



DANGEROUS GOODS PANEL (DGP)

TWENTY-FIFTH MEETING

Montréal, 19 to 30 October 2015

Agenda Item 5: Development of a comprehensive strategy to mitigate risks associated with the transport of lithium batteries including development of performance-based packaging standards and efforts to facilitate compliance

CONSIDERATION OF REVISIONS TO PACKING INSTRUCTION 965

(Presented by D. Brennan)

SUMMARY

This information paper provides for consideration and discussion some potential changes that could be introduced into Packing Instruction 965 and Packing Instruction 968 that would allow lithium ion and lithium metal batteries to be transported more safely on passenger and cargo aircraft.

1. INTRODUCTION

1.1 There are a number of working papers under Agenda Item 5 of DGP/25 that propose revisions to Packing Instruction 965 such as the deletion of Section II of Packing Instruction 965 (DGP/25-WP/21 and DGP/25-WP/29) and restricting Packing Instruction 965 to cargo aircraft only (DGP/25-WP/24).

1.2 In considering the proposals in these working papers with representatives from a number of member States it is believed that before proceeding with discussion around deleting Section II and/or a prohibition on the carriage of UN 3480 on passenger aircraft, that there should be consideration of other available options that will enhance safety.

1.3 In considering the available options, the Second International Multidisciplinary Lithium Battery Transport Coordination Meeting came out with a total of fourteen recommendations. Of these recommendations, Recommendation 2/14 was that lithium ion cells be shipped at a reduced state of charge (SoC). The SoC indicated in this recommendation was 30% for lithium ion cells, with no recommended value for lithium ion batteries.

1.4 Another recommendation from the Second Multidisciplinary meeting, 8/14, was the development of testing to move to performance based packaging for lithium batteries.

1.5 At DGP-WG/15 there was further discussion around the need for the development of performance based standards based on the principle that hazardous effects from the batteries would be contained within the package. To move this forward DGP-WG/15 developed terms of reference for a working group of the panel that would be held following DGP-WG/15 with a view to developing recommendations for DGP/25.

1.6 The working group proposed by DGP-WG/15 subsequently became the Third International Multidisciplinary Lithium Battery Transport Coordination Meeting that was held in Montréal from 28 to 30 July 2015.

1.7 Unfortunately, the results of the Third International Multidisciplinary Lithium Battery Transport Coordination Meeting were a little limited, although there was a high-level standard developed as follows:

- The meeting agreed the following standards to be appropriate to mitigate the risks posed by a fire developing inside a package containing lithium batteries or cells and determined that they could be met at either the package or battery/cell level:
 - a) no hazardous amount of flame is allowed outside the package;
 - b) the external surface temperature of the package cannot exceed the amount that would ignite adjacent packing material or cause batteries or cells in adjacent packages to go into thermal runaway [100°C];
 - c) no hazardous fragments can exit the package and the package must maintain structural integrity; and
 - d) the quantity of flammable vapour must be less than the amount of gas that when mixed with air and ignited could cause a pressure pulse in a [2.83 m³] volume that could dislodge the overpressure panels of the compartment or damage the cargo liner [3.45 kpa].

Note.— [2.83 m³] volume is representative of the empty volume in the forward cargo compartment of a 737-200 aircraft with a 70 percent cargo load factor which when ignited could cause a pressure pulse that, according to airframe manufacturers' specifications, could dislodge the overpressure panels of the compartment or damage the cargo liner [3.45 kpa].

1.8 There were also a number of interim recommendations from the third multidisciplinary meeting, which include shipping lithium ion cells and batteries at a reduced SoC to mitigate the risk and also that operators conduct safety risk assessments to establish if they can carry lithium batteries as cargo with the available mitigation measures.

1.9 Based on the above, it is believed that introducing a reduced SoC into Packing Instruction 965 as proposed in DGP/25-WP/22 should be considered. However, it is believed that to simply make a statement that lithium ion cells and batteries must be shipped at a reduced SoC, it is believed that there must be a requirement for some verification or control on just which shippers are using reduced SoC when shipping lithium ion cells and batteries.

1.10 In considering what verification of control could be introduced it is believed that at least in the first instance that shippers that wish to use reduced SoC should be required to register as such with the civil aviation authority in the State from which the lithium ion batteries will be consigned. The registration should include as a minimum the shipper's company name and address and the model number or other identification of the lithium ion cells and/or batteries such that there is the opportunity to verify compliance with the SoC statement.

1.11 Should a shipper wish to ship at other than 30% SoC the shipper should be required to have testing done by a third-party to independently verify that there is no cell-to-cell or battery-to-battery fire propagation and that there are no hazardous effect outside the package.

1.12 It is also believed that there should be some provision for the use of enhanced packaging to ship lithium batteries, particularly as for some shippers reducing SoC may not be feasible or manageable.

1.13 It is recognized that there has been no substantial movement toward the development of a comprehensive test protocol and set of standards, however, it is believed that to wait what may be two years or more for the development of this standard represents a lost opportunity to introduce additional levels of safety into the system.

1.14 For this reason it is proposed to use the high-level standard contained in the report of the third multidisciplinary meeting on the basis that as a standard is further developed the test requirements can be refined and improved.

1.15 Below for consideration and discussion are some potential changes that could be introduced into Packing Instruction 965 and Packing Instruction 968 that would allow lithium ion and lithium metal batteries to be transported more safely on passenger and cargo aircraft.

Packing Instruction 965

Passenger and cargo aircraft for UN 3480

1. Introduction

This entry applies to lithium ion or lithium polymer batteries. This packing instruction is structured as follows:

- Section IA applies to lithium ion cells with a Watt-hour rating in excess of 20 Wh and lithium ion batteries with a Watt-hour rating in excess of 100 Wh, which must be assigned to Class 9 and are subject to all of the applicable requirements of these Instructions;
- Section IB applies to lithium ion cells with a Watt-hour rating not exceeding 20 Wh and lithium ion batteries with a Watt-hour rating not exceeding 100 Wh packed in quantities that exceed the allowance permitted in Section II, Table 965-II; and
- Section II applies to lithium ion cells with a Watt-hour rating not exceeding 20 Wh and lithium ion batteries with a Watt-hour rating not exceeding 100 Wh packed in quantities not exceeding the allowance permitted in Section II, Table 965-II.

A single cell battery as defined in Part III, sub-section 38.3.2.3 of the UN *Manual of Tests and Criteria* is considered a "cell" and must be transported according to the requirements for "cells" for the purpose of this packing instruction.

2. Lithium batteries forbidden from transport

The following applies to all lithium ion 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.

IA. SECTION IA

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

1A.1 General requirements

Part 4;1 requirements must be met.

Table 965-IA

<i>UN number and proper shipping name</i>	<i>Net quantity per package</i>	
	<i>Passenger</i>	<i>Cargo</i>
UN 3480 Lithium ion batteries	5 kg	35 kg

Packing Instruction 965

IA.2 Additional requirements

- Lithium ion cells and batteries must be protected against short circuits.
- Lithium ion 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 ion 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.
- Batteries manufactured after 31 December 2011 must be marked with the Watt-hour rating on the outside case.

Lithium ion cells and batteries prepared for transport on passenger aircraft

Lithium ion cells or batteries must be designed or packaged to preclude propagation in the case of a thermal runaway event in a single cell or battery during transport. The criteria to be met at the cell/battery or package level is as follows:

- a) no hazardous amount of flame is allowed outside the package;
- b) the external surface temperature of the package cannot exceed the amount that would ignite adjacent packing material or cause batteries or cells in adjacent packages to go into thermal runaway (100°C);
- c) no hazardous fragments can exit the package and the package must maintain structural integrity; and
- d) the quantity of flammable vapour must be less than the amount of gas that when mixed with air and ignited could cause a pressure pulse in a [2.83 m³] volume that could dislodge the overpressure panels of the compartment or damage the cargo liner (3.45 kPa); or
- e) lithium ion cells and batteries must be offered for transport at a state of charge (SoC) not to exceed 30¹ percent of their rated design capacity.

¹ The SoC limit is based on test data indicating that reducing the cell or battery state of charge to not more than 30% prevents thermal runaway propagation for commonly carried cells. A shipper may ship cells and/or batteries at a SoC of greater than 30% provided that the shipper can demonstrate by testing that cells and/or batteries as packaged for transport at the intended SoC meets the conditions set out in a) to d) above when one cell in the package is forced into thermal runaway.]

IA.3 Outer packagings

Boxes

Aluminium (4B)
 Fibreboard (4G)
 Natural wood (4C1, 4C2)
 Other metal (4N)
 Plastics (4H1, 4H2)
 Plywood (4D)
 Reconstituted wood (4F)
 Steel (4A)

Drums

Aluminium (1B2)
 Fibre (1G)
 Other metal (1N2)
 Plastics (1H2)
 Plywood (1D)
 Steel (1A2)

Jerricans

Aluminium (3B2)
 Plastics (3H2)
 Steel (3A2)

Packing Instruction 965

IB. SECTION IB

Quantities of lithium ion cells or batteries that exceed the allowance permitted in Section II, Table 965-II 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 provisions of Part 6.

Lithium ion 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 "965" required by 5;4.1.5.8.1 a) must be supplemented with "IB". All other applicable provisions of Part 5;4 apply.

Lithium ion 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 the following:

- 1) for lithium ion cells, the Watt-hour rating (see the Glossary of Terms in Attachment 2) is not more than 20 Wh;
- 2) for lithium ion batteries, the Watt-hour rating is not more than 100 Wh;
 - the Watt-hour rating must be marked on the outside of the battery case except for those batteries manufactured before 1 January 2009;

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).

Table 965-IB

Contents	Net quantity per package	
	Passenger	Cargo
Lithium ion cells and batteries	10 kg	10 kg

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 marked with the appropriate lithium battery mark (Figure 5-3) in addition to the Class 9 hazard label.

Note.— Figure 5-32 and the provisions for a lithium battery handling label as contained in the 2015-2016 Edition of these Instructions may continue to be used until 31 December 2018.

[Lithium ion cells and batteries prepared for transport on passenger aircraft]

[Lithium ion cells or batteries must be designed or packaged to preclude propagation in the case of a thermal runaway event in a single cell or battery during transport. The criteria to be met at the cell/battery or package level is as follows:

- a) no hazardous amount of flame is allowed outside the package;
- b) the external surface temperature of the package cannot exceed the amount that would ignite adjacent packing material or cause batteries or cells in adjacent packages to go into thermal runaway (100°C);
- c) no hazardous fragments can exit the package and the package must maintain structural integrity; and
- d) the quantity of flammable vapour must be less than the amount of gas that when mixed with air and ignited could cause a pressure pulse in a [2.83 m³] volume that could dislodge the overpressure panels of the compartment or damage the cargo liner (3.45 kPa); or
- e) lithium ion cells and batteries must be offered for transport at a state of charge (SoC) not to exceed 30¹ percent of their rated design capacity.

¹ The SoC limit is based on test data indicating that reducing the cell or battery state of charge to not

Packing Instruction 965

more than 30% prevents thermal runaway propagation for commonly carried cells. A shipper may ship cells and/or batteries at a SoC of greater than 30% provided that the shipper can demonstrate by testing that cells and/or batteries as packaged for transport at the intended SoC meets the conditions set out in a) to d) above when one cell in the package is forced into thermal runaway.]

IB.3 Outer packagings

Boxes

Drums

Jerricans

Strong outer packagings

II. SECTION II

Lithium ion cells and batteries, when complying with Section II of this Packing Instruction, are only subject to the following additional provisions of these Instructions:

- Part 1;2.3 (General — Transport of dangerous goods by post);
- Part 5;1.1 g) and j) (Shipper's responsibilities — General requirements);
- Part 7;4.4 (Operator's responsibilities — Reporting of dangerous goods accidents and incidents);
- Part 8;1.1 (Provisions concerning passengers and crew — Dangerous goods carried by passengers or crew); and
- Paragraph 2 of this packing instruction.

Lithium ion 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 the following:

- 1) for lithium ion cells, the Watt-hour rating (see the Glossary of Terms in Attachment 2) is not more than 20 Wh;
- 2) for lithium ion batteries, the Watt-hour rating is not more than 100 Wh;
 - the Watt-hour rating must be marked on the outside of the battery case except for those batteries manufactured before 1 January 2009.

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 965-II

<i>Contents</i>	<i>Lithium ion cells and/or batteries with a Watt-hour rating not more than 2.7 Wh</i>	<i>Lithium ion cells with a Watt-hour rating more than 2.7 Wh, but not more than 20 Wh</i>	<i>Lithium ion batteries with a Watt-hour rating more than 2.7 Wh, but not more than 100 Wh</i>
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
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 965-II must not be combined in the same package.

Packing Instruction 965

II.2 Additional requirements

- Cells and batteries must be packed in inner packagings that completely enclose the cell or battery then placed in a strong rigid 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 marked with the appropriate lithium battery mark (Figure 5-3).
 - the package must be of such size that there is adequate space to affix the mark on one side without the mark being folded.

Note.— Figure 5-32 and the provisions for a lithium battery handling label as contained in the 2015-2016 Edition of these Instructions may continue to be used until 31 December 2018.

- A shipper is not permitted to present for transport more than two (2) packages prepared according to this section in any single consignment.
- The words "lithium ion batteries, in compliance with Section II of PI965" must be placed on the air waybill, when an air waybill is used.
- Packages ~~and overpacks~~ of lithium ion batteries prepared in accordance with the provisions of Section II must be offered to the operator separately from cargo which is not subject to these Instructions and must not be loaded into a unit load device before being offered to the operator.
- 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

<i>Boxes</i>	<i>Drums</i>	<i>Jerricans</i>
Aluminium	Aluminium	Aluminium
Fibreboard	Fibre	Plastics
Natural wood	Other metal	Steel
Other metal	Plastics	
Plastics	Plywood	
Plywood	Steel	
Reconstituted wood		
Steel		

II.4 Overpacks

- ~~Not more than [four (4)] packages may be placed into an overpack and the overpack must not contain other packages containing dangerous goods]. When packages are placed in an overpack, the lithium battery mark required by this packing instruction must either be clearly visible or the mark must be affixed on the outside of the overpack and the overpack must be marked with the word "Overpack".~~

Packing Instruction 968

Cargo aircraft only for UN 3090

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II. SECTION II

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II.2 Additional requirements

- Cells and batteries must be packed in inner packagings that completely enclose the cell or battery, then placed in a strong rigid 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 marked with the appropriate lithium battery mark (Figure 5-3) and the cargo aircraft only label (Figure 5-28).
 - the package must be of such size that there is adequate space to affix the mark on one side without the mark being folded.
 - the cargo aircraft only label must be located on the same surface of the package near the lithium battery handling mark, if the package dimensions are adequate.

Note.— Figure 5-32 and the provisions for a lithium battery handling label as contained in the 2015-2016 Edition of these Instructions may continue to be used until 31 December 2018.

- A shipper is not permitted to present for transport more than two (2) packages prepared according to this section in any single consignment.
- The words "lithium metal batteries, in compliance with Section II of PI968 — cargo aircraft only" or "lithium metal batteries, in compliance with Section II of PI968 — CAO" must be placed on the air waybill, when an air waybill is used.
- Packages ~~and overpacks~~ of lithium metal batteries prepared in accordance with the provisions of Section II must be offered to the operator separately from cargo which is not subject to these Instructions and must not be loaded into a unit load device before being offered to the operator.
- Any person preparing or offering cells or batteries for transport must receive adequate instruction on these requirements commensurate with their responsibilities.

II.4 Overpacks

~~Not more than [four (4)] packages may be placed into an overpack and the overpack must not contain other packages containing dangerous goods. When packages are placed in an overpack, the lithium battery mark and the cargo aircraft only label (Figure 5-28) required by this packing instruction must either be clearly visible or the mark and label must be affixed on the outside of the overpack and the overpack must be marked with the word "Overpack".~~

— END —