2025

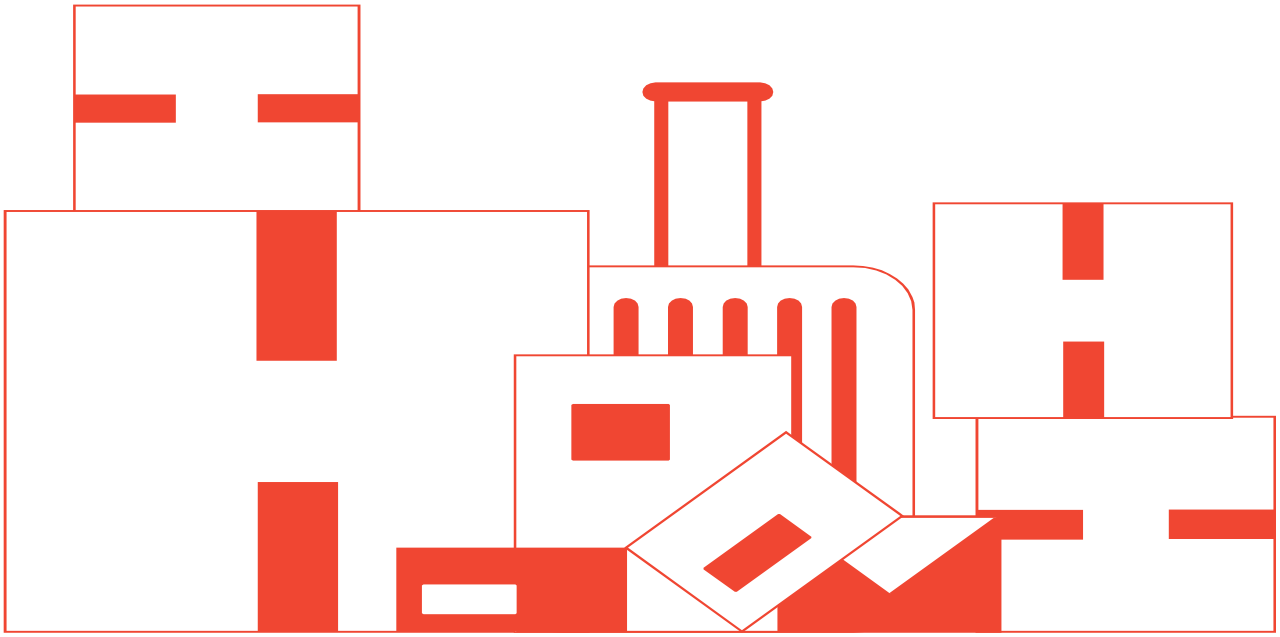
Lithium Battery Risk Assessment

in

Carriage of Cargo, Mail and Baggage

Guidance for operators

Edition 2



IATA

DISCLAIMER

The content, data and information (the "Content") contained in this publication ("Publication"), is provided for information purposes only and is made available to you on an "AS IS" and "AS AVAILABLE" basis.

IATA has used reasonable efforts to ensure the Content of this Publication is accurate and reliable. We, however, do not warrant, validate, or express any opinions whatsoever as to the accuracy, genuineness, origin, tracing, suitability, availability or reliability of the sources, completeness, or timeliness of such Content. IATA makes no representations, warranties, or other assurances, express or implied, about the accuracy, sufficiency, relevance, and validity of the Content. IATA's observations are made on a best efforts and non-binding basis, and shall not be deemed to replace, interpret, or amend, in whole or in part, your own assessment and evaluation or independent expert advice. Nothing contained in this Publication constitutes a recommendation, endorsement, opinion, or preference by IATA.

IATA has no obligation or responsibility for updating information previously furnished or for assuring that the most up-to-date Content is furnished. IATA reserves the right to remove, add or change any Content at any time. Links to third-party websites or information directories are offered as a courtesy. IATA expresses no opinion on the content of the websites of third parties and does not accept any responsibility for third- party information. Opinions expressed in advertisements appearing in this publication are the advertiser's opinions and do not necessarily reflect those of IATA. The mention of specific companies or products in advertisements does not imply that they are endorsed or recommended by IATA in preference to others of a similar nature which are not mentioned or advertised.

This Publication is not intended to serve as the sole and exclusive basis for assessment and decision making and is only one of many means of information gathering at your disposal. You are informed to make your own determination and make your own inquiries as you may deem necessary and suitable. You shall independently and without solely relying on the information reported in this Publication, perform your own analysis and evaluation regarding the nature and level of information you may require, based upon such information, analyses, and expert advice as you may deem appropriate and sufficient, and make your own determination and decisions pertaining to the subject matter under consideration.

TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, IATA DISCLAIMS ANY REPRESENTATION OR WARRANTY (I) AS TO THE CONDITION, QUALITY, PERFORMANCE, SECURITY, NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OF THIS PUBLICATION AND CONTENT; OR (II) THAT THE ACCESS TO OR USE OF THIS PUBLICATION (INCLUDING ANY AUTOMATED FEEDS OR OTHER DELIVERY MODES) OR ANY CONTENT SUPPLIED OR CONTRIBUTED TO THIS PUBLICATION BY THIRD PARTIES, WILL BE UNINTERRUPTED, ACCURATE, THE MOST UP TO DATE, COMPLETE OR ERROR-FREE. IATA EXCLUDES ALL LIABILITY (TO THE EXTENT PERMITTED BY APPLICABLE LAW) FOR ANY COSTS, LOSSES, CLAIMS, DAMAGES, EXPENSES OR PROCEEDINGS OF WHATEVER NATURE INCURRED OR SUFFERED BY YOU OR ANY OTHER PARTY ARISING DIRECTLY OR INDIRECTLY IN CONNECTION WITH THE USE OF THIS PUBLICATION OR ANY CONTENT CONTAINED OR ACCESSED THEREFROM, OR DUE TO ANY UNAVAILABILITY OF THIS PUBLICATION IN WHOLE OR IN PART.

Montreal - Geneva
Cataloguing in Publication data can be obtained from Library and Archives Canada

Introduction

△ This document is based on the International Civil Aviation Organization (ICAO) Annex 6 – *Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes and* the associated *Guidance for Safe Operations Involving Aeroplane Cargo Compartments* Doc (10102), the ICAO *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Technical Instructions) (Doc 9284) and the 66th Edition (2025) of the IATA Dangerous Goods Regulations (DGR).

In the context of Annex 6, Chapter 15, the strategies outlined in this guidance document are primarily directed at an operator's internal risk management processes, operational procedures, and engaging with other entities in the supply chain, such as manufacturers of lithium batteries, shippers, freight forwarders, designated postal operators and the travelling public in addressing and mitigating the risk associated with the transport of lithium batteries.

This document is divided into cargo operations, focusing on cargo and mail transported in aircraft cargo compartments, and passenger operations, paying particular attention to both carry-on and checked baggage that are carried by passengers and crew.

Please note that there has been some restructuring of the material in this document. When compared to the 2024 edition of this document, certain text changes can be identified by:

☐	Addition of an item
△	Change to an item
⊗	Deletion of an item

Contents

Background

Following DGP-WG/15 the ICAO Air Navigation Commission (ANC) charged the Flight Operations Panel with the task of introducing requirements into Annex 6 – Operation of Aircraft, for operators to conduct safety risk assessments on the transport of cargo, including the transport of dangerous goods. In support of this provision, the Panel was tasked with the creation and ongoing revision of a guidance manual. This work was conducted on behalf of the Flight Operations Panel by the multi-disciplinary Cargo Safety Sub-Group (CSSG).

The result of that work was the adoption of a new Chapter 15 – Cargo Compartment Safety into ICAO Annex 6 – Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes, and the associated Guidance for Safe Operations Involving Aeroplane Cargo Compartments (Doc 10102).

Chapter 15 to Annex 6 requires that:

"In approving the transport of items in the cargo compartment, the State of the Operator shall ensure that the operator establishes policy and procedures for that purpose which include the conduct of a specific safety risk assessment. The safety risk assessment shall include at least the:

a) specific hazards associated with the properties of the items to be transported;
b) capabilities of the operator;
c) operational considerations (e.g. passenger/cargo, area of operations, diversion time);
d) capabilities of the aeroplane and its systems (e.g. cargo compartment fire suppression capabilities);
e) containment characteristics of unit load devices;
f) packing and packaging;
g) safety of the supply chain for items to be transported; and
h) quantity and distribution of dangerous goods items to be transported."

Lithium batteries power many portable electronic devices (PEDs) as well as heavy duty machinery and vehicles; they have become the battery of choice due to their high energy density, which allows them to operate for a long duration, and the availability of various types with different chemistries makes them suitable for a wide range of electronic products. These batteries and the products that are operated by them are also very often transported by air because of the tight timeframe to assemble the products and consequentially to launch the products in a timely manner, the short product shelf-life and sometimes need to be delivered at short notice in the case of life- saving medical devices.

There are well-established and stringent international requirements applicable to the manufacture, testing and transport of lithium batteries, and the legitimate lithium battery industry has an outstanding safety record since these batteries started to be transported by air in the mid-1970s; however, they can possibly go into a thermal runaway if the design type has not been subjected to mandatory safety tests or they are not handled properly and subsequently lead to deformation. In addition, with the reported occurrences of undeclared dangerous goods around the world, consideration must always be given to the potential of undeclared dangerous goods, which may also present a significant risk.

Overview of Lithium Batteries

A battery is defined as two or more cells which are electrically connected together and fitted with devices necessary for use, for example, a case, terminals, marking and protective devices. The term "lithium battery" refers to a family of different chemistries, comprising many types of cathodes and electrolytes. Units that are commonly referred to as "battery packs", "modules", "battery assemblies", "power banks", or "power generators" having the primary function of providing a source of power to another piece of equipment are, for the purposes of this guidance document and the IATA Dangerous Goods Regulations, to be classified as batteries.

Lithium batteries are separated into two main categories, lithium metal batteries and lithium-ion batteries:

Lithium metal batteries are generally primary (non-rechargeable) batteries that have lithium metal or lithium compounds as an anode. Also included in this category are lithium alloy batteries. Lithium metal batteries are generally used to power devices such as watches, calculators, cameras, temperature data loggers, car key fobs and defibrillators.

***Note**: Lithium metal batteries packed as per Packing Instruction 968 (not contained in or packed with equipment) are forbidden for transport as cargo on passenger aircraft, unless shipped under the conditions of an exemption issued by all States concerned, or as permitted under an approval in accordance with Special Provision A201.*

Figure 1 – Example of lithium metal cells and batteries

Lithium-ion batteries (sometimes abbreviated to Li-ion batteries) are secondary (rechargeable) batteries where the lithium is only present in an ionic form in the electrolyte. Also included within the category of lithium- ion batteries are lithium polymer batteries. Lithium-ion batteries are generally used to power devices such as mobile telephones, laptop computers, tablets, power tools and e-bikes.

***Note:** Lithium-ion batteries packed as per Packing Instruction 965 (not contained in or packed with equipment):*

(a) must be shipped at a state of charge (SoC) not exceeding 30% of their rated capacity. Cells and/or batteries at a SoC of greater than 30% may only be shipped with the approval of the State of Origin and the State of the Operator under the written conditions established by those authorities, see Special Provision A331; and

(b) are forbidden for transport as cargo on passenger aircraft, unless shipped under the conditions of an exemption issued by all States concerned, or as permitted under an approval in accordance with Special Provision A201.

Figure 2 – Example of lithium-ion cells and batteries

□ Sodium Ion Batteries

Sodium Ion Batteries, with organic electrolyte, was entered into the UN list of dangerous goods, with effect from 1 January 2025. Whilst there are some similar characteristics to lithium-ion cells and batteries; the expectations are that sodium ion batteries will be of a larger format (size), less susceptible to problems with recharging following a complete discharge, and with fewer hazardous effects when compared to lithium batteries. It is expected that as these batteries are developed, and tested, there will be greater understanding and awareness of the hazards.

Sodium ion battery is a rechargeable electrochemical system where the positive and negative electrode are both intercalation or insertion compounds, constructed with no metallic sodium (or sodium alloy) in either electrode or with an organic non aqueous compound as an electrolyte.

Sodium ion cells and batteries **with organic electrolyte must** be transported as UN 3551 or UN 3552 as appropriate. Throughout this document, unless specified, Sodium ion batteries will be taken to mean those with organic liquid electrolyte.

Note: *Sodium-ion batteries* ***with aqueous alkali electrolyte*** *must be transported as* ***UN 2795*** *Batteries, wet, filled with alkali.*

Figure 3 - Example of Sodium Ion Cells and Batteries

More information about the safe transport of lithium and sodium ion batteries by air can be found in the IATA Battery Guidance Document.

Cargo Operations

Challenges

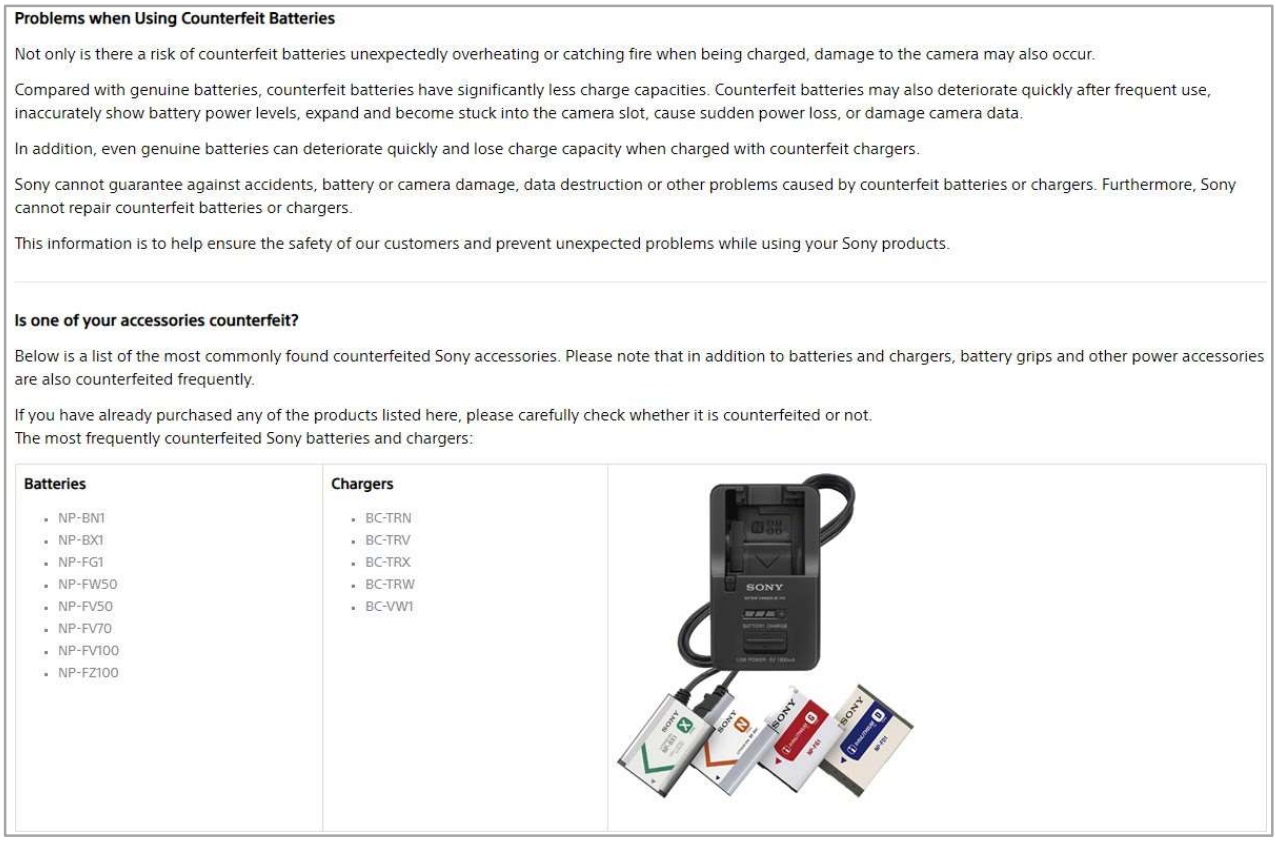
Due to the huge, worldwide demand for lithium batteries, billions of them are shipped annually as air cargo. Volumes are increasing every year where the batteries becoming smaller, more powerful and even much longer lasting.

Counterfeit & Substandard Lithium Batteries

According to the international air transport regulations, each cell or battery type must be proven to have met the requirements of each test of the UN Manual of Tests and Criteria, Part III, subsection 38.3 (i.e. UN 38.3 test).

However, many lithium batteries that do not meet the UN 38.3 test requirements are available for sale on the Internet and in some parts of the world. These batteries are sometimes manufactured to look alike to the genuine branded products and are very often sold at a price that is far cheaper than the genuine products.

As these batteries have not been tested to the UN 38.3 test standards, they are less safe to transport, with higher potential risk and may fail or catch fire when subjected to the shocks and loadings encountered under the normal conditions of transport.



Problems when Using Counterfeit Batteries

Not only is there a risk of counterfeit batteries unexpectedly overheating or catching fire when being charged, damage to the camera may also occur.

Compared with genuine batteries, counterfeit batteries have significantly less charge capacities. Counterfeit batteries may also deteriorate quickly after frequent use, inaccurately show battery power levels, expand and become stuck into the camera slot, cause sudden power loss, or damage camera data.

In addition, even genuine batteries can deteriorate quickly and lose charge capacity when charged with counterfeit chargers.

Sony cannot guarantee against accidents, battery or camera damage, data destruction or other problems caused by counterfeit batteries or chargers. Furthermore, Sony cannot repair counterfeit batteries or chargers.

This information is to help ensure the safety of our customers and prevent unexpected problems while using your Sony products.

Is one of your accessories counterfeit?

Below is a list of the most commonly found counterfeited Sony accessories. Please note that in addition to batteries and chargers, battery grips and other power accessories are also counterfeited frequently.

If you have already purchased any of the products listed here, please carefully check whether it is counterfeited or not.
The most frequently counterfeited Sony batteries and chargers:

Batteries

- NP-BN1
- NP-BX1
- NP-FG1
- NP-FW50
- NP-FV50
- NP-FV70
- NP-FV100
- NP-FZ100

Chargers

- BC-TRN
- BC-TRV
- BC-TRX
- BC-TRW
- BC-VW1

Figure 4 – Information on counterfeit batteries released by Sony
(https://www.sony.co.uk/electronics/support/articles/00200938)

Undeclared Lithium Batteries

Lithium batteries have become such a common, everyday commodity which have been taken for granted by consumers, with little thought given to the precautions that need to be taken to ensure lithium batteries do not pose a risk in air transport. This is an issue for passenger baggage as well as air cargo. Experience has shown that there are shippers who, either deliberately or due to lack of knowledge, do not follow the requirements set out in the DGR. Consequently, incidents involving lithium batteries catching fire on board aircraft have occurred. It is not always possible to determine the cause of such incidents, but where a cause has been determined, they would appear to be almost invariably due to non-compliance with the requirements.

Figure 5 – Fire damage to a package of incorrectly packed lithium metal button cells, which occurred after unloading

There was a great deal of publicity surrounding the loss of three cargo aircraft due to on board cargo fires:

- 7 February 2006: DC-8 Philadelphia – aircraft landed safely but was destroyed by fire which had started in the descent.
- 3 September 2010: Boeing 747, Dubai – the aircraft crashed during an attempt to return to Dubai due to a severe in-flight fire; both crew members were killed.
- 27 July 2011: Boeing 747, 130 km west of Jeju Airport, South Korea – the aircraft crashed into the sea following a severe in-flight fire; both crew members were killed.

It is known that all three aircraft were carrying lithium batteries as cargo, some of which on the Boeing 747 that crashed in Dubai were subsequently determined to have not complied with the regulatory requirements.

However, the degree to which the lithium batteries were involved in these incidents (i.e. whether they were the cause of or aggravated the fire) could not be concluded.

Airmail

Safety concerns are not restricted to baggage and cargo. Mail is carried extensively on board passenger and cargo aircraft, both internationally and on relatively short domestic flights. Lithium batteries, whether shipped on their own or packed with equipment, are not permitted in airmail. Nevertheless, numerous websites advertise lithium batteries for sale with delivery by airmail as an option. Couple this with the fact that a number of such batteries may not comply with the regulatory requirements, with the batteries not meeting the UN 38.3 testing requirements, incorrectly packaged or exceeding 30% state of charge, it is not surprising that there have been a number of incidents involving lithium batteries in airmail.

Figure 6 – A non-compliant laptop battery ordered online and sent by airmail, which caught fire shortly after being unloaded from a passenger aircraft at London Heathrow Airport

There are provisions that allow for lithium batteries, when contained in equipment only, to be sent by airmail providing the Civil Aviation Authority (CAA) has approved the Designated Postal Operator (DPO) of the State (country) in which the airmail is offered for carriage. However, in many parts of the world, there is a lack of communication between the DPO and CAA and so the approval system may not be in place in some countries. There may also be other problems, such as:

- the CAA may not have authority over airmail or the DPO, and is therefore unable to exercise the necessary oversight; and
- the postal authority may not be subject to the civil aviation regulations.

Consequently, it is recommended that operators carrying airmail should liaise closely with the CAA and DPO in their State.

The Universal Postal Union (UPU) provides a list of designated postal operators that have received approval to accept equipment containing lithium batteries in airmail. The dates from which these DPOs have been authorized to accept these mail packages and other related information can be found on the UPU website. A summary table, as at the end of 2024, is located at Appendix A to this document.

It is important to note that the approval for the DPO is only valid for international airmail offered in that State. Some of the approved DPOs may have satellite branches established in States outside of their own for which they have received the approval. This practice is commonly known as Extraterritorial Office of Exchange (ETOE), which is a facility belonging to a postal operator outside its national territory in another country.

However, ETOE without an approval granted by their operating state is not permitted to accept equipment containing lithium batteries in airmail.

E-commerce

E-commerce is growing at an unprecedented rate recently. The rapid growth of e-commerce is mainly due to the advanced technology, special offers from online shops, change in purchase behaviour and the wide range and availability of products.

The growth of e-commerce not only offers a business opportunity for small start-up companies and retailers, but also logistics players in the supply chain, such as air operators as well as freight forwarders. E-commerce is slightly different from the mail business, which primarily handles letters and small parcels, and have limitations on the types of lithium batteries (contained in equipment only) that can be accepted. E-commerce packages are very often transported as traditional air cargo, containing various products (including lithium batteries shipped alone and packed with equipment), consolidated from different sources and sometimes might also be transported in a comparably less rigid and robust packaging. From experience, some of these shipments are initially consigned as a shipper-built unit (BUP), and on arrival at the destination, the units will be broken down by freight forwarders and the individual packages will be re-consigned as domestic postal parcels through local mail service.

The combination of the complexity of e-commerce implies that these packages might have a potentially higher risk level than traditional cargo.

Safety Risk Assessment

General

Although the implementation of Chapter 15 – Cargo Compartment Safety to ICAO Annex 6 – *Operation of Aircraft, been* effective since 5 November 2020 mandates the operators to conduct safety risk assessments when transporting items in aircraft cargo compartments namely cargo, baggage and mail, it is not intended for every flight.

The potential hazards will depend on the nature of the operation, which includes the type of operation (e.g. all- cargo, passenger and cargo, or passenger only), types of cargo being uplifted (e.g. general cargo only or a combination of general cargo, mail and dangerous goods), location of the operator's hub (e.g. a location from which large quantities of dangerous goods such as lithium batteries are transported or a place that has easy access to some remote areas) and locations where the operator is operating to (e.g. locations served by only a small number of operators).

Operators should consider the potential entry points for hazards associated with the carriage of cargo, mail, and baggage. These may be internal, such as for aircraft components, e.g. oxygen cylinders, used fuel control units and chemical oxygen generators or materials used to repair and maintain aircraft, e.g. adhesives, two-part epoxy resin kits and paints being shipped from the engineering or stores area. Entry points may also be external such as items presented for carriage from customers (shippers, freight forwarders, designated postal operators or passengers).

Analysis of reports of dangerous goods accidents and dangerous goods incidents should be used as part of the safety risk assessment process. These may identify issues such as incorrect handling of liquids in single packagings (e.g., drums and jerricans), damage to packages from insufficient strapping or lack of restraint in unit load devices (ULD) or bulk loaded cargo compartments. Reports where undeclared or misdeclared dangerous goods were identified in cargo, mail or baggage may indicate that the barriers to the introduction of undeclared dangerous goods are insufficient and should be reviewed and strengthened.

The process of identifying the potential hazards should consider the processes applicable to carriage of cargo, mail, and baggage separately as the hazards and potential risks will differ. In this respect the operator personnel responsible for the safety risk assessment process should include those responsible for the oversight of cargo, mail, and passenger operations. The operator should also ensure that the process for shipping of company materials (COMAT) including the process for the uplift of "aircraft on ground" (AOG) spares is included in the safety risk assessment as there have been many incidents where aircraft components classified as dangerous goods or with residues of dangerous goods (e.g., fuel control units) were loaded onto an aeroplane without being processed through the cargo system as is required for dangerous goods offered as cargo.

Where there is a change to the operation on which the initial safety risk assessment was based, then the operator should re-evaluate the safety risk assessment to determine if the change to the operation may have introduced new hazards. Examples of changes to an operation that may have an impact on a previous safety risk assessment include:

a) a new destination is to be introduced;

b) a new aeroplane type is to be introduced;

c) a new commodity is to be carried / or new business to be commenced;

d) a new operation type (e.g., freighter, charter) is to be commenced;

e) a new ground service provider is contracted;

f) new ULDs or accessories (e.g., fire containment covers, fire-resistant containers) are introduced.

Identify the hazards

The first step to conduct a safety risk assessment is to identify potential hazards. In the case of carriage of lithium batteries as cargo, here are some examples of potential hazards that can be found:

- poor quality of the lithium batteries manufactured in the surrounding areas of the operator's hub and network (e.g. counterfeit or substandard lithium batteries);
- the acceptance policy of other operators in the market as well as different local regulatory requirements in the nearby States (e.g. if some operators are imposing more requirements / restrictions on accepting lithium batteries, some shippers might channel some poor quality shipments to other operators or might even not declare the shipments);
- lack of competence / training program of employees, including those of contracted ground handling agents, resulting in the acceptance of non-compliant shipments;
- lack of monitoring of ground handling agents (including cargo terminal operators and ramp handling agents), leading to mishandling of shipments and consequently potential damage to lithium batteries that could result in cell failure leading to thermal runaway;
- low credibility of shippers / freight forwarders and in some cases, co-loaders (i.e. consolidating through multiple layers of shippers / freight forwarders before handing over to the operator's appointed cargo agent);
- DPOs that do not have an approval from the Civil Aviation Authority of the State might be accepting lithium battery shipments in mail, send by air as cargo and subsequently after the breakdown of the cargo, the shipment turns into mail again at the destination sorting facility; and
- large volume of e-commerce parcels containing high capacity lithium batteries that are packed in plastic bags or simply undeclared.

Assess the Likelihood of Occurrence

After identifying the potential hazards, assess the likelihood of the hazards to occur. There can be five levels of occurrence probability:

Likelihood	Description	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur sometimes (has occurred infrequently)	4
Remote	Unlikely to occur, but possible (has occurred rarely)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely improbable	Almost inconceivable that the event will occur	1

Table 1 – Possible risk probability

Evaluate the Severity of the Occurrence

Once the likelihood of occurrence is determined, move forward to evaluate the severity of the hazards in conjunction with the potential consequences caused by the hazards. Similar to occurrence probability, there are generally five levels of risk severity:

Severity	Description	Value
Catastrophic	▪ Aircraft / equipment destroyed ▪ Multiple deaths	A
Hazardous	▪ A large reduction in safety margins, physical distresses or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely ▪ Serious injury ▪ Major equipment damage	B
Major	▪ A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency ▪ Serious incident ▪ Injury to persons	C
Minor	▪ Nuisance ▪ Operating limitations ▪ Use of emergency procedures ▪ Minor incident	D
Negligible	▪ Few consequences	E

Table 2 – Possible safety risk severity

Risk Index Rating

By combining the occurrence probability and the severity of the risk (i.e. likelihood x severity), a risk index rating can be assigned. This risk index rating will give an indication on how tolerable the risk is and can assist and guide an operator to put more focus and investment on risk mitigation measures for the high-risk areas.

Safety Risk		Severity									
Probability		Catastrophic	A	Hazardous	B	Major	C	Minor	D	Negligible	E
Frequent	5	5A		5B		5C		5D		5E	
Occasional	4	4A		4B		4C		4D		4E	
Remote	3	3A		3B		3C		3D		3E	
Improbable	2	2A		2B		2C		2D		2E	
Extremely improbable	1	1A		1B		1C		1D		1E	

Table 3 – Example of a safety risk matrix

Safety Risk Index Range	Safety Risk Description	Recommended Action
5A, 5B, 5C, 4A, 4B, 3A	INTOLERABLE	Take immediate action to mitigate the risk or stop the activity. Perform priority safety risk mitigation to ensure additional or enhanced preventative controls are in place to bring down the safety risk index to tolerable.
5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A	TOLERABLE	Can be tolerated based on the safety risk mitigation. It may require management decision to accept the risk.
3E, 2D, 2E, 1B, 1C, 1D, 1E	ACCEPTABLE	Acceptable as is. No further safety risk mitigation required.

Table 4 – Possible safety risk tolerability

Example 1

Below is an example on conducting safety risk assessments with respect to lithium batteries consigned as cargo.

An operator of all-cargo aircraft wishes to assess the risk associated with the carriage of cargo from Hong Kong.

Likelihood – Experience has shown that a few previous incidents were related to some undeclared or non- compliant lithium battery shipments accepted for air transport in Hong Kong. Consequently, a fire in cargo is possible and likelihood should be Level 3.

Severity level – If the cargo catches fire on the main deck of a cargo aircraft, this may become uncontrollable, resulting in a catastrophic situation. Therefore, the severity level should be catastrophic (A).

Therefore, the risk index would be likelihood (3) x severity (A) = 3A Intolerable.

In this case, the operator will need to implement additional mitigations to reduce the safety risk into at least the tolerable range although it is preferable to try to achieve a level of risk that is acceptable. Given that the safety risk level is intolerable, all risk mitigations in place should be reviewed. This process may involve senior representatives from cargo, engineering, flight operations and safety departments. In considering the review, the following factors should be considered:

Preventative controls – lithium batteries must comply with very stringent regulatory requirements before being offered for carriage by air.

Escalation factors – shippers' inadvertent or willful non-compliance with the requirements.

Escalation controls – operator considers a system whereby lithium batteries will only be accepted from freight forwarders or shippers who have been vetted by the operator.

Despite preventive controls being in place, there is always the possibility that an unsafe event (in this case a lithium battery thermal event) can occur. Consequently, "recovery measures" must be considered (i.e. what can be done to prevent the unsafe event developing into the ultimate consequence, the loss of life or the aircraft). However, as with preventive controls, recovery measures can also be weakened by escalation factors that need to be controlled.

The following may apply for the example:

Recovery measure – fire containment covers on all pallets or use of fire-resistant containers.

Escalation factor – covers incorrectly applied, reducing their effectiveness.

Escalation control – covers are only applied by trained personnel and the deployment of covers will be verified by another qualified staff member.

The above elements can be more easily demonstrated with a bowtie risk analysis model, which has been adopted by some operators and regulators. The strength of a bowtie model is that it allows users to easily visualize the assessment and identify the safety barriers that are in place, or lack of, to minimize the likelihood of the occurrence of an unsafe event.

Example 2

Below is an example on conducting safety risk assessments with respect to spare lithium batteries, power banks and e-cigarettes carried by passengers that may get into checked baggage.

An operator of passenger aeroplanes within Europe wishes to risk assess the possible risk of spare lithium batteries, power banks and e-cigarettes in checked baggage.

Likelihood – Looking at available incident data and the operator's own incident experience, it would be reasonable to assume that spare lithium batteries, power banks and e-cigarettes carried by passengers may get into checked baggage, and so the likelihood in this example is Level 4 (occasional).

Severity level – If a lithium battery has a thermal event in checked baggage, the smoke detectors in the cargo compartment will detect if there is any smoke and/or fire. The Halon fire suppression system should be able to adequately suppress any fire and the flight crew will have time to land the aeroplane. Therefore, on the basis that an abnormal flight operations incident procedure would be applied (activation of fire suppression system and diversion to the nearest adequate airport), with few other consequences, it may be appropriate to assign a severity level of C (Major).

Therefore, the risk index would be likelihood (4: Occasional) x severity (C: Major) = 4C "Tolerable" The following factors should be considered:

Preventative control – there is an existing regulatory prohibition on the transport of spare lithium batteries, including power banks and e-cigarettes in checked baggage.

Escalation factor – passengers' ignorance of the regulations.

Escalation control – operator has a robust process to ensure that all passengers are made aware of the regulatory requirement (e.g., by questioning of passengers at check-in kiosks and / or counters) and where items of carry-on baggage are surrendered to be loaded in the cargo compartment, that ground staff are trained to ask passengers specifically if the baggage item contains any lithium batteries.

Despite preventive controls being in place, there is always the possibility that an unsafe event (in this case a lithium battery thermal event) can occur. Consequently, the operator may consider additional preventative measures (i.e., what additional controls can be implemented to prevent the unsafe event from occurring. The operator may also look at possible recovery measures to prevent a potential fire from developing into the ultimate negative consequence, the loss of life or of the aeroplane.

In the example above, the following may apply:

Additional preventative control – the operator requests that the airport operator upgrade the baggage screening process to also detect the presence of lithium batteries in checked baggage.

Recovery measure – purchase of FRCs that are to be used for passenger baggage; Escalation factor – damaged FRCs do not properly contain a fire;

Escalation control – robust process in place to ensure that all FRCs used for passenger baggage are checked for damage prior to use.

The above elements can be more easily demonstrated, for example, by use of a bowtie risk analysis model, which has been adopted by some operators and regulators. The strength of a bowtie model is that it allows users to easily visualise the assessment and identify the safety

barriers that are in place, or lack of them, to minimise the likelihood of an occurrence developing into an unsafe event.

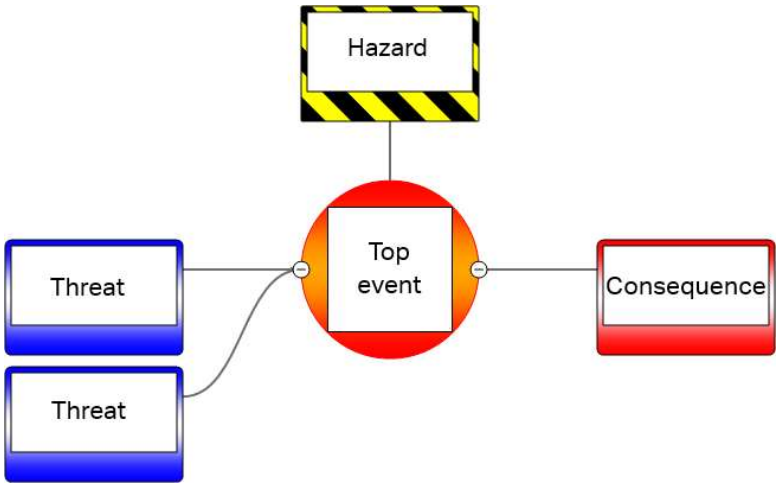


Figure 7 – An example of a bowtie risk analysis model

The bowtie risk analysis model puts the focus around the hazard that can potentially cause damage to the organization and the top event that will be led by the identified hazard. The threats that can contribute to the top event as well as the ultimate consequence that is to be caused by the top event shall be laid out to the left and right respectively.

This process can stimulate to the identification of preventative measures which can eliminate the threat or prevent the threat from triggering the occurrence of the top event and explore potential measures that reduce the likelihood of an event or mitigate the severity of the consequence should the top event occur.

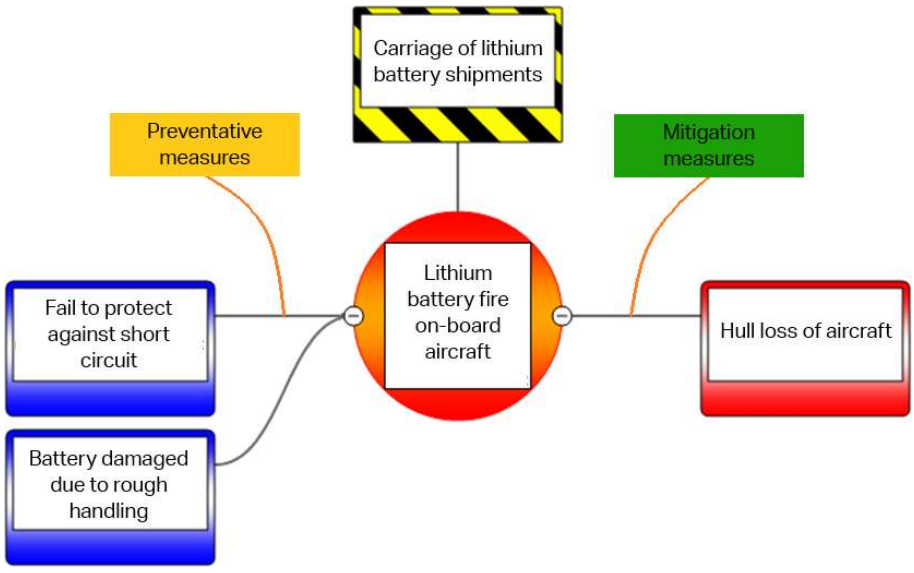


Figure 8 – An example of a bowtie risk analysis model for the carriage of lithium battery shipments

A sample of a complete bowtie risk model compiled by the UK Civil Aviation Authority can be downloaded for reference.

Determination of severity levels and likelihood can be subjective, but it is always important that the safety culture of an operator embraces the concept that many activities associated with air transport, including the carriage of lithium batteries, involve risks that must be identified and mitigated to achieve an acceptable level of safety.

It is essential that each operator conducts and documents their own safety risk assessments based on their own operational realities. The risks and their severity, the effectiveness of mitigations and controls, as well as the overall risk tolerance will be unique to each operation. As such, it is important to stress that this document is just a guidance and should not be considered as an actual assessment of an operation. In keeping with safety management system (SMS) requirements, it is important to note that any safety risk assessment completed should be regularly reviewed and updated accordingly. This is to ensure that any operational or regulatory changes as well as advances in industry technology are reflected in the final outcome.

Risk Mitigation Measures

Operators should be mindful that threats may arise due to some external factors that are beyond their control. Not all safety risks can be eliminated entirely but operators can consider various approaches to mitigate the risks to as low as practicable and acceptable.

Below are some risk mitigation areas that operators can consider:

- training program and competency;
- acceptance and handling procedures;
- outreach and awareness; and
- future asset investment.

Training Program & Competency

Due to the prevalence of lithium batteries and their inherent properties, incidents may occur in baggage, cargo and mail whether through non-compliance with the air transport requirements, or through subsequent damage. Possibly the greatest mitigation measure is the appropriate training program to all the employees to be able to intervene in an incident or, better still, prevent an incident from occurring.

Employees are required to be trained to carry out the functions for which they are responsible, and it is important for operators to consider the extent to which staff need to be trained.

With respect to lithium batteries, training program can be:

Preventative (i.e. to stop an incident from occurring) and is generally relevant to staff handling cargo, mail and baggage before flight (e.g. dangerous goods and cargo acceptance staff, and loaders). Other staff (e.g. sales and reservation staff) can also have a preventative role. Training program should focus on detection of:

- undeclared hidden lithium battery shipments;
- damaged packages; and
- declared shipments containing lithium batteries but not in compliance with the regulations (e.g. declaring a power bank shipment as lithium batteries contained in equipment).

Reactive (i.e. respond to an incident involving fire, smoke or fumes) and is relevant to flight and cabin crew. It is essential that, in addition to general familiarization training program, flight and cabin crew

receive comprehensive safety training program to cover the hazards presented by lithium batteries, including safe handling and emergency procedures.

Incidents also provide an indication of the effectiveness of the preventative barriers. For this reason, it is critical that operators implement a "just culture" approach to reporting of dangerous goods incidents. All staff should be encouraged to report all dangerous goods incidents, even when the incident may have occurred as a result of an error or mistake by the staff member, e.g. a Unit Load Device (ULD) falling off a dolly due to the locks not being properly deployed / raised.

The incident report and subsequent investigation allow the operator to revise policies, procedures or work instructions to strengthen the preventative barriers, which act to reduce the exposure to risk.

For operators that have their operational functions outsourced to ground handling agents, they should ensure that their suppliers are following the same principle, and their employees are trained and competent. In order to achieve this, operators can implement periodic audit programs and carry out random checks on shipments which have been accepted on their behalf.

Training Program for Flight Crew

In any cargo fire, the options available to flight crew are severely limited. During the flight, it is impossible for flight crew to determine whether lithium batteries are involved, or indeed, whether the smoke / fire warning is genuine. It must be appreciated that the notification to captain (NOTOC) will only detail the fully regulated dangerous goods being carried as cargo. It shall never be assumed that, if lithium batteries are stated on the NOTOC, they are the source of the fire. Similarly, the absence of lithium batteries on the NOTOC does not necessarily mean that none are being carried; there is always the possibility of undeclared lithium batteries in cargo.

Flight crew should be trained to respond to an emergency suspected of involving lithium batteries carried as cargo by following the standard operating procedure for smoke or fire events, the most important aspect of which is: Land As Soon As Possible.

Flight crew of cargo aircraft have options not available to those of passenger aircraft. Experience has shown that once a fire has become uncontrollable, a catastrophic situation can quickly develop, and it may not be possible to reach a suitable airport in time to land. Should a suitable airport not be within reach, it may be necessary to verify that the smoke / fire warning on the main cargo deck is genuine by visual inspection. Flight crew can also establish the extent and severity of the fire at this time. If this cannot be achieved from the flight deck (e.g. through a porthole), it may be necessary to investigate further. Ideally, someone other than a member of the operating crew should do this, but this may not always be possible (i.e. the operating crew may be the only occupants). If a closer visual inspection is required, this should be done with extreme caution. Flight crew may achieve this by opening the flight deck door as little as possible to obtain a view of the cargo compartment. However, if this is not possible, it may be necessary to access the cargo compartment using appropriate personal protective equipment (PPE) such as fire gloves and portable breathing equipment (PBE). The following are the objectives of visual inspection:

- determine whether smoke or fire is present. Even if there are no signs of smoke or fire, it must not be assumed that the warning was false, and the appropriate procedures, including landing as soon as possible, should still be followed. The situation should be monitored regularly for the remainder of the flight;
- if smoke is present, and a small fire is the obvious source, it may be possible to extinguish the fire using a portable on board fire extinguisher. After the fire is extinguished, if it is apparent that lithium batteries were involved, they should be doused with copious amounts of water to cool them and prevent reignition. After this has been done, the crew member should return to the flight deck and the appropriate procedures for smoke / fire on the main deck should be followed, with the affected cargo being regularly monitored for the remainder of the flight for

any signs of smoke or fire;

- if it is apparent that a large fire is present, no attempt should be made to enter the main deck cargo compartment. In this instance, as well as following the appropriate procedures, consideration should be given to the possibility that continued flight may not be possible and other options (e.g. ditching, forced landing) may need to be considered.

Clearly, the presence of fire on board an aircraft is an extremely stressful situation for flight crew, which can be made worse should smoke penetrate the flight deck. Consequently, practical emergency training program should address the difficulties that will be encountered in continuing to control an aircraft if there is smoke on the flight deck.

Acceptance & Handling Procedures

Acceptance

In addition to a comprehensive acceptance check, which seeks to verify that all applicable requirements for packages (and documentation) have been met for fully regulated dangerous goods, ICAO and IATA require measures to be taken to ensure packages are not damaged during handling or transport and these are particularly relevant to lithium batteries. For example, packages must be:

- secured in an aircraft in a manner that will prevent movement;
- protected against damage:
  - during flight, for example by the movement of baggage, mail, stores or other cargo;
  - during their preparation for transport, for example during handling after acceptance and prior to loading.

Whilst an acceptance check is only required when fully regulated dangerous goods are first accepted for carriage by air, when packages are transshipped, operators should verify packages are free from damage or leakage and the marks and labels are still intact (labels must be replaced by the operator if they have become lost, detached or illegible).

Loading

Specifically, for (standalone) lithium batteries (UN 3090 or UN 3480), they must be segregated from other dangerous goods classified in Class 1 (explosives) other than Division 1.4S, Division 2.1 (flammable gases), Class 3 (flammable liquids), Division 4.1 (flammable solids) and Division 5.1 (oxidizers).

There are no specific regulatory requirements addressing where lithium batteries should be loaded on an aircraft, operators may wish to consider loading them in a "Class C" cargo compartment and avoid the critical avionic systems. A Class C cargo compartment is one, where:

- there is a separate approved smoke detector or fire detector to give a warning to the flight crew;
- there is an approved built-in fire extinguishing system controllable from the flight deck;
- there are means of excluding hazardous quantities of smoke, flames or extinguishing agent from any compartment occupied by the crew or passengers;
- there are means of controlling ventilation and draughts within the compartment so that the extinguishing agent used can control any fire that may start within the compartment.

In order to identify how the declared shipments shall be segregated and loaded, operators can differentiate the shipments by way of an IATA Shipper's Declaration for Dangerous Goods and an air waybill (AWB), (if applicable).

For lithium batteries packed with equipment or contained in equipment, there are no specific regulatory requirements on segregation and loading. Operators may also choose to adopt the same restrictions mentioned above for these shipments if it fits the operational needs.

- Operators should have additional handling procedures to ensure that they store lithium batteries in a cool, dry area away from direct sunlight, heaters, or any other heat sources while awaiting loading and consider loading lithium batteries onto the aircraft last with a view to enable easier access to them in case of an incident.

They should establish a no-blame culture where staff feel safe to report any incidents or potential damage or hazards involving lithium batteries. This will encourage transparency and help identify and address and hazards promptly.

Additional post-loading inspections are necessary to check for any signs of damage, such as dents, leaks, or exposure to liquids. This is also to ensure that lithium batteries are not over-stowed with other cargo, especially liquids, to prevent contamination or short-circuiting.

Operators should develop and implement response plans for dealing with lithium battery shipments that may have been damaged during transit or trans-shipment. These plans should include procedures for isolating damaged batteries, notifying relevant authorities, and safely disposing of or handling the affected items.

Operator Approval

△ The incidents that have occurred have usually been caused by non-compliance, but not all have been undeclared. They may have been accompanied by a Shipper's Declaration for Dangerous Goods but may not have been adequately protected against short-circuit by the shipper / packer. Consequently, operators may wish to consider, as one of the available risk mitigation measures, accepting lithium batteries, especially batteries shipped alone (without the equipment) only from pre-approved shippers and freight forwarders. When establishing the approval process, operators can consider the following factors:

- whether or not the lithium batteries are of a type that have successfully passed the UN 38.3 tests*;
- whether the manufacturer has the required quality management program (DGR 3.9.6.2.1(e))
- if the lithium batteries are individually protected or not and how these are then packed inside the outer packaging;
- whether the manufacturer/shipper has a rigorous process to ensure that lithium ion batteries are shipped with a State of Charge not exceeding 30%.
- whether the shipper/forwarder has a formal external and independent accreditation, such as ISO 9001 certification or an IATA CEIV in Lithium batteries;
- the credibility of the battery manufacturers, shippers and freight forwarders; and
- the dangerous goods qualification of shippers and freight forwarders;
- the development of a graduated pathway; where trusted and reputable manufacturers and shippers experience a "green-lane" acceptance process, whilst those from unknown, unverified, infrequent shippers are subjected to additional scrutiny and checks.

Such approval process could then provide better visibility to the operator on what is being accepted.

*From 1 January 2020, manufacturers and subsequent distributors of cells or batteries manufactured after 30 June 2003 must make available the test summary as specified in the UN Manual of Tests and Criteria, Part III, sub-section 38.3, paragraph 38.3.5. This test summary can be made available electronically or in printed format and is also applicable to cells and batteries that are contained in equipment. It is not required to accompany every shipment, but it can be one of the documents to be considered when approving the carriage of certain battery types.

General Cargo

Clearly, the measures above are not possible for lithium batteries that have not been declared to the operator. Therefore, efforts must be made to detect these undeclared batteries. These could include implementing:

- enhanced cargo acceptance processes and training program to better detect non-compliant shipments. This could include greater scrutiny of the descriptions of goods on accompanying paperwork. For example, items described on an air waybill as “electrical / electronic equipment” or “film crew and media equipment” or “no battery” when the product described is an electronic device, may contain lithium batteries;
- establish a database to screen the description of goods shown on both the master air waybill data (FWB) and house manifest data (FHL), if applicable;
- additional training program for ground handling agents and cargo terminal personnel to better detect undeclared shipments, raise awareness of the need to detect and remove damaged packages from the transport stream;
- carry out risk-based target or random screening, by means of x-ray technology or even physical hand searching of cargo, if applicable. Coordinate with the appointed security screening companies on the screening requirement for lithium battery shipments and jointly establish a seamless communication procedure;
- in cases where lithium battery related shipments are not accepted (for either regulatory or operators’ policy), operators may want to consider other more restrictive measures, such as not allowing shipper- built units (BUP) and prohibiting the use of opaque plastic sheets covering cargo (at package level and skid level);
- coordinate closely with competent authorities, ensure that occasions of undeclared dangerous goods, including lithium batteries, are reported to the appropriate authority of the State of the operator and the State in which it occurred in accordance with DGR 9.6.5.

Engagement & Awareness

Engagement with Shippers

As the originators of cargo, shippers offering compliant shipments are first and foremost, they are the key entities for safety compliance. For most operators, they seldom have direct contact with shippers; however, should there be opportunities to interact with shippers, particularly on the shipping of lithium batteries, it is appropriate to ensure they have the relevant training program and always only offer compliant shipments.

Engagement with Freight Forwarders

Freight forwarders are an important interface between shippers and operators but are largely unregulated. Engagement with freight forwarders, including advising them of the consequences of failure to comply with the requirements, can be very beneficial. Additionally, operators may also consider vetting freight forwarders on a regular basis to ensure that they also have a stringent acceptance procedure and processes aimed at detecting non-compliant shipments.

Engagement with Designated Postal Operators

Experience has shown that the general public is generally ignorant about the dangerous goods that can and, more importantly, cannot be sent in the mail. ICAO requires that the appropriate civil aviation authority of the State to review and approve the procedures of the Designated Postal Operator (DPO) to control the introduction of permitted dangerous goods into the mail.

For DPOs that have not been approved to accept any lithium batteries contained in equipment in mail, operators can consider visiting and understanding how the DPOs are isolating mail that potentially contains such unapproved items.

It is always beneficial for operators and DPOs to work together in developing awareness strategies.

Warning Notices

Sufficient notices must be prominently displayed at visible locations at cargo acceptance points to alert shippers and freight forwarders about any dangerous goods that may be contained in their shipments. As shippers do not tend to tender shipments to operators directly in traditional cargo operations, it is also worth of displaying similar notices in the premises of freight forwarders and integrators' drop-off counters or service points.

Figure 9 – Lithium battery warning notice

Websites

Operators can also remind shippers about their policy and develop their own guidance documents to assist their shippers in understanding regulatory requirements related to shipping lithium batteries as well as their own handling procedures.

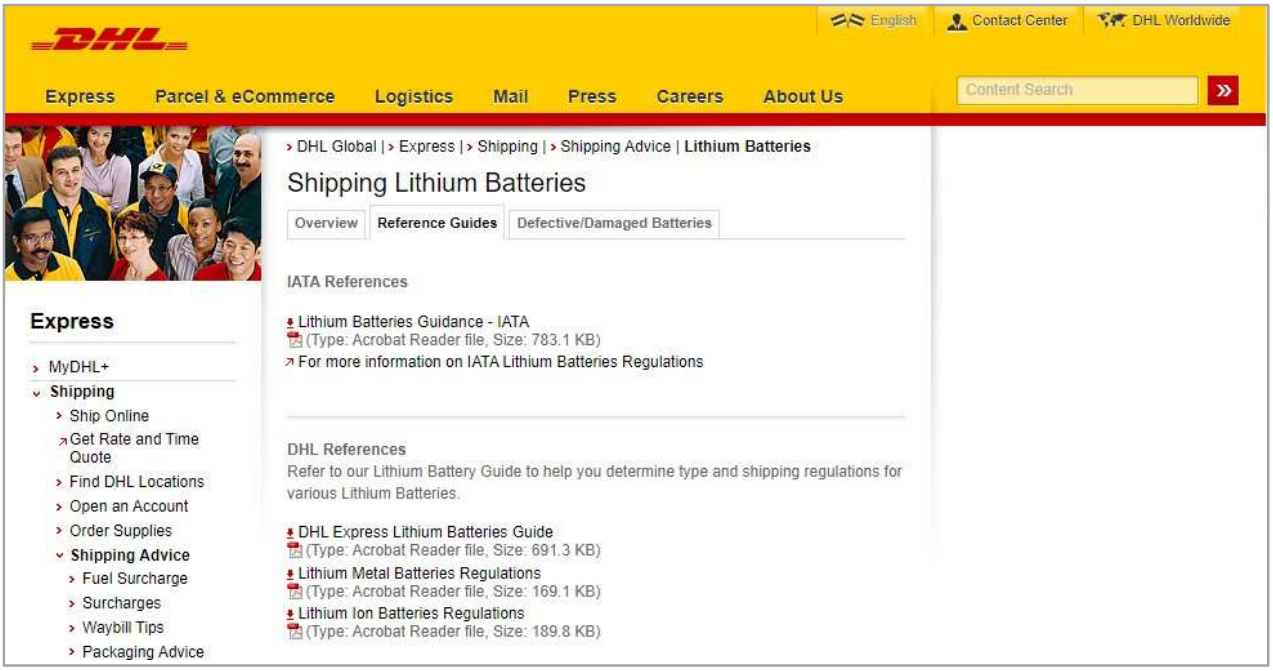


Figure 10 – Website showing additional lithium battery shipment related guidelines
(https://www.dhl.com/en/express/shipping/shipping_advice/lithium_batteries.html#guides_materials)

Seminars

Lithium battery transport requirements can be a subject that is very helpful to the industry, to be covered in seminars. Apart from the benefit of providing learning opportunities, seminars can bring together many interested parties who may not normally encounter one another, and therefore, facilitate an understanding of each other's perspectives.

Future Asset Investment

The incidents and accidents that have occurred where lithium batteries are known to have been a factor (or were present on board) have highlighted the vulnerability of cargo aircraft to main deck cargo compartment fires and, in particular, how quickly a situation can become catastrophic. Consequently, a number of technologies are being studied and developed by industry and regulators to enhance fire protection, particularly on cargo aircraft as these may not have the same level of fire suppression as passenger aircraft. However, it would be wrong to believe that such measures are necessary only when it is known that lithium batteries are being carried. Undeclared shipments are commonplace; therefore, such provisions should be applied even when no consignments of lithium batteries have been declared to an operator.

At a recent lithium battery workshop, several new and developing technologies were showcased. Some examples of these are shown in the following section.

Fire-Resistant Containers

Fire-resistant containers (FRC) can be made and used in the same way as certified aircraft containers. They are constructed of fire-resistant material, similar to that used in body armor. There are multiple suppliers on the market, and some FRCs have been demonstrated to be able to contain an internal fire of up to 650°C for at least four hours. Depending on the materials, some have the advantage of being lighter than conventional aluminum containers, offering a weight savings of as much as 30 kg per container. In terms of use, loading and tie-down, they are the same as the traditional certified aircraft containers.

Figure 11 – Main deck fire-resistant containers

Fire Containment Covers

Many shipments containing lithium batteries are loaded on open aircraft pallets, and consequently, fire resistant containers might not be appropriate for use, but rather, fire containment covers (FCC) that are deployed over the cargo but under the net may be used. There are different suppliers on the market and some operators have been deploying FCCs on palletized cargo for many years whilst others are considering their use. Some FCCs currently in production can contain a fire of up to 815°C for four hours or even more, which can potentially offer more time for flight crew to find the closest airport to land should an emergency situation arise.

In terms of deployment, FCCs can be more complex than FRCs. Depending on the design and make, they can weigh approximately 40 kg to 50 kg, and require at least two trained staff to deploy and remove the cover.

Figure 12 – Fire containment cover for lower deck and main deck deployment

Fire Containment Bags

The same materials used for the manufacture of fire containment covers are used to produce smaller size fire containment bags (FCB). Due to their smaller size, the deployment process of these bags is comparably simpler than that of fire containment covers and can also be used over small packages. Once the FCBs are deployed, they can either be loaded on the aircraft pallets or in the aircraft containers or even loaded into non-containerized aircraft (bulk loaded).

Figure 13 – Fire containment bags loaded on a certified aircraft pallet and in a certified lower deck aircraft container

Smoke Displacement Systems

A smoke-filled cockpit can restrict or completely block a pilot's view of the outside world and essential cockpit instrumentation. Vision can be restored by smoke displacement systems, which use self-inflating transparent plastic envelopes to provide a clear space through which a pilot can see flight instruments and the outside world.

Figure 14 – Smoke displacement system (EVAS – Enhanced vision assurance system)

In February of 2015, the VisionSafe Corporation received Supplemental Type Certification (STC) for the Emergency Vision System (EVAS) Cockpit Smoke Displacement equipment applicable to the Boeing 777. The Boeing 777 is the latest aircraft to get FAA certified equipment and includes models 777-200, -200LR, -300, - 300LR and the 777F. The company now has EVAS STC's for over 80 aircraft types.

The FAA recommends that aircraft meet higher standards for continuous cockpit smoke protection (FAA AC25.109). The U.S. Air Line Pilots Association's (ALPA) in-flight fire project reported more than 1,100 in-flight smoke and fire incidents over a period of 10 months, resulting in 360 emergency landings.

The FAA's concern about smoke events continues and remains a serious problem with the statistics are essentially unchanged. The Flight Safety Foundation ranks smoke / fire emergencies as the 3rd highest cause of fatalities. Smoke is also a leading cause of diversions of ETOPS aircraft.

Quick-Donning Full-Face Oxygen Masks

Unlike traditional flight crew oxygen masks, which require two hands to don, new face masks can be donned with only one hand and in a couple of seconds. These new masks can be used in conjunction with smoke displacement systems.

Figure 15 – Quick-donning full-face oxygen mask

Performance-Based Packaging Standard

The SAE G-27 committee, consisting of battery manufacturers, regulators, operators and packaging manufacturers, was established at the request of ICAO to develop a performance-based packaging standard for standalone lithium batteries (AS 6413). The intent is to develop a test standard for designing a packaging for specific types of batteries prepared as for transport, so that when a lithium battery fails and goes into thermal runaway, the consequence of the event can be contained inside the packaging, so as to prevent hazardous flame, fragments or flammable gases from exiting the package and consequently causing damage to the aircraft or other cargo.

△ In October 2024, the SAE G-27 Committee published AS6413, the Performance-Based Package Standard for Lithium-Ion Cylindrical Cells as Cargo on Aircraft. This standard defines testing requirements, including the necessary equipment, to evaluate whether a package of lithium-ion cylindrical cells (UN3480) in the 21700 format or smaller can prevent hazardous effects to an aircraft in the event of a cell failure.

The standard applies exclusively to lithium-ion cylindrical cells of 21700 format or smaller. It does not cover other lithium-ion cell types or any lithium-metal cells. Future updates to AS6413 may expand its scope to include additional cell geometries and lithium-metal technologies as more information and advancements become available.

Additionally, the committee finalized AIR6840, an Aerospace Information Report that provides background information and the rationale for specific elements within AS6413. It is a hope that in the near future, a technology may be developed that will prevent cells from going into thermal runaway by this standard's test protocol.

While this will make compliant shipments even safer, it will have no effect on the arguably biggest risk (i.e. non-compliant or undeclared lithium battery shipments).

For more information, visit http://works.sae.org

To purchase the document, visit http://www.sae.org/technical/standards/AIR6840

Enhanced Security Screening

X-ray machines can also be an effective tool in identifying lithium batteries contained inside a shipment. However. the algorithms used by x-ray machines in security screening are traditionally set to detect explosives automatically. Furthermore, lithium batteries in small packages are more identifiable through visual x-ray compared to those in large consignments. For many years, the United Kingdom Civil Aviation Authority has been exploring the feasibility of detecting lithium batteries in cargo using existing x-ray technology, and in recent years, due to the rising demand to detect undeclared lithium battery shipments by using x-ray machines, some manufacturers are starting to review their technology to offer automated lithium battery detection.

Figure 16 – X-ray images of different battery types

However, it is important to note that although the technology is available, authorized airport security companies traditionally and primarily focus on identifying security related items, such as an improvised explosive device (IED), rather than dangerous goods or lithium batteries. Therefore, if operators have expectations to detect undeclared lithium batteries in packages, they are encouraged to liaise with the security companies locally so as to ensure that expectations are well defined, communicated and executed.

Passenger Operations

Challenges

Very similar to one of the many challenges encountered by cargo operations, many counterfeit and substandard lithium batteries can also be found in passengers' baggage. With the rapid evolvement of technology and massive number of air travelers every day, the challenges in passenger operations can be even more onerous than those in cargo operations.

Safety Risk Assessment

Details on safety risk assessments and how a safety risk assessment should be carried out can be found under Cargo Operations in the previous section.

Identify the hazards

Below are some examples of potential hazards that can be found in passenger operations:

- PEDs powered by a damaged / defective lithium battery is brought on board the aircraft (e.g. the user has been finding the lithium battery of the mobile phone is overheating);
- PEDs that are not switched off or in hibernation mode, and stowed in checked baggage;
- passengers not complying with the regulations and carry a large number of spare batteries and PEDs in their carry-on and checked baggage that are also not for personal use;
- spare batteries, e-cigarettes or power banks are placed in carry-on baggage but later on due to insufficient space in the overhead locker of the passenger cabin, the bag is moved to the cargo compartment without removing the spare batteries, e-cigarettes or power banks;
- power banks containing substandard lithium batteries and are being recharged during flight; and
- PEDs slipping into the seat and being crushed, resulting in a fire, when the passenger attempts to retrieve the device by adjusting the seat.

Example

An operator of passenger aircraft within Europe wishes to risk assess the carriage of portable electronic devices (PED) in the cabin of their aircraft.

Likelihood – Given the propensity for portable electronic devices (PED) to be carried by passengers, it would be reasonable to assume that such an incident might occur at some time, and so the likelihood would be Level 3.

Severity level – If a PED catches fire in the cabin, fire extinguishers will be readily available to cabin crew, who will have been trained in their use. Additionally, water, which is necessary to cool lithium batteries involved in an incident, will be on hand. Therefore, on the basis that an abnormal flight operations incident procedure would be applied (firefighting by cabin crew), with few other consequences, it may be appropriate to assign a severity level of major (C).

Therefore, the risk index would be likelihood (3) x severity (C) = 3C "Tolerable"

The following factors should be taken into account:

Preventative control – prohibition of spare lithium batteries in checked baggage.

Escalation factor – passenger's ignorance of the requirement.

Escalation control – operator has a robust process to ensure that all passengers are made aware of the requirement (e.g. by questioning at check-in kiosks and / or counters).

Despite preventive controls being in place, there is always the possibility that an unsafe event (in this case a lithium battery fire / event) can occur. Consequently, recovery measures must be considered (i.e. what can be done to prevent the unsafe event developing into the ultimate negative consequence, the loss of life or the aircraft). However, as with preventive controls, recovery measures can also be weakened by escalation factors that need to be controlled.

In the example above, the following may apply:

Recovery measure – Halon fire extinguishers and water available to cabin crew;

Escalation factor – fire extinguishers out of date, insufficient water carried;

Escalation control – robust process in place to ensure an aircraft cannot depart with expired extinguisher or less than certain volume of water.

Risk Mitigation Measures

Whether for cargo or passenger operations, operators should always be mindful that threats may arise due to some external factors that are beyond their control. Not all safety risks can be eliminated entirely but operators can consider various approaches to mitigate the risks to as low as practicable and acceptable.

Below are some risk mitigation areas that operators can consider:

- training program and competency;
- acceptance and handling procedures; and
- outreach and awareness.

Training Program & Competency

Due to the common use of lithium batteries for powering electronic devices, such as mobile phones, tablets, laptops and mobility aids, and the possibility of having substandard batteries on board, incidents may occur in both the cabin and baggage. The best mitigation measure may be appropriate training program to all the employees to be able to intervene and control an incident or even to prevent an incident from occurring.

According to the regulations, employees are required to be trained to carry out the functions for which they are responsible, and it is important for operators to consider the extent to which employees need to be trained.

With respect to lithium batteries, training program can be:

Preventative (i.e. to stop an incident from occurring) and is relevant to frontline passenger facing staff, especially before flight (e.g. ticketing staff, check-in counter staff and boarding gate agents). Training program should focus on detection of:

- (any kinds of) spare batteries (including power banks) in checked baggage, and this should include questioning passengers when carry-on baggage is surrendered for carriage in the cargo compartment;
- excessive number of portable electronic devices and spare batteries in baggage;
- large capacity lithium batteries (e.g. more than 100 Wh but not exceeding 160 Wh) carried without an operator approval.

Reactive (i.e. respond to an incident involving fire, smoke or fumes) and is relevant to flight and cabin crew. It is essential that, in addition to general familiarization training program, flight and cabin crew receive comprehensive safety training program to cover the hazards presented by lithium batteries, including safe handling and emergency procedures.

Training Program for Cabin Crew

In addition to the items carried by passengers and crew members, there are many devices on the flight deck or in the passenger cabin that are powered by lithium batteries, such as electronic flight bags, emergency torches, or even the offline credit card machines. In the event of one of these items failing and causing a fire, it is understandable that there may be reluctance to introduce liquid onto the flight deck; however, if the battery is not cooled with water (or other non-flammable liquid), the fire may continue to propagate and worsen.

Cabin crew members are most likely to have to deal with an in-flight lithium battery fire and have a vital role to play in dealing with incidents. Because a fire in the cabin can quickly become uncontrollable, with potentially disastrous consequences, it is vital that cabin crew are trained to respond quickly, using the procedures and checklists published in the ICAO *Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods* (Doc 9481), (The "Red Book") and IATA's *Cabin Operations Safety Best Practices Guide*. These procedures have been developed by the IATA Cabin Safety Task Force in conjunction with ICAO and have been incorporated into the "Red Book".

In order to ensure that all crew members are competent to deal with a lithium battery event from a damaged / defective portable electronic device, their competency should be verified by practical demonstration of dealing with a lithium battery incident in the cabin.

Below are some scenarios to be considered in the safety training program for cabin crew.

Overheat Event

If an electrical burning smell from a portable electronic device (PED) is detected, or a PED is suspected of overheating, the passenger should be asked to turn off the device immediately. If the PED is plugged into the aircraft power supply, the power supply must be disconnected if safe to do so and the in-seat power should also be turned off. Although a PED may be "switched off," unstable / damaged batteries can still ignite and so the PED must remain off and be monitored closely for the remainder of the flight.

Fire Event

As with any fire occurring in the cabin, the use of personal protective equipment (PPE) such as fire gloves and portable breathing equipment should be considered, but it is important to note that this does not delay the response to the incident. Although following recommended procedures present a sequence of tasks, some of these actions occur simultaneously when carried out by multiple crew members.

Figure 17 – A burning laptop

1. Identify the item

It may not be possible to identify the item (source of fire) immediately, especially if the fire has started in a seat pocket or the device is not readily accessible. In this case, fire-fighting procedures should be applied as a first step. Once it is possible to do so, identify the item after the fire is under control. If the item is contained in baggage, the crew's actions would be similar to the actions for a device that is visible or readily accessible.

Caution: In order to avoid injury from a flash fire, it is not recommended to open the affected baggage when there is any indication of smoke or flames. However, in certain situations, cabin crew members may assess and deem it necessary to slightly open baggage to allow entry of the extinguishant and non-flammable liquid. This should be done with extreme caution and only after donning appropriate protective equipment, available on the aircraft.

2. Determine and apply fire-fighting procedure

Any occurrence concerning a fire in the cabin should be notified immediately to the pilot-in-command who should be kept informed of all actions taken and their effects. It is essential that the cabin crew and the flight crew coordinate their actions and that each are kept fully informed of the other's actions and intentions.

Appropriate firefighting and emergency procedures must be used to deal with any fire. In a multi-cabin crew operation, the actions detailed in the fire-fighting procedure should be coordinated and conducted simultaneously. On aircraft operated with only one cabin crew member, the aid of a passenger should be sought in dealing with the situation.

- The appropriate response will be shaped by the device and the nature of the concern. A mobile phone with a single cell battery, will have a different response to a laptop, which typically has a battery comprised of around eight cells, and therefore an increased risk of thermal runaway in adjacent cells and a continuing fire. The laptop usually has some ability for water to pass through the keyboard to enabling cooling of the battery, whilst a small, sealed tablet such as an iPad, which typically has four cells in the battery, will not be able to be cooled in the same way.
- Similarly, a device which has "become hot" will not be responded to in the same way as one which is giving off smoke. A burning device should elicit a different treatment to one that is smoking; as should one that is ejecting flammable battery electrolyte.

Halon, halon replacement or water extinguishers should be used to extinguish the fire and prevent its spread to other flammable materials. It is important to wear available protective equipment (e.g. protective breathing equipment, fire gloves) when fighting a fire.

If fire develops, cabin crew should take prompt action to move passengers away from the area involved and, if necessary, provide wet towels or cloths and give instructions for passengers to breathe through them. Minimizing the spreading of smoke and fumes into the flight deck is critical for the continued safe operation of the aircraft. Therefore, it is always essential to keep the flight deck door closed. Crew communication and coordination is of utmost importance. The use of the interphone should be the primary means of communication unless the interphone system fails.

If fire or smoke is seen coming from a baggage compartment, such as a wardrobe or overhead locker, passengers should be moved and asked if they are carrying anything that could be the cause. The exact location of the fire should be determined carefully by checking for heat with the back of an un-gloved hand.

Figure 18 – Determining the location of a fire in an overhead locker.
After first considering the use of PPE, a fire extinguisher should be discharged into the locker.

Figure 19 – Discharging a fire extinguisher into an overhead locker

The compartment should be closed for a few seconds to allow for the extinguishant to take effect. Further extinguishant should be discharged until it is safe to fully open the compartment, when the cause of the fire will be located.

3. Remove power

It is important to instruct the passenger to disconnect the device from any power supply if it is deemed safe to do so. A battery has a higher likelihood of catching fire due to overheating during or immediately following a recharging cycle even though the effects may be delayed for a period of time. Removing the external power supply from the device will ensure that additional energy is not being fed to the battery to promote a fire.

Turn off the in-seat power to all the remaining electrical outlets until it can be established that a malfunctioning aircraft system does not result in additional failures of the passengers' portable electronic devices.

If the device was previously plugged in to in-seat power, visually check that power to the remaining electrical outlets remain off until the aircraft's system can be determined to be free of faults.

The removal of power may occur simultaneously to other cabin crew actions (e.g. obtaining water to immerse the device). Depending on the aircraft type, the in-seat power supply may have to be turned-off by the flight crew physically than remotely.

4. Immerse the device in water (or other non-flammable liquid)

If the incident device is not inside a bag or it is in a bag that is not intact, the device should not be moved but left in place and be flooded with water to prevent the spread of heat to other cells in the battery.

Should water not be available, any non-flammable liquid may be used to cool the device.

If the incident device is contained in an intact bag and no flames can be seen, the bag should be removed and placed in a watertight container (or one made watertight by using a bin liner) and flooded with water.

Figure 20 – A laptop being doused with water from the galley

Figure 21 – Applying water to a burning device without removing it from the overhead locker. It is important to note that liquid may turn to steam when it is applied to heated batteries.

Caution:

- do not attempt to pick-up or move the device; batteries may explode or burst into flames without warning. The device must not be moved if any of the following exist: flames / flaring, smoke, unusual sounds (such as crackling), debris or shards of material separating from the device;
- do not cover or enclose the device as it could cause the device to get hotter and overheat; and
- do not use ice or dry ice to cool the device. Ice or other materials will insulate the device, increasing the likelihood that additional battery cells will heat-up and reach thermal runaway.

Figure 22 – A demonstration of the effect of applying ice to a burning laptop

5. Leave the device in place and monitor for any reignition

A battery involved in a fire can reignite and emit flames multiple times when heat is transferred to other cells in the battery. Therefore, the device must be monitored regularly to identify if there is any indication that a fire risk may still exist. If there is any smoke or indication of fire, the device must be immersed in water (or other non-flammable liquid).

6. When the device has cooled, after approximately 10 – 15 minutes

The device can be moved with caution once it has cooled down and if there is no evidence of smoke, heat, or if there is a reduction in the crackling or hissing sound usually associated with a lithium battery fire (after approximately 10 – 15 minutes). The waiting period may vary, based on the device and its size. The different circumstances (e.g. types of devices and phase of flight) should be addressed in the operator's training program.

A suitable empty container, such as a pot, jug, galley unit or waste bin (with a water-tight liner if needed), must be filled with sufficient water or non-flammable liquid to completely immerse the device. It is important to wear available protective equipment (e.g. protective breathing equipment and fire gloves), when moving any device involved in a fire. Once the device is completely submerged, the container used must be stowed (e.g. in a toilet or wardrobe), monitored and, if possible, secured to prevent spillage.

Figure 23 – A laptop in a bag being immersed in water inside a toilet waste bin

Figure 24 – The toilet waste bin with water holding the damaged device should be stowed and isolated in a toilet

As not all containers are watertight, so plastic bin liners should be used.

Figure 25 – A bar box made watertight by using a plastic bin liner

Lithium Battery Fire Prevention

There have been reported incidents on board by operators as a result of the inadvertent crushing or damage of a portable electronic device, and some of these crushed devices had even caught fire.

Figure 26 – A mobile phone crushed in an electrically adjustable seat

Figure 27 – The charred remains of a mobile phone

Due to the design of some electrically adjustable passenger seats, it is possible for small electronic devices, such as mobile phones, tables, e-readers or MP3 players to slip under a seat covering and / or cushion, behind an armrest or down the side of a seat and becoming a potential fire hazard. These types of seats are primarily installed in premium class cabins.

- Passenger awareness on how to use and stow their devices while in flight can help mitigate these incidents. Human factors considerations, also play a major part in passenger awareness and reporting. The embarrassment of having misplaced their device, and not wanting to draw attention to themselves, is a strong factor in passengers trying to retrieve the device; even if the messaging is that such actions may cause a fire. Passengers are more likely to seek assistance if they are concerned that their retrieval attempts are more likely to damage their personal device.

  To prevent crushing of the PED and reduce the potential fire hazard to the device and the surrounding area, cabin crew and / or passengers must not use the electrical or mechanical seat functions in an attempt to retrieve a lost PED. The seat movement may crush / damage the PED's lithium battery and potentially result in a lithium battery fire. Cabin crew should always advise the flight deck of such a situation. Ask the passenger concerned to identify the item, and where they suspect it may have dropped or slipped into, and if they have moved the seat since misplacing the PED. Arrange the passenger to leave the area temporarily, and, if applicable, also arrange the passenger seated next to the affected seat to be moved. If available, don fire gloves before trying to retrieve the item. Do not move the seat! If it is not possible to retrieve the item, it may be necessary to move the passenger to another seat and block the affected seat to be used.

  In the event that the situation develops into a lithium battery fire, cabin crew should apply the following as per their respective operator procedures:

  - lithium battery fire-fighting procedures;
  - post-event procedures (on board);
  - first point of landing offloading procedures.

  After landing, the crew must inform ground staff where the device is stowed and make an appropriate entry in the aircraft technical log. The PED must be removed from the aircraft before it operates the forthcoming sector, as lithium batteries that are damaged are forbidden for carriage. Devices involved in a fire should be retained on the ground to enable investigation by competent authorities.

Small Aircraft Operations

The operational environment for small aircraft (e.g. narrow body aircraft) can be very different, with only one or two cabin crew on board the aircraft, and on some occasions, might even require assistance from passengers. Additionally, considerations will need to be given as to what items are

available to use in the event of an incident. It is suggested that all aircraft, as a minimum, should carry the following equipment on top of that usually on board:

- fire / heat resistant gloves;
- heavy duty plastic bin liners; if the aircraft has no suitable container that something the size of a laptop can fit into, these can be filled with water before placing the damaged device in the bin liner;
- fire containment bags, which can be used to contain a damaged PED while it is being cooled off and isolated, and can be stowed conveniently;
- suitable receptacles, e.g. jugs to transfer water from the galley or toilet to the incident area should insufficient bottled water be carried.

Figure 28 – Fire containment bag for damaged device in passenger cabin

Check-in & Handling Procedures

The wide use of portable electronic devices means that all passenger aircraft will be carrying lithium batteries in both carry-on and checked baggage. On a typical wide-body aircraft, the number of these devices on board could be in the hundreds. Although they are dangerous goods, certain types and quantities of these devices are permitted to be carried by passengers and crew.

Check-in

All spare batteries, not only lithium batteries but also dry batteries, are not permitted in checked baggage and must only be carried in the passenger cabin. Consequently, if there is a need for carry-on baggage to be loaded in the cargo compartment (e.g. due to shortage of overhead lockers for baggage), ground staff or cabin crew must alert the affected passengers to remove spare lithium batteries, including power banks and e-cigarettes, from the baggage before transferring it to the cargo compartment. Batteries removed from the baggage must only be carried in the passenger cabin.

Details of the check-in and handling procedures for mobility aids powered by lithium batteries can be found in the Battery-Powered Wheelchair and Mobility Aid Guidance Document.

On Board the Aircraft

There have been a number of incidents where mobile phones have been dropped by passengers into the workings of their seat and were crushed when the seat was moved. This scenario is most likely to occur in electrically powered seats found in premium cabins. To reduce the likelihood of this happening, it is suggested that operators incorporate advice into the passenger pre-flight briefing, such as:

△ "If you are intending to sleep during the flight, please make sure any small electronic devices such as mobile phones, mp3 players and tablets are stowed safely either in seat pocket, a bag or in an overhead locker so that they don't fall into the seat mechanism where they may be damaged. If you do lose your electronic device in your seat, do not move the seat, as this may damage your device. Inform a member of the crew; they will be happy to retrieve the device for you."

Another occasion when lithium batteries could potentially cause an incident is when they are being replaced in on board equipment such as credit card readers. When this is being done, care must be taken to ensure that neither the old nor the new batteries are dropped into inaccessible locations, where if damaged, short-circuiting could occur and lead to a fire.

△ The use of on-board power to recharge devices which are switched-on and active, yet sitting in the cloth seat-pocket, where the is a lack of natural air circulation, can result in the device overheating. Aircraft seating material is required to meet fire-retardant standards, which may increase the rate of thermal runaway in the battery and provide an additional challenge for cabin crew response. Seat design, which enables more airflow for devices that are being recharged, will be a more effective, engineered response, than announcements that passengers should not have devices in seat pockets whilst they are plugged into the aircraft power supply.

Engagement & Awareness

Warning Notices

Warning notices must be displayed at check-in counters at airports, warning passengers of the type of dangerous goods they must not carry. It should be noted that these warning notices are often generic in nature and some passengers may simply ignore them. However, it is essential to remind and raise the awareness of passengers to remove any of the prohibited items from their baggage, especially before they are checked in for carriage.

Operators should consider specific warnings at airports where there are known problems, such as the prevalence of counterfeit and substandard lithium batteries widely available for purchase in street markets. At those airports, displaying warning notices at the baggage reclaim areas to warn passengers can also be effective.

Figure 29 – Warning notice aimed at passengers
(http://www.casa.gov.au/wcmswr/_assets/main/dg/luggage/lithium_battery_poster.pdf)

In addition to the general warning notices, operators should also consider displaying topical warning notices based on the rising trend of certain items being carried by passengers.

Figure 30 – Warning notice on e-cigarettes and spare lithium batteries

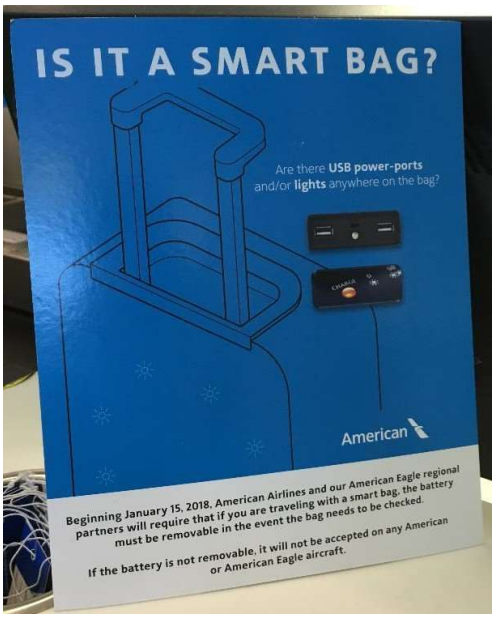


Figure 31 – Warning notice on smart bags at check-in counters

Websites

It is important to warn passengers about the restrictions that apply to baggage at the earliest opportunity, ideally before they leave home. There are regulatory requirements that online ticket purchases can only be completed once information about dangerous goods has been displayed and an acknowledgement by passengers made that this information has been read and understood. Similar requirements apply to online check-in. These requirements are not fool proof, as the person purchasing the ticket or checking in may not necessarily be the person travelling or may click that they have read the information without actually reading it. Nevertheless, this information should include specific information about the carriage of lithium batteries.

Beyond these requirements, websites present other excellent opportunities to educate passengers on the limitations regarding dangerous goods in baggage.

It is very common for operators having alliances and code share flights, the general public can be ignorant about the baggage restrictions of different operators, especially if one is imposing a more restrictive policy based on their operational needs. Hence, it is valuable for customers that member operators in an alliance to include information of each other's policies and requirements.

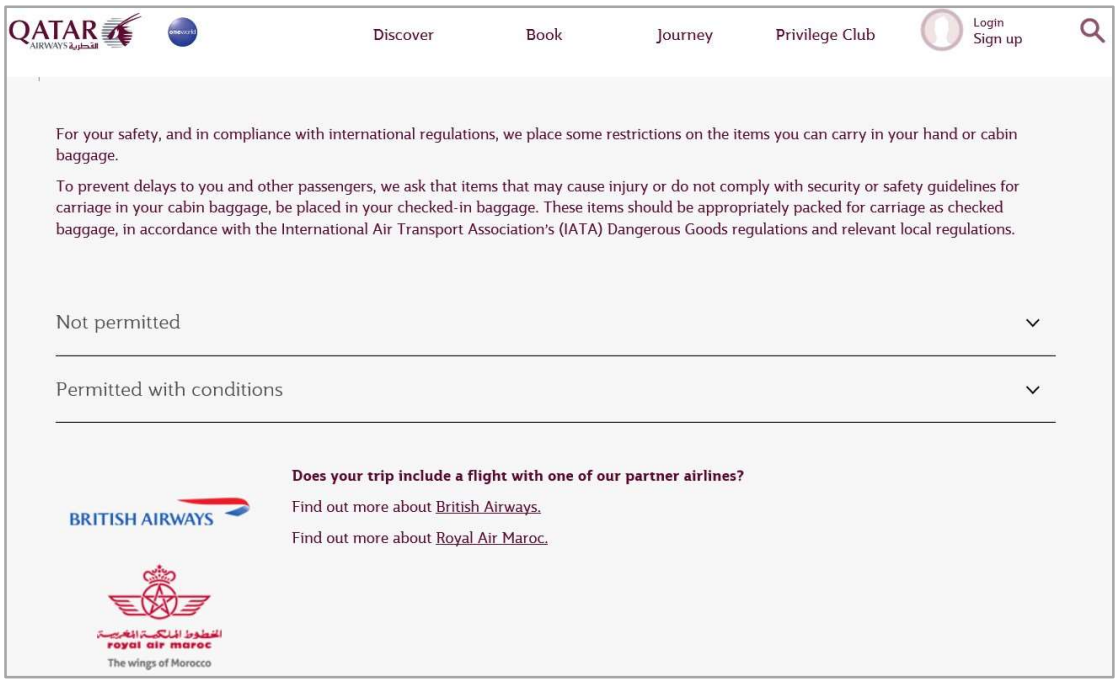


Figure 32 – A website including other operators' baggage restrictions (https://www.qatarairways.com/en-gb/baggage.html)

In-flight Magazines

Although it is too late to prevent batteries from being carried in a manner that does not comply with the regulatory requirements, an article in an in-flight magazine may help passengers pay more attention when packing their baggage for a subsequent flight.

Arrival Videos

At the end of a flight, passengers may be shown an information video about the city they are visiting. This provides a unique opportunity to inform a "captive" audience about the perils of purchasing cheap, possibly counterfeit and substandard lithium batteries from market stalls, and highlight the potential safety risks that these batteries can pose.

Recreational Press

Magazines produced for specific recreational activities involving lithium batteries (e.g. radio-controlled models) may publish articles provided by operators. Such magazines are guaranteed to reach the relevant audience.

Newspapers, Television and Radio Advertisements

Advertising in newspapers can be expensive; yet, potentially effective due to their reach to a very wide audience. Broadcasting on television and radio can also be an option for reaching out to the general public.

Schools

In some parts of the world, it is possible to cooperate with education authorities or individual institutes to conduct a brief session for students on what can and cannot be carried in baggage. Through this channel, it is not only that the students will be educated, but the information is also likely to be passed on to their parents and friends.

Social Media

Operators can make use of social media, such as Facebook, Twitter and LinkedIn, to show tips and video clips about various items that can and cannot be brought in baggage.

Figure 33 – A Tweet on lithium batteries in cargo while promoting an exhibition booth

Tourism Conferences

There are many tourism conferences held around the world every year. Even if operators find it cost prohibitive to participate as an exhibitor to have a booth, partnering with the organizers or advertising in the conference magazine with information about the carriage of lithium batteries in baggage is also an option.

Figure 34 – An exhibition booth to promote the safe transport of dangerous goods, including lithium battery cargo

Collaborate with Regulators and Airport Authorities

There are different types of communication channels available at the airport, such as display cabinets, transit vehicles and airport magazines. However, in some locations, it may not be possible for operators to broadcast the information individually but rather collectively. Thus, it may be necessary to work closely with local regulators and airport authorities to deliver a collaborative message.

Other Publicity Materials

Small gadgets or giveaways, such as drinks coasters and baggage tags, can also be designed to promote flight safety information.

Figure 35 – Baggage tag and t-shirt to promote lithium battery safety

Conclusion

Experience has shown that compliant shipments of lithium batteries offered for air transport pose a very low risk. However, experience has also shown that there are many shippers that lack the requisite knowledge and offer counterfeit and substandard batteries for transport as well as some that will deliberately mis-declare shipments of lithium batteries in an attempt to avoid complying with the regulations.

To ensure that the potential risks do not result in a dangerous goods accident, operators must develop and implement a comprehensive and robust safety risk assessment and risk mitigation process. There is no "one size fits all" for this. Each operator is unique based on the airports to which they operate, the aircraft types, passenger flights or freighters, and the operator's "risk appetite".

Therefore, it is essential for operators to conduct their own safety risk assessment based on their operational needs and environment, to identify various risk mitigation measures that will reduce the risks to as low as practicable to achieve an acceptable level of safety.

Additional Information

Some of the links are listed below for additional information:

IATA	https://www.iata.org/en/programs/cargo/dgr/batteries/
ICAO	https://www.icao.int/Pages/default.aspx
EASA	https://www.easa.europa.eu/en/the-agency/faqs/lithium-batteries
UK CAA	https://www.caa.co.uk/search?query=lithium+batteries#
FAA	https://www.faa.gov/hazmat/resources/lithium_batteries
	https://www.phmsa.dot.gov/lithiumbatteries

Appendix A – List of Designated Postal Operators authorized to accept equipment containing admissible lithium cells or batteries into air mail

Name of Country / Territory	Designated Postal Operator	Date Authorized to Accept Mail Items Containing Lithium Batteries	Date Acceptance of Equipment Containing Admissible Lithium Cells or Batteries Began
Australia	Australia Post (Australian Postal Corporation)	01-Nov-12	30-Nov-15
Austria	Österreichische Post AG	04-Jul-13	04-Jul-13
Belgium	Post	01-Apr-14	01-Apr-14
Canada	Canada Post Corporation	11-Jul-14	20-Oct-14
Chile	CorreosChile	05-Dec-16	09-Dec-16
Croatia	Croatian Post Inc.	08-Apr-15	01-May-15
Denmark	Post Denmark A/S	01-Jan-13	01-Jan-13
El Salvador	Dirección General de Correos	01-Jul-16	13-Feb-17
Estonia	Estonian Post	05-May-14	05-May-14
Finland	Posti Ltd	21-Dec-15	01-Jan-16
France	La Poste	01-Jan-18	01-Jan-18
—French Polynesia	Office des postes et tálácommunications	26-Jan-18	14-Jun-18
—New Caledonia	Office des postes et tálácommunications	24-Apr-24	02-Sep-24
Great Britain	Royal Mail Group plc	21-Dec-12	14-Jan-13
—Gibraltar	Change Management Ltd	13-Oct-15	13-Oct-15
Hungary (Rep.)	Magyar Posta	01-Jan-13	01-Jan-13
Italy	Poste Italiane S.P.A.	25-Feb-20	25-Feb-20
Japan	Japan Post Co., Ltd	01-Jan-13	01-Jan-13
Korea (Rep.)	Korea Post	21-Jun-13	01-Jan-15
Latvia	Latvia Post	02-Aug-19	05-Aug-19
Lithuania	Public Limited Company "Lietuvos paštas"	05-Oct-15	12-Oct-15
Malaysia	Malaysia Post	21-Oct-14	01-Nov-14
Mongolia	Mongol Post	15-Aug-14	01-Sep-14
Netherlands	Royal Post NL B.V.	13-Dec-12	01-Jan-13
New Zealand	New Zealand Post Ltd	20-Dec-12	25-Nov-13
Norway	Norway Post	01-Jan-13	01-Jan-13
Portugal	CTT—Correios de Portugal SA	25-Jul-19	25-Jul-19
Qatar	General Postal Corporation	04-Oct-22	04-Oct-22
Saudi Arabia	Saudi Post	23-Dec-12	05-Jan-13
Singapore	Singapore Post Ltd	11-Dec-12	01-Jan-13
Slovenia	Pošta Slovenije, d.o.o.	10-Jun-20	01-Aug-20
Spain	Sociedad estatal Correos y Telégrafos SA	05-Dec-14	05-Dec-14
Sweden	Posten AB (publ)	01-Apr-13	01-Apr-13
Switzerland	La Poste Suisse	20-Dec-13	01-Jan-14
Türkiye	Directorate-General of PTT	28-Jul-17	28-Jul-17
United Arab Emirates	Emirates Post	12-Jul-24	TBC
United States of America	United States Postal Service	01-Nov-12	15-Nov-12