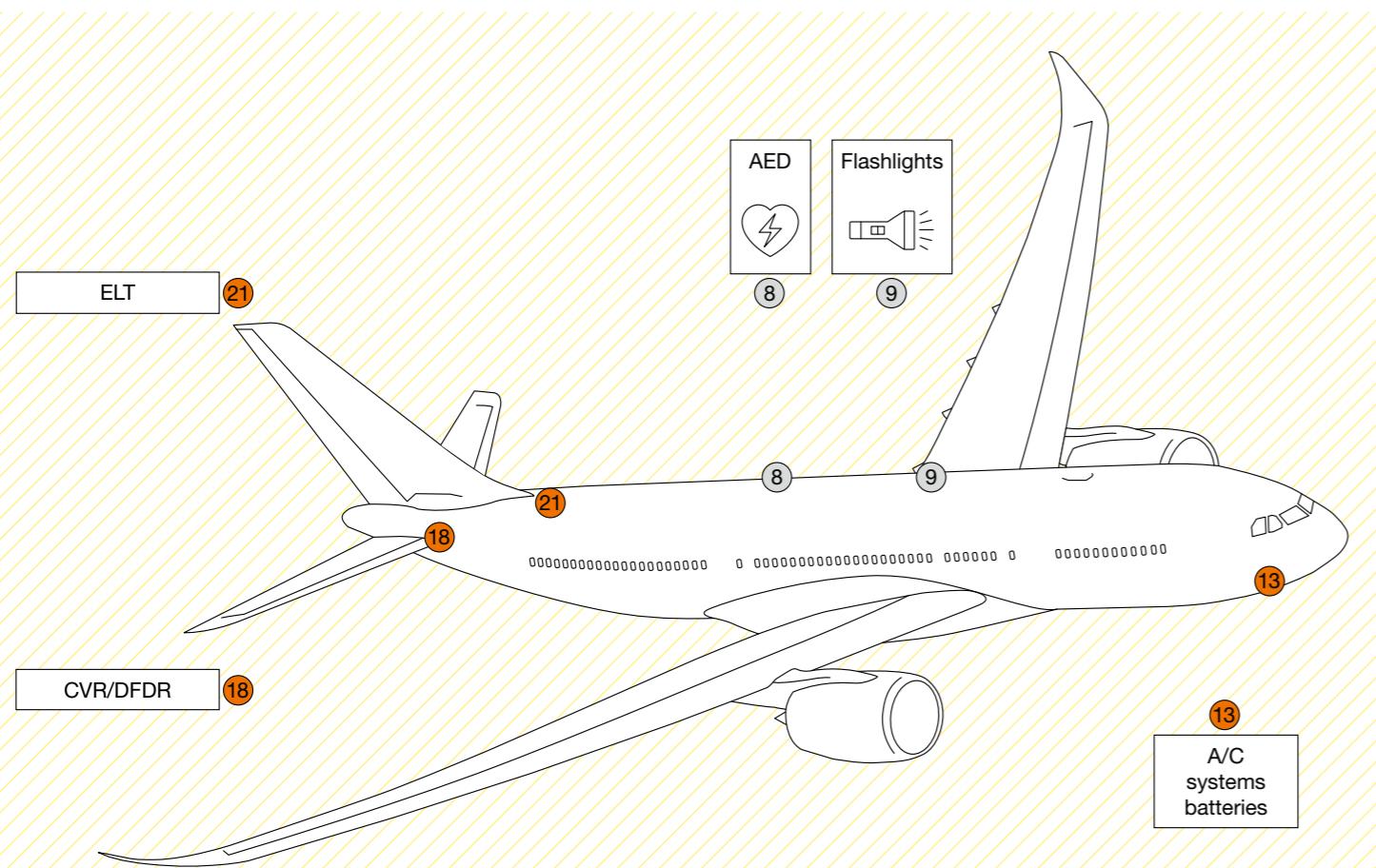
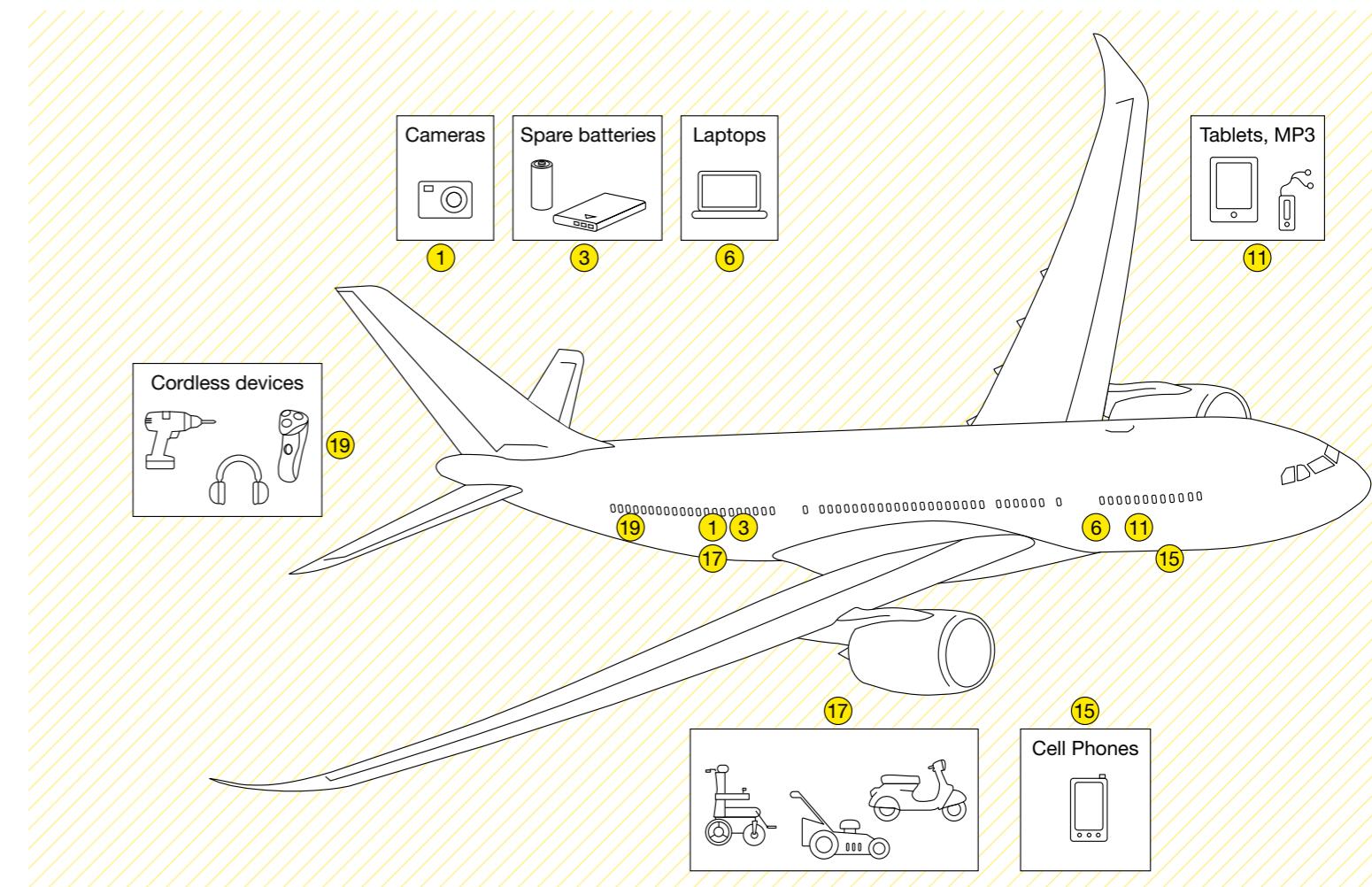
Permanently installed batteries

Mitigating the risks posed by Lithium batteries and preventing a thermal runaway or a fire starts with securing the batteries that form 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.



DID YOU KNOW

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 and OIT 999.0145/14.



Carriage of Lithium batteries as air 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 the shipping as freight. The existing ICAO regulations 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 to 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.

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.

Investigations have shown that the cargo compartment fire protection standards described in CS/FAR25 are not sufficient to protect the aircraft from fires involving high density shipments of Lithium batteries.

“High density” describes a quantity of Lithium batteries that has the potential to overwhelm the cargo compartment fire protection system. In fact, the

Lithium batteries: safe to fly?

“ Today's cargo compartments do not demonstrate resistance to a fire involving Lithium-metal and Lithium-ion batteries. ”

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 item of the regulated packaging size, has the potential to lead to significant damage of 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 systems – 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 sys-

tems are not capable of containing 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.

With these findings, the aviation industry came to the conclusion that today's cargo compartments, which are certified to US CFR Part 25.857 and EASA CS 25.857, do not demonstrate resistance to a fire involving Lithium-metal and Lithium-ion batteries. For this reason, the inability to contain a Lithium battery fire for sufficient time to secure safe flight and landing of the aircraft, is an identified risk to the air transport industry.

What the regulations say

In the light of the risks identified, in January 2015, the ICAO Dangerous Goods Panel took the position to ban the carriage of Lithium-metal batteries of all types, as cargo on passenger aircraft.

However, whilst this was an important development, Lithium-metal batteries only account for a small proportion of all Lithium batteries carried annually as air cargo. Consequently, research into the impact of a Lithium-ion batteries fire has continued. As already noted, this research has demonstrated that Lithium-ion batteries themselves represent a significant threat due to the fact that the existing cargo compartment fire suppression functions are ineffective against a Lithium-ion battery fire.

As a result, regulatory authorities are now heading towards a larger ban on Lithium battery shipments as cargo on passenger planes that would include

non-rechargeable and rechargeable batteries alike. At time of publication of this article, these discussions are on-going. At their last meeting in October 2015, the ICAO Dangerous Goods Panel (DGP) proposed 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.

At the same time, discussions in ICAO are 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.

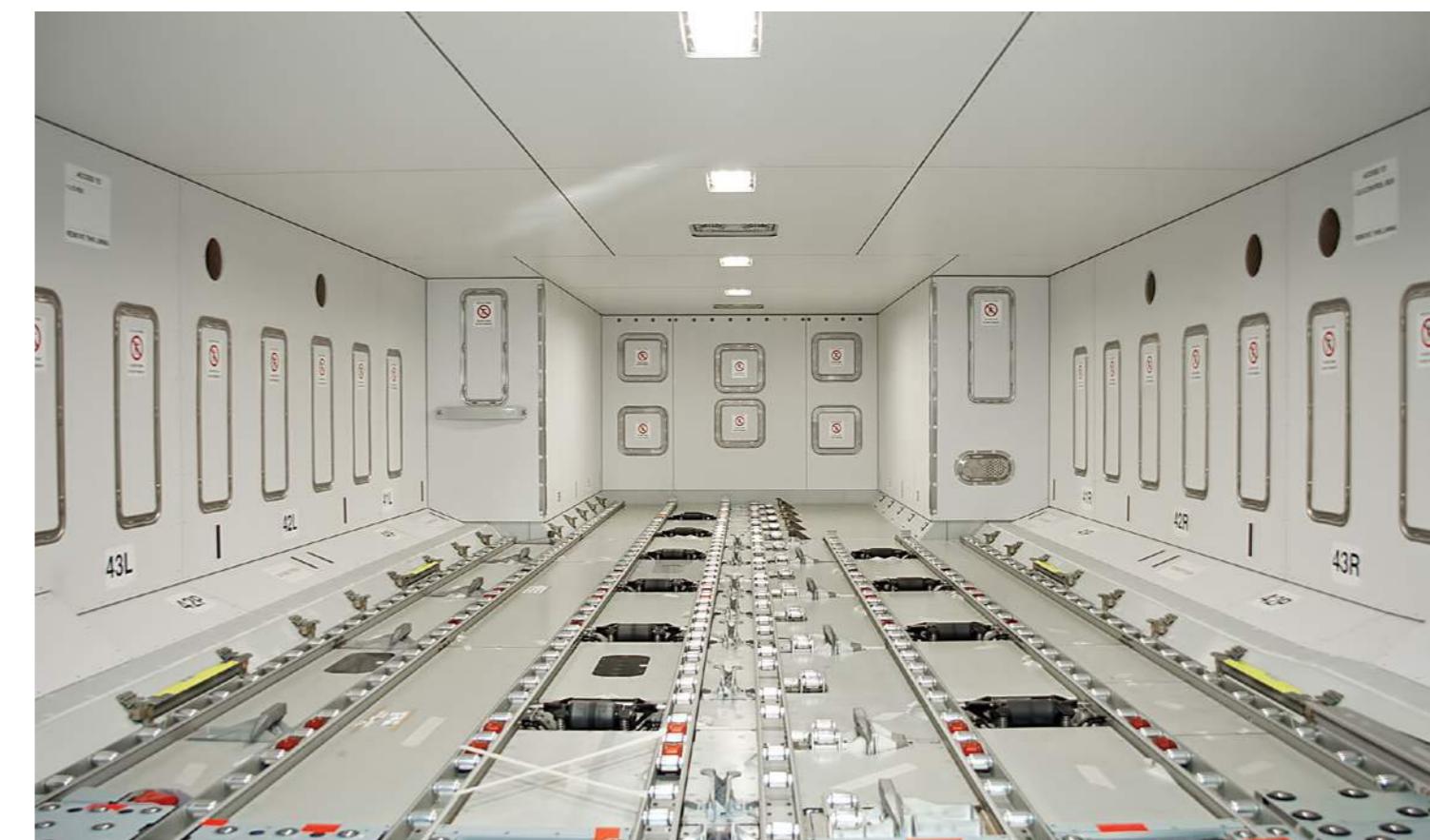
The importance of correct transport and shipping of Lithium batteries therefore becomes key, and the involvement of the shipper and operator is crucial.

“ Primary (non-rechargeable) Lithium-metal batteries are forbidden for transportation aboard passenger-carrying aircraft. ”

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 D compartments need to be equipped with:
 - Ventilation control
 - Fire resistant linings (passive protection)
 - It needs to be demonstrated that no hazardous quantity of smoke or flames are able to enter occupied areas.
- 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:
 - Smoke/fire detection system
 - Ventilation control
 - Built-in fire suppression system
 - Fire resistant linings (passive protection)
 - It needs to be demonstrated that no hazardous quantity of smoke, flames or fire extinguishing agents are able to enter occupied areas.
- Class E compartments are only allowed for freighter aircraft. They need to be equipped with:
 - Smoke/fire detection system
 - Ventilation control
 - Only critical systems need to be protected from fire
 - It needs to be demonstrated that no hazardous quantity of smoke, flames or noxious gases are able to enter occupied areas.



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 appli-

cable 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

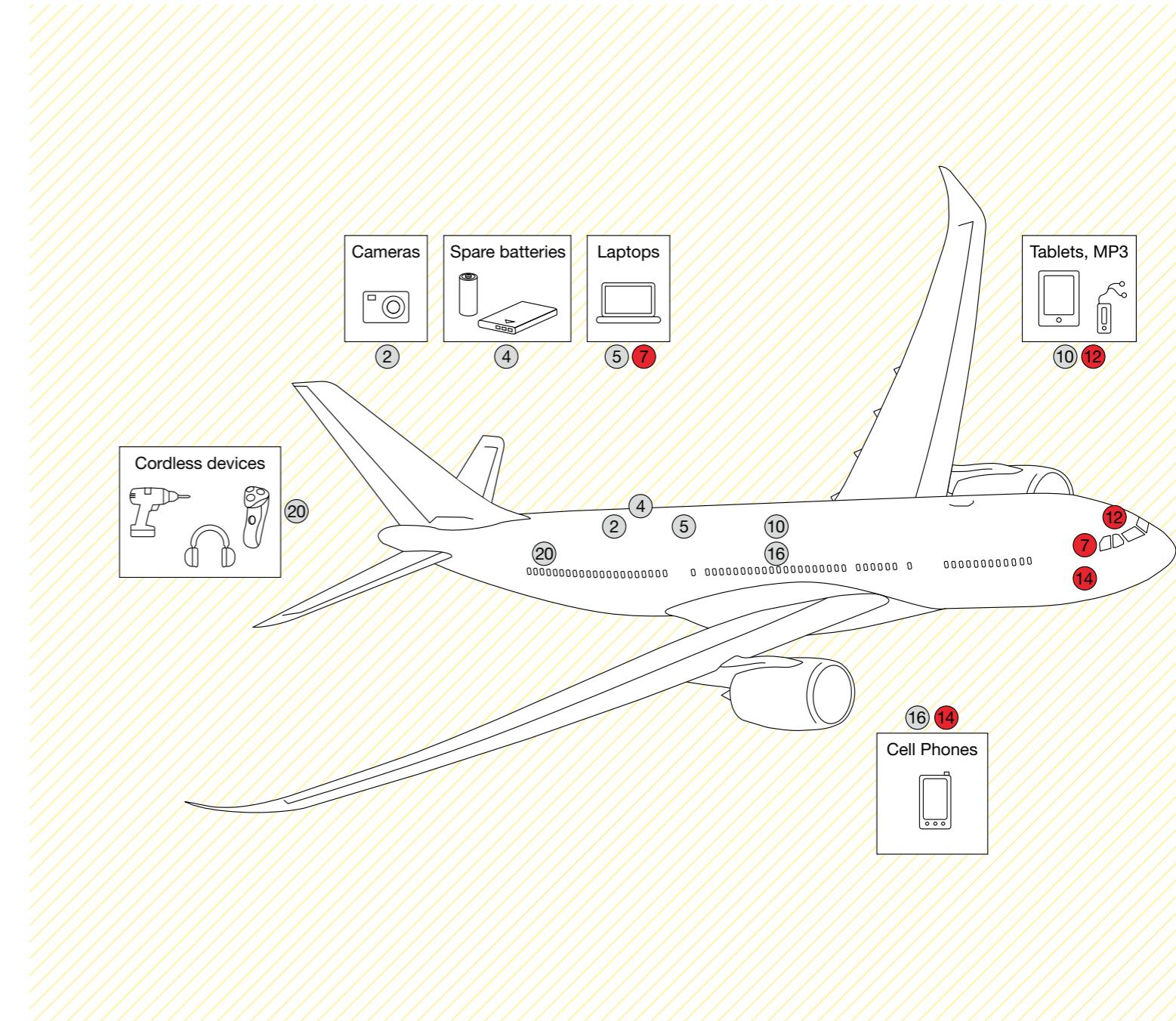
Local and/or international regulations provide the applicable set of rules that need to be complied with when transporting Lithium batteries. Attention should be given to:

- Training and awareness of employees regarding:
 - The aircraft limitations against a Lithium battery fire and existing mitigation means.
 - Regulations, handling procedures, the dangers of mishandling, and methods to identify Lithium battery shipments.
- Packaging:
 - Clearly identify shipments of Lithium batteries by information on airway bills and other documents.
 - Make sure that the packaging is correctly labelled and identified as dangerous goods according to ICAO technical instructions.
 - 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).



DID YOU KNOW

More information on the carriage of Lithium-ion batteries is provided in Airbus ISI 00.00.00182 dated 24 July 2015. 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.



Carriage of 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 to carrying Lithium batteries.

Raising passengers awareness before boarding

Recommendations have been developed with respect to what can or cannot be carried in passenger baggage. ICAO and 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.

The key however is making both the customer facing representatives 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 to 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, FAA have issued Safety Alerts for Operators (SAFO) number 15010, which deals with "Carriage of Spare Lithium Batteries in Carry-on and Checked Baggage".

Raising passengers awareness on-board

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 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

IATA has issued more information on the risk mitigations for operators on carriage of Lithium batteries. Visit their website (<http://www.iata.org/whatwedo/cargo/dgr/Pages/lithium-batteries.aspx>) for more information and guidance on different situations, making sure the last approved versions are used.

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 loads conform with ICAO / IATA labelling, packaging and handling recommendations.
- Ensure compliance to the Airbus Parts Catalogue when replacing batteries.
- Ensure that ground, flight and cabin crews are trained and passengers are aware of Lithium batteries specificities. ■

HOW TO MANAGE THE CONSEQUENCES OF A LITHIUM BATTERY FIRE

As detailed previously, proactive action by making passengers and airline personnel aware of the risks posed by Lithium batteries is preferable than reacting to a fire caused by a Lithium battery. Therefore knowing what to do in the unlikely event of a Lithium battery

fire is essential. The key principles to safely and efficiently tackling a Lithium battery fire, whether it is in the cabin or flight deck, being:

- Keep people away from the fire
- Minimize risks of fire propagation
- Apply specific firefighting principles.

Apply specific firefighting principles

Classical firefighting procedures and fire extinguishing means are not efficient to stop a lithium battery fire.



Halon can suppress open flames, but it is ineffective in addressing the source of fire. Use of water is the best option to allow cooling and limit the propagation to adjacent cells. ■

Once a lithium battery cell has ignited then the effort must concentrate on cooling the surrounding cells by use of water (or other non-alcoholic liquid) and preventing deterioration of the situation to avoid any fire propagation to the adjacent battery cells.

To this extent specific procedures that provide guidance on managing Lithium battery fires have recently been included for both cabin crew (in the CCOM) and flight crew (in the FCOM/QRH/FCTM).

“ Halon can suppress open flames, but it is ineffective in addressing the source of fire. Use of water is the best option to allow cooling and limit the propagation to adjacent cells. ■”

Lithium batteries: safe to fly?

“ In the cabin, do not try to pick up and attempt to move a burning device or a device that is emitting smoke. ”

Cabin crew procedures

Isolate the source of fire

Reacting to a Lithium battery fire in the cabin starts with isolating the source of fire. Indeed, a smoking battery may explode at any time, due to the highly exothermic thermal runaway. In the cabin, do not try to pick up and attempt to move a burning device or

a device that is emitting smoke. Prevent propagation by ensuring that no flammable material (fluids, gas, devices) are near the smoking battery. Also relocate passengers away from the burning or heating device.

Fight the fire according to specific procedures

Once the burning / heating device has been isolated, the fire itself needs to be addressed. To this end, three specific cabin crew procedures to

deal with Lithium batteries fires have been developed based on the FAA recommendations.

» Lithium battery fire procedure

This procedure (fig.8) proposes the use of Halon to extinguish open flames, and water (or a non-alcoholic liquid) to cool the device down.

The recommendation is then to im-

merse the device in a suitable container (such as a waste bin, or standard galley container) to secure against thermal runaway (refer to the third step below).

(fig.8)

Lithium battery fire CCOM procedure

LITHIUM BATTERY FIRE	
Ident.: 09-020-00015205.0001001 / 28 JAN 14	
Criteria: LR	
Applicable to: ALL	
<p>The roles of the firefighter, assistant firefighter and communicator must be distributed according to the basic firefighting procedure.</p> <p>In the case of PED or spare lithium battery fire in the cabin or when notified by the flight crew:</p> <ul style="list-style-type: none"> If there are flames: <p>FIREFIGHTING EQUIPMENT..... TAKE Consider the use of a PBE and fire gloves.</p> <p>HALON EXTINGUISHER..... DISCHARGE Halon extinguisher must be discharged to suppress the flames prior to cool down the PED or the Spare lithium battery.</p> When the flames are suppressed or If there are no flames: <p>ON PED or spare lithium battery..... POUR WATER OR NON-ALCOHOLIC LIQUID The PED or Spare lithium batteries must be cooled down by pouring water or non-alcoholic liquids</p> <p>STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE APPLY</p> 	
WARNING	<ul style="list-style-type: none"> - Do not attempt to pick up and move a smoking or burning device - Do not cover the device or use ice to cool down the device. Ice or other materials insulate the device increasing the likelihood that additional battery cells will ignite. - Do not use fire resistant burn bags to isolate burning lithium type batteries. Transferring a burning appliance into a burn bag may be extremely hazardous.
END OF PROC	

» Overhead bin smoke/fire procedure

Lithium battery fires may sometimes not easily be identified, and considering the specific cases when fires have actually

occurred in service, the procedure for fire in the overhead compartment (fig.9) now considers as a base that

a Lithium battery powered device may be at the origin of the fire. Therefore the overhead bin smoke/fire procedure now covers the use of Halon and liquid to tackle the fire, and makes reference to the other two cabin crew procedures to address a Lithium battery fire.

OVERHEAD BIN SMOKE/FIRE PROCEDURE	
Ident.: 09-020-00004671.0001001 / 28 JAN 14	
Criteria: LR	
Applicable to: ALL	
<p>Smoke/fire in overhead bins may be caused by the contents (i.e. electronic device, spare lithium battery) or electrical malfunction in the Passenger Service Unit (PSU). The firefighter, the assistant firefighter, the communicator and the support crewmembers must conduct their tasks simultaneously.</p> <ul style="list-style-type: none"> When smoke is coming from an overhead bin: <p>FIREFIGHTER AND ASSISTANT FIREFIGHTER PBE..... DON</p> <p>FIREFIGHTER FIRE EXTINGUISHER..... TAKE</p> <p>Note: Consider the use of fire gloves.</p> <p>ASSISTANT FIREFIGHTER WATER OR NON-ALCOHOLIC LIQUID..... TAKE</p> <p>Note: Water or non-alcoholic liquid is required if the fire involves lithium battery.</p> <p>SUPPORT CREWMEMBERS PASSENGERS..... RELOCATE</p> <p>COMMUNICATOR FLIGHT CREW..... NOTIFY IMMEDIATELY VIA INTERPHONE</p> <p>FIREFIGHTER OVERHEAD BIN..... CHECK FOR HEAT Using the back of the hand, feel the overhead bin to determine the temperature and presence of fire.</p> <p>(*')OVERHEAD BIN..... OPEN SLIGHTLY Enough to pass the nozzle of the fire extinguisher.</p> 	
CAUTION	Opening the overhead bin more than necessary can cause contamination of the cabin with smoke, and can result in smoke inhalation.
(*')FIRE EXTINGUISHER DISCHARGE
<p>Note: The fire extinguisher must be discharged into the overhead bin, away from the seat, to prevent debris from contaminating the cabin.</p>	
(*')OVERHEAD BIN CLOSE AND LATCH
Continued on the following page	

OVERHEAD BIN SMOKE/FIRE PROCEDURE (Cont'd)	
FIREFIGHTING.....	REPEAT AS NECESSARY
(*')Repeat last three steps of the procedure, as necessary.	
<ul style="list-style-type: none"> When the flames are suppressed: <p>FIREFIGHTER OVERHEAD BIN..... CHECK THE SOURCE OF FIRE</p> <p>Note: The assistant firefighter must support the firefighter in the case of re-ignition by using fire extinguisher.</p> If source of smoke/fire is coming from a visible PED and/or Spare batteries: <p>FIREFIGHTER ON PED OR SPARE LITHIUM BATTERIES..... POUR WATER OR NON-ALCOHOLIC LIQUID</p> <p>The PED or Spare lithium batteries must be cooled down by pouring water or non-alcoholic liquids.</p> If the source of smoke/fire is coming from an identified item: <p>FIREFIGHTER IDENTIFIED ITEM..... TAKE OUT ON IDENTIFIED ITEM..... POUR WATER OR NON-ALCOHOLIC LIQUID</p> <p>The identified item must be cooled down by pouring water or non-alcoholic liquids.</p> If the source of smoke/fire is coming from a non-identified item: <p>FIREFIGHTER OVERHEAD BIN..... EMPTY WITH CAUTION</p> <p>Note: Empty the overhead bin until the source of smoke/fire is identified.</p> <p>ON IDENTIFIED ITEM..... POUR WATER OR NON-ALCOHOLIC LIQUID</p> <p>The identified item must be cooled down by pouring water or non-alcoholic liquids.</p> 	
STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE APPLY	
END OF PROC	

(fig.9)

Overhead bin smoke/ fire CCOM procedure

Lithium batteries: safe to fly?

(fig.10)

Storage after a Lithium battery fire CCOM procedure

» Storage procedure after a Lithium battery fire

As referenced in the first step above, this procedure (fig.10) is called at the end of the two previous procedures. Once the fire has been contained and the device can be safely moved, this procedure recommends to place receptacle where the burning/heating device was immersed in a lavatory and

subject it to regular monitoring. The lavatory is proposed as it contains a means of smoke detection, but is also a location that can secure the device away from the passengers and provides waterproof floor designed to receive water in case of turbulent conditions.

STORAGE PROCEDURE AFTER A LITHIUM BATTERY FIRE																					
Ident.: 09-020-00015206.0001001 / 28 JAN 14																					
Criteria: LR																					
Applicable to: ALL																					
<ul style="list-style-type: none"> When the PED or the spare battery can be safely moved: <table> <tr> <td>FIRE GLOVES.....</td> <td>PUT ON</td> </tr> <tr> <td>RECEPTACLE.....</td> <td>TAKE</td> </tr> <tr> <td colspan="2">Consider the use of any suitable empty receptacle (e.g. standard unit or lavatory waste bin ...)</td> </tr> <tr> <td>RECEPTACLE.....</td> <td>FILL WITH WATER OR NON-ALCOHOLIC LIQUID</td> </tr> <tr> <td>PED OR SPARE BATTERY.....</td> <td>IMMERSE</td> </tr> <tr> <td colspan="2">Total immersion of the PED or the spare battery will prevent fire re-ignition.</td> </tr> <tr> <td>RECEPTACLE.....</td> <td>STORE INTO THE NEAREST LAVATORY</td> </tr> <tr> <td>LAVATORY.....</td> <td>SET AS INOPERATIVE</td> </tr> <tr> <td>AFFECTED LAVATORY.....</td> <td>MONITOR</td> </tr> <tr> <td colspan="2">The affected lavatory must be regularly monitored for the remainder of the flight to ensure that the device remains immersed.</td> </tr> </table> 		FIRE GLOVES.....	PUT ON	RECEPTACLE.....	TAKE	Consider the use of any suitable empty receptacle (e.g. standard unit or lavatory waste bin ...)		RECEPTACLE.....	FILL WITH WATER OR NON-ALCOHOLIC LIQUID	PED OR SPARE BATTERY.....	IMMERSE	Total immersion of the PED or the spare battery will prevent fire re-ignition.		RECEPTACLE.....	STORE INTO THE NEAREST LAVATORY	LAVATORY.....	SET AS INOPERATIVE	AFFECTED LAVATORY.....	MONITOR	The affected lavatory must be regularly monitored for the remainder of the flight to ensure that the device remains immersed.	
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Flight crew procedure

More and more flying crews are taking advantage of the capabilities offered by Electronic Flight Bags (EFBs), the majority of which use Lithium batteries as a primary power source. But Lithium batteries may also enter a cockpit in the form of a flashlight, laptop, tablet, camera, mobile phone,... i.e. any Portable Electronic Devices (PEDs).

With the aim to preventing a Lithium battery fire, the key is to ensure that the EFBs and other PEDs are not exposed to abuse conditions (i.e. dropped or damaged), and if damaged, not used until confirmed serviceable. However, if the feared situation occurs, flight crew procedures have been developed on the basis of key principles: Fly, Navigate, Communicate, with appropriate task sharing.

The philosophy of the Airbus "Smoke/Fire from Lithium battery" procedure (fig.11) is:

- One pilot needs to continue flying the aircraft, while the second pilot will address the detected fire. If necessary, transfer control. Usually the fire fighter is the one the closest to the fire.
- Establish communication with the cabin – a Lithium battery fire should be managed as a whole crew concern – to initiate the "Storage after a Lithium battery fire" procedure.
- Secure the safety of the flight crew: the Pilot Flying should don the oxygen mask, while the pilot that will tackle the fire should don the Portable Breathing Equipment (PBE).
- Use Halon to extinguish any open flames.

“ Flight crew procedures have been developed on the basis of key principles: Fly, Navigate, Communicate, with appropriate task sharing. ”

- Once there are no more open flames:
 - If it is not possible to remove the burning/heating device from flight deck, pour water or non-alcoholic liquid on the device to cool it down. Be aware of possible explosion. Tests completed by Airbus have confirmed that a small quantity of water

aimed at the device is sufficient to cool it and mitigate the consequences of the thermal runaway.

- If it is possible to move the device: transfer it to the cabin and use the Cabin Crew Lithium battery procedures to secure it, by immersion in water or non-alcoholic liquid. ■

SMOKE/FIRE FROM LITHIUM BATTERY

If necessary, transfer control to the flight crew member seated on the opposite side of the fire

CKPT/CAB COM..... ESTABLISH
STORAGE AFTER Li BAT FIRE cabin procedure.....
..... REQUEST INITIATION

● If there are flames:

CREW OXY MASK (PF)..... USE
SMOKE HOOD (PM)..... USE
HALON EXTINGUISHER..... USE

● If there are no flames or when flames are extinguished:

■ If not possible to remove device from the cockpit:
WATER or NON-ALCOHOLIC LIQUID.....
..... POUR ON DEVICE
DEVICE..... MONITOR
■ If possible to remove device from the cockpit:
DEVICE..... TRANSFER TO CABIN

(fig.11)

Smoke/fire from Lithium battery QRH procedure



DID YOU KNOW

To know more about Lithium battery fires management in the cabin, and cabin safety issues in general, read our brochure "Getting to grips with cabin safety", available on Airbus World.



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 – whether carried as cargo, or installed as equipment in the flight deck or cabin, or just as part of the passengers carry-on baggage.

Article contributors include Joerg KLOCKGETHER and Dieter JUST.