



Safety Risk Assessment

1st | Edition

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Senior Vice President
Airport, Passenger, Cargo and Security
International Air Transport Association
800 Place Victoria
P.O. Box 113
Montreal, Quebec
CANADA H4Z 1M1

Web Download:

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Chapter 1—Carriage of Lithium Batteries

1.1 Disclaimer

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Senior Vice President
Safety and Flight Operations
International Air Transport Association
800 Place Victoria, P.O. Box 113
Montréal, Québec

1.2 Background

The carriage of lithium batteries has been identified as an emerging risk to airline operations. Testing conducted by the Federal Aviation Authority (FAA) of lithium batteries when exposed to high temperatures has identified that as individual lithium cells are forced into thermal runaway and catch fire, that this fire can propagate from cell to cell in the same package.

The FAA testing also identified that a fire involving large quantities of lithium ion cells may overwhelm the Halon fire suppression system that is used in aircraft Class C cargo compartments. Based on the results of the FAA tests, the major aircraft manufacturers issued bulletins to operators recommending that operators not carry “high density” quantities of lithium ion batteries on passenger aircraft until safer methods of transport are developed.

Based on the testing and the position of the aircraft manufacturers, there was pressure on ICAO to take action on limiting carriage of lithium ion batteries as cargo on passenger aircraft. As a result of this pressure, on 22 February 2016, the ICAO Council adopted the recommendation of the ICAO Air Navigation Commission (ANC) that lithium ion batteries (UN 3480, Packing Instruction 965 only) be forbidden, on an interim basis, as cargo on passenger aircraft. In addition, and also effective 1 April 2016, lithium ion cells and batteries must be offered for transport at a state of charge (SoC) not exceeding 30% of their rated design capacity.

While the prohibition will stop the shipment of legitimate shipments of lithium ion batteries, the prohibition does not address the shipment of lithium batteries that may be offered for transport either incorrectly declared or undeclared. Due to this potential hazard, there may be a need for risk-based additional screening, dependent on the operator’s exposure. As such, aligned with SMS methodology, IATA’s recommendation is that each operator conduct a safety risk assessment based on the nature of their operation.

To facilitate this task, IATA has produced a sample Safety Risk Assessment (SRA) which captures examples each carrier could use in their existing SRA process. After evaluating Industry-wide fundamentals with respect to the carriage of lithium batteries and considering existing risk assessments, bow-tie analysis and the latest battery testing and analysis, this document provides examples of potential failure modes, and possible mitigations for consideration.

The intent is that this document will help individual carriers to complete their respective safety risk assessments, by providing an aid to the thought processes required.

The sample risk matrix, including proposed mitigation actions is documented in Appendix A.

1.3 Regulation

Lithium batteries are classified as dangerous goods. As such, all lithium batteries are subject to regulations that prescribe specific design type, testing, packaging, quantity limits, labelling and documentation requirements for carriage as cargo by air. These requirements are contained in the IATA Dangerous Goods Regulations and the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air.

Effective April 1, 2016 lithium ion batteries (UN 3480) are forbidden as cargo on passenger aircraft.

1.4 Working Group

Derived from a request by the IATA Director of Safety, a small working group was formed to identify and document risks associated with the carriage of lithium batteries, in order to identify Industry-wide risks. This group was also tasked to formulate a template to facilitate operators to conduct their own risk assessment, to ensure an acceptable level of safety is maintained at all times during this specific type of operation.

Following are the names and titles of those who prepared this SRA.

Nancy Rockbrune ~ Head of SMS, IATA

David Tindley ~ Manager Safety, IATA

Dave Brennan ~ Assistant Director, Cargo Safety and Standards, IATA

1.5 Assumptions

This SRA follows the recommendations and methodology of IATA and the IATA Safety Group in encouraging operators to conduct an SRA concerning the carriage of lithium batteries on their commercial aircraft.

The ICAO Risk Model, as documented in Doc 9859, Safety Management Manual (SMM) Ed.3, was used to conduct this SRA.

Test results and incident statistics for quality compliant lithium battery manufacturers and shippers, provided to IATA by the PRBA, the Rechargeable Battery Association, and NEMA, the National Electrical Manufacturers Association, formulated the risk rating for the probability of an occurrence in the SRA.

SRA's should be reviewed and updated accordingly to reflect advances in scientific study, operational data and / or regulatory changes.

1.6 Accident Analysis

Over the last ten years there have been three aircraft accidents where lithium batteries may have, or are suspected to have, been involved.

Of these accidents, only one was attributed, "with reasonable certainty," to a fire in a pallet loaded with thousands of lithium batteries, some of which were not properly declared or in compliance with the ICAO Technical Instructions.

Another of the accidents had a fire that broke out in the area where dangerous goods, including lithium batteries, were loaded, however it was impossible for investigators to determine with certainty the source of the fire. For the third accident, it was determined that the fire started elsewhere in the cargo hold and spread to the pallet containing lithium batteries.

For all three incidents, it is evident that once there is a fire with large quantities of lithium batteries, the time from ignition to uncontrollable fire is quite short ~ 17 minutes, 23 minutes and 27 minutes respectively. However, it must be noted that each of these incidents are in the context of large quantities of lithium metal and/or lithium ion batteries.

Please note, that due to the small number of accidents in relation to the number of passenger and cargo flights operated over this ten year period, an accident rate has not been calculated. Additionally, since there is no way to determine declared vs. undeclared carriage of lithium batteries, it was impossible to determine a rate based on carriage of compliant shipments of lithium batteries and related incidents.

The following provides comparative details from the accident reports:

	Accident/Incident #1	Accident/Incident #2	Accident/Incident #3
LI batteries on board	Yes	Yes	Yes
Declared?	Yes	No	Lithium – Yes Other items – no <i>(not considered a factor)</i>
Hull loss	Yes	Yes	Yes
Fatalities (%)	2 (100%)	2 (100%)	0 (0%)
Phase of flight	Early cruise	Early cruise	Descent
Time into flight	50 minutes	22 minutes	c. 2 hours
Time to uncontained fire	17 minutes	23 minutes	27:45 minutes

1.7 Supporting Documentation

- ICAO SMM ~ Doc 9859, Edition 3
- Dangerous Goods Regulations (DGR) ~ 2016 (57th edition)
- IATA “Lithium Batteries as Cargo in 2016, Update III”
- Technical Instructions for the Safe Transport of Dangerous Goods by Air Doc 9284 ~ 2015-2016 Edition
 - Addendum No. 3 to the 2015-2016 edition of the Technical Instructions to address the changes applicable to lithium batteries
 - Addendum No. 4 to the 2015-2016 edition of the Technical Instructions to address the changes applicable to lithium batteries
- United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations (Revision 19) ~ July 2015

- US DOT SAFO 16004
- IATA Lithium Battery Risk Mitigation Guidance for Operators 1st Edition ~ January 2015

1.8 Conclusion

The carriage of lithium batteries as cargo on commercial aircraft poses a risk. Although the probability of an event occurring is extremely low, the severity of such an incident may be high if there are large quantities of lithium batteries involved. As such, it is recommended that operators perform a safety risk assessment, in order to mitigate these risks, to an acceptable level of safety, within their own specific operation.

In order to perform such a safety risk assessment, information on the types and quantities of lithium batteries and cells being transported should be considered. In addition, the capabilities of the available fire protection system should also be taken into account. Following on from such a safety risk assessment, the operator would be able to implement effective mitigations that address the risks pertaining to the carriage of lithium batteries, specific to their operation.

Millions of lithium batteries are transported around the globe everyday with no incident and there are a number of quality controls in place. The risk to the safety of aircraft operations due to the carriage of lithium batteries is arguably primarily driven through non-compliant shippers / shipments. It is believed that the industry-wide ban on the carriage of lithium batteries could introduce a secondary risk, as it would not act as a deterrent for those already operating outside of regulations. Furthermore, it could exacerbate the problem of undeclared shipments, while also giving operators a false sense that the prohibition has mitigated the risk.

1.9 Recommendation

All operators should conduct a thorough risk assessment, in order to ensure that effective controls are in place to mitigate the risk pertaining to the carriage of lithium batteries to an acceptable level.

Industry must remain committed to sharing information, and conducting further scientific research with the purpose to improve the knowledge and understanding on this important topic.



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Appendix A

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk				
					Probability	Severity	Rating				Probability	Severity	Rating		
Battery Quality															
1	OEMs applying QMS	Internal failure leading to thermal runaway causing onboard fire	Hull Loss	Extensive battery testing aligned with regulatory requirements Shipped in accordance with DGR and IATA LI Battery Guidance Onboard fire suppression	2	A	Tolerable (with mitigation)	Specific fire containment strategies for LI batteries Limitation of battery quantities per pack / consolidated pack / per aircraft	OEMs and ICAO / DGP ICAO DGP / IATA DGB	State oversight Operator compliance with regulations and internal oversight	1	A	Acceptable		
2	Counterfeit / Untested Batteries	Internal failure leading to thermal runaway causing onboard fire	Hull Loss	Unknown / non-existent testing	3*	A	Intolerable	Specific fire containment strategies for LI batteries Screening of shipments from known problem areas System of registering known shippers	OEMs and ICAO / DGP State / Operator and Shippers State	State oversight Oversight State oversight	2	A	Tolerable (with mitigation)		



Safety Risk Assessment (SRA)

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
Type of Battery													
3	Li Metal	Battery failure or external heat source leading to thermal runaway causing onboard fire	Hull Loss	Limit quantities in accordance with DGR	3*	A	Intolerable	Further limit quantities to be shipped Fire resistant packaging Onboard fire suppression systems Performance standards	ICAO DGP	State oversight	2	A	Tolerable (with mitigation)
4	LI Ion	Battery failure or external heat source leading to thermal runaway causing onboard fire	Hull Loss	Limit quantities in accordance with DGR	2	A	Tolerable (with mitigation)	Further limit quantities to be shipped Battery state of charge in accordance with requirements Fire resistant packaging Onboard fire suppression systems Performance standards	ICAO DGP Shipper ICAO DGP ICAO DGP	State oversight	1	A	Acceptable

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
Shipper / Freight Forwarder													
5	Shipping large bulk (excessive) quantities of LI batteries not packed in accordance with DGR)	Battery failure or short-circuit leading to thermal runaway causing onboard fire unable to be suppressed by onboard suppression	Hull Loss	Limit quantities in accordance with DGR Acceptance checks Battery SoC in compliance with requirements	3*	A	Intolerable	System of registering known shippers Screening Overpack limits Consolidation limits Aircraft limits FCC/FRC use	State Operator Freight Forwarder	State oversight Operator internal program Security screening enhancements	2	A	Tolerable (with mitigation)
6	Undeclared and misdeclared lithium batteries	Unknown quantity / quality including packaging and build/design leading to fire	Hull Loss	Security Screening Freight Forwarder Documentation review	3*	A	Intolerable	System of registering known shippers Screening CONTROL NEEDED (Enhanced Scanning Capability) FCC/FRC use	State Operator Freight Forwarder	Enhanced Freight Forwarder Participation Safety screening of advanced data	2	A	Tolerable (with mitigation)



Safety Risk Assessment (SRA)

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
7	Freight Forwarder consolidation of shipments (quantity of batteries shipped)	Battery failure or short-circuit leading to thermal runaway causing onboard fire unable to be suppressed by onboard suppression	Hull Loss	<i>Effective April 2016:</i> Limit of 1 package Package = no more than 8 Li-ion cells or 2 Li-ion batteries Overpacks forbidden	2	A	Tolerable <i>(Risk level is dependent on new packaging limits demonstrating desired effect)</i>		ICAO DGP / IATA DGB	State oversight Operator internal program Security screening enhancements	2	A	Tolerable (with mitigation)
Manual Handling													
8	Shipment is damaged through mishandling	Battery failure or short-circuit leading to thermal runaway causing onboard fire	Hull Loss	Screening for package damage at acceptance, buildup and loading ~ damaged packages not loaded Damaged batteries without package damage compromises existing controls	3*	A	Intolerable	Oversight of entire supply chain Awareness and training to increase staff vigilance Communication to increase public awareness	All stakeholders	Increased awareness on cargo type handling	2	A	Tolerable (with mitigation)

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
9	Battery is damaged through mishandling	Battery failure or short-circuit leading to thermal runaway causing onboard fire	Hull Loss	Existing mitigations are compromised through unknown physical damage	3*	A	Intolerable	<p>Oversight of entire supply chain</p> <p>Awareness and training to increase staff vigilance</p> <p>Communication to increase public awareness</p> <p>CONTROL NEEDED (Enhanced scanning capability)</p>	All stakeholders	Enhanced handling procedures	2	A	Tolerable (with mitigation)
10	Shipment is damaged during shipment acceptance, buildup and aircraft loading	Battery failure or short-circuit leading to thermal runaway causing onboard fire	Hull Loss	<p>Screening for package damage at acceptance, buildup and loading ~ damaged packages not loaded</p> <p>Damaged batteries without package damage compromises existing controls</p>	3*	A	Intolerable	<p>Safety oversight (State / Operator)</p> <p>Awareness and training and staff vigilance</p> <p>Communication to increase public awareness</p>	<p>State / Operator</p> <p>Operator / RHA/GSP</p>	<p>State oversight / Operator internal audit program / IOSA / ISAGO</p> <p>No fault reporting for all parties</p>	2	A	Tolerable (with mitigation)



Safety Risk Assessment (SRA)

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
Inflight Fire													
11	Fire originating in shipment	Battery failure leading to thermal runaway causing onboard fire	Hull Loss	<p>Extensive battery testing aligned with regulatory requirements</p> <p>Limitation of battery quantities per pack</p> <p>Shipped in accordance with DGR</p> <p>Onboard fire suppression</p>	2	A	Tolerable <i>(Risk level is dependent on new packaging limits demonstrating desired effect)</i>	Specific fire containment strategies for LI batteries	OEMs and ICAO / DGP	<p>State oversight</p> <p>Operator compliance with regulations and internal oversight</p> <p>FCC/FRC use</p>	2	A	Tolerable (with mitigation)
12	Fire originating elsewhere in hold	External heat source leading to thermal runaway causing onboard fire	Hull Loss	<p>Onboard fire suppression</p> <p>Limitation of battery quantities per pack</p>	2	A	Tolerable <i>(Risk level is dependent on new packaging limits demonstrating desired effect)</i>	Specific fire containment strategies for LI batteries	ICAO DGP	<p>State oversight</p> <p>Operator compliance with regulations and internal oversight</p> <p>Development of performance based specifications for the segregation of batteries</p>	2	A	Tolerable (with mitigation)

	Event	Hazard	Consequence <i>(worst case scenario)</i>	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
Total Ban ~ Consequential Risk													
1	Carriage of lithium batteries banned on all commercial aircraft	Due to commercial pressure batteries are shipped anyway, either undeclared or mis-declared. No knowledge by operator where in the aircraft they may be, how many, what types, etc. As such no mitigations in place. Battery failure leading to thermal runaway causing onboard fire.	Hull Loss	Onboard fire suppression	3*	A	Intolerable	Specific fire containment strategies for LI batteries Existing screening of shipments	OEMs Operator and Shippers	State oversight Oversight	3*	A	Intolerable



Safety Risk Assessment (SRA)

	Event	Hazard	Consequence (worst case scenario)	Existing Controls	Risk			Mitigation Action	Ownership	New Controls	Risk		
					Probability	Severity	Rating				Probability	Severity	Rating
2	Carriage of lithium batteries banned on all commercial aircraft	Due to commercial pressure batteries are shipped anyway, either undeclared or mis-declared. No knowledge by operator where in the aircraft they may be, how many, what types, etc. As such no mitigations in place. Battery failure leading to thermal runaway causing onboard fire.	Hull Loss	Onboard fire suppression	3*	A	Intolerable	<p>Risk-based screening (relevant ot risk exposure)</p> <p>Risk-based scanning of shipments (as technology allows)</p>	Operators	Operator compliance with regulations and internal oversight	1	A	Acceptable



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custserv@iata.org

+1 800 716 6326