Lithium Batteries in Multimodal Transport
Ground, sea and air transport of Lithium-batteries

08/31/2010 - WORKSHOP ON TRANSPORT REGULATION FOR USED LITHIUM BATTERIES, Bruessel

Rainer Kern (SB LiMotive); Hans-Jürgen Niegel (Daimler AG)
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Introduction
Li-ion Batteries for automotive Applications

- Modular concept: Cell ⇒ Module ⇒ Battery System (Battery Pack)

- Weight and volume of automotive batteries much higher than for consumer applications. E.g.:
  - HEV Battery system 5 kg – 25 kg
  - EV Battery system 200 kg – 400 kg
Multimodal transport of new, used and defect automotive batteries including batteries integrated in vehicles is an important topic for the electrification of the worldwide automotive market.
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### Legal basis for the transport of Lithium-batteries

#### Lithium-batteries (type)

<table>
<thead>
<tr>
<th>Shipping labeling / description</th>
<th>UN No.</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium-ion-batteries (including Lithium-ion-polymer-batteries)</td>
<td>UN3480</td>
<td>Secondary Lithium-batteries (rechargeable)</td>
</tr>
<tr>
<td>Lithium-ion-batteries (including Lithium-ion-polymer-batteries) packed WITH equipment</td>
<td>UN3481</td>
<td></td>
</tr>
<tr>
<td>Lithium-ion-batteries (including Lithium-ion-polymer-batteries) IN equipment</td>
<td>UN3481</td>
<td></td>
</tr>
<tr>
<td>Lithium-metal-batteries</td>
<td>UN3090</td>
<td>Primary Lithium-batteries (non-rechargeable)</td>
</tr>
<tr>
<td>Lithium-metal-batteries packed WITH equipment</td>
<td>UN3091</td>
<td></td>
</tr>
<tr>
<td>Lithium-metal-batteries IN equipment</td>
<td>UN3091</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** the word "Lithium-batteries" includes all cells and batteries, that contain Lithium in any form.
# Legal basis for the transport of Lithium-batteries

## Overview: regulations for UN 3090 / UN 3480

<table>
<thead>
<tr>
<th></th>
<th>Europe</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![UN logo]</td>
<td>![Lorry]</td>
<td>![Ship]</td>
<td>![Plane]</td>
</tr>
<tr>
<td>Classification</td>
<td>9, II</td>
<td>9, II</td>
<td>9, II</td>
<td>9, II</td>
</tr>
<tr>
<td>Special regulations</td>
<td>9, II</td>
<td>9, II</td>
<td>9, II</td>
<td>9, II</td>
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<tr>
<td>188</td>
<td>188</td>
<td>188</td>
<td>A88</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>230</td>
<td>230</td>
<td>A99</td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>310</td>
<td>310</td>
<td>A154</td>
<td></td>
</tr>
<tr>
<td>348</td>
<td>348</td>
<td>636</td>
<td>A164</td>
<td></td>
</tr>
<tr>
<td>LQ- / EQ-transport</td>
<td>0 / E0</td>
<td>0 / E0</td>
<td>0 / E0</td>
<td>- / E0</td>
</tr>
<tr>
<td></td>
<td>UN 3090</td>
<td>UN 3480</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging regulation</td>
<td>P903</td>
<td>P903</td>
<td>P903</td>
<td>P903</td>
</tr>
<tr>
<td>Amount per package</td>
<td>2,5 kg G</td>
<td>35 kg G</td>
<td>5 kg G</td>
<td>35 kg G</td>
</tr>
<tr>
<td>Limiting amount</td>
<td>333 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Legal basis for the transport of Lithium-batteries

#### Overview: special regulations (SP)

| SP 188 | Transport of small cells / batteries under simplified conditions (max. 20 Wh for cells) |
| SP 230 | Testing and design requirements for cells / batteries |
| SP 310 | Transport of prototypes and small production runs (≤ 100 pieces) |
| SP 348 | From 31.12.11 marking with Watt-hour |
| SP 636 | Used cells / batteries with a gross weight of max. 500 g |
| SP 957 | Transition period for cells / batteries with a production date before 01.01.2003 |
| A 48 | Packaging without UN-specification (only UN3091 / UN 3481) |
| A 88 | Transport of prototypes and small production runs |
| A 99 | Exception for transport of packages with a gross mass > 35 kg (only for UN 3090 / UN 3480) |
| A 154 | Transport of prototypes and small production runs; prohibition of transport of „defect“ cells / batteries |
| A 164 | General requirements for the transport of electrical batteries, cordless devices and vehicles |
Legal basis for the transport of Lithium-batteries

Overview: packaging instructions for Li-ion Batteries

- Packaging group II
- Conditions for batteries in and with equipment
- Conditions for batteries > 12kg

Used batteries with a gross mass > 500g:
- Packaging group II
- Conditions for packages ≤ 30kg

Used batteries with a gross mass ≤ 500g, only for disposal and for collection with other battery types:
- 1H2, 4H2 on packaging group II
- 1A2, 4A on packaging group II with add. Req.
- Conditions for packages ≤ 30kg

General Reg: Test and design requirements according SP 230 UN Rec.

Section I: Fully regulated Li-Ion Batteries
- Packaging group II
- Conditions for batteries > 12kg
- Max. Quantity per package: PAX 5 kg; CAO 35 kg

Section II: Excepted Li-Ion Batteries
- Special conditions for cells ≤ 20 Wh / batteries ≤ 100 Wh
Legal basis for the transport of Lithium-batteries
Decision matrix on the application for UN 3090 / UN 3480

- **UN 3090 Lithium-metal-battery** or **UN 3480 Lithium-ion-battery**

- **Cells / batteries tested according to 38.3 UN-Manual?**
  - **Yes**
    - Li-ion-cell / -battery is conform to SP 230
      - ADR
      - IMDG
      - IATA-DGR
    - Cell / battery is conform to SP 188 / PI 965, Part II IATA (small cell / battery)
      - Yes
        - P 903
          - P 903a
          - P 903b
        - Transportation according requirements of SP 188 / PI 965, part II
      - No
        - P 903
          - P 903a
          - P 903b
          - PI 965, PI
            - PAX ≤ 5 kg G
              - CAO ≤ 35 kg G
                - package > 35 kg G
                  - SP A99
              - Approval federal state authority
            - SP A88
          - Approval federal state authority
    - Transportation as UN 3480, according to the regulations / approvals that have to be applied

- **No**
  - ADR
  - IMDG
  - IATA-DGR
  - SP 310
  - SP 310
  - SP A88
  - Approval federal state authority
  - EXEMPTION according chapter 1.1.2 ICAO T.I. of all involved countries
### Test series acc. to subsection 38.3 UN-manual of Tests and Criteria

<table>
<thead>
<tr>
<th>Test</th>
<th>Li-cell</th>
<th>Li-battery</th>
<th>Testing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Altitude simulation</td>
<td>X</td>
<td>X</td>
<td>No mass loss</td>
</tr>
<tr>
<td>(11.6 kPa at 20 °C ± 5°C)</td>
<td></td>
<td></td>
<td>No leakage</td>
</tr>
<tr>
<td>2. Thermal test</td>
<td>X</td>
<td>X</td>
<td>No venting</td>
</tr>
<tr>
<td>(75 °C / -40°C)</td>
<td></td>
<td></td>
<td>No disassembly</td>
</tr>
<tr>
<td>3. Vibration</td>
<td>X</td>
<td>X</td>
<td>No breakage</td>
</tr>
<tr>
<td>(1 – 8g)</td>
<td></td>
<td></td>
<td>No fire</td>
</tr>
<tr>
<td>4. Shock</td>
<td>X</td>
<td>X</td>
<td>OCV after test not smaller than 90% compared to beginning of test</td>
</tr>
<tr>
<td>(150g / 50 g, 18 times)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. External short circuit</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6. Impact</td>
<td>X</td>
<td>Not required</td>
<td>No disassembly</td>
</tr>
<tr>
<td>(9.1 kg from 0.62m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Overcharge</td>
<td>Not required</td>
<td>X</td>
<td>No fire within 7 days after end of test</td>
</tr>
<tr>
<td>8. Forced discharge</td>
<td>X</td>
<td>Not required</td>
<td></td>
</tr>
</tbody>
</table>

**WITHOUT complete and successful tests a legal transport of batteries from mass production is not possible**
Legal basis for the transport of Lithium-batteries

Decision matrix on the application for UN 3090 / UN 3480

UN 3090 Lithium-metal-battery or UN 3480 Lithium-ion-battery

Regulations for Li-metal-batteries

UN 3090

UN 3480 Lithium-ion-battery, class 9, PG II

Cells / batteries tested according to 38.3 UN-Manual?

<table>
<thead>
<tr>
<th>Yes</th>
<th>Li-ion-cell / -battery is conform to SP 230</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADR</td>
</tr>
<tr>
<td></td>
<td>Cell / battery is conform to SP 188 / PI 965, Part II IATA (small cell / battery)</td>
</tr>
<tr>
<td>Yes</td>
<td>P 903</td>
</tr>
<tr>
<td></td>
<td>P 903a</td>
</tr>
<tr>
<td></td>
<td>package &gt; 35 kg G</td>
</tr>
<tr>
<td></td>
<td>Approval federal state authority</td>
</tr>
<tr>
<td></td>
<td>Transportation as UN 3480, according to the regulations / approvals that have to be applied</td>
</tr>
</tbody>
</table>

No

ADR | IMDG | IATA-DGR

SP 310 | SP 310 | SP A88

Approval federal state authority

Yes | No

EXEMPTION according chapter 1.1.2 ICAO T.I. of all involved countries
Legal basis for the transport of Lithium-batteries
Special provision (SP) 230

SP 230 - general requirements

→ Term contains each kind of cell / battery that contains Lithium, including Lithium-polymer- or Lithium-ion-cells or batteries

Transport of Lithium-cells / -batteries is permitted if:

→ Cell / battery is consistent with a kind / type that has been tested according to UN-manual „Tests and Criteria“, part III subsection

→ Cells / batteries are equipped with protection devices against inner overpressure OR against forced rupture under normal transport conditions

→ Cell / battery is equipped with an active device to prevent outer short circuits

→ Cells connected in parallel or batteries containing parallel connected cells are equipped with an active device to prevent dangerous back currents (e.g. diodes, fuses...)
Legal basis for the transport of Lithium-batteries
Decision matrix on the application for UN 3090 / UN 3480

UN 3090 Lithium-metal-battery or UN 3480 Lithium-ion-battery

Regulations for Li-metal-batteries

UN 3090

UN 3480 Lithium-ion-battery, class 9, PG II

Cells / batteries tested according to 38.3 UN-Manual?

Yes

No

Li-ion-cell / -battery is conform to SP 230

ADR

IMDG

IATA-DGR

Cell / battery is conform to SP 188 / PI 965, Part II IATA (small cell / battery)

Yes

No

Transport according requirements of SP 188 / PI 965, part II

Transportation as UN 3480, according to the regulations / approvals that have to be applied

ADR

IMDG

IATA-DGR

SP 310

SP 310

SP A88

Approval federal state authority

Yes

No

EXEMPTION according chapter 1.1.2 ICAO T.I. of all involved countries
Transport of prototypes and pre-production samples
Special provision (SP) 310

SP 310 – ADR / IMDG-Code

Valid for:

→ UN 3090 / UN 3480 Lithium-cells and -batteries
→ without testing according to subsection 38.3 of the UN-manual
→ Series of production of max. 100 Lithium-cells and -batteries
→ Pre-production prototypes of Lithium-cells and -batteries
→ Transportation exclusively for the purpose of testing

Requirements:

→ Outer package + barrel made of metal, plastic or wallboard
  + box made of metal, plastic or wood
→ Outer package corresponds to packaging group I (X-coding)
→ Each cell / battery packed individually in an inner packages inside of the outer package
→ Usage of non-flammable, non-conductive padding material
7. Transport of prototypes and pre-production samples
7.3 Air transport according to SP A88 – IATA DGR

### Special Provision A88 – IATA-DGR

**Valid for:**
- Prototypes / test model of cells / batteries **without testing** according to subsection 38.3 of the UN-manual

**Requirements:**
- **Approval of the responsible authority** of the country of origin
- **Maximum 24 cells or 12 batteries per package**
- Outer case + barrel made of metal, plastic or wallboard + box made of metal, plastic or wallboard
- Outer case corresponds to **packaging group I (X-coded)**
- Each cell / battery individually packed in an inner packages within the outer case
- Usage of **non-flammable, non-conductive padding material**

**Remark:**
- PAX 5 kg and CAO 35 kg limitation is still valid (Blue pages IATA)
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  › Regulations for defect batteries
  › Regulations for used batteries
  › Identification of tested batteries
Open questions

→ Regulations for used batteries for UN recommendations and for sea transport has to be defined.

Conditions for used batteries may differ:

› Used batteries which have the same quality and safety as new batteries
› Used batteries which are at their end-of-life without further defects
› Used batteries which are defect.
Open questions

→ Defect batteries have to be transported during their life time for recycling as well as for analysis of the defects:

  • Development phase: Prototypes will be tested in order to ensure a safe product and may be defect after testing (Electrical, environmental and abuse testing, vehicle crash tests)

  • Series production: Series products may get defect due to e.g. accidents or at end-of-life
Open questions

→ Regulations for defect batteries for UN recommendations and for all mode of transportation has to be defined (defect prototypes, defect series batteries)

→ Criteria of “defect battery” has to be defined. Different cases exist, e.g.:
  › Batteries which are defect but have no limitations for safe transport
  › Batteries which are defect but have limitations for safe transport: (Defective for safety reasons or damaged see IATA SP A154)

→ Identification of tested batteries