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

TRANSPORT OF LITHIUM ION BATTERIES AS CARGO BY AIR

(Presented by RECHARGE)

SUMMARY

This information paper addresses DGP/25-WP/24 and the formal proposal to forbid the transport of lithium ion batteries on passenger aircraft.

Action by the DGP: The DGP is invited to consider the conditions allowing for the transport of lithium ion batteries on passenger aircraft as presented in this information paper.

1. INTRODUCTION

1.1 As indicated in the introduction of DGP/25-WP/24, "high density packaging" of lithium ion batteries (UN 3480) have been identified as requiring specific attention because of the risk of thermal runaway propagation.

1.2 The various types of lithium batteries can represent different hazards in transport, according their chemistry and the way they are packaged. The appendix to this document is introducing the main categories of Li batteries that are transported by air, and some recommendations for transport, based on the examples of safety results of cells/batteries thermal runaway.

1.3 Based on these recommendations, it is proposed, as a transitory measure to allow for transport of lithium-ion batteries in cargo of passenger aircrafts, compliance with one of the following conditions:

1.3.1 To require from shippers that the state of charge of shipped cells/batteries be kept at or below [40%].

1.3.2 Alternatively, to require that shippers who wish to ship at a higher state of charge than [40%] supply a declaration that the thermal runaway propagation risk is controlled for cells /batteries as packaged for transport. This risk control declaration shall be based on evidence arising from tests conducted at said higher state of charge. The criteria for success shall be the fulfilment of the criteria identified in the Third International Multidisciplinary Lithium Battery Transport Coordination Meeting (held in Montréal, 28 to 30 July 2015).

1.4 It is considered that the responsibility of the shipper for this declaration is similar to the existing one relative to the qualification for transport according UN 38.3 *Manual of Tests and Criteria*. In a similar way, the evidence of the tests results or of the state of charge control should be available on demand.

1.5 The implementation of a standard defining the testing conditions for this risk control declaration is necessary to allow for the control and harmonisation of the testing results. Until this standard is available, it is proposed that the quality of the evidence presented is assessed by the manufacturer, or the operator taking the responsibility of the transport during the safety assessment, or a third party.

2. DISCUSSION

2.1 The DGP is invited to consider the conditions allowing for the transport of lithium ion batteries on passenger aircraft as presented in the appendix to this information paper.

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APPENDIX

RECHARGE POSITION FOR THE TRANSPORT BY AIR OF LITHIUM BATTERIES

1. Setting the scene: what products are we talking about?

Under the word "Li-battery", several very different products can be found. They all have different designs, contained energy, number of shipments they represent and quantity of units per shipment …

1st segment: Li button cells:

These products are essentially Li-primary batteries (a large part of the market is Li-MnO2 chemistry). Manufacturing of the cells occurs mostly in Asia, but as well in Europe and the United States.

When no adequate land or sea options are available, these are shipped by air.

a) From cell manufacturers to OEMs in **BULK of several thousand units:**

   1) from Asia to the United States and from Asia to Europe by boat, except when required by logistic urgency, they are shipped by air;
   2) within United States by cargo aircraft;
   3) within EU by road;

b) From OEM to end users and distribution channels in, **in quantities ranging from a few units to a few hundred units**, sometimes by air.

2nd segment: Small Li-primary cells/batteries for industrial, professional and consumer uses (< 1g Li/cell or 2g Li/battery)

These products are used both for the consumer market and to power professional and industrial equipment such as utility metering devices (for water, gas and electricity). Manufacturing occurs in Asia, North America and Europe.

Several technologies are used for these markets: Li-MnO2, Li-FeS2 , Li-SO2 and Li-SOCl2.

When no adequate land or sea options are available, these are shipped by air:

a) From cell Manufacturers to Pack-makers, OEMs and Distribution channels **in BULK of several thousand units** (as cells/batteries),
b) From Pack-makers, OEMs and Distribution channels to End users **in quantities ranging from a few units to a few hundred units** (as cells/batteries).

3rd segment: Small Li-rechargeable cells/batteries (<20 Wh/cell or <100 Wh/battery, < 1g Li/cell or <2g Li/battery)

These products are used to power many equipment such as laptops, power tools, cell and smart phones Manufacturing of the cells occurs mostly in Asia, but the assembly into batteries (battery packs) occurs across the world.

When no adequate land or sea options are available, these are shipped by air:

a) From Manufacturers to Pack makers and OEMS **in BULK of several thousand units** (as cells/batteries)
b) From Pack makers and OEMs to Distribution channels and End users **in quantities ranging from a few units to a few hundred units** (only assembled in batteries).

4th segment: large Li-rechargeable cells/batteries for industrial and automotive uses, as well as energy storage in homes

These products are used to supply back-up or motive power to a wide range of industrial equipment (trains, aircrafts, space, telecom networks and IT systems, forklifts …) as well as electric bicycles and EV/HEV vehicles, and as energy storage units in buildings/grid networks. Manufacturing occurs mostly in Asia, and also to some extent in Europe and North America.

When no adequate land or sea options are available, these are shipped by air:

a) From Manufacturers to Pack makers and OEMs in BULK of several thousand units as large cells (for small cells, see segment 2), when no adequate land or sea solutions are available),
b) From Manufacturers and Pack makers to OEMs and End users, shipping occurs in quantities ranging from a few units to a few hundred units (as modules/batteries).

2. Good practices applied by industry for safe shipment

Based on the type of product considered, the risk can be addressed adequately in different ways. For this reason it is necessary to consider the existing good shipment practices implemented by industry, and focus on improvements where necessary.

1st segment: Li button cells:

Safety test data of button cells have demonstrated the limited impact of incidents during transport, such as short circuits, mechanical crushing or other…

Proposals for transport:

We support the proposal to distinguish lithium metal button cells from other types of lithium metal cells. However, we do not believe lithium metal button cells should be subject to any additional restrictions or new regulatory requirements.

We do not support the proposed change in the exceptions for small lithium cells/batteries shipped by air (sections IB and II of Packing Instruction 965):

- The section II is not only used for the transport of small quantities, but also for the transport of large quantities of button cells. Its elimination would have a major effect on industry,
- In addition, the proposal describes the consolidation of IA and IB/II: this means all types of batteries would be fully regulated, along with additional requirements. For example, the additional drop test proposed does not seem to be necessary, as an approved packaging is already required.

Recharge proposes a more effective regulatory change, with a view to prohibit the risk of undeclared high density packaging. Recharge supports the prohibition of over-packing for Sections II lithium cells/batteries, with an exemption for button cells.

2nd segment: Small Li-primary cells/batteries for industrial, professional and consumer uses (< 1g Li/cell or 2g Li/battery)

The safety properties of several examples of these products have been tested. The result is highly dependent on the type of chemistry used: some products have a stable behavior when submitted to a thermal runaway propagation test (see annex 1).

Proposals for transport:

It is clear that these products are only transported fully charged. Nevertheless, when products have been tested, **and proven to have a safe behavior in case of thermal run-away (as shown in annex 1), RECHARGE proposes to maintain the usage of existing applicable UN packaging.**

***3rd segment: Small Li-rechargeable cells/batteries (*<20 Wh/cell or <100 Wh/battery, < 1g/cell or <2g Li/battery)**

These cells are transported generally at a reduced state of charge (typically 50-60% SOC).

Proposal for transport:

Recharge supports PRBA's position.

4th segment: Large Li-rechargeable cells/batteries for industrial and automotive uses, as well as energy storage in homes

These products are largely based on Li-ion or lithium polymer chemistries. Nevertheless, the safety properties do not only depend on the chemistry type, but are also highly dependent on the product design: particularly, modules and battery design may represent excellent protection in case of thermal runaway of one cell. Testing results to support this are presented in annex 2. As indicated in the tests presented, a safe behavior is obtained with a SOC of 60%.

It is important to allow for a minimum SOC adapted to the logistics chain possible constraints. Self-discharge usually comes from the electronics, and depends on each system developed by the manufacturer. As 2% to 3% monthly of self-discharge may be observed, a 15% SOC would allow for a short logistical chain (less than 5 month), which is often not fit for purpose. Applying such a too low SOC would require a lengthy redevelopment of new electronics with lower energy consumption during transport. In addition, there is in general no practical mean to change the SOC in the supply chain (no technical equipment available for charging).

Proposal:

Recharge proposes to ship large lithium ion cells/batteries at a reduced state of charge:

Most of the products are transported for safety reason at an adapted 50 to 60% SOC. According to the testing results, such a level of SOC is efficient in avoiding the risk of thermal runaway propagation.

If, as part of temporary measures, a mandatory SOC for transportation was proposed, Recharge would support the setting of a SOC for transportation at [40%].

However Manufacturers or Pack makers who wish to ship at a higher SOC shall be allowed to do so provided they can demonstrate and certify to the airline company by means of testing results that there is no propagation of thermal runaway and no release of flames in case of a cell runaway incident in the packaged goods of their particular shipment.

Controlling the SOC after the manufacturer has shipped the product is an issue which may need to be addressed in the standard in development.

Packaging requirements.

Concerning the packaging, it is proposed to consider 2 strategies to comply with the criteria developed for the testing standard:

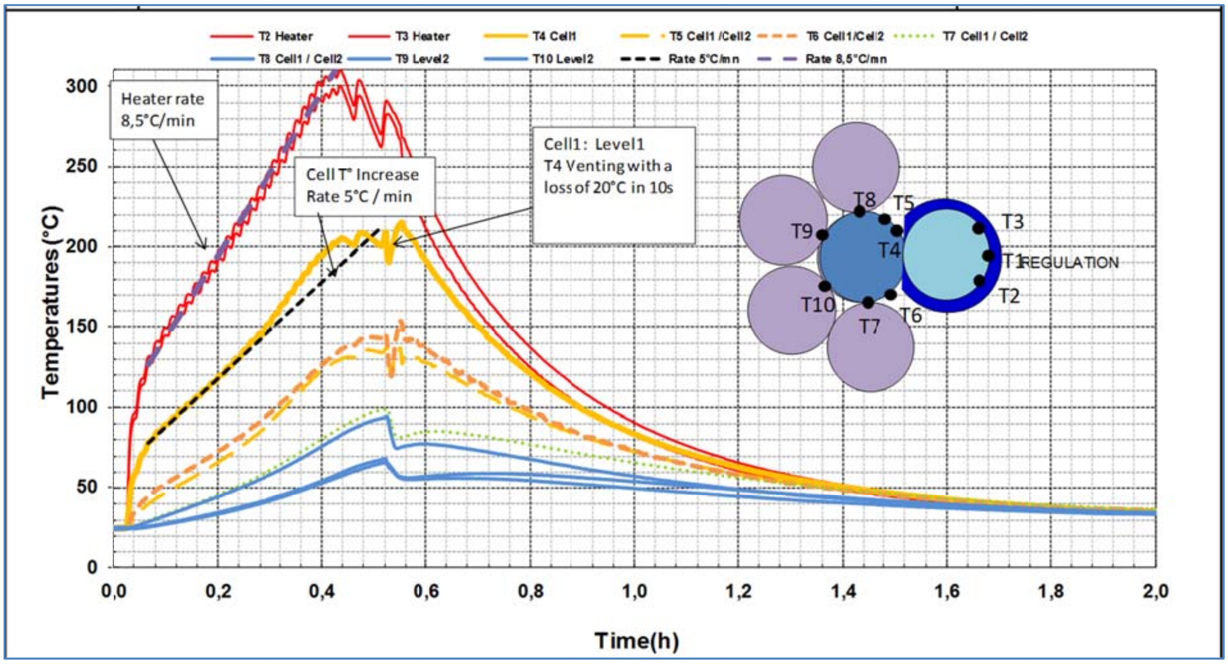
— Comprehensive packaging: this strategy is based on the ability of the package to limit the thermal run-away propagation or contain its consequences. It is applicable particularly to high density packaging.

— Low density packaging: this strategy consists in reducing the cells/batteries density by weight or by volume in the packaging, in order to avoid the risk of thermal runaway propagation. It is proposed to develop conditions making possible the transport in low density packaging, allowing for higher SOC: A simple calculation provided by the shipper or the manufacturer, indicating the ratio of cells relative to packaging (as in individual carton box) and providing the maximum acceptable Wh/liter or Wh/kg should be sufficient.

— RECHARGE considers that qualified packaging corresponding to both strategies should be accepted for transport.

ANNEX 1: ***Tests on 2nd segment: Small Li-primary cells/batteries for industrial and professional uses, and some consumer segments (higher power and energy)***

Propagation test on Li-SOCl2 D size cells: no thermal run-away propagation to the surrounding cells.



ANNEX 2: ***Tests on 4th segment: large Li-rechargeable cells/batteries for industrial and automotive uses, as well as energy storage in homes***

1. Large cells Li-ion (>50 AH, NCA chemistry)

Test: internal short circuit simulated through a pin test with a 1mm pin which perforate the 2 last external turns of the jelly roll.

Results provide the following information:

SOC	Release of flames	Sparks in the fumes
100%	YES	YES
80%	YES	YES
60%	NO	NO

2. Large cells Li-ion (>30 Ah, NCA chemistry)

Test: external short-circuit with a resistance of 0.3 mΩ

Results provide the following information:

SOC	Temperature of the cell beginning of test	Mode of reaction	Release of flame	Sparks in the fumes	Temperature surface of the cell (max)
100%	20°C to 30°C	Runaway	YES	YES	370 to 460°C
80%	20°C	Venting only	NO	NO	130 to 140°C
60%	20°C	Venting only	NO	NO	120 to 130°C
60%	50°C	Venting only	NO	NO	120 to 125°C

3. Electrical Cabinet filled with 6 battery modules (NCA chemistry, 15kW)

This type of product has been designed with the following features:

— **Non propagation of the thermal runaway between cells** in case of an internal short circuit of one cell

— Release of gas at a specific location (in this example orientation of the gas release at the top above the cabinet)

This cabinet is an assembly of 6 modules.

Tests were performed by triggering an internal short circuit with a small heater inside one cell of aone module which is surrounded by 2 other modules, one above and one below. Tested states of charge were 60, 80 and 100%. Modules were heated +45°C at the beginning of the test.

The results demonstrate that it is possible to so design a battery that:

— Whatever the state of charge:

1) <u>There is no propagation of the thermal runaway</u> to neighboring cells,

2) <u>Gas is released in a controlled area</u> (reduced size and localized area, here the top of the cabinet only),

— For a state of charge below 60%, there is no flame emission.

Table of data below:

SOC	Release of flame	Temperature on the wall of the cabinet (in the area of the gas conduction) Bottom/Middle/Top in °C
100%	YES	130/100/40
80%	NO	130/76/-
60%	NO	80/50/40

The test results prove the absence of risk for thermal runaway propagation from one cabinet to another when several cabinets are transported together in the same consignment.

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