International Civil Aviation Organization

Safety Enhancement Implementation Group

Fifth Meeting (SEIG/5)
(Doha, Qatar, 15-17 October 2023)

Agenda Item 2: Regional Performance Framework for Safety

GUIDANCE MATERIAL ON CARRIAGE AND TRANSPORT OF LITHIUM BATTERIES

(Presented by IATA)

SUMMARY

This paper presents the Guidance material developed by IATA and the Risk assessment document in response to G2-SEI-04: Enhance State Oversight on Dangerous Goods. (A2 Develop guidance material on carriage and transport of Lithium batteries).
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Action by the meeting is at paragraph 3.

REFERENCES

- MID-RASP 2023-2025 Edition
- CONCLUSION 10/7: MID-RASP 2023-2025 EDITION.

1. INTRODUCTION

1.1 Because of the huge, worldwide demand for lithium batteries, billions of them are shipped annually as air cargo. Volumes are expected to increase substantially over the coming years, with batteries becoming smaller, more powerful and even more longer lasting. The IATA Dangerous Goods Board previously estimated that, on some routes, lithium batteries were present in some 25% of cargo shipments.

1.2 The carriage of LB has been identified as an emerging risk to airlines operations .Lithium batteries (LB) are classified as dangerous goods and are subject to regulations that prescribe specific design type ,testing ,packaging ,quantity limits ,labelling and documentations requirements for carriage as a cargo by air .These requirements are contained in the ICAO technical instructions for the safe transport of dangerous goods by air and in IATA dangerous goods regulations .

2. DISCUSSION

2.1 The carriage of LB has been identified as an emerging risk to airlines operations .Lithium batteries (LB) are classified as dangerous goods and all LB are subject to regulations that prescribe specific design type ,testing ,packaging ,quantity limits ,labelling and documentations requirements for carriage as a cargo by air .These requirements are contained in the ICAO technical instructions for the safe transport of dangerous goods by air and in IATA dangerous goods regulations

2.2 G2-SEI-04: **Enhance State Oversight on Dangerous Goods**. A2 action tasked IATA to develop guidance material on carriage and transport of Lithium batteries.

2.3 To address these regional operational risks IATA developed Guidance Material document. The purpose of the document is to provide guidance for complying with provisions applicable to the transport by air of lithium batteries as set out in the DGR manual. Specifically, the document provides information on:

- Definitions.
- Classification (including classification flowcharts).
- Prohibitions.
- Restrictions.
- Frequently Asked Questions
- Additional Information
- Abbreviations, Acronyms, Symbols

2.4 The second document is **Lithium Battery Risk Assessment Guidance** for Operators The document is based on the International Civil Aviation Organization (ICAO) Annex 6 – Operation of Aircraft, Part I – International Commercial Air Transport – Airplanes and the associated Guidance for Safe Operations Involving Airplane Cargo Compartments Doc (10102), the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air (Technical Instructions) (Doc 9284) and the 61st Edition of the IATA Dangerous Goods Regulations (DGR).

2.5 It is designed to outline **potential strategies operators may wish to consider for addressing and mitigating the risks associated with the transport of lithium batteries**, in cargo and mail as well as in passenger and crew baggage.

2.6 The strategies outlined in the guidance document are primarily directed at an operator's internal processes and procedures, although there are strategies for engaging with other entities in the supply chain, such as manufacturers of lithium batteries, shippers, freight forwarders and the travelling public.

2.7 The guidance 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.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the content of the Guidance material at appendix "A." and Appendix "B".
b) States to request the shippers and airlines to use the information contained in the documents.

Lithium Battery Risk Assessment Guidance for Operators – 3rd Edition

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 61st Edition of the IATA Dangerous Goods Regulations (DGR). It is designed to outline potential strategies operators may wish to consider for addressing and mitigating the risks associated with the transport of lithium batteries, in cargo and mail as well as in passenger and crew baggage.

Following the published position by the aircraft manufacturers in 2015 that the original equipment manufacturer's fire suppression systems in aircraft cargo compartments were not designed to contain the hazards associated with the carriage of dangerous goods, including lithium batteries, various actions have been taken to mitigate the risk through a multi-layer approach, such as forbidding the carriage of lithium ion batteries (UN 3480) as cargo on passenger aircraft, limiting the state of charge of lithium ion batteries to not exceeding 30% of their rated capacity for air transport, establishing the SAE Aerospace G-27 Committee to develop a performance-based standard for lithium battery packaging and from recommending to mandating operators to conduct safety risk assessments for the transport of items cargo compartments.

The strategies outlined in this guidance document are primarily directed at an operator's internal processes and procedures, although there are strategies for engaging with other entities in the supply chain, such as manufacturers of lithium batteries, shippers, freight forwarders and the travelling public.

This guidance document is divided into cargo operations, focussing 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.

Background

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 by themselves (not contained in or packed with equipment) (Packing Instruction 968) 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.

Figure 2 – Example of lithium ion cells and batteries

Note:
Lithium ion batteries packed by themselves (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.

More information about the safe transport of lithium batteries by air can be found in the IATA Lithium Battery Guidance Document (www.iata.org/lithiumbatteries).

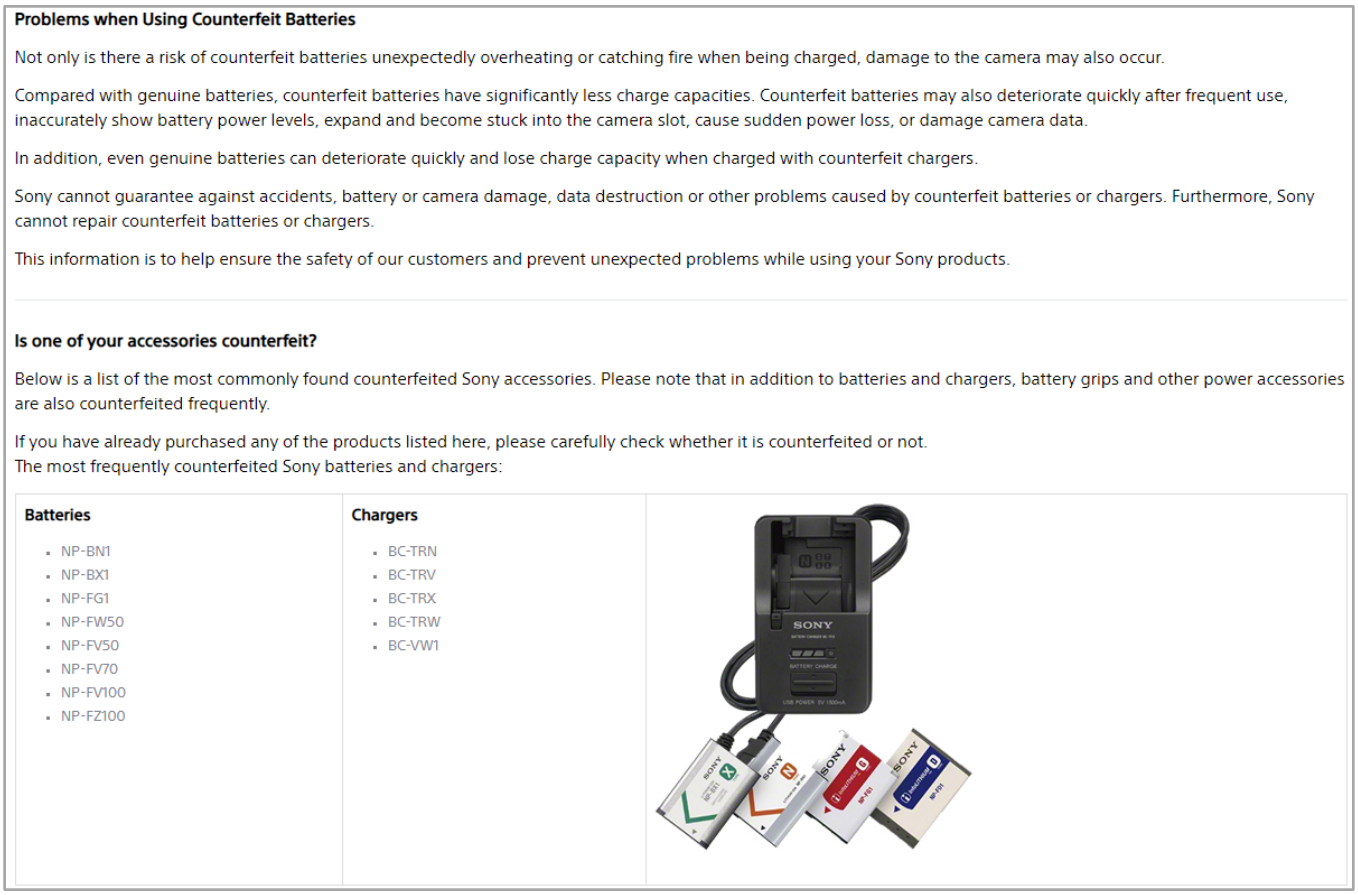
Cargo Operations

Challenges

Because of the huge, worldwide demand for lithium batteries, billions of them are shipped annually as air cargo. Volumes are expected to increase substantially over the coming years, with batteries becoming smaller, more powerful and even more longer lasting. The IATA Dangerous Goods Board previously estimated that, on some routes, lithium batteries were present in some 25% of cargo shipments. This estimate only takes into account those lithium batteries that are known to be transported (i.e. those that have been declared to the operator). It does not include undeclared shipments, the exact amount of which is unknown.

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 3 – 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 that they 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 through ignorance, 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 4 – 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 5 – 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 authorised to accept these mail packages and other related information can be found on the UPU website at the following link:

http://www.upu.int/fileadmin/documentsFiles/activities/postalSecurity/listAuthorizedDOsLithiumBatteriesEn.pdf

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 in recent years and is expected to grow by 20% by 2022 globally with some regions having even more significant growth. The rapid growth of e-commerce is mainly because of the maturity of technology, special offers from online shops, change of purchase behaviour and the wide 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

Introduction

With the entry into effect from 5 November 2020 of Chapter 15 – Cargo Compartment Safety to ICAO Annex 6 – *Operation of Aircraft*, it will be mandatory for operators to conduct safety risk assessments when transporting items in aircraft cargo compartments. This requirement will be applicable to all operators that transport items in the aircraft cargo compartments, namely cargo, baggage and mail. The safety risk assessments shall include at least the:

- hazards associated with the properties of the items to be transported;
- capabilities of the operator;
- operational considerations;
- capabilities of the aeroplane and its systems;
- containment characteristics of unit load devices;
- packing and packaging;
- safety of the supply chain for items to be transported; and
- quantity and distribution of dangerous goods items to be transported.

The ICAO *Safety Management Manual* (Doc 9859) and ICAO *Guidance for Safe Operations Involving Aeroplane Cargo Compartments* (Doc 10102) contain comprehensive guidance for both industry and regulators on safety risk assessments. This guidance will not reproduce large parts of these documents, but it is useful to consider the basic elements of safety risk assessment as it applies to lithium batteries.

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 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 mis-handling 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

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 taken into account:

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

Escalation factors – shippers' inadvertent or wilful 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 visualise the assessment and identify the safety barriers that are in place, or lack of, to minimise the likelihood of the occurrence of an unsafe event.

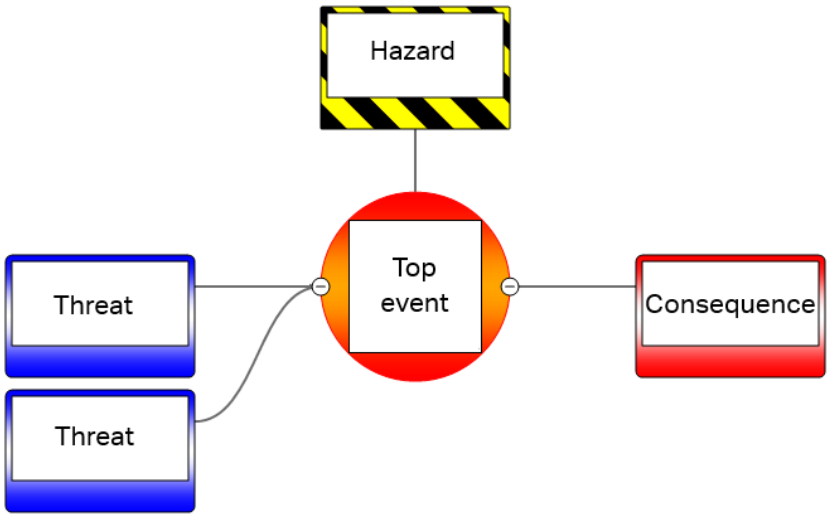


Figure 6 – An example of a bowtie risk analysis model

The bowtie risk analysis model puts the focus around the hazard that can potentially cause damage to the organisation 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 elimiate 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.

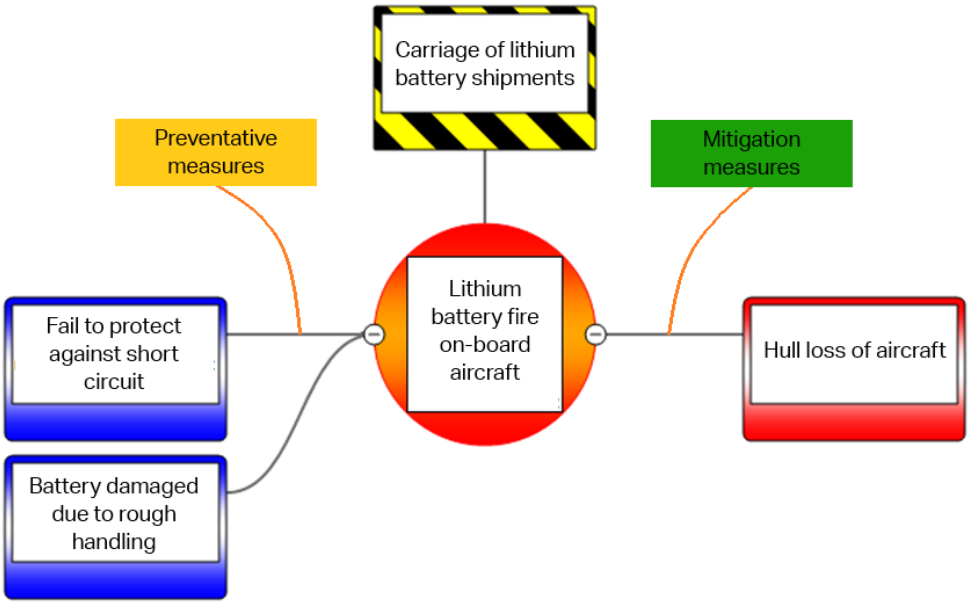


Figure 7 – An example of a bowtie risk analysis model for the carriage of lithium battery shipments

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

Training & Competency

Because of 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 of all staff to be able to intervene in an incident or, better still, prevent an incident from occurring.

Staff 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 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 should concentrate 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 familiarisation training, flight and cabin crew receive comprehensive safety training 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 programmes and carry out random checks on shipments which have been accepted on their behalf.

Safety Training for Flight Crew

As with 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 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 as far as possible 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.

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 an IATA 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*;

- if the lithium batteries are individually protected or not and how these are then packed inside the outer packaging;
- the credibility of the battery manufacturers, shippers and freight forwarders; and
- the dangerous goods qualification of shippers and freight forwarders.

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 above measures 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 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 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.

Outreach & 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 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 there is a great deal of ignorance among the general public about what dangerous goods 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 8 – 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.

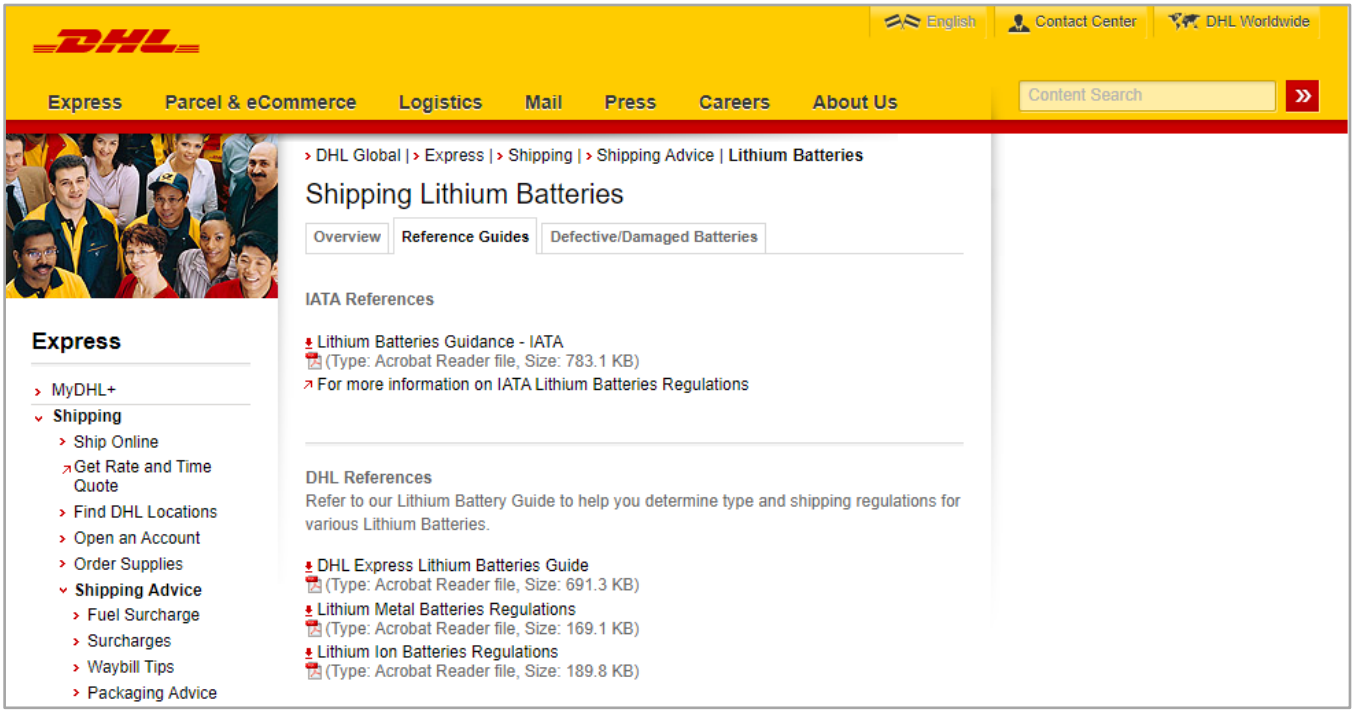


Figure 9 – Website showing additional lithium battery shipment related guidelines
(https://www.dhl.com/en/express/shipping/shipping_advice/lithium_batteries.html#guides_materials)

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 armour. 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 aluminium 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 10 – 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 palletised 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 11 – 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-containerised aircraft (bulk loaded).

Figure 12 – 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 13 – 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 14 – 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. 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).

As of today, this standard is still under development.

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 15 – X-ray images of different battery types

However, it is important to note that although the technology is available, authorised 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 travellers 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

Here is an example on conducting safety risk assessments with respect to lithium batteries carried by passengers.

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

Training & 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 of all staff to be able to intervene and control an incident or even to prevent an incident from occurring.

According to the regulations, staff 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 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 should concentrate 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 familiarisation training, flight and cabin crew receive comprehensive safety training to cover the hazards presented by lithium batteries, including safe handling and emergency procedures.

Safety Training 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 programme 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

Figure 16 – A burning laptop

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.

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. 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 fire-fighting 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.

   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. Minimising 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.

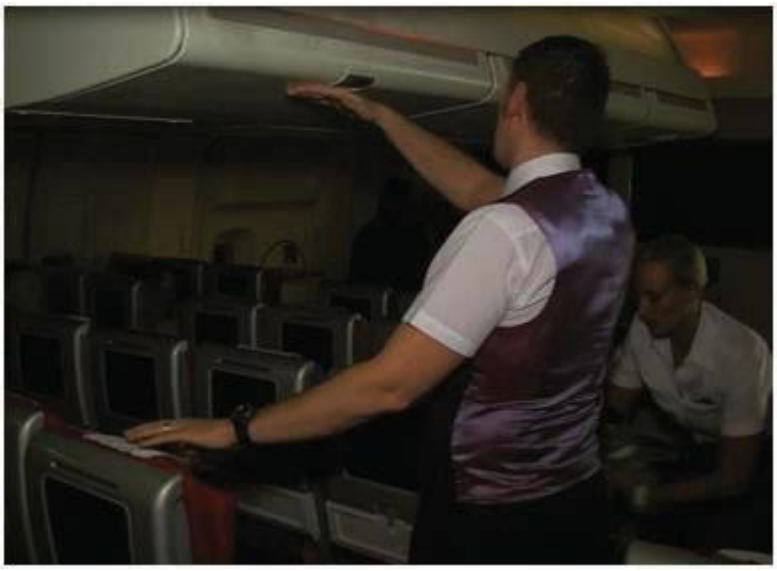


Figure 17 – Determining the location of a fire in an overhead locker

After first considering the use of PPE, a fire extinguisher should be discharged into the locker.

Figure 18 – 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. By removing the external power supply from the device, it 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 remains 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 19 – A laptop being doused with water from the galley

Figure 20 – 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 21 – 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 programme.

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

Figure 23 – 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 24 – 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 25 – A mobile phone crushed in an electrically adjustable seat

Figure 26 – 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.

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 27 – 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 Battery Powered Wheelchair and Mobility Air Guidance Document (www.iata.org/dgr-guidance).

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 and inform a member of the crew."

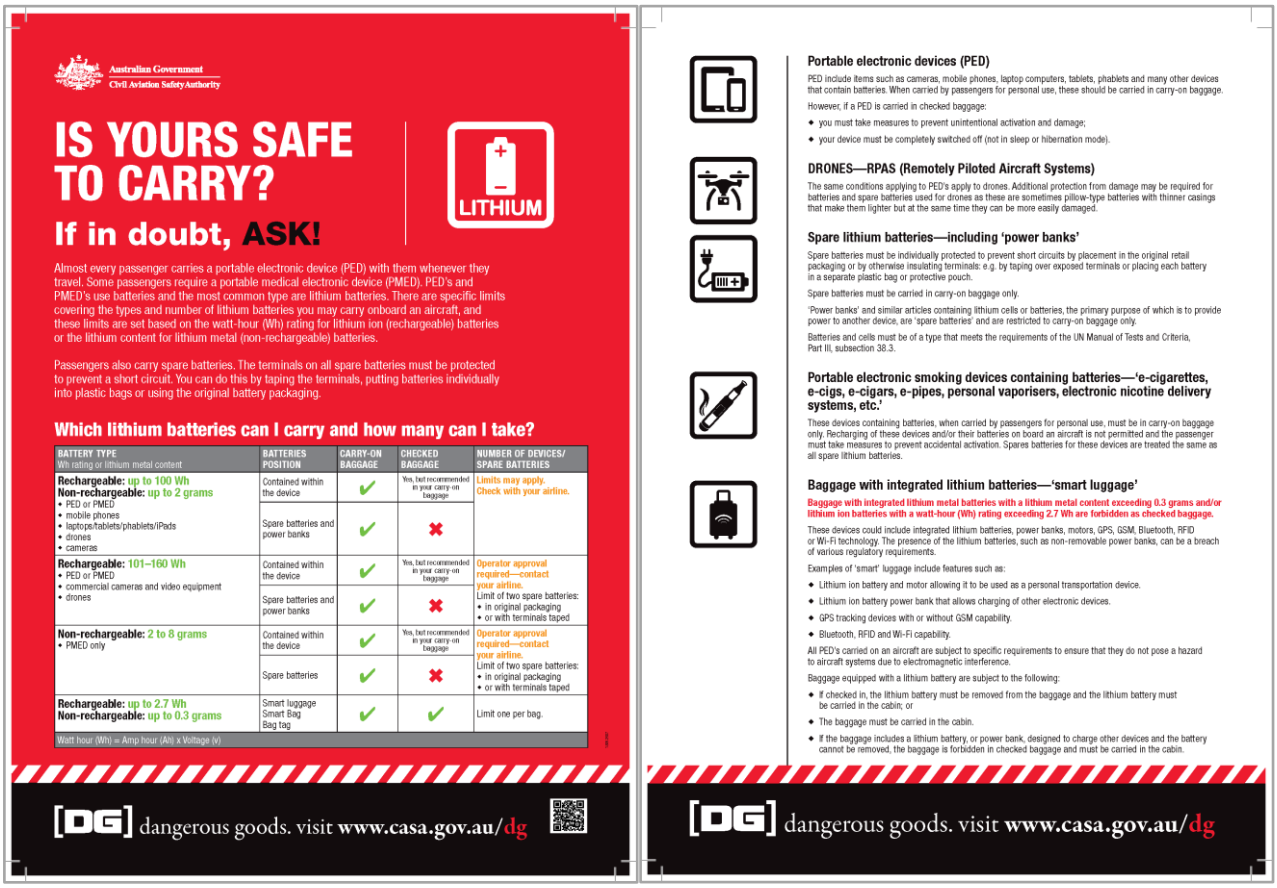
Another occasion when lithium batteries could potentially cause an incident is when they are being replaced in on board equipment such as credit card readers. When this is being done, care must be taken to ensure that neither the old nor the new batteries are dropped into inaccessible locations, where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

Outreach & 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.



Australian Government
Civil Aviation Safety Authority

IS YOURS SAFE TO CARRY?

If in doubt, ASK!

LITHIUM

Almost every passenger carries a portable electronic device (PED) with them whenever they travel. Some passengers require a portable medical electronic device (PMED). PED's and PMED's use batteries and the most common type are lithium batteries. There are specific limits covering the types and number of lithium batteries you may carry onboard an aircraft, and these limits are set based on the watt-hour (Wh) rating for lithium ion (rechargeable) batteries or the lithium content for lithium metal (non-rechargeable) batteries.

Passengers also carry spare batteries. The terminals on all spare batteries must be protected to prevent a short circuit. You can do this by taping the terminals, putting batteries individually into plastic bags or using the original battery packaging.

Which lithium batteries can I carry and how many can I take?

BATTERY TYPE Wh rating or lithium metal content	BATTERIES POSITION	CARRY-ON BAGGAGE	CHECKED BAGGAGE	NUMBER OF DEVICES/ SPARE BATTERIES
Rechargeable: up to 100 Wh **Non-rechargeable:** up to 2 grams • PED or PMED • mobile phones • laptops/tablets/phablets/iPads • drones • cameras	Contained within the device	✔	Yes, but recommended in your carry-on baggage	Limits may apply. Check with your airline.
	Spare batteries and power banks	✔	✖	
Rechargeable: 101–160 Wh • PED or PMED • commercial cameras and video equipment • drones	Contained within the device	✔	Yes, but recommended in your carry-on baggage	Operator approval required—contact your airline. Limit of two spare batteries: • in original packaging • or with terminals taped
	Spare batteries and power banks	✔	✖	
Non-rechargeable: 2 to 8 grams • PMED only	Contained within the device	✔	Yes, but recommended in your carry-on baggage	Operator approval required—contact your airline. Limit of two spare batteries: • in original packaging • or with terminals taped
	Spare batteries	✔	✖	
Rechargeable: up to 2.7 Wh **Non-rechargeable:** up to 0.3 grams	Smart luggage Smart Bag Bag tag	✔	✔	Limit one per bag.

Watt hour (Wh) = Amp hour (Ah) x Voltage (v)

[DG] dangerous goods. visit www.casa.gov.au/dg

Portable electronic devices (PED)

PED include items such as cameras, mobile phones, laptop computers, tablets, phablets and many other devices that contain batteries. When carried by passengers for personal use, these should be carried in carry-on baggage.

However, if a PED is carried in checked baggage:

- you must take measures to prevent unintentional activation and damage;
- your device must be completely switched off (not in sleep or hibernation mode).

DRONES—RPAS (Remotely Piloted Aircraft Systems)

The same conditions applying to PED's apply to drones. Additional protection from damage may be required for batteries and spare batteries used for drones as these are sometimes pillow-type batteries with thinner casings that make them lighter but at the same time they can be more easily damaged.

Spare lithium batteries—including 'power banks'

Spare batteries must be individually protected to prevent short circuits by placement in the original retail packaging or by otherwise insulating terminals: e.g. by taping over exposed terminals or placing each battery in a separate plastic bag or protective pouch.

Spare batteries must be carried in carry-on baggage only.

'Power banks' and similar articles containing lithium cells or batteries, the primary purpose of which is to provide power to another device, are 'spare batteries' and are restricted to carry-on baggage only.

Batteries and cells must be of a type that meets the requirements of the UN Manual of Tests and Criteria, Part III, subsection 38.3.

Portable electronic smoking devices containing batteries—'e-cigarettes, e-cigs, e-cigars, e-pipes, personal vaporisers, electronic nicotine delivery systems, etc.'

These devices containing batteries, when carried by passengers for personal use, must be in carry-on baggage only. Recharging of these devices and/or their batteries on board an aircraft is not permitted and the passenger must take measures to prevent accidental activation. Spares batteries for these devices are treated the same as all spare lithium batteries.

Baggage with integrated lithium batteries—'smart luggage'

Baggage with integrated lithium metal batteries with a lithium metal content exceeding 0.3 grams and/or lithium ion batteries with a watt-hour (Wh) rating exceeding 2.7 Wh are forbidden as checked baggage.

These devices could include integrated lithium batteries, power banks, motors, GPS, GSM, Bluetooth, RFID or Wi-Fi technology. The presence of the lithium batteries, such as non-removable power banks, can be a breach of various regulatory requirements.

Examples of 'smart' luggage include features such as:

- Lithium ion battery and motor allowing it to be used as a personal transportation device.
- Lithium ion battery power bank that allows charging of other electronic devices.
- GPS tracking devices with or without GSM capability.
- Bluetooth, RFID and Wi-Fi capability.

All PED's carried on an aircraft are subject to specific requirements to ensure that they do not pose a hazard to aircraft systems due to electromagnetic interference.

Baggage equipped with a lithium battery are subject to the following:

- If checked in, the lithium battery must be removed from the baggage and the lithium battery must be carried in the cabin; or
- The baggage must be carried in the cabin.
- If the baggage includes a lithium battery, or power bank, designed to charge other devices and the battery cannot be removed, the baggage is forbidden in checked baggage and must be carried in the cabin.

[DG] dangerous goods. visit www.casa.gov.au/dg

Figure 28 – 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 29 – Warning notice on e-cigarettes and spare lithium batteries

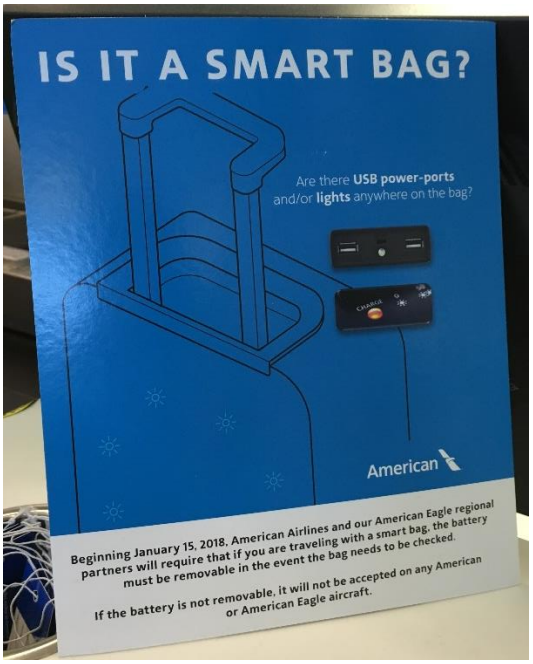


Figure 30 – Warning notice on smart bags at check-in counters

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.

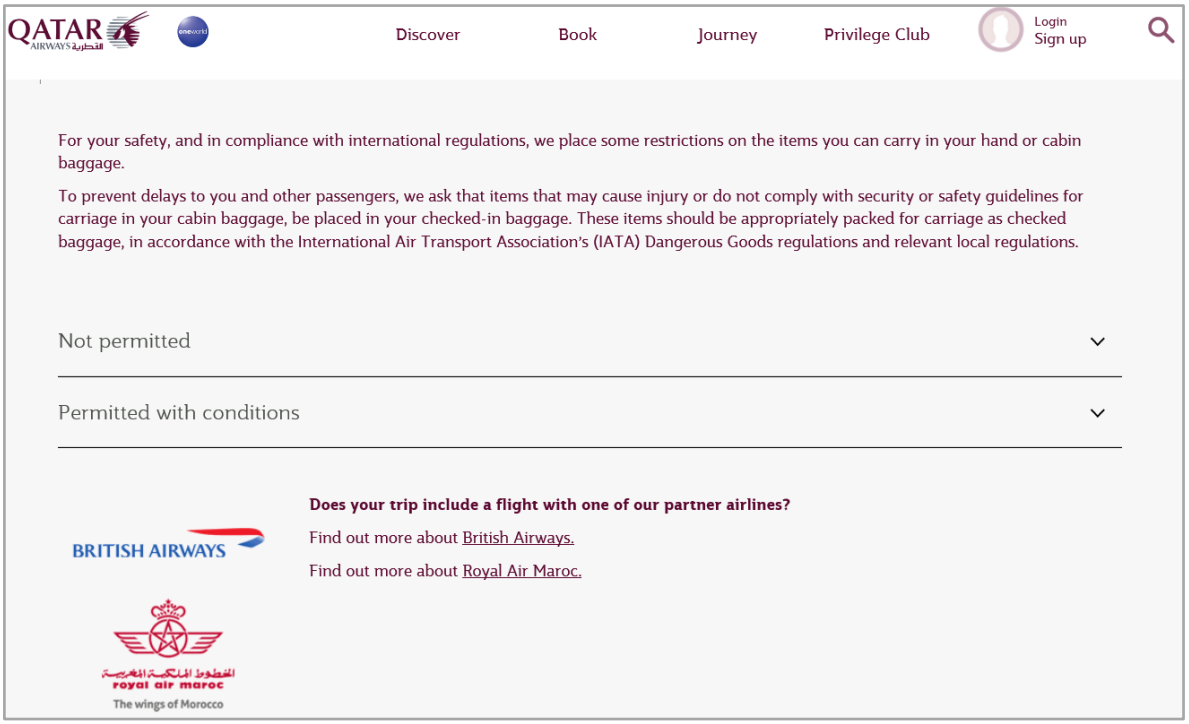


Figure 31 – A website including other operators' baggage restrictions (https://www.qatarairways.com/en-gb/baggage.html)

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, 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 32 – 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 organisers or advertising in the conference magazine with information about the carriage of lithium batteries in baggage is also an option.

Figure 33 – 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 34 – 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.

Supplementary Information

Cargo

Organisation	Subject	URL
Federal Aviation Administration	Lithium battery safety resources	https://www.faa.gov/hazmat/resources/lithium_batteries/
	Lithium battery basics	https://www.faa.gov/tv/?mediaId=1951
	SafeCargo for Shippers & Startups	https://www.faa.gov/hazmat/safecargo/
IATA	Lithium batteries	https://www.iata.org/lithiumbatteries
Transport Canada	Shipping and importing devices containing lithium batteries	https://www.tc.gc.ca/eng/tdg/shipping-importing-devices-containing-lithium-batteries.html
	Safety alerts: transportation of lithium ion or lithium metal batteries as cargo on aircraft	https://www.tc.gc.ca/en/services/aviation/reference-centre/safety-alerts/transportation-lithium-ion-lithium-metal-batteries-cargo-aircraft.html
UK Royal Mail	Prohibited and restricted items	https://personal.help.royalmail.com/app/answers/detail/a_id/96
UK Civil Aviation Authority & Federal Aviation Administration	Posting lithium batteries in the mail	https://www.youtube.com/watch?v=nGhLA7brx44&list=PLig80S1opAEK_Ys1ImbatqCxNwEUUc0cB&index=4&t=0s
	Lithium batteries: guidance for cargo and ramp personnel	https://www.youtube.com/watch?v=UmESPM3U5T4&list=PLig80S1opAEK_Ys1ImbatqCxNwEUUc0cB&index=6

Passenger

Organisation	Subject	URL
Australian Civil Aviation Safety Authority	Least wanted dangerous goods	https://www.casa.gov.au/safety-management/dangerous-goods/least-wanted-dangerous-goods
	Travelling safely with batteries and portable power banks	https://www.casa.gov.au/standard-page/travelling-safely-batteries
	Before you pack your bags	https://www.casa.gov.au/safety-management/dangerous-goods/you-pack-your-bags
Federal Aviation Administration	Pack Safe	https://www.faa.gov/hazmat/packsafe/
IATA	Travelling with portable electronic devices (PEDs)	https://www.iata.org/ped
Transport Canada	Safety alerts: the possibility of smoke or fire from electronic flight bags (EFBs) or their lithium ion batteries	https://www.tc.gc.ca/en/services/aviation/reference-centre/safety-alerts/possibility-smoke-fire-electronic-flight-bags-lithium-ion-batteries.html
UK Civil Aviation Authority	One team one goal – guidance on the safe loading and transport of electric mobility aids	https://www.youtube.com/watch?v=IFyEVckQEjc
UK Civil Aviation Authority & Federal Aviation Administration	Lithium batteries: guidance for crew	https://www.youtube.com/watch?v=pOiwEW54xL8&list=PLig80S1opAEK_Ys1ImbatqCxNwEUUc0cB&index=4
	Lithium batteries: guidance for passenger handling staff	https://www.youtube.com/watch?v=cJ7r91IZYOc&list=PLig80S1opAEK_Ys1ImbatqCxNwEUUc0cB&index=5

2023 Lithium Battery Guidance Document

Transport of Lithium Metal and Lithium Ion Batteries

Revised for the 2023 Regulations

Introduction

△ This document is based on the provisions set out in the 2023-2024 Edition of the ICAO *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Technical Instructions) and the 64th Edition of the IATA Dangerous Goods Regulations (DGR).

The provisions of the DGR with respect to lithium batteries may also be found in the IATA lithium Battery Shipping Regulations (LBSR) 10th Edition. In addition to the content from the DGR, the LBSR also has additional classification flowcharts and detailed packing and documentation examples for lithium batteries.

Information on the DGR and LBSR can be found here:

http://www.iata.org/dgr

http://www.iata.org/lbsr

The purpose of this document is to provide guidance for complying with provisions applicable to the transport by air of lithium batteries as set out in the DGR. Specifically, the document provides information on:

- Definitions;
- Classification (including classification flowcharts);
- Prohibitions;
- Restrictions;
- Frequently Asked Questions
- Additional Information
- Abbreviations, Acronyms, Symbols

Definitions

Lithium Battery – The term "lithium battery" refers to a family of batteries with different chemistries, comprising many types of cathodes and electrolytes. For the purposes of the DGR they are separated into:

Lithium metal batteries. Are generally primary (non-rechargeable) batteries that have lithium metal or lithium compounds as an anode. Also included within lithium metal 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 by themselves (not contained in or packed with equipment) (Packing Instruction 968) are forbidden for transport as cargo on passenger aircraft). In accordance with Special Provision A201, lithium metal cells or batteries that meet the specified quantity limits may be shipped on a passenger aircraft under an approval issued by the authority of the State of Origin, State of Destination and State of the Operator. Or in the case of urgent medical need, one consignment of lithium batteries may be transported as Class 9 (UN 3090) on passenger aircraft with the prior approval of the authority of the State of Origin and with the approval of the operator, see Special Provision A201. All other lithium metal cells and batteries can only be shipped on a passenger aircraft under exemption issued by all States concerned.

Figure 1 - Example of Lithium Metal Cells and Batteries

Lithium-ion batteries (sometimes abbreviated Li-ion batteries) are a secondary (rechargeable) battery 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.

Figure 2 - Example of Lithium Ion Cells and Batteries

Note:
Lithium ion batteries packed by themselves (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) in accordance with Special Provision A201, lithium ion cells or batteries that meet the specified quantity limits may be shipped as cargo on a passenger aircraft under an approval issued by the authority of the State of Origin, State of Destination and State of the Operator. Or in the case of urgent medical need, one consignment of lithium batteries may be transported as Class 9 (UN 3480) on passenger aircraft with the prior approval of the authority of the State of Origin and with the approval of the operator, see Special Provision A201. All other lithium ion cells and batteries can only be shipped as cargo on a passenger aircraft under exemption issued by all States concerned.

Aggregate lithium content means the sum of the grams of lithium content contained by the cells comprising a battery.

The technical definition of a battery and cell, as indicated in the UN *Manual of Tests and Criteria*, is as follows:

Battery means two or more cells or batteries which are electrically connected together and fitted with devices necessary for use, for example, case, terminals, marking and protective devices. Units which have two or more cells that are commonly referred to as "battery packs", "modules" or "battery assemblies" having the primary function of providing a source of power to another piece of equipment are for the purposes of the UN Model Regulations and this guidance document treated as batteries. See definitions for "cell" and "single cell battery". (See also "Power Banks")

Button cell or battery means a round small cell or battery when the overall height is less than the diameter.

Cell means a single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals. Under the UN Model Regulations, UN *Manual of Tests and Criteria* and this guidance, to the extent the encased electrochemical unit meets the definition of "cell" herein, it is a "cell", not a "battery", regardless of whether the unit is termed a "battery" or a "single cell battery" outside of the UN Model Regulations, the UN *Manual of Tests and Criteria* and this guidance.

Consignment, one or more packages of dangerous goods accepted by an operator (airline) from one shipper at one time and at one address, receipted for in one lot and moving to one consignee at one destination address.

Net quantity, either:

(a) the weight or volume of the dangerous goods contained in a package excluding the weight or volume of any packaging material; or

(b) the weight of an unpackaged article of dangerous goods (e.g. UN 3166).

For the purposes of this definition "dangerous goods" means the substance or article as described by the proper shipping name shown in Table 4.2, e.g. for "Fire extinguishers", the net quantity is the weight of the fire extinguisher. For articles packed with equipment or contained in equipment, the net quantity is the net weight of the article, e.g. for "Lithium ion batteries contained in equipment", the net quantity is the net weight of the lithium ion batteries in the package.

Overpack means an enclosure used by a single shipper to contain one or more packages and to form one handling unit for convenience of handling and stowage. Dangerous goods packages contained in the overpack must be properly packed, marked, labelled and in proper condition as required by the IATA Dangerous Goods Regulations.

The overpack must not contain packages enclosing different substances which might react dangerously with each other or packages of dangerous goods which require segregation according

to Table 9.3.A. In addition, packages containing UN 3090, lithium metal batteries prepared in accordance with Section IA or Section IB of PI968 or UN 3480, lithium ion batteries prepared in accordance with Section IA or Section IB of PI 965 are not permitted in an overpack with packages containing dangerous goods classified in Class 1 other than Division 1.4S, Division 2.1, Class 3, Division 4.1 or Division 5.1.

Power bank (power pack, mobile battery, etc.), these are portable devices designed to be able to charge consumer devices such as mobile phones and tablets. For the purposes of this guidance document and the IATA Dangerous Goods Regulations, power banks are to be classified as batteries and must be assigned to UN 3480, lithium ion batteries, or UN 3090, lithium metal batteries, as applicable. For carriage by passengers, power banks are considered spare batteries and must be individually protected from short-circuit and carried in carry-on baggage only.

Rated capacity means the capacity, in ampere-hours or milliampere-hours, of a cell or battery as measured by subjecting it to a load, temperature and voltage cut-off point specified by the manufacturer.

Note:

The following IEC standards provide guidance and methodology for determining the rated capacity:

(1) IEC 61960 (First Edition 2003-12): Secondary cells and batteries containing alkaline or other non-acid electrolytes -Secondary lithium cells and batteries for portable applications;

(2) IEC 62133 (First Edition 2002-10): Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications;

(3) IEC 62660-1 (First Edition 2011-01): Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 1: Performance testing.

State of Origin, the country (State) in the territory of which the consignment is to first be loaded on an aircraft.

State of the Operator, the country (State) in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

Watt-hour rating, expressed in Watt-hours (Wh), the Watt-hour rating of a lithium cell or battery is calculated by multiplying the rated capacity in ampere-hours by the nominal voltage.

Classification (DGR 3.9.2.6)

Lithium batteries are classified in Class 9 – Miscellaneous dangerous goods as:

- UN 3090, **Lithium metal batteries**; or
- UN 3480, **Lithium ion batteries**

or, if inside a piece of equipment or packed separately with a piece of equipment to power that equipment as:

- UN 3091, **Lithium metal batteries contained in equipment**; or
- UN 3091, **Lithium metal batteries packed with equipment**; and
- UN 3481, **Lithium ion batteries contained in equipment**; or
- UN 3481, **Lithium ion batteries packed with equipment**.

△ Lithium battery test summary – except for button cells installed in equipment (including circuit boards), manufacturers and subsequent distributors of cells or batteries and equipment powered by cells and batteries manufactured after 30 June 2003 must make available the test summary as

specified in the UN *Manual of Tests and Criteria*, Revision 7. 1, Part III, sub-section 38.3, paragraph 38.3.5.

Note:
The requirement is for the manufacturer and subsequent distributors to make this test summary available. There are numerous ways this can be achieved, such as by listing the applicable summary document on the company website. There is no expectation for the shipper/distributor to provide paper copies with each consignment containing lithium batteries. The supply chain are encouraged to make use of technology to facilitate the availability of the test summary.

△ The following table provides details of the information required in the test summary:

Lithium cell or battery test summary in accordance with sub-section 38.3 of Manual of Tests and Criteria
The following information shall be provided in this test summary: **(a)** Name of cell, battery, or product manufacturer, as applicable; **(b)** Cell, battery, or product manufacturer's contact information to include address, phone number, email address and website for more information; **(c)** Name of the test laboratory to include address, phone number, email address and website for more information; **(d)** A unique test report identification number; **(e)** Date of test report; **(f)** Description of cell or battery to include at a minimum: **(i)** Lithium ion or lithium metal cell or battery; **(ii)** Mass; **(iii)** Watt-hour rating, or lithium content; **(iv)** Physical description of the cell/battery; and **(v)** Model numbers. **(g)** List of tests conducted and results (i.e., pass/fail); **(h)** Reference to assembled battery testing requirements, if applicable (i.e. 38.3.3 (f) and 38.3.3 (g)); **(i)** Reference to the revised edition of the Manual of Tests and Criteria used and to amendments thereto, if any; and **(j)** Name and title of responsible person as an indication of the validity of information provided.

Further information on the test summary and FAQ's is available in Part 4 of this guidance document.

△ Classification Flowcharts

The following (2) classification flowcharts are intended to provide guidance on the classification for lithium ion and lithium metal batteries.

Classification Flowchart – Lithium Ion Batteries

All cells and batteries must be tested in accordance with the UN Manual of Tests and Criteria Part III Subsection 38.3 (DGR 3.9.2.6)

Passed UN?

No → Redesign

Yes

Lithium Ion Batteries Contained in Equipment

Cells >20 Wh;
Batteries > 100 Wh

UN3481
PI 967 Section I
IMP: RLI

Limit per package:
Pax A/C = 5 kg
CAO = 35 kg

Cells ≤20 Wh;
Batteries ≤100 Wh
UN3481

PI 967 Section II *
IMP: ELI

Limit per package:
Pax A/C = 5 kg
CAO = 5 kg

Lithium Ion Batteries (limited to a maximum of 30% SoC)

Cells > 20 Wh;
Batteries > 100 Wh

UN3480
PI 965
Section IA
IMP: RBI

Limit per package:
Pax A/C = Forbidden
CAO = 35 kg

Cells ≤ 20 Wh;
Batteries ≤100 Wh
UN3480
PI 965
Section IB
IMP: RBI

Limit per package:
Pax A/C = Forbidden
CAO = 10 kg

Lithium Ion Batteries Packed with Equipment

Cells > 20 Wh;

Batteries > 100 Wh

UN3481
PI 966
Section I
IMP: RLI

Limit per package:
Pax A/C = 5 kg
CAO = 35 kg

Cells ≤ 20 Wh;
Batteries ≤100 Wh

UN3481
PI 966
Section II
IMP: ELI

Limit per package:
Pax A/C = 5 kg
CAO = 5 kg

* exceptions exist to the marking requirements – see PI 967 Section II

Classification Flowchart – Lithium Metal Batteries

All cells and batteries must be tested in accordance with the UN Manual of Tests and Criteria Part III Subsection 38.3 (DGR 3.9.2.6)

Passed UN?

No → Redesign

Yes

Lithium Metal Batteries Contained in Equipment

Cells >1 g; **Batteries** > 2 g

UN3091
PI 970
Section I
IMP: RLM

Limit per package:
Pax A/C = 5 kg
CAO = 35 kg

Cells ≤ 1 g;
Batteries ≤ 2 g

UN3091
PI 970
Section II *
IMP: ELM

Limit per package:
Pax A/C = 5 kg
CAO = 5 kg

Lithium Metal Batteries

Cells >1 g;
Batteries > 2 g

UN3090
PI 968
Section IA
IMP: RBM

Limit per package:
Pax A/C = Forbidden
CAO = 35 kg

Cells ≤ 1 g;
Batteries ≤ 2 g

UN3090
PI 968
Section IB
IMP: RBM

Limit per package:
Pax A/C = Forbidden
CAO = 2.5 kg

Lithium Metal Batteries Packed with Equipment

Cells >1 g;
Batteries > 2 g

UN3091
PI 969
Section I
IMP: RLM

Limit per package:
Pax A/C = 5 kg
CAO = 35 kg

Cells ≤ 1 g;
Batteries ≤ 2 g

UN3091
PI 969
Section II
IMP: ELM

Limit per package:
Pax A/C = 5 kg
CAO = 5 kg

* exceptions exist to the marking requirements – see PI 970 Section II

Prohibitions

Lithium ion batteries

All lithium ion cells and batteries shipped by themselves (UN 3480) are forbidden for transport as cargo on passenger aircraft. All packages prepared in accordance with Packing Instruction 965, Section IA and IB, must bear a Cargo Aircraft Only label, in addition to other required marks and/or labels.

Lithium metal batteries

All lithium metal cells and batteries shipped by themselves (UN 3090) are forbidden for transport as cargo on passenger aircraft. All packages prepared in accordance with Packing Instruction 968, Section IA and IB, must bear a Cargo Aircraft Only label, in addition to other required marks and/or labels.

Restrictions

Lithium ion batteries

All lithium ion cells and batteries (UN 3480 only) 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.

Packing Restrictions

PI 965 & PI 968 Section IA & IB

UN 3090, lithium metal batteries prepared in accordance with Section IA or Section IB of PI 968 and UN 3480, lithium ion batteries prepared in accordance with Section IA or Section IB of PI 965 must not be packed in the same outer packaging with 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) or Division 5.1 (oxidizers). Packages containing cells or batteries must not be placed in an overpack with packages containing dangerous goods classified in Class 1 other than Division 1.4S, Division 2.1, Class 3, Division 4.1 or Division 5.1.

Frequently Asked Questions

Part 1 – Questions Related to Definitions

A. What are the various types of lithium batteries?

Lithium batteries fall into two broad classifications; lithium metal batteries and lithium ion batteries. Lithium metal batteries are generally non-rechargeable and contain metallic lithium. Lithium ion batteries contain lithium which is only present in an ionic form in the electrolyte and are rechargeable.

Within these two broad classifications there are many different chemistries. For example within lithium ion batteries there are lithium polymer, lithium iron phosphate ($LiFePO_4$), lithium air to name a few.

B. What is the difference between a lithium cell and a lithium battery?

A lithium cell is a single encased electrochemical unit consisting of one positive and one negative electrode that exhibits a voltage differential across the two terminals. A lithium battery is two or more cells electrically connected. A single cell battery is considered a cell and not a battery for the purposes of the limitations set out in the DGR.

Note:
Units that are commonly referred to as "battery packs" or "power banks" having the primary function of providing a source of power to another piece of equipment are for the purposes of these Regulations treated as batteries. This includes uninterruptible power supply (UPS) fitted with lithium ion batteries. Refer to the section on Definitions for complete details.

C. How are component cells connected to form a battery?

Cells in batteries may be connected in parallel, in series, or in a combination of the two. When cells are connected in series, the voltage of the battery increases but the capacity in ampere-hours (Ah) does not change. By contrast, when cells are connected in parallel the capacity in ampere-hours of the battery (Ah) increases but the voltage stays the same.

D. How do I determine the watt-hour rating for a particular lithium ion battery?

The Watt-hour (Wh) rating is a measure by which lithium ion batteries are regulated. Lithium ion batteries with a Watt-hour rating in excess of 100 Wh manufactured after 31 December 2011 and lithium ion batteries with a Watt-hour rating not exceeding 100 Wh manufactured after 1 January 2009 are required to be marked with the Watt-hour rating on the outside case.

You can also arrive at the number of Watt-hours your battery provides if you know the battery's nominal voltage (V) and capacity in ampere-hours (Ah):

Ah x V = Wh

Note:
If only the milliampere-hours (mAh) are marked on the battery then divide that number by 1000 to get ampere-hours (Ah) (i.e. 4400 mAh / 1000 = 4.4. Ah).

Most lithium ion batteries marketed to consumers are below 100 Watt-hours. If you are unsure of the Watt-hour rating of your lithium ion battery, contact the manufacturer.

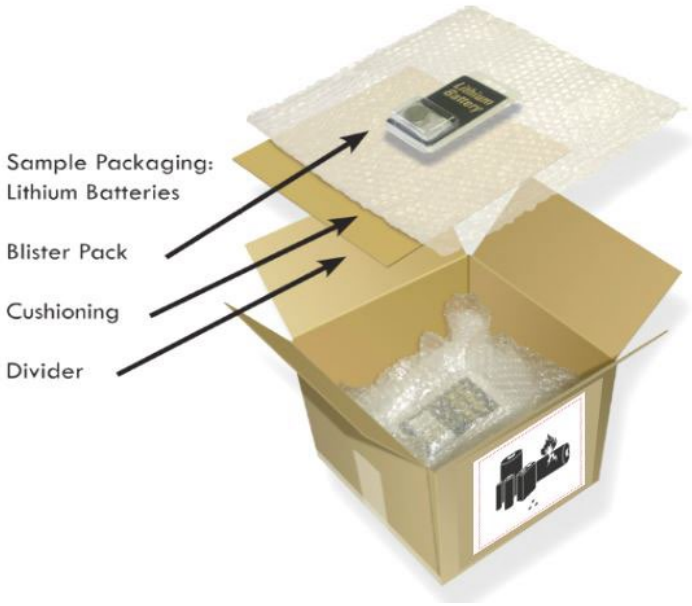
E. What is a button cell battery?

A button cell battery is a small round cell where the overall height is less than the diameter. Button cells are often referred to as "coin" cells.

Part 2 – Questions related to Packaging and Transport Provisions

A. How do I safely package lithium batteries for transport?

One of the major risks associated with the transport of batteries and battery-powered equipment is short-circuit of the battery as a result of the battery terminals coming into contact with other batteries, metal objects, or conductive surfaces. Packaged batteries or cells must be separated in a way to prevent short circuits and damage to terminals. They must be packed in a strong rigid outer packaging unless when contained in equipment, the battery is afforded equivalent protection by the equipment in which it is contained. Sample packaging meeting these requirements is shown below:



B. How can batteries be effectively protected against short circuit?

Methods to protect against short circuit include, but are not limited to, the following methods:

a. Packing each battery or each battery-powered device when practicable, in fully enclosed inner packagings made of non-conductive material (such as a plastic bag);

b. Separating or packing batteries in a manner to prevent contact with other batteries, devices or conductive materials (e.g. metal) in the packagings; and

c. Ensuring exposed terminals or connectors are protected with non-conductive caps, non-conductive tape, or by other appropriate means.

If not impact resistant, the outer packaging must not be used as the sole means of protecting the battery terminals from damage or short-circuiting. Batteries should be securely cushioned and packed to prevent shifting which could loosen terminal caps or reorient the terminals to produce short circuits.

Terminal protection methods include but are not limited to the following:

a. Securely attaching covers of sufficient strength to protect the terminals;

b. Packaging the battery in a rigid plastic packaging; and

c. Constructing the battery with terminals that are recessed or otherwise protected so that the terminals will not be subjected to damage if the package is dropped.

C. I'm shipping using Section II of the packing instructions, what constitutes "adequate instruction"?

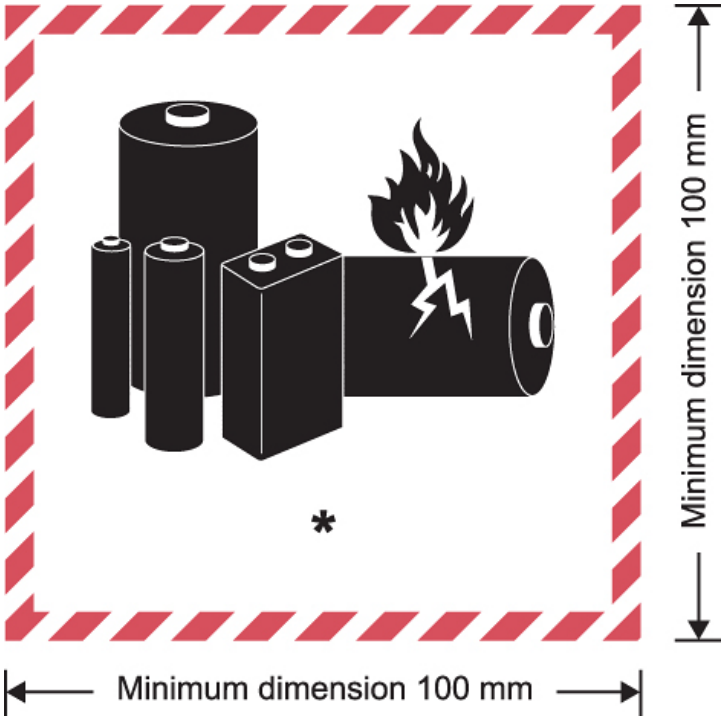
Shippers of lithium batteries prepared in accordance with Section II of the lithium battery packing instructions are not subject to the formal dangerous goods training requirements set out in DGR 1.5. However, persons preparing such shipments must be provided with "adequate instruction" as described in DGR 1.6.

The following is offered as a starting point for an employer on what could be considered as being adequate instruction:

1. The employer must identify the different configurations of lithium batteries that they ship, i.e. lithium batteries and/or lithium batteries packed with equipment and/or lithium batteries contained in equipment; lithium metal batteries and/or lithium ion batteries.
2. The employer must document the procedures that apply to the configurations and battery types that they ship as determined in 1, above.
3. The procedures should be written up as a clear work instruction or other information that is available to all employees responsible for the preparation of lithium battery shipments.
4. All employees that are involved in the process of preparing lithium battery shipments must be taken through the procedure to ensure that they understand and can demonstrate the correct application of documented procedures for the packing, labelling, marking and documentations requirements, as applicable to their job function.
5. A record must be maintained that identifies each applicable employee and the date(s) that this instruction was provided.
6. Employees should be given periodic refresher, or at least demonstrate that they remain "adequately" instructed on how to perform the task. This should be done at least every two years or whenever the procedure is revised, or regulations are changed, whichever is sooner.
7. Companies that are involved in reverse logistics, i.e. arranging for returns of lithium batteries, lithium batteries packed with equipment or lithium batteries contained in equipment must develop a clear instruction for consumers on the process to be followed for returning products. This instruction must include packaging materials and lithium battery marks, as necessary. The instruction must also include the transport method and mode of transport that must be followed; this must include a clear statement on applicable prohibitions.

△ D. What does the lithium battery mark look like and when is it required?

The lithium battery mark is required as specified in the additional requirements of Section II of Packing Instructions 966, 967, 969 and 970. It is also required as specified in the additional requirements of Section IB of Packing Instructions 965 and 968 in addition to the Class 9 lithium battery hazard label and Cargo Aircraft Only label. The mark (see below) is as shown in Figure 7.1.C of the IATA Dangerous Goods Regulations. The border of the mark must have red diagonal hatchings with a minimum width of 5 mm. The symbol (group of batteries, one damaged and emitting flame, above the UN number for lithium ion or lithium metal batteries or cells) must be black on white or suitable contrasting background. The lithium battery mark may be printed directly on the outer packaging provided that there is sufficient contrast between the elements of the lithium battery mark and the colour of the packaging material. The mark must be in the form of a rectangle or a square with minimum dimensions of 100 mm x 100 mm. If the size of the package so requires, the dimensions may be reduced to not less than 100 mm wide x 70 mm high, and all features must be in approximate proportion to those shown on the full-size mark.



* Place for UN number(s), i.e. UN 3090, UN 3091, UN 3480 and/or UN 3481, as applicable. The UN number(s) indicated on the mark should be at least 12 mm high.

⊗

E. If I have smaller packages, can I use a smaller lithium battery mark?

Where the packages are of dimensions such that they cannot bear the full-size lithium battery mark, the mark dimensions may be reduced to 100 mm wide × 70 mm high. The design specifications remain otherwise the same.

Where any face of a package is large enough to bear the full-size lithium battery mark, the full-size mark must be used.

F. When is a lithium battery mark not required on the package?

A lithium battery mark must not be affixed to packages prepared in accordance with Section IA of Packing Instructions 965 and 968 and Section I of Packing Instructions 966, 967, 969 and 970.

A lithium battery mark is **not required** for packages prepared in accordance with Section II of PI 967 or PI 970 containing only button cell batteries installed in equipment (including circuit boards) or consignments of two packages or less where each package contains no more than four cells, or two batteries installed in equipment.

Note:
The Air Waybill is required to contain the statements "Lithium [ion or metal] batteries in compliance with Section II of PI9XX" when the lithium battery mark is affixed to the package(s).

G. Section II in Packing Instructions 967 and 970 states that "the lithium battery mark is not required on consignments of two packages or less where each package contains no more than four cells, or two batteries installed in equipment." What is the intent of this provision?

This provision is to require, where there are more than two packages in the consignment, that each package bears the lithium battery mark, and therefore the air waybill has the compliance statement e.g. "Lithium [ion or metal] batteries in compliance with Section II of PI 9xx [67 or 70]".

The provision continues to allow for small consignments of one or two packages, containing no more than four cells or two batteries installed in equipment per package, to move without the lithium battery mark and therefore without the compliance statement on the air waybill.

Note:
A consignment is one or more packages of dangerous goods accepted by an operator (airline) from one shipper at one time and at one address, receipted for in one lot and moving to one consignee at one destination address.

H. I have a mobile (cell) phone that contains one single-cell lithium ion battery. Do I have to mark the shipping box that contains each mobile phone? What if I place five mobile phones in a shipping box? Does this require the lithium battery mark?

For packages of a single mobile phone, no lithium battery mark would be required since you can place up to 4 of these single-cell batteries in a box without applying the lithium battery mark on the outer box. In the case where 5 mobile phones are in a shipping package, a lithium battery mark on the shipping package is required.

☐ **I. If I pack three mobile phones each containing a single cell lithium ion battery, can I also pack a laptop with a lithium ion battery in the same package and not apply the lithium battery mark using the 4 cell, 2 battery exception?**

No, the exception is for 4 cells or 2 batteries. You cannot mix and match.

J. Can a single lithium battery mark be used to identify that both lithium metal and lithium ion batteries are contained inside the package?

Yes. The mark may bear all applicable UN numbers, e.g. UN 3091, UN 3481, to identify that the package contains lithium metal batteries packed with or contained in equipment and lithium ion batteries packed with, or contained in equipment.

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K. Must the lithium battery mark be placed on the same face of the package with the Class 9 hazard label and/or Cargo Aircraft Only label?

No, the lithium battery mark does not have to be on the same face of the package with these labels. It may be placed on a different face. However, if the package is of sufficient size all required marks and labels should be applied to one face of the package.

L. For the purposes of the lithium battery packing instructions, what is considered the "package"?

The package is the complete product of the packing operation that satisfies the requirements of the packing instruction and in a manner ready to be presented for transport (shipper/consignee information, hazard communication, etc.). The package may contain multiple batteries or pieces of equipment provided the limitations set out in the applicable packing instruction are not exceeded. The package must be marked and labelled as required by the packing instruction. A single package may be offered for transport, or one or more packages may then be placed into an overpack for ease of handling or transport purposes. When an overpack is used, the package marks and labels must be duplicated on the overpack unless the marks and labels required on individual packages are visible or are not required by the packing instruction (i.e. not more than 4 cells or 2 batteries when contained in equipment and no more than two packages in the consignment).

M. Does the IATA DGR require a MSDS or SDS containing the UN test data?

No. The IATA DGR does not require a safety data sheet (SDS) when offering lithium batteries for transport.

Notes:

1. *A SDS is not a transport document. A SDS is only required for the supply and use of a substance or mixture meeting the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) classification criteria. GHS does not include provisions for manufactured articles.*

2. *Except for button cells installed in equipment (including circuit boards), manufacturers and subsequent distributors of lithium cells and batteries and equipment with installed lithium cells or batteries must make available a test summary that identifies that the cell and battery types have passed the applicable UN 38.3 tests, see Part 4 of this document.*

N. Under Packing Instructions 966 and 969, it states that "The maximum number of batteries in each package must not exceed the minimum number required to power the equipment, plus two spare sets. A "set" of cells or batteries is the number of individual cells or batteries that are required to power each piece of equipment". If a package contains 4 power tools (each tool contains 1 lithium ion battery), can 2 extra lithium ion batteries be placed in the package for each piece of equipment for a total of 12 batteries?

Yes, providing you do not exceed the maximum net quantity for the relevant section of the packing instruction and the chosen aircraft type. The 12 batteries reflect two spare sets (8) for each of the 4 power tools in the outer package plus one each to power the device (4).

O. May lithium battery packages be placed in an overpack in accordance with the IATA Dangerous Goods Regulations?

Yes, but there are segregation requirements that need to be considered for certain other classes of dangerous goods. UN 3090, lithium metal batteries prepared in accordance with Section IA or Section IB of PI 968 and UN 3480, lithium ion batteries prepared in accordance with Section IA or Section IB of PI 965 are not permitted in the same outer packaging with dangerous goods classified in Class 1 other than Division 1.4S, Division 2.1, Class 3, Division 4.1 or Division 5.1. The overpack may also contain goods not subject to the Regulations provided there are no packages enclosing different substances which might react dangerously with each other. An overpack must be marked with the word "overpack" and must be labelled with the lithium battery mark (DGR Figure 7.1.C), unless the mark(s) on the package(s) inside the overpack are visible or not required by the Packing Instruction.

P. Do the quantity limits shown in the lithium battery packing instructions apply to overpacks containing lithium batteries?

No. The quantity limits shown in the packing instructions refer to the maximum net weight of the lithium cells or batteries that is permitted in each package. Provided each package remains within the limit specified in the packing instruction, there are no limits specified for an overpack.

☐ **Q. Can I use a nylon bag to contain the individual packages prepared in accordance with Section II of Packing Instruction 967 to form an overpack?**

No, because the packages placed in an overpack must be secured within the overpack and that the intended function of each package must not be impaired by the overpack.

△ **R. Packing Instructions 966 and 969 Section II specify that packages must be capable of withstanding a 1.2 metre drop test. What portion or portions of the package are subject to this test?**

The completed package containing batteries as prepared for transport in accordance with the relevant packing instruction must be capable of withstanding the 1.2 m drop test. This could apply to a package solely containing batteries that is packaged in full compliance with the provisions of the packing instruction (to include the 1.2 m drop test capability requirement) and is then packed with equipment in a strong rigid outer packaging and offered for transport. Or, it could apply to a package that includes batteries properly packed in inner packaging and equipment or other non-dangerous goods that are placed in a strong rigid outer packaging. The package that includes both the inner packaging containing batteries and the equipment must comply with the packing instruction to include meeting the capability to pass the 1.2 m drop test.

☐ **S. Packing Instructions 965 and 968 Section IB specify that packages must be capable of withstanding a 3 metre stack test. Do I have to have my package tested?**

No, but the shipper must, if required, be able to demonstrate to the appropriate authority that they have determined the capability of the package to withstand a 3 m stack test for a period of 24 hours. One method could be that the shipper prepares a package containing batteries as tendered for transport in accordance with the relevant packing instruction and then places a weight equivalent to the weight of similar packages if stacked 3 m high and leaving that for 24 hours. This could be documented as evidence of demonstrating capability.

T. How do I transport prototype lithium cells and batteries that have not passed the UN 38.3 Tests?

Pre-production prototypes of lithium batteries or cells, when these prototypes are transported for testing, or low-production runs (i.e. annual production runs consisting of no more than 100 lithium cells and batteries) of lithium cells or batteries that have not been tested to the requirements in subsection 38.3 of the UN Manual of Tests and Criteria may be transported aboard cargo aircraft, if approved by the appropriate authorities of the State of Origin and the State of the Operator and the requirements in Packing Instruction 910 of the Supplement to the Technical Instructions are met (see Special Provision A88).

The appropriate authority of the State of Origin should provide details of PI 910 as part of the approval process.

U. Can I ship recalled, damaged or non-conforming cells or batteries?

Lithium batteries, identified by the manufacturer as being defective for safety reasons, or that have been damaged, that have the potential of producing a dangerous evolution of heat, fire or short circuit are forbidden for transport by air (e.g. those being returned to the manufacturer for safety reasons). This applies also to lithium cells or batteries installed inside equipment such as mobile phones, laptops or tablets where the devices are subject to recall due to the safety concerns of the lithium cell or battery installed in the device, see Special Provision A154 in the DGR.

Batteries which have some other defective feature (e.g. LEDs not showing charge, incorrect model number on label, or batteries not holding enough charge) could still be shipped by air. Also, laptops being returned may not have a defective battery, it may not meet the needs of the customer, may be defective itself (but not the battery), etc. In these situations air transport would be permitted. The battery or equipment manufacturer should be contacted to determine the appropriate shipping method.

V. How do I protect against "inadvertent activation"?

When batteries are contained in equipment, the equipment must be packaged in a manner that prevents unintentional activation or must have an independent means of preventing unintentional activation (e.g. packaging restricts access to activation switch, switch caps or locks, recessed switches, trigger locks, temperature sensitive circuit breakers, etc.). This requirement does not apply to devices which are intentionally active in transport (RFID transmitters, watches, sensors, etc.) and which are not capable of generating a quantity of heat sufficient to be dangerous to packaging or personal safety.

W. What is the maximum weight of batteries per package for fully regulated batteries contained in equipment (Section I)?

The maximum weight is 5 kg of lithium batteries per package for passenger and cargo aircraft and 35 kg of lithium batteries per package for cargo aircraft only. The net quantity shown excludes the weight of the equipment:

	Net Quantity per Package Passenger Aircraft	Net Quantity per Package Cargo Aircraft Only
Lithium Ion & Lithium Metal cells and batteries contained in equipment	5 kg	35 kg

X. Do I need to declare a gross weight or a net weight for lithium batteries (Section I)?

All lithium battery shipments, including when packed with or contained in equipment, must be declared by the net weight of lithium cells or batteries contained in the package.

The net weight that must be declared is the weight of the lithium cell or batteries contained in the package. This applies for both lithium ion cells and batteries and lithium metal cell and batteries.

Y. I am shipping Section IB lithium [ion or metal] batteries; do I need dangerous goods training?

Yes. All the applicable provisions of the Dangerous Goods Regulations apply to shipments of Section IB batteries. Therefore, dangerous goods training as indicated in Subsection 1.5 of the Dangerous Goods Regulations is required.

Z. What are the additional marking requirements for a package prepared under Section IB of Packing Instruction 965 and 968?

Because all of the requirements of the dangerous goods regulations apply other than the requirement to use UN specification packaging, each package must be marked with:

- the UN Number preceded by "UN" and the Proper Shipping Name (DGR 7.1.4.1 (a));
- the name and address of the shipper and consignee (DGR 7.1.4.1 (b));
- in addition, the net weight as required by (DGR 7.1.4.1(c)) must be marked on the package; and
- the lithium battery mark (see Part 2, D) in addition to the Class 9 lithium battery hazard label and Cargo Aircraft Only label.

Note:
When using an overpack, each package must be marked in accordance with the Regulations and then, when placed in an overpack, marked as required by DGR 7.1.7.

AA. I work for a pharmaceutical manufacturer that is shipping vaccines and other pharmaceutical products with lithium battery powered temperature or data loggers; do I need to follow the Dangerous Goods Regulations?

Yes. All the applicable provisions for lithium batteries will need to be followed by the shipper of such devices, including the limitations for devices that are "active" (on) during transport.

However, there are exceptions for packages containing only COVID-19 pharmaceuticals in Special Provision A220 that these packages containing cargo tracking devices containing lithium batteries are not subject to the marking and documentation requirements of Section II of Packing Instruction 967 or 970. This same exception is also applicable to the same package configuration, when consigned without the COVID-19 pharmaceutical for the purposes of use or re-use when prior arrangements have been made with the operator.

Note:

1. *The IATA Temperature Control Regulations (TCR) also apply to such shipments.*
2. *Further information on active devices in the guidance document that is posted on the IATA website – www.iata.org/pharma*

BB. Do I need to include an additional document or statement to certify that my lithium ion batteries are at no more than 30% SoC?

No. For lithium ion batteries shipped in accordance with Section IA or Section IB of PI 965, which must be on a Shipper's Declaration, the Shipper's Declaration includes a certification statement "I declare that all of the applicable air transport requirements have been met."

By signing the Shipper's Declaration the shipper is making a legal statement that all the applicable provisions of the DGR have been complied with, which includes that the lithium ion batteries are at no more than 30% SoC.

CC. I have lithium ion batteries packed with equipment (PI 966, Section I) where the lithium ion batteries are packed in a UN specification fibreboard (4G) box and then that box is packed with the equipment in a fibreboard outer packaging. Is this an overpack?

No, Section I of PI 966 (and also PI 969) allows two methods of having lithium batteries packed with equipment. Either:

(a) the lithium batteries are packed into a UN specification packaging meeting Packing Group II performance standards and then packed with the equipment in a strong rigid outer packaging; or

(b) the lithium batteries are packed into an inner packaging and then packed with the equipment into a UN specification packaging meeting Packing Group II performance standards.

In either case what is presented for transport is a "package" and not an overpack.

DD. Does the definition of "consignment" apply to the house air waybill (HAWB) or to the master air waybill (MAWB)?

The use of HAWB or MAWB has no direct relationship to what a "consignment" is. For example a MAWB may have multiple consignments where each of the consignments are from separate shippers, or are from one shipper but to separate consignees, or the MAWB may be just be a single consignment from one shipper to one consignee.

The following limitation applies to consignments:

1. a shipper is not permitted to consign more than two packages of lithium batteries contained in equipment under Section II of PI 967 and PI 970 where there are no more than 4 cells or 2 batteries in the package without the application of the lithium battery mark on the package.

The objective of this condition is to:

1. require appropriate hazard communication on packages and on the air waybill where a shipper has more than two packages of lithium batteries contained in equipment.

   Notes:

   1. *This does not mean that every retail "package" must bear the lithium battery mark. A shipper may place multiple retail boxes, each containing a lithium battery meeting Section II installed in equipment, into an outer packaging to form the package for air transport. There is no limit on the number of individual retail boxes that can be placed into the outer packaging, except that a "package" must not contain more than 5 kg net weight of lithium batteries. Each such package must bear the lithium battery mark and when an air waybill is used, the air waybill must show the applicable compliance statement, e.g. "lithium ion batteries in compliance with section II of PI 967".*

2. *Shippers or freight forwarders should not try to split a consignment across multiple air waybills to try to avoid the application of the lithium battery mark where there are more than two packages with lithium batteries contained in equipment under Section II in a consignment.*

EE. What is the correct classification where I want to ship 2 mobile phones in the same package with 2 power banks?

The power banks are classified as UN 3480, **Lithium ion batteries** and therefore must be shipped in accordance with Section IB of PI 965 if the power bank has a Watt-hour rating not exceeding 100 Wh or in accordance with Section IA of PI 965 if the Watt-hour rating exceeds 100 Wh. Under the provisions of PI 965 Section IA and IB other lithium battery-powered equipment may be packed in the same outer packaging provided that all applicable parts of the relevant packing instructions are followed, which includes the net weight of lithium batteries contained in the package. Therefore, the package must be classified as UN 3480, Lithium ion batteries. The power banks are also not considered as "spares" for the purposes of PI 966, Lithium ion batteries packed with equipment.

FF. What is the correct classification for hearing aids or Bluetooth® "earbuds" that are shipped in a charging case or with a charging case in the same package?

Bluetooth® earbuds or hearing aids that are shipped in or with a charging case should be classified as "UN3481, Lithium batteries packed with equipment" and packaged in accordance with PI 966. If the charging case is shipped without the earbuds, the case must be classified as "UN3480, Lithium ion batteries" and packaged in accordance with PI 965.

GG. Can a package containing an AC adaptor or charger and lithium ion batteries be classified as UN 3481, Lithium ion batteries packed with equipment?

No, for the purpose of Packing Instruction 966, "equipment" means the device or apparatus for which the lithium ion batteries will provide electrical power for its operation. When a package contains only the AC adaptor or charger and lithium ion batteries, the package must be classified as "UN 3480, Lithium ion batteries" and packaged in accordance with PI 965.

Part 3 – Questions Related to Design Type Testing Provisions

A. Where can I find requirements related to testing of battery design types?

The UN Manual of Tests and Criteria sets out specific tests that must be conducted on each lithium cell or battery design type. Each test is intended to either simulate a common transportation occurrence such as vibration or changes in altitude or to test the integrity of a cell or battery. You may obtain a copy of these testing requirements via the following website: http://www.unece.org/trans/danger/publi/manual/manual_e.html

B. What constitutes a design change requiring renewed design type testing?

The following provisions are taken from the 7th revised edition of the UN Manual of Tests and Criteria, paragraph 38.3.2.2.

A cell or battery that differs from a tested design by:

(a) For primary cells and batteries, a change of more than 0.1 g or 20% by mass, whichever is greater, to the cathode, to the anode, or to the electrolyte;

(b) For rechargeable cells and batteries, a change in Watt-hours of more than 20% or an increase in voltage of more than 20%; or

(c) A change that would materially affect the test results.

shall be considered a new type and shall be subjected to the required tests.

Note: the type of change that might be considered to differ from a tested type, such that it might lead to a failure of any of the test results, may include, but is not limited to:

(a) A change in the material of the anode, the cathode, the separator or the electrolyte;

(b) A change of protective devices, including the hardware and software;

(c) A change of safety design in cells or batteries, such as a venting valve;

(d) A change in the number of component cells;

(e) A change in connection mode of component cells;

(f) For batteries which are to be tested according to T.4 with a peak acceleration less than 150 g_n, a change in the mass which could adversely impact the result of the T.4 test and lead to a failure.

In the event that a cell or battery type does not meet one or more of the test requirements, steps shall be taken to correct the deficiency or deficiencies that caused the failure before such a cell or battery type is retested.

△ C. Which edition of the UN Manual of Tests and Criteria must be used when testing new lithium cell or battery designs

If a newly produced lithium cell or battery design is being tested for the first time, then the edition of the UN *Manual of Tests and Criteria* in effect at the time that the cell or battery designs are first tested must be used. For example, a new lithium ion battery design is produced for the first time in March 2023. This battery must be tested in accordance with the provisions of the 7th revised edition, amendment 1 of the UN *Manual of Tests and Criteria* as this is the edition in effect as of 1 January 2023, see Note under DGR 1.1.1 (1.1 of the LBSR).

Part 4 – Questions Related to the Lithium Battery Test Summary[1]

△ **A. Does the test summary apply to equipment containing lithium cells or batteries?**

Except where the equipment, including circuit boards, contains only lithium button cells, the test summary applies to all lithium cells and batteries, irrespective of whether they are shipped alone or contained in equipment.

B. Can multiple batteries/manufacturers/products be listed on one report?

Yes, it is acceptable to have a single document that addresses multiple batteries / manufacturers / products, provided all required information is stated. For example, a tablet manufacturer may purchase lithium ion batteries from three different battery manufacturers. The test summary for the product will therefore list batteries and all related information (e.g. Watt-hours, test labs) from the three battery manufacturers without naming the manufacturer due to confidentiality issues.

C. Is it acceptable to list the various test houses, tests and range of revisions tested to for the UN 38.3 revision and amendments?

Yes, it is acceptable to have multiple test houses and their addresses, email information, etc. listed provided all required information is stated. The test house is not required to be aligned to a specific battery or product on the test summary when the test summary covers multiple batteries/products. It is required to have the test report number and date of test for each cell/battery/product listed on the test summary.

D. What is meant by physical description of cell or battery?

A physical description is intended to provide a check for the person requesting the test summary to know that it applies to the cell/battery/product covered by the test summary, i.e. if a cellular phone is the product being shipped, the invoice description or marketing name of the product as the physical description could be used on the test summary.

E. What does availability of report mean: "When requested?"

The test summary must be made available upon request. Any individual or entity in the supply chain may request the test summary, e.g. regulator, consumer, or transport provider.

F. Can the test summary provider require a requestor to obtain the document from a website?

Yes, it is acceptable for the provider to require the requestor to obtain a document electronically from a provider's website. The provider must ensure that the cell/battery/product has appropriate identifiers to align to the test summary.

G. If a manufacturer considers their suppliers, test house and battery data confidential and competitive information, how would test summary compliance be achieved?

All 10 data elements and listed subsets of information are required to be on the test summary. As indicated above, the test house information may be listed to cover a range of products.

H. If a test summary is requested by a dangerous goods enforcement agency, how quickly must the test summary be made available? For example, would a manufacturer be expected to immediately produce a test summary or provide it within a certain amount of time (e.g. 72 hours)

Due to the large volume of lithium batteries and lithium battery powered products that are shipped daily, manufacturers and distributors should not be expected to immediately provide a test summary for every product they ship. Manufacturers and distributors should be provided a reasonable amount of time to provide the required test summary.

I. Would manufacturers and distributors of battery powered vehicles (UN3171) and hybrid vehicles containing a lithium battery (UN3166) be expected to provide a test summary?

Yes. The test summary requirement applies to manufacturers and distributors of lithium cells and batteries. Therefore, a test summary must be made available for lithium battery-powered vehicles and other vehicles containing lithium batteries.

J. Is there a mandated format for the test summary that manufacturers and distributors must follow?

No. Manufacturers and distributors may compile the information required in the test summary using any format. Below are 3 examples of a test summary:

Example 1 of a Lithium Ion Battery Test Summary

LITHIUM CELLS OR BATTERIES TEST SUMMARY
IN ACCORDANCE WITH SUB-SECTION 38.3
OF UN MANUAL OF TESTS AND CRITERIA

Revision Date: March 27, 2017 Revision Number: 001

Product Manufacturer: Beta Bell Phone Company
123 Beta Bell Lane
Bellweather, Arizona 99999

Telephone: 800-999-4545
Email: betabell@gmail.com
Web: www.betabell.com

Beta Bell's product lithium ion cells and batteries have been successfully tested and comply with the UN Model Regulations, Manual of Test and Criteria, Part III, subsection 38.3.

PERFORMED TESTS			RESULTS
38.3.4.1	T1	Altitude Simulation	Pass
38.3.4.2	T2	Thermal Test	Pass
38.3.4.3	T3	Vibration	Pass
38.3.4.4	T4	Shock	Pass
38.3.4.5	T5	External Short Circuit	Pass
38.3.4.6	T6	Impact / Crush	Pass
38.3.4.7	T7	Overcharge	Pass
38.3.4.8	T8	Forced Discharge	Pass

The UN38.3 tests were performed by one of the following test houses and were tested to UN Manual Test and Criteria Revision 3 Amendment 1 or subsequent revisions or amendments.

Test House A 123 Alpha Street Shanghai China E: testhousea@gmail.com T: 086-0310-04566 U: www.testhousea.com	Test House C 123 Chi Street Shanghai China E: testhouseC@gmail.com T: 086-0310-04588 U: www.testhousec.com
Test House B 123 Beta Street Shanghai China E: testhouseb@gmail.com T: 086-0310-04577 U: www.testhouseb.com	Test House D 123 Delta Street Shanghai China E: testhoused@gmail.com T: 086-0310-04599 U: www.testhoused.com

LITHIUM CELLS OR BATTERIES TEST SUMMARY
IN ACCORDANCE WITH SUB-SECTION 38.3
OF UN MANUAL OF TESTS AND CRITERIA

Product Test Information

Model numbers	Physical Description	Battery weight (kg) Mass	Wh rating	Test report number	Test report date
BB12389	Li ion polymer Cell phone Alpha A	0.035	6.25	RTS123, NMD456PO98 N4569-2 BN890A	03.02.2010 03.07.2010 03.10.2010 03.15.2010
BB12450	Li ion polymer Cell Phone Beta B	0.090	6.76	TYh765-KL-09 567-908HGT	08.09.2012 09.01.2012
BB67896	Li ion polymer Cell phone Chi C	0.026	5.25	89065RT-90 NHI-kl09	07.07.2010 07.04.2010
etc					
etc					
etc					
etc					
etc					
etc					

Signature _____

Name, Title

Example 2 of a Lithium Ion Battery Test Summary

	UN38.3 Lithium Battery Test Summary for GreenTech Tablet Model No. T54321
1	**Battery Manufacturer** *Confidential and Proprietary GreenTech Information*
2	**Product Manufacturer** GreenTech 123 Main Street Annapolis, MD 21012 888.111.2345 contact@greentech.com; www1.greentech.com
3	**UN38.3 Test Lab** Bob's Battery Test Lab 1600 Pennsylvania Avenue Smithfield, VA 12345 Phone: 211.789.2345 bob@testlab.org; www.testlab.org
4	**Test Report Number** Liion621345
5	**Date of Test Report** April 1, 2017
6	**Description of Cell or Battery** 7.4 V, 1800 mAh, 13.32 Wh Li ion battery, Model No. P1789 Small, rectangular plastic case, 100 grams
7	**UN38.3 Tests Performed and Successfully Passed** T.1, T.2, T.3, T.4, T.5, and T.7. (Note that T.6 and T.8 are not applicable to batteries.)
8	**Assembled Battery Testing Requirements** Not Applicable
9	**Edition of UN Manual of Tests and Criteria Used** Sixth Revised Edition
10	**Name and Title of Signatory** *Jason Alexander* Jason Alexander GreenTech Staff Engineer

Example 3 of a Lithium Metal Cell Test Summary

LITHIUM CELLS OR BATTERIES TEST SUMMARY
IN ACCORDANCE WITH SUB-SECTION 38.3
OF MANUAL OF TESTS AND CRITERIA

BATTERY TRANSPORTION INFORMATION

Name of cell, battery or product manufacturer, as applicable:

Item Number : 4A23123
Item Name : Battery Alpha Prime
Item Description : Lithium Metal Battery (Primary)

Cell, battery or product manufacturer's contact information to include address, phone number, email address and website for more information:

Manufacturer XYZ
3480 Lithium cells Rd
Lithiumionville, CA 98765
United States
(+1-987) 987-6543
email@xyz.com

Name of the test laboratory to include address, phone number, email address and website for more information:

Test Lab A
1919 Alpha St
Testcity, IA 55555
USA
(+1-333) 555-1122
email@testlab.com

A unique test report identification number:
ABC12345

Date of the test report:
03-Apr-2013

Description of cell or battery to include at a minimum: Lithium ion or Lithium metal cell or battery; Mass; Watt-hour rating, or lithium content; Physical description of the cell/battery; and Model numbers:

Battery used in consumer power tools

Cell/battery Type : Lithium metal
Cell or Battery : Cell
LC or W/h rating : LC (g): >0.3 <= 1
Cell or Battery Weight : 12.00 Grams

List of tests conducted and results (i.e., pass/fail):

Test T.1: Altitude Simulation	:	Pass
Test T.2: Thermal Test	:	Pass
Test T.3: Vibration	:	Pass
Test T.4: Shock	:	Pass
Test T.5: External short circuit	:	Pass
Test T.6: Impact/Crush	:	Pass
Test T.7: Overcharge	:	Not applicable
Test T.8: Forced discharge	:	Pass

Testing additional comments:

Reference to assembled battery testing requirements, if applicable (i.e., 38.3.3(f) and 38.3.3;(g)):
Not applicable

Reference to the revised edition of the Manual of Tests and Criteria used and to amendments thereto, if any:
Revision 5

For air transport only:
Does the cell or battery comply with the 30% State of Charge?
Not Applicable

PRODUCT CLASSIFICATION FOR TRANSPORT (According to UN - DGP)

UN Classification:
UN 3090

Proper Shipping Name:
Lithium metal batteries

Signature with name and title of signatory as an indication of the validity of information provided:
Wayne Purple
Testing Manager

Date document was generated:
04-Mar-2017 11:49 am

This document remains valid as long as no changes, modifications, or additions are made to the model(s) described in this document, after being transported from a Manufacturer XYZ facility.
The model(s) has (have) been classified according to the applicable transport regulations and the UN Manual of Tests and Criteria as of the date of the certification. The model(s) must be packaged, labeled, and documented according to country and other international regulations for transportation.

Page 1 of 1

[1] Information in Part 4 kindly provided by PRBA – The Rechargeable Battery Association, RECHARGE the Advanced Rechargeable & Lithium Batteries Association and the Medical Device Battery Transport Council

Additional Information

Further information can be found here:

http://www.iata.org/lithiumbatteries

Information for passengers can be found here:

http://www.iata.org/dgr-guidance

www.faa.gov/go/safecargo

You may also contact the airline of your choice or your national civil aviation authority if you have any further concerns about travelling with lithium metal or lithium ion batteries.

You can also contact the IATA Dangerous Goods Support team if you have questions or concerns which may not have been addressed in this document: dangood@iata.org.

Abbreviations, Acronyms, Symbols

The following abbreviations, acronyms and symbols are used throughout the document.

Abbreviation	Meaning
A/C	Aircraft
Li Ion (li-ion)	Lithium ion
Li batt.	Lithium battery
Pax	Passenger
Acronym	**Meaning**
CAO	Cargo Aircraft Only
DGD	Shipper's Declaration for Dangerous Goods
DGR	IATA Dangerous Goods Regulations
LBSR	IATA Lithium Battery Shipping Regulations
Symbol	**Meaning**
≥	Equal to or greater than
≤	Equal to or less than
>	Greater than
<	Less than
☐	Addition of an item
△	Change to an item
⊗	Deletion of an item