



**WORKING PAPER**

**DANGEROUS GOODS PANEL (DGP)  
MEETING OF THE WORKING GROUP OF THE WHOLE**

**Montréal, 15 to 19 April 2013**

**Agenda Item 2: Development of recommendations for amendments to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) for incorporation in the 2015-2016 Edition**

**2.3 : Part 3 — Dangerous Goods List, Special Provisions and Limited and Excepted Quantities**

**SECONDARY LITHIUM BATTERIES**

(Presented by H. Brockhaus)

**SUMMARY**

This paper proposes adding a new special provision in order to enable the safe transport of lithium batteries larger than 35 kg gross mass. This proposal enhances the previous proposal in DGP-WG/12-WP/40 presented and discussed at the meeting of the working group of the whole in October 2012 in Montreal. This working paper is presented to provide additional information and amended proposal details in response to the feedback received in October as documented in DGP-WG/12-WP/54.

Action by the DGP-WG is in paragraph 6.

**1. INTRODUCTION**

1.1 Transport regulations for large lithium ion batteries were discussed at:

- a) DGP Working Groups of the Whole Meetings in Montreal (DGP-WG/12, 15 to 19 October 2012) (DGP-WG/12-WP/40) and in Atlantic City (DGP-WG/11, 4 to 8 April 2011 (DGP-WG/11-WP/50)); and
- b) The Twenty-Third Meeting of the Dangerous Goods Panel in Montreal (DGP/23, 11 to 21 October 2011) (DGP/23-WP/34, see paragraph 5.1.1 of the DGP/23 Report).

1.2 At the last meeting in October 2012 in Montreal, DGP-WG/12-WP/40 was presented and discussed. The report for this meeting stated that there was general support for the request to establish a new special provision. From our point of view, the extract from the DGP-WG/12 report (DGP-WG/12-WP/54) is as follows:

“3.5.1.2 There was general support for the amendment in that it would provide a uniform way of transporting what was now being transported through State approvals. It was felt, however, that the amendment was not yet mature enough to be incorporated in the Instructions. Some of the concerns raised were:”

- a) definition of terms used, such as impact resistant, fire and flame resistant and non-combustible;
- b) maximum size permitted per unit load; and
- c) state of charge (SOC).

These items will be further detailed and explained to enable the panel to finally discuss necessary provisions for the transport of single large lithium ion batteries.

1.3 The requirements in the proposed new special provision in Appendix A are based and verified against the latest findings and technological results in flight safety. They reflect the experience gained through the issuance of 179 approvals granted from 2009 to February 2013 by the German national authority for the transport of lithium batteries which were based on Special Provisions A88 and A99. The maximum gross weight of the batteries transported with these approvals is 800 kg. In recent (during this period) years no incident or accident during transport has been recorded or reported.

1.4 This working paper is an amended version of earlier papers presented to the DGP which takes into account the above-mentioned approvals, discussions during previous DGP meetings and input received through DGP/23-WP/34. The proposed new special provision in Appendix A provides clear requirements related to which battery and packaging requirements are applicable for single packed lithium batteries larger than 35 kg gross mass. The requirement for a quality management programme is already adopted in the Technical Instructions.

## 2. TERMS USED

2.1 Terms used in this and earlier working papers intended to describe and explain technical parameters for the battery, the packaging and other regulation details are already widely used in the Technical Instructions in the provisions for lithium batteries, i.e.:

- a) **Strong, impact resistant outer casing.** Used in Packing Instruction 965 to describe the quality of the battery outer casing when the battery is shipped with a non-type approved packaging.
- b) **Fire and flame resistance.** This term is already widely used to describe packaging material properties in approvals in accordance with Special Provisions A99 and A88. Within these approval documents no further specification have been added for e.g. the minimum time a material must resist a certain temperature before showing adverse reactions etc. Therefore we feel that there is already a sufficient level of common sense about the meaning.

- c) **Non-combustible, non-flammable.** These terms are commonly used within the Technical Instructions and other modal regulations to describe the non-flammable nature of packaging material. Only a few materials used for inner dangerous goods packagings are prone to provide these properties in combination with other features like absorbency for liquids. Flammability is defined in places such as paragraph 2.4.1 of the UN Model Regulations and Part 2;4.2.2.1 of the Technical Instructions and can serve as classification criteria for non-flammability.
- d) **Non-conductive.** Packaging material must not be electrically conductive and Ohm resistance must be high enough to prevent from currency and voltage. Special Provision A88 already uses this wording.

Should the panel have persistent objections to the use of the above terms or feel that they are not precise or clear enough to allow consistent handling of dangerous goods, it is recommended that appropriate initiatives be taken at the UNECE.

### 3. WEIGHT LIMITATION OF THE BATTERY OFFERED FOR AIR TRANSPORTATION

3.1 The electrification of vehicles is currently the most important trigger for global battery shipments. The following table outlines approximate weights of battery systems for typical applications.

Vehicle type	Approximate battery capacity	Approximate weight
Full hybrid passenger vehicle	0,5 - 2,0 kWh	25 - 50 kg
Plug in hybrid pass. vehicle	5 - 10 kWh	80 - 150 kg
Full electric pass. vehicles	20 - 35 kWh	200 - 400 kg
Full electric light commercial vehicle	30 - 50kWh	300 – 600 kg

3.2 The majority of actual battery designs on the market or in the development pipeline are below 400 kg gross weight. Upcoming light commercial vehicle (LCV) batteries will exceed the 400 kg weight limit to be in line with customer requirements in urban areas and short-range delivery business.

3.3 The engineering parameters of large lithium ion batteries are described by strong impact resistant waterproof casings to withstand operational conditions and weather exposure when fitted to vehicles. Casings are made from steel sheet metal. Furthermore, additional weight is added by air or liquid coolant systems, sensors and electronics to control the battery functions when in service as well as by internal framing and a separator structure to hold the cells in place. These non-battery active masses represent up to 35% of the total battery mass.

3.4 Consequently, the proposed weight limitation of 400 kg will cover the majority of battery types with air transportation requirements.

3.5 High battery weights do not result in additional transport risks because the cells become larger but still have the same safe behaviour of cells used in lighter batteries, e.g. full hybrid vehicles. Dangerous reverse current is prevented by technical means as required in accordance with Packing

Instruction 965. Therefore, the parallel connection of cells in larger batteries typically used for full electric vehicles has no negative impact on air transport safety.

3.6 The HV battery system voltage is typically between 250 and 350 volts. The number of cells required to achieve this system voltage is approximately between 60 and 90 cells. Higher capacities and Wh ratings are usually achieved by parallel connections of more than one cell.

#### 4. **OVERVIEW OF ALREADY-ISSUED APPROVALS IN ACCORDANCE WITH SPECIAL PROVISIONS A99 AND A88**

4.1 Many approvals have been and continue to be issued to shippers by the national competent authorities. Most of these approvals include common and similar requirements for the battery, the packaging, the documentation and the handling of lithium battery consignments. Typical requirements are:

- a) Packing Group I packaging for the lithium battery;
- b) one single battery per package only; and
- c) full description of affected battery in approval document to ensure that only this battery type is covered.

These requirements are reasonably less stringent than those proposed in this working paper. Until now no issues, safety concerns or accidents have been reported for consignments in line with Special Provision A99 or A88 approvals provided. Consequently, it is recommended to accept the provisions as proposed to be sufficient for lithium ion battery transportation.

4.2 Typical packaging solutions for single battery shipments of prototype, non-38.3 tested batteries are shown in Appendix C. To meet the requirements of Special Provision A88 and further requirements as per State approval, the packaging consists of a Packing Group I metal outer box with inner packaging consisting of non-flammable, non-conductive foam pads to prevent the battery from inadvertent movement and non-flammable, non-conductive suction material, such as loose Vermiculite, Vermiculite cushions or form pressed Vermiculite.

4.3 SOC safety impact during transport of lithium ion batteries and cells is subject to on-going discussion. The types of cells and batteries which were successfully tested according to the UN Manual of Test and Criteria, Part III, subsection 38.3 have shown adequate safety under various transport relevant stress also at 100% SOC (i.e. fully charged). Furthermore, a specific SOC is not generally required when prototype, non-tested batteries are shipped in accordance with Special Provision A88. Therefore, we still propose not to stipulate a reduced SOC in the new special provision.

4.4 The following items have been discussed on battery and regulator expert level and comments were developed to respond to previously raised comments and concerns from the DGP:

##### 4.4.1 **UN 38.3 testing at 100% SOC**

4.4.1.1 Testing of lithium ion batteries according to UN 38.3 provides the full test programme to be carried out with fully charged batteries (SOC = 100%). Besides that, the batteries to be used for the testing must have already run through 25 full electrical cycles (0 to 100% SOC) before beginning with the

test procedure at the final SOC of 100%. The cycling ensures that battery type related potential weaknesses will be identified during the subsequent testing. This is especially true for the mechanical part of the test programme, e.g. mechanical shock and vibration.

#### 4.4.2 **Quality management programme**

4.4.2.1 According to Part 2;9.3 of the Technical Instructions, lithium cells and batteries must be manufactured under a quality management programme. This ensures that the lithium ion battery products are identical in design, construction, power performance and mechanical properties to the samples used for the UN 38.3 testing. This enables a high standard for transportation safety.

#### 4.4.3 **Influence of SOC on risk of catching fire**

4.4.3.1 Lithium ion batteries with a low SOC and those with a high SOC do not differ in cases where the battery package catches fire from an external source. In cases where the battery catches fire from a fire or a heat source in its vicinity, it is mostly the organic electrolyte and the carbon-based materials in the electrochemical cells which nourish the fire and the thermal event.

#### 4.4.4 **Conclusion**

4.4.4.1 Based on these assumptions, a legal provision for SOC is not necessary for the safe transport of lithium ion batteries. Furthermore, the general requirement to transport under reduced SOC may lead to the overall impression that cells and batteries are generally safer under those conditions. This may easily result in losing track to fulfil the high design standard for cells and batteries needed to fulfil the harsh conditions tested according to UN38.3.

4.4.4.2 Any requirements for a defined SOC may lead to situations where the actual level of SOC of a battery is measured incorrectly prior to transportation or even where the measurement is manipulated or where the declaration does not meet the actual battery status to overcome the significant operational roadblock to meeting the defined SOC and operational difficulties with measuring the SOC outside well-equipped laboratories or workshops.

### 5. **LABELING AND MARKING**

5.1.1 As the successful passing of the UN 38.3 test programme with a 100% charged battery is regarded a very reliable proof of the safety for all kinds of Lithium ion battery transportation, it is recommended to label all batteries which have successfully passed that test procedure with a corresponding mark. Labels should be fixed directly on the housing of the battery system and on its transportation packaging as well. This will improve the ability for operations (OPS) personnel to recognize a quality battery.

6. **ACTION BY THE DGP-WG**

6.1 The DGP-WG is invited to:

- a) add a new special provision as shown in Appendix A to this working paper; and
  - b) issue an addendum to the 2013/2014 Edition of the Technical Instructions which would incorporate the new special provision shown in Appendix A.
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APPENDIX A

PROPOSED AMENDMENT TO THE 2015-2016 EDITION OF  
THE TECHNICAL INSTRUCTIONS

Part 3  
DANGEROUS GOODS LIST,  
SPECIAL PROVISIONS AND  
LIMITED AND EXCEPTED QUANTITIES

Chapter 3  
SPECIAL PROVISIONS

1. NEW SPECIAL PROVISION AXXX:

<u>TIs</u>	<u>UN</u>
<u>AXXX</u>	<p><u>Irrespective of the quantity limits for cargo aircraft specified in column 13 of Table 3-1 and in Section I of Packing Instructions 965, a lithium ion or lithium polymer battery (UN 3480) with a mass exceeding 35 kg that meets the requirements of this special provision may be offered for transport on cargo aircraft only, if the following requirements are met:</u></p> <p><u>a) requirements for batteries:</u></p> <p><u>1) each cell and each battery must be the type proven to meet the requirements in 2;9.3.1:</u></p> <hr/> <p>See listing in Appendix B</p> <p><u>2) each battery must have a strong, impact-resistant outer casing:</u></p> <p><u>3) each battery or battery assembly must provide a means of fully disconnecting the external battery terminals from the internal electrical components (e.g. service disconnect, circuit breaker, removable fuse):</u></p> <p><u>4) the battery must be clearly marked as having passed all applicable tests in accordance with the UN Manual of Tests and Criteria, Part III, subsection 38.3:</u></p> <hr/> <p>Proposal of such a marking is shown in Appendix D</p> <p><u>b) packing requirements</u></p> <p><u>1) lithium ion or lithium polymer batteries must be protected against short circuits;</u></p> <p><u>2) the packaging must be UN type approved and meet the requirements of Packing Group I;</u></p> <p><u>3) packagings must be fire and flame resistant:</u></p> <hr/> <p>To be discussed: Whether a specific packaging material is to be specified or whether a packaging material coating is acceptable.</p> <p><u>4) only one battery per packaging is permitted:</u></p> <p><u>5) the battery must be surrounded by cushioning material that is non-combustible and non-conductive and must be secured to prevent inadvertent movement during transport:</u></p>

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6. in addition to the requirements in 5:2 of these Instructions, the packaging must be marked with the words "Single battery per package, transport in accordance with Special Provision Axxx". Letters and numerals must be at least 12mm high. This marking must be reproduced on an overpack, if used;

7. in addition to the requirements in 5:2 of these Instructions, the packaging must be clearly marked to indicate that the battery has passed all applicable tests in accordance with the UN Manual of Tests and Criteria, Part III, subsection 38.3.

Proposal of such a marking is shown in the appendix D

c) documentation and handling requirements

1) the use of Special Provision Axxx must be documented on the transport document in the "Additional Handling Information" field with the following sentence:

"Single battery per package, transport in accordance with Special Provision Axxx"

All other requirements of these Instructions regarding marking, labelling, documentation and handling must apply.

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2. **AMENDMENT TO TABLE 3-1**

A new special provision assigned to **Lithium ion batteries** (UN 3480) in column 7 of in Table 3-1 should be added:

Name	UN No.	Class or division	Subsidiary risk	Labels	State variations	Special provision	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	5	6	7	8	9	10	11	12	13
Lithium ion batteries (including lithium ion polymer batteries)	3480	9		Miscellaneous		A51 A88 A99 A154 A164 A183 Axxx	II	E0	See	965	See	965

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## APPENDIX B

### 1. Listing of requirements for lithium cells and batteries according to ICAO Technical Instruction Part 2;9.3.1

The adopted DGP/23-WP/5 implements a quality management program for the manufacturing of lithium batteries. The text in this WP must therefore not include provisions for the quality management program.

Lithium battery provisions have been summarized in Part 2, Chapter 9.3. This text has been released with the ICAO T.I. in 2013. These requirements are not part of the packing instructions PI965-PI970 and therefore apply to all lithium batteries offered for transport including those transported according to special provisions unless stated otherwise (e.g. A88).

### 9.3 LITHIUM BATTERIES

9.3.1 Cells and batteries, cells and batteries contained in equipment, or cells and batteries packed with equipment, containing lithium in any form must be assigned to UN Nos. 3090, 3091, 3480 or 3481 as appropriate. They may be transported under these entries if they meet the following provisions:

- a) each cell or battery is of the type proved to meet the requirements of each test of the UN *Manual of Tests and Criteria*, Part III, sub-section 38.3. 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, sub-section 38.3 may continue to be transported;

*Note.— Batteries must be of a design type proved to meet the testing requirements of the UN Manual of Tests and Criteria, Part III, sub-section 38.3, irrespective of whether the cells of which they are composed are of a tested design type.*

- b) each cell and battery incorporates a safety venting device or is designed to preclude a violent rupture under conditions normally incident to transport;
- c) each cell and battery is equipped with an effective means of preventing external short circuits;
- d) each battery containing cells or series of cells connected in parallel is equipped with effective means as necessary to prevent dangerous reverse current flow (e.g. diodes, fuses, etc.);
- e) cells and batteries must be manufactured under a quality management programme that includes:
  - 1) a description of the organizational structure and responsibilities of personnel with regard to design and product quality;

- 2) the relevant inspection and test, quality control, quality assurance, and process operation instructions that will be used;
- 3) process controls that should include relevant activities to prevent and detect internal short circuit failure during manufacture of cells;
- 4) quality records, such as inspection reports, test data, calibration data and certificates. Test data must be kept and made available to the appropriate national authority upon request;
- 5) management reviews to ensure the effective operation of the quality management programme;
- 6) a process for control of documents and their revision;
- 7) a means for control of cells or batteries that are not conforming to the type tested in accordance with Part III, sub-section 38.3 of the *UN Manual of Tests and Criteria*;
- 8) *training* programmes and qualification procedures for relevant personnel; and
- 9) *procedures* to ensure that there is no damage to the final product.

*Note.— In-house quality management programmes may be accepted. Third party certification is not required, but the procedures listed in 1) to 9) above must be properly recorded and traceable. A copy of the quality management programme must be made available to the appropriate national authority upon request.*

## 2. **Listing of test requirements of the *UN Manual of Test and Criteria*, Part3, subsection 38.3**

Cells and batteries of a type proven to meet the requirements of each test in the *UN Manual of Test and Criteria*, Part III, section 38.3 have passed the following tests.

- Test T.1: Altitude simulation - applicable to cells and batteries
- Test T.2: Thermal test - applicable to cells and batteries
- Test T.3: Vibration - applicable to cells and batteries
- Test T.4: Shock - applicable to cells and batteries
- Test T.5: External short circuit – applicable to cells and batteries
- Test T.6: Impact – applicable to cells or component cells
- Test T.7: Overcharge - applicable to batteries
- Test T.8: Forced discharge – applicable to cells

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### APPENDIX C

Typical packaging method for the shipment of a non-tested prototype lithium ion battery in accordance with Special Provision A88.

A „Zarges“ aluminum outer packaging is used together with non-conductive, non-combustible foam pads for secure positioning of battery in box. Additionally Vermiculite cushions and pressed Vermiculite pads are applied. Finally this is covered by a layer of loose Vermiculite



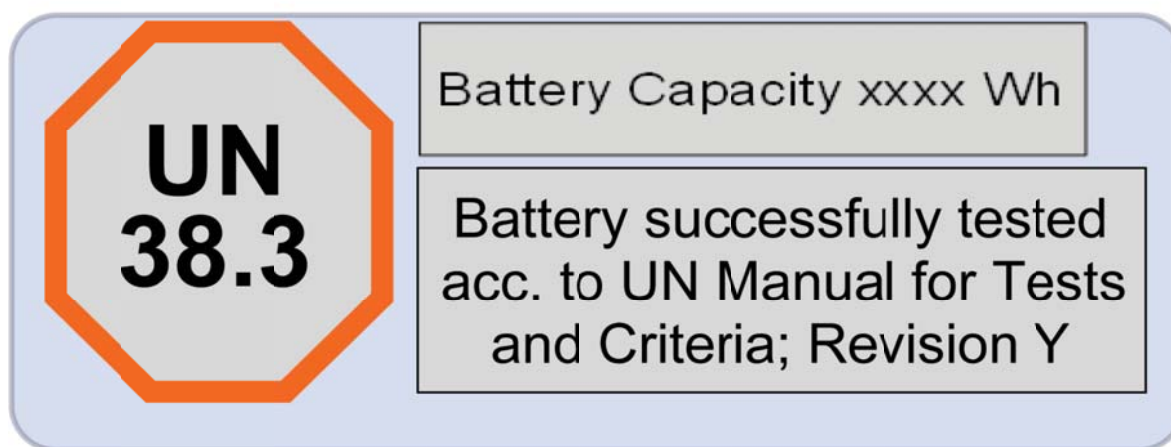


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## APPENDIX D

Proposal for a battery and outer packaging marking to indicate that the lithium ion battery shipped by air has passed all applicable tests in accordance with the UN Manual of Tests and criteria, Part 3, subsection 38.3.

Proposal follows the approach as outlined in document UNECE TDG ST/SG/AC.10/C.3/2011/35, issued by the United States of America



The report ST/SG/AC.10/C.3/80 of that respective meeting included comments as per attached extract:

### “Lithium battery mark

*Document:* ST/SG/AC.10/C.3/2011/35 (United States of America)

42. The proposal to require a mark on cells to indicate that the cell model had successfully passed the required design type tests was widely supported. However, some delegations expressed reservations with respect to the added value of such a mark from the point of view of safety in the absence of appropriate steps to ensure traceability and enforcement. Others considered that the mark would impose additional verification responsibilities.

43. Following an exchange of opinions on the subject, the Sub-Committee decided that in principle such a mark should be developed, and the expert from the United States was invited to reformulate the proposal, taking into consideration the comments made during the discussion.”

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## APPENDIX E

Example of transport conditions of Lithium cells & batteries by **sea transport** is exemplary shown to provide an understanding of the similarities between both transport modes.

Conditions for both transport modes are:

- Cells, batteries and battery assemblies are classified as dangerous goods
- For regular transport only allowed when tested in accordance with 38.3
- Those which are not successfully tested in line with 38.3 can only be transported under special conditions
- Packaging is defined
- Total amount of goods per transport unit is not defined
- In case of emergency, response is limited to onboard measures

Millions of cells and batteries are transported in sea containers with high container payloads

Transport Mode	Cells /Box	Boxes /Pallet	Cells /Pallet	Pallets /Container	Cells /Container	Box & Pallet Size (mm)
Air	16	20	320	--	--	490*386*260 1100*800*1450
Sea 40ft.	16	24	384	24	9,216	490*386*260 1100*800*1710



The theoretical endangerment is not caused

- by the mass of a load but by single live cells or batteries
- by the self-ignition of the lithium in lithium ion batteries, but by development of heat caused by electric current and ignition of the flammable materials

Therefore a restriction of load per cargo unit does not reduce the likelihood for the risk to happen.

REMEMBER: This is a sea transport example only and shall not serve as the role model for air carriage/

— END —