International Civil Aviation Organization

DGP-WG/LB/2-WP/2
17/3/14

WORKING PAPER

DANGEROUS GOODS PANEL (DGP)
WORKING GROUP ON LITHIUM BATTERIES

SECOND MEETING

Montréal, 7 to 11 April 2014

Agenda Item 1: Mitigating risks associated with the carriage of lithium metal batteries

LITHIUM METAL BATTERIES — BAN ON PASSENGER AIRCRAFT

(Presented by the Secretary)

SUMMARY

This working paper proposes forbidding the transport of lithium metal batteries as cargo on passenger aircraft. Justification for the proposal is based on the fire risk these batteries present and on test results which demonstrate that lithium metal batteries cannot be adequately suppressed by current fire suppression systems. The proposal takes into account the conclusions and recommendations of the Multidisciplinary Lithium Battery Transport Coordination Meeting (Atlantic City, 4 to 6 February 2014).

Action by the DGP-WG/LB is in paragraph 4.

1. INTRODUCTION

1.1 A proposal to ban lithium metal batteries from passenger and cargo aircraft was considered at DGP/24. Although there was agreement that additional measures were needed to mitigate the risks lithium metal batteries pose and that the status quo was unacceptable, there was little support for a full ban on both passenger and cargo aircraft. Various options were discussed, but an agreement could not be reached. The meeting determined that a multidisciplinary approach involving experts from different aviation segments in addition to dangerous goods was needed to address the risks. To this end, the Federal Aviation Administration (FAA) William J. Hughes Technical Centre offered to host a multidisciplinary meeting on behalf of ICAO which took place in Atlantic City from 4 to 6 February 2014.

1.2 This working paper presents a new proposal which focuses on the risks to passenger aircraft by banning the transport of lithium metal batteries as cargo on passenger aircraft. Discussions at DGP/24 were taken into account in developing this proposal (see paragraph 5.1 of the DGP/24 Report) as were the conclusions and recommendations of the Multidisciplinary Lithium Battery Transport Coordination Meeting (Atlantic City, 4 to 6 February 2014) (presented in DGP-WG/LB/2-WP/1).

2. DISCUSSION

2.1 Ban on lithium metal batteries on passenger aircraft

2.1.1 The knowledge that current fire suppression systems in cargo holds did not adequately supress lithium metal fires and the fact that currently required packagings could not contain a fire was the main justification for the proposal presented to DGP/24. A basic tenet of safety management system principles is that layered defences against safety risks are necessary in ensuring that single-point failures are rarely consequential. Aircraft fire suppression systems are the last line of defence in the event of a fire, and their inability to suppress a lithium metal fire would likely result in a catastrophic event. Continuing to transport lithium metal batteries despite the known risks was argued to be an unacceptable safety risk.

2.1.2 There was concern at DGP/24 that a ban on the transport of lithium metal batteries as cargo would increase the risk as it would serve only to stop compliant shipments of batteries and that non-compliant shipments would continue and likely increase in number.

2.1.3 While the risks related to non-compliant shipments of lithium metal batteries must be mitigated, continuing to permit their transport on passenger aircraft despite the known risks should not be considered an acceptable mitigation strategy. It is not a strategy employed by ICAO in setting Standards and is arguably not a strategy employed by any legislative body responsible for safety. Most citizens and organizational entities are known to be law abiding and do not violate restrictions or prohibitions. Banning the transport of lithium metal batteries on passenger aircraft would reduce the exposure rate thereby eliminating a significant risk to passengers. It would increase awareness of the risks they pose and allow for appropriate enforcement to be taken when necessary.

2.1.4 Lithium metal batteries present risks in air transport regardless of whether or not a shipment is compliant. These include:

a) FAA Technical Centre testing has shown that the heat from an external, suppressed fire may reach temperatures capable of igniting lithium metal batteries. Thus, a relatively small fire, not ignited by the lithium metal batteries, could lead to a catastrophic fire that cannot be adequately suppressed when the batteries become involved. In addition, a thermal runaway event which can be caused by manufacturing defects, handling and unknown conditions can provide an ignition source for a cargo fire exceeding fire suppression capabilities.

b) FAA Technical Centre testing has also shown that the risks posed by lithium metal batteries are dependent on many factors such as the manufacturer, chemistry, size and design of the cell. In fact, testing on a certain chemistry employing a non-flammable electrolyte resulted in an explosion when thermal runaway was induced by a cartridge heater. Future changes in technology could result in new risks for which mitigation strategies have not been considered.

c) There is always the risk of damage to shipments during land transport prior to transport by air; the probability of the damage increases proportionately to the number of batteries being shipped.

2.1.5 An additional concern raised at DGP/24 were a ban to be implemented was the belief that there were parts of the world which cargo aircraft did not service routinely, and therefore there needed to be an allowance for lithium metal batteries to be transported on passenger aircraft. However, if there was a need for transport and other forms of transport were not feasible, transport under an exemption in accordance with the Technical Instructions would be possible.

3. CONCLUSIONS AND RECOMMENDATIONS OF THE MULTIDISCIPLINARY LITHIUM BATTERY TRANSPORT COORDINATION MEETING

3.1 The Multidisciplinary Lithium Battery Transport Coordination Meeting concluded that fires in flight involving certain types and quantities of lithium metal batteries had the potential to result in an uncontrolled fire leading to a catastrophic failure of the airframe. This was substantiated by a safety risk mitigation analysis presented at the meeting which used tools contained in the *Safety Management Manual (SMM)* (Doc 9859). The outcome of the analysis suggested that the transport of lithium metal batteries on passenger aircraft posed an unacceptable risk under existing circumstances on the basis that the likelihood of an even occurring was remote but the severity of the consequence of the event would be catastrophic. The presence of airframe manufacturers at the multidisciplinary meeting highlighted the need for increased coordination between airframe manufacturers and dangerous goods regulators. It was revealed that airframe manufacturers operated on the basis that restrictions placed on dangerous goods by regulators provided an acceptable level of safety and that certification for cargo fire protection did not specifically address the risks posed by the carriage of dangerous goods. The meeting tabled four recommendations which are reproduced in Appendix A to this working paper.

3.2 This proposal addresses the first recommendation and considers Option 1 (total prohibition on passenger aircraft until such time as the data supporting safe transport is available) to be the most appropriate. In the absence of specific conditions where the types, quantities and packaging containing lithium metal batteries would not allow a fire from within the package to propagate beyond the packaging or adversely affect flight safety, Option 2 (prohibition with an approval provision) is not supported. Likewise, in the absence of performance-based criteria for packaging batteries, Options 3 (permission to transport certain limited lithium metal batteries based on performance-based criteria) and 4 (Option 3 plus permission to transport very small cells) are not supported.

4. ACTION BY THE DGP-WG/LB

4.1 The DGP-WG/LB is invited to:

a) amend the Technical Instructions as proposed in Appendix B to this working paper;

Note.— Amendments agreed at DGP/24 are included with the proposal. Additional amendments proposed in this working paper are shaded in yellow.

b) if the panel agrees to the amendment forbidding lithium metal batteries on passenger aircraft, consider whether Section II of Packing Instruction 968 should be deleted;

c) provide recommendations on ways to improve oversight and enforcement activities in relation to the transport of lithium batteries, such as focused audits on large manufacturing States; and

d) agree to address the remaining recommendations of the International Multidisciplinary Lithium Battery Transport Coordination Meeting (Recommendations 2, 3 and 4) (reproduced in Appendix A) during the next biennium.

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APPENDIX A

RECOMMENDATIONS OF THE INTERNATIONAL MULTIDISCIPLINARY LITHIUM BATTERY TRANSPORT COORDINATION MEETING

Recommendation 1 — Further restrictions on the carriage of lithium metal batteries in commercial passenger carrying operations

That the carriage of lithium metal batteries as cargo should be further restricted, up to and including a potential ban, on passenger carrying aircraft in commercial air transport. Options for these restrictions should be considered and decided upon by the DGP at its Working Group of the Whole on Lithium Batteries (7 to 11 April 2014) and implemented as soon as possible.

Options include:

Option 1 — Total prohibition on passenger carrying aircraft until such time as the data supporting safe transport is available

Option 2 — Prohibition with an approval provision (guidance to be provided in the *Supplement to the Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284SU))

The specific conditions to support an approval process, where the types, quantities and packaging containing lithium metal batteries would not allow a fire from within the package to propagate beyond the packaging or adversely affect flight safety, would be developed for inclusion in the Supplement to the Technical Instructions. Guidance would be developed no later than the next regular amendment to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284).

Option 3 — Permission to transport certain limited lithium metal batteries based upon a performance-based criteria for packaging such batteries. Performance-based criteria would be developed for inclusion in the Technical Instructions.

Option 4 — Option 3, plus permission to transport very small cells (e.g. button cells). The number and package configuration would be validated based upon a specification (may or may not be fully declared)

Recommendation 2 — Performance based approach

That a small multidisciplinary cargo safety group be formed to develop a performance-based approach to the conditions of carriage on passenger aircraft

using the draft flow chart prepared by the FAA Technical Center (see Appendix F) as the basis for its deliberations.

Recommendation 3 — Cargo aircraft

That risks associated with lithium metal batteries on cargo aircraft be mitigated using the lessons learned in the development of a performance-based approach to controlling the risks associated with the carriage of lithium metal batteries on passenger aircraft, as well as any other potential strategies. A decision on the way forward to be taken during the next DGP working group of the whole meeting in October 2014.

Recommendation 4 — Multidisciplinary approach to cargo safety

That a multidisciplinary approach involving all stakeholders be taken as an essential step to advancing the issue of cargo safety.

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APPENDIX B

PROPOSED AMENDMENT TO THE TECHNICAL INSTRUCTIONS

Part 3

DANGEROUS GOODS LIST, SPECIAL PROVISIONS AND LIMITED AND EXCEPTED QUANTITIES

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Chapter 2

ARRANGEMENT OF THE DANGEROUS GOODS LIST (TABLE 3-1)

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Table 3-1. Dangerous Goods List

Name	*UN No.*	*Class or division*	*Subsidiary risk*	*State variations*	*Special provisions*	*UN packing group*	*Excepted quantity*	*Passenger aircraft*		*Cargo aircraft*	
								Packing instruction	*Max. net quantity per package*	*Packing instruction*	*Max. net quantity per package*
1	*2*	*3*	*4*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Lithium metal batteries (including lithium alloy batteries)†	3090	9		US 2 US 3	A88 A99 A154 A164 A183		E0	~~See~~ FORB	~~968~~ DDEN	See	968
Lithium metal batteries contained in equipment (including lithium alloy batteries) †	3091	9		US 2 US 3	A48 A99 A154 A164 A181 A185		E0	970	5 kg	970	35 kg
Lithium metal batteries packed with equipment (including lithium alloy batteries) †	3091	9		US 2 US 3	A99 A154 A164 A181 A185		E0	969	5 kg	969	35 kg

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Part 4

PACKING INSTRUCTIONS

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Chapter 11

CLASS 9 — MISCELLANEOUS DANGEROUS GOODS

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Editorial Note.— Amendments agreed at DGP/24 are included with this proposal. Additional amendments proposed in this working paper are shaded in yellow.

Packing Instruction 968

~~Passenger and c~~Cargo aircraft for UN 3090

1. **Introduction**

This entry applies to lithium metal or lithium alloy batteries. This packing instruction is structured as follows:

— Section IA applies to lithium metal cells with a lithium metal content in excess of 1 g and lithium metal batteries with a lithium metal content in excess of 2 g, which must be assigned to Class 9 and are subject to all of the applicable requirements of these Instructions;
— Section IB applies to lithium metal cells with a lithium metal content not exceeding 1 g and lithium metal batteries with a lithium metal content not exceeding 2 g packed in quantities that exceed the allowance permitted in Section II, Table 968-II; and
— Section II applies to lithium metal cells with a lithium metal content not exceeding 1 g and lithium metal batteries with a lithium metal content not exceeding 2 g packed in quantities not exceeding the allowance permitted in Section II, Table 968-II.

2. **Lithium batteries forbidden from transport**

The following applies to all lithium metal cells and batteries in this packing instruction:

Cells and 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 (e.g. those being returned to the manufacturer for safety reasons).

Waste lithium batteries and lithium batteries being shipped for recycling or disposal are forbidden from air transport unless approved by the appropriate national authority of the State of Origin and the State of the Operator.

DGP/24-WP/3 (paragraph 3.5.3) and paragraph 2.4.1.1 of this report

IA. **SECTION IA**

~~Section IA requirements apply to lithium metal cells with a lithium metal content in excess of 1 g and lithium metal batteries with a lithium metal content in excess of 2 g that have been determined to meet the criteria for assignment to Class 9.~~

Each cell or battery must meet all the provisions of 2;9.3.~~:~~.

~~1) be of the type proven to meet the requirements of each test in the UN *Manual of Tests and Criteria*, Part III, subsection 38.3;~~

~~*Note 1. Batteries are subject to these tests irrespective of whether the cells of which they are composed have been so tested.*~~

~~*Note 2. Batteries and cells manufactured before 1 January 2014 conforming to a design type tested according to the requirements of the fifth revised edition of the UN Manual of Tests and Criteria, Part III, subsection 38.3 may continue to be transported.*~~

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~~2) incorporate a safety venting device or be designed to preclude a violent rupture under conditions normally incident to transport and be equipped with an effective means of preventing external short circuits; and~~

~~3) be manufactured under a quality management programme as described in 2;9.3.1 e).~~

~~Each battery containing cells or a series of cells connected in parallel must be equipped with an effective means, as necessary, to prevent dangerous reverse current flow (e.g. diodes, fuses).~~

IA.1 **General requirements**

Part 4;1 requirements must be met.

Table 968-IA

UN number and proper shipping name	*Net quantity per package*	
	Passenger	*Cargo*
UN 3090 **Lithium metal batteries**	~~2.5 kg~~ Forbidden	35 kg

IA.2 **Additional requirements**

— Lithium metal cells and batteries must be protected against short circuits.
— Lithium metal cells and batteries must be placed in inner packagings that completely enclose the cell or battery, then placed in an outer packaging. The completed package for the cells or batteries must meet the Packing Group II performance requirements.
— Lithium metal batteries with a mass of 12 kg or greater and having a strong, impact-resistant outer casing, or assemblies of such batteries, may be transported when packed in strong outer packagings or protective enclosures (e.g. in fully enclosed or wooden slatted crates) not subject to the requirements of Part 6 of these Instructions, if approved by the appropriate authority of the State of Origin. A copy of the document of approval must accompany the consignment.
~~— For lithium metal cells and batteries prepared for transport on passenger aircraft as Class 9:~~
~~— — cells and batteries offered for transport on passenger aircraft must be packed in intermediate or outer rigid metal packaging; and~~
~~— — cells and batteries must be surrounded by cushioning material that is non-combustible and non-conductive, and placed inside an outer packaging.~~

IA.3 **Outer packagings**

Boxes	*Drums*	*Jerricans*
Aluminium (4B)	Aluminium (1B2)	Aluminium (3B2)
Fibreboard (4G)	Fibre (1G)	Plastics (3H2)
Natural wood (4C1, 4C2)	Other metal (1N2)	Steel (3A2)
Other metal (4N)	Plastics (1H2)	
Plastics (4H1, 4H2)	Plywood (1D)	
Plywood (4D)	Steel (1A2)	
Reconstituted wood (4F)		
Steel (4A)		

IB. **SECTION IB**

~~Section IB requirements apply to lithium metal cells with a lithium metal content not exceeding 1 g and lithium metal batteries with a lithium metal content not exceeding 2 g packed in quantities that exceed the allowance permitted in Section II, Table 968-II~~.

DGP/24-WP/55 (paragraph 5.1.10 of this report)

Quantities of lithium metal cells or batteries that exceed the allowance permitted in Section II, Table 968-II, ~~must be assigned to Class 9 and~~ are subject to all of the applicable provisions of these Instructions (including the requirements in paragraph 2 of this packing instruction and of this section) except for ~~the following:~~ : the provisions of Part 6.

Lithium metal cells or batteries shipped in accordance with the provisions of Section IB must be described on a dangerous goods transport document as set in Part 5;4. The packing instruction number “968” required by 5;4.1.5.8.1 a) must be supplemented with “IB”. All other applicable provisions of Part 5;4 apply.

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~~— the provisions of Part 6; and~~
~~— the dangerous goods transport document requirements of 5;4, provided alternative written documentation is provided by the shipper describing the contents of the consignment. Where an agreement exists with the operator, the shipper may provide the information by electronic data processing (EDP) or electronic data interchange (EDI) techniques. The information required is as follows and should be shown in the following order:~~

~~1) the name and address of the shipper and consignee;~~
~~2) UN 3090;~~
~~3) Lithium metal batteries PI 968 IB;~~

DGP/24-WP/3 (paragraph 3.5.4) DGP/24-WP/55 and paragraphs 2.4.1.1 and 5.1.10 of this report

~~4) the number of packages and the gross mass of each package.~~

DGP/24-WP/3 (paragraph 3.5.3) and paragraph 2.4.1.1 of this report

Lithium metal or lithium alloy cells and batteries may be offered for transport provided that each cell and battery meets the provisions of 2;9.3.1 a) and e) and~~if they meet all of~~ the following:

1) for lithium metal cells, the lithium content is not more than 1 g;
2) for lithium metal or lithium alloy batteries, the aggregate lithium content is not more than 2 g~~;~~.
~~3) each cell or battery is of the type proven to meet the requirements of each test in the UN *Manual of Tests and Criteria*, Part III, subsection 38.3;~~
~~*Note 1.— Batteries are subject to these tests irrespective of whether the cells of which they are composed have been so tested.*~~

~~*Note 2.— Batteries and cells manufactured before 1 January 2014 conforming to a design type tested according to the requirements of the fifth revised edition of the UN* Manual of Tests and Criteria~~*, Part III, subsection 38.3 may continue to be transported.*~~
~~4) cells and batteries must be manufactured under a quality management programme as described in 2;9.3.1 e).~~

IB.1 **General requirements**

Cells and batteries must be packed in strong outer packagings that conform to Part 4;1.1.1, 1.1.3.1 and 1.1.10 (except 1.1.10.1).

DGP/24-WP/3 (paragraph 3.5.4) and paragraph 2.4.1.1 of this report

Table 968-IB

Contents	*Net quantity per ~~P~~package ~~quantity~~*	
	Passenger	*Cargo*
Lithium metal cells and batteries	~~2.5 kg G~~ Forbidden	2.5 kg ~~G~~

IB.2 **Additional requirements**

— Cells and batteries must be packed in inner packagings that completely enclose the cell or battery then placed in a strong outer packaging.
— Cells and batteries must be protected so as to prevent short circuits. This includes protection against contact with conductive materials within the same packaging that could lead to a short circuit.
— Each package must be capable of withstanding a 1.2 m drop test in any orientation without:
  — damage to cells or batteries contained therein;
  — shifting of the contents so as to allow battery to battery (or cell to cell) contact;
  — release of contents.
— Each package must be labelled with a lithium battery handling label (Figure 5-31) in addition to the Class 9 hazard label.
— Each consignment must be accompanied with a document with an indication that:
  — the package contains lithium metal cells or batteries;

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— the package must be handled with care and that a flammability hazard exists if the package is damaged;
— special procedures must be followed in the event the package is damaged, to include inspection and repacking if necessary; and
— a telephone number for additional information.

DGP/24-WP/55 (paragraph 5.1.10 of this report)

Note.— This information may be provided on the dangerous goods transport document.

IB.3 **Outer packagings**

Boxes	*Drums*	*Jerricans*
Strong outer packagings		

DGP/24-WP/3 (paragraph 3.5.3) and paragraph 2.4.1.1 of this report

II. **SECTION II**

With the exception of Part 1;2.3 (Transport of dangerous goods by post), 7;4.4 (Reporting of dangerous goods accidents and incidents), 8;1.1 (Dangerous goods carried by passengers or crew)and paragraph 2 of this packing instruction, lithium metal or lithium alloy cells and batteries offered for transport are not subject to other additional requirements of these Instructions if they meet the requirements of this section.

Lithium metal or lithium alloy cells and batteries may be offered for transport provided that each cell and battery meets the provisions of 2;9.3.1 a) and e) and ~~if they meet all of~~ the following:

1) for a lithium metal cell, the lithium content is not more than 1 g;
2) for a lithium metal or lithium alloy battery, the aggregate lithium content is not more than 2 g~~;~~.
~~3) each cell or battery is of the type proven to meet the requirements of each test in the UN *Manual of Tests and Criteria*, Part III, subsection 38.3;~~

~~*Note 1.— Batteries are subject to these tests irrespective of whether the cells of which they are composed have been so tested.*~~

~~*Note 2.— Batteries and cells manufactured before 1 January 2014 conforming to a design type tested according to the requirements of the fifth revised edition of the UN* Manual of Tests and Criteria*, Part III, subsection 38.3 may continue to be transported.*~~

~~4) cells and batteries must be manufactured under a quality management programme as described in 2;9.3.1 e).~~

II.1 **General requirements**

Cells and batteries must be packed in strong outer packagings that conform to Part 4;1.1.1, 1.1.3.1 and 1.1.10 (except 1.1.10.1).

Table 968-II

Contents	*Lithium metal cells and/or batteries with a lithium content not more than 0.3 g*	*Lithium metal cells with a lithium content more than 0.3 g but not more than 1 g*	*Lithium metal batteries with a lithium content more than 0.3 g but not more than 2 g*
1	*2*	*3*	*4*
Maximum number of cells / batteries per package	No limit	8 cells	2 batteries
Maximum net quantity (mass) per package	2.5 kg	n/a	n/a

The limits specified in columns 2, 3 and 4 of Table 968-II must not be combined in the same package.

II.2 **Additional requirements**

— Cells and batteries must be packed in inner packagings that completely enclose the cell or battery, then

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placed in a strong outer packaging.

- Cells and batteries must be protected so as to prevent short circuits. This includes protection against contact with conductive materials within the same packaging that could lead to a short circuit.
- Each package must be capable of withstanding a 1.2 m drop test in any orientation without:
  - damage to cells or batteries contained therein;
  - shifting of the contents so as to allow battery to battery (or cell to cell) contact;
  - release of contents.
- Each package must be labelled with a lithium battery handling label (Figure 5-31).
- Each consignment must be accompanied with a document with an indication that:
  - the package contains lithium metal cells or batteries;
  - the package must be handled with care and that a flammability hazard exists if the package is damaged;
  - special procedures must be followed in the event the package is damaged, to include inspection and repacking if necessary; and
  - a telephone number for additional information.
- The words “lithium metal batteries, in compliance with Section II of PI968” must be placed on the air waybill, when an air waybill is used.
- Any person preparing or offering cells or batteries for transport must receive adequate instruction on these requirements commensurate with their responsibilities.

II.3 **Outer packagings**

Boxes	*Drums*	*Jerricans*
Strong outer packagings		

II.4 **Overpacks**

When packages are placed in an overpack, the lithium battery handling label required by this packing instruction must either be clearly visible or the label must be affixed on the outside of the overpack and the overpack must be marked with the word “Overpack”.

— END —