Lithium Battery Shipping Basics

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Lithium batteries are widely used in consumer electronic devices nowadays. However, batteries may pose a fire hazard and endanger aviation safety if they are not properly packed and handled.
WHAT ARE THE HAZARDS?

• Dangerous generation of heat
• Source of ignition
• Chemical and electrical
• Short circuit
• Propagation of fire/heat
• Not easily extinguished
WHY THE CONCERN?

- DOT is aware of more than 132 incidents.

- Product recalls, have raised concerns about the potential for battery-related fires aboard aircraft.

- This is not just speculation…we have had fires on aircraft involving both cargo and passenger carry-on items.
Lithium Metal vs. Lithium Ion

Are all Lithium Batteries Regulated?
CELL OR BATTERY?

• **Definitions:**

  – Battery means **two or more cells** which are electronically connected together.

  – Cell means a single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals.
Definitions – Lithium Batteries & Cells

Cells
- Cylindrical
- Prismatic

Batteries
- Polymer
- Camcorder
- Laptop
- Hybrid Vehicle
Lithium Metal vs. Lithium Ion Batteries

• **Lithium Metal Batteries (LiM)**
  - “Primary” batteries, non-rechargeable (one-time use)
  - Lithium metal or lithium compounds as an anode
  - Used to power watches, calculators etc.

• **Lithium Ion Batteries (LiO)**
  - “Secondary” batteries, rechargeable
  - Lithium ion or polymer; one or more cells per battery pack
  - Commonly used in consumer electronics such as cell phones and laptops
Classification

• UN Manual of Tests and Criteria
  – Section 38.3
    • Requires a number of cells and batteries to be tested
      – Altitude, Vibration, Shock, Short circuit, Overcharge

• Prototype batteries
  – 173.185(e) – Can be shipped for testing by highway as Class 9
  – A55 Cargo aircraft under approval

• Low production runs
  – SP29 low production runs of not more than 100 highway, rail, sea as Class 9
  – A88 Cargo aircraft under approval

• Approvals – 173.185(f)
IF YOU SHIP LITHIUM CELLS/BATTERIES, YOU MUST FIRST DETERMINE:

- Whether lithium cells/batteries must have passed the UN 38.3 test.
- Manufactured under a quality control system?
- The shipment does not contain damaged or defective batteries.
- Type of battery.
- The watt-hour rating or lithium content limit.
- What regulations apply based on the size of your battery.
HAVE THE CELLS/BATTERIES BEEN TESTED?

• What is a valid test report?

• How do I know?

• What can I do to protect my company?

• Where can I get my battery tested?

• Batteries must be tested even if they are assembled from tested cells (often misunderstood).
WATT-HOUR CALCULATION

– To determine the section lithium ion cells/batteries can ship under, you may need to perform a calculation to figure out the Watt-hour rating.

– The calculation used to determine Watt-hours is below:

\[ \text{Volts} \times \text{Ampere Hour (Ah)} = \text{Watt Hours} \]

– A Milliampere hour (mAh) is one-thousandth of an Ampere hour (Ah). If you are provided the Ampere hour rating in Milliampere hours instead of Ampere hours, you need to divide by 1,000 to convert Milliampere hours into Ampere hours.

– EXAMPLE: You want to ship a 3.7 volt cell rated at 1,500 mAh.

\[
\begin{align*}
\text{Step 1: Convert mAh to Ah} & \rightarrow 1,500 \text{ mAh} \div 1,000 = 1.5 \text{ Ah} \\
\text{Step 2: Use calculation} & \rightarrow 3.7 \text{ Volts} \times 1.5 \text{ Ah} = 5.55 \text{ Wh}
\end{align*}
\]
3.7V \times 800/1000 = 2.96 \text{ Wh}

3.7V \times 0.9 \text{ Ah} = 3.33 \text{ Wh}
Damaged or Defective Batteries

Make sure the shipment **does not** contain damaged or defective batteries.

**Signs of Battery Damage**

- Punctures
- Dings
- Dents
- Bloating
- Thermal event
• Training requirements for lithium battery shipments:
  – When shipping fully regulated lithium batteries, a complete training program as specified in §172.700-704 must be completed with certification upon conclusion.
  – When shipping excepted lithium batteries, adequate instruction in the specific provisions that relate to offering according to applicable requirements.
DETERMINING YOUR SHIPPING SCENARIO

- The shipment of lithium batteries varies based upon the type of battery (lithium ion vs lithium metal) and the location of the battery (standalone, packed with, or contained in).
  - Standalone = package ONLY contains the battery; NO equipment
  - Packed with = package contains equipment + batteries that are NOT installed in the equipment
  - Contained in = package has equipment with batteries installed

- See the table below for the 6 shipping scenarios possible.

<table>
<thead>
<tr>
<th></th>
<th>Lithium Ion</th>
<th>Lithium Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone</td>
<td>Lithium Ion Standalone</td>
<td>Lithium Metal Standalone</td>
</tr>
<tr>
<td>Packed With</td>
<td>Lithium Ion Packed with</td>
<td>Lithium Metal Packed with</td>
</tr>
<tr>
<td>Contained In</td>
<td>Lithium Ion Contained In</td>
<td>Lithium Metal Contained In</td>
</tr>
</tbody>
</table>
Once you have determined your shipping scenario, there are six packing instructions that apply for air shipments:

- **Stand alone batteries**
  - Lithium Ion (PI 965)
  - Lithium Metal (PI 968)

- **Equipment packed with spare batteries**
  - Lithium Ion (PI 966)
  - Lithium Metal (PI 969)

- **Equipment containing batteries**
  - Lithium Ion (PI 967)
  - Lithium Metal (PI 970)
PACKING INSTRUCTIONS FOR LITHIUM BATTERIES - OTHER MODES OF TRANSPORT

– When shipping lithium batteries by ground or ocean, there are specific packing instructions that apply.

– These packing instructions are listed in the different modal regulations.
New Air Shipping Requirements

• PI 965 and 968 divided into 3 parts...
  – *General Requirements*
    • Applies to all batteries
  – *Section IA*
    • Applies to fully regulated batteries
  – *Section IB*
    • Applies to Section II batteries exceeding the quantity limits in Section II
  – *Section II*
    • Applies to small excepted batteries
Shipping by Air

• PI 965 and 968 divided into 3 parts...
  – *Section IA*
    • Minor changes, mainly to numbering and structure
    • Applies to cells greater than 20 Wh or 1 g lithium content
    • Applies to batteries greater than 100 Wh or 2 g lithium content
    • Fully regulated batteries
Shipping by Air

• PI 965 and 968 divided into 3 parts...
  – *Section IB*
    • New Section
    • Applies to Section II cells/batteries which exceed package allowances.
    • Package Gross Weight limitations
      – 10 kg G for lithium ion; 2.5 kg G for lithium metal
    • Will have double labels – Class 9 AND Lithium Battery handling label
    • Shipper’s Dec not required but alternate documentation required – such as air waybill, etc.

    **UN Spec packaging NOT required...but all other requirements apply!!!**

• *Employee Training is required*
Shipping by Air

• PI 965 and 968 divided into 3 parts...

  – Section II
  • New table

<table>
<thead>
<tr>
<th>Contents</th>
<th>&lt; or = 2.7 Wh/ 0.3 g LC</th>
<th>Cells &gt;2.7 Wh/ 0.3 g LC but &lt;20 Wh/1 g LC</th>
<th>Batteries &gt;2.7 Wh/0.3 g LC but &lt;100 Wh/2 LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Max # or cells/batteries per package</td>
<td>No limit</td>
<td>8 Cells</td>
<td>2 Batteries</td>
</tr>
<tr>
<td>Max Net Quantity per package</td>
<td>2.5 kg</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Max Net Quantity per package
EQUIPMENT CONTAINING LITHIUM ION CELLS AND BATTERIES

• Packaging, marking and documentation are similar to stand-alone LiO battery shipments except when:

• Package contains equipment with not more than 2 multi-celled batteries or 4 cells including single-celled LiO batteries,
  – In this scenario, a lithium battery label, markings or documentation is not required

• Package contains equipment with more than 2 multi-celled batteries or 4 cells including single-celled LiO batteries,
  – In this scenario, a LiO battery handling label, markings and documentation is required
Shipping by Air

- PI 966, 967, 969, and 970 changes...
  - **Section II**
    - Limit **net weight** of lithium ion or metal batteries to
    - **5 kg for passenger**
    - **5 kg for cargo aircraft***
      
This was previously 35 kg

- **Training - Adequate Instructions**

**All changes went into effect January 1, 2013!**
Shipping Process/Packaging of Stand Alone Lithium Ion Batteries

Battery

inner packaging

outer packaging.

Outer packaging placed in Masterpack (overpack)

Masterpack closed - labels & document reproduced and marked with “OVERPACK”

Masterpacks on pallet - No sleeve

Masterpacks on pallet - sleeved
An OVERPACK is an enclosure used by a single shipper to contain one or more packages and to form one handling unit for convenience of handling and stowage.

Multiple boxes labeled and placed on a skid and into an OVERPACK.
• Below are some markings and labels that help convey information about the package. They may be required depending on your shipping scenario.
120mm x 110 mm or 105mm x 74 mm if the size of the package requires the smaller handling label
DOCUMENTATION REQUIREMENTS

– For fully regulated shipments, a shipping paper is required (see sample of a U.S. ground shipping paper below).

– For excepted shipments, a shipping paper is not required. In some excepted scenarios though, a document must accompany the shipment that indicates the package contains lithium batteries and special procedures should be followed if the package is damaged.
Shipping by 49 CFR

• Proper Shipping Names (172.101)
  Lithium Metal and Ion Batteries
  – UN 3090 Lithium Batteries
  – UN 3091 Lithium Batteries contained in equipment
  – UN 3091 Lithium Batteries packed with equipment

  *PHMSA now permits use of UN, IMDG and ICAO PSN*
  • UN 3480, Lithium ion batteries
  • UN 3481, Lithium ion batteries packed with equipment
  • UN 3481, Lithium ion batteries contained in equipment
  • UN 3090, Lithium metal batteries
  • UN 3091, Lithium metal batteries packed with equipment
  • UN 3091, Lithium metal batteries contained in equipment
Shipping by 49 CFR

- **172.101 Table**
  - Lithium Batteries
  - Class 9
  - UN 3091
  - SPs 29, 188, 189, 190, A54, A55, A100, A101, A103, A104
  - Packaging under 173.185
  - Package limitations
    - A100 for Passenger Aircraft 5kg *recently changed 215L*
    - 35 kg gross weight for Cargo Aircraft
DETAILED SHIPPING SCENARIOS

– The following slides will outline the excepted and fully regulated shipping scenarios for U.S. ground and Canada ground.

– U.S. ground
  ✓ Excepted Special Provision 188
  ✓ Excepted Special Provision 189
  ✓ Fully Regulated 173.185

– Canada ground
  ✓ Excepted Special Provision 34 (3)
  ✓ Fully Regulated Special Provision 34 (1)
GENERAL REQUIREMENTS U.S. GROUND EXCEPTED SP 188

- For all shipping scenarios, each cell and battery is of the type proven to meet the requirements of each test in the UN Manual of Tests and Criteria.
- For all shipping scenarios, cells/batteries are separated or packaged in a way to prevent short circuits and are packed in a strong outer packagings or are contained in equipment.
- For lithium metal cells, the lithium content is not more than 1.0 g. For lithium ion cells, the equivalent lithium content is not more than 1.5 g (20 Watt hours).
- For lithium metal batteries, the aggregate lithium content is not more than 2.0 g. For lithium ion batteries, the aggregate equivalent lithium content is not more than 8 g (100 Watt hours).
- A written report must be submitted to Pipeline and Hazardous Materials Safety Administration (PHMSA) if the cell or battery or a battery powered device are involved in an incident resulting in fire, violent rupture, explosion or dangerous evolution of heat.
LITHIUM ION CELLS/ BATTERIES U.S. GROUND EXCEPTED SP 188

– The requirements vary depending on how many batteries or cells are in the package. If you have no more than 24 cells or 12 batteries (either standalone, contained in, or packed with), you only need to meet the general requirements outlined on the previous slide.

– If you exceed 24 cells or 12 batteries, you must meet requirements below in addition to those on the previous slide.

### LITHIUM ION- MORE THAN 24 CELL OR 12 BATTERIES

<table>
<thead>
<tr>
<th></th>
<th>Standalone</th>
<th>Packed with</th>
<th>Contained In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>1.2 m drop test</td>
<td>1.2 m drop test</td>
<td>No additional requirements</td>
</tr>
<tr>
<td>Markings</td>
<td>Lithium Battery Marking (slide 9)</td>
<td>Lithium Battery Marking (slide 9)</td>
<td>No marking requirement</td>
</tr>
<tr>
<td>Documentation</td>
<td>Document indicating contents and special procedures if damaged (slide 11)</td>
<td>Document indicating contents and special procedures if damaged (slide 11)</td>
<td>No documentation requirement</td>
</tr>
<tr>
<td>Weight requirement</td>
<td>Gross package weight cannot exceed 30 kg</td>
<td>No weight requirement</td>
<td>No weight requirement</td>
</tr>
</tbody>
</table>
LITHIUM METAL CELLS/ BATTERIES U.S. GROUND EXCEPTED SP 188 (NO MORE THAN 24 CELLS OR 12 BATTERIES)

- If you have no more than 24 cells or 12 batteries, you must meet the requirements below in addition.

<table>
<thead>
<tr>
<th>LITHIUM METAL- LESS THAN OR EQUAL TO 24 CELLS OR 12 BATTERIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Packaging</strong></td>
</tr>
<tr>
<td>Standalone</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>No additional requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Markings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone</td>
</tr>
<tr>
<td>Lithium Battery Forbidden Marking (slide 9)</td>
</tr>
<tr>
<td>CAO label (slide 9)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Documentation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone</td>
</tr>
<tr>
<td>No documentation requirement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Weight requirement</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone</td>
</tr>
<tr>
<td>No weight requirement</td>
</tr>
</tbody>
</table>
SP 188 (MORE THAN 24 CELLS OR 12 BATTERIES)

– If you have more than 24 cells or 12 batteries, you must meet the requirements below in addition to those on slide 13.

<table>
<thead>
<tr>
<th>LITHIUM METAL - MORE THAN 24 CELLS OR 12 BATTERIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Packaging</strong></td>
</tr>
<tr>
<td><strong>Standalone</strong></td>
</tr>
<tr>
<td><strong>Markings</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
</tr>
<tr>
<td><strong>Weight requirement</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
GENERAL REQUIREMENTS FOR U.S. GROUND EXCEPTED SP 189

– For all shipping scenarios, each cell and battery is of the type proven to meet the requirements of each test in the UN Manual of Tests and Criteria.

– For all shipping scenarios, cells/batteries are separated or packaged in a way to prevent short circuits and are packed in a strong outer packaging or are contained in equipment.

– For lithium metal cells/batteries, the lithium content can be no more than 5 g per lithium metal cell or 25 grams per lithium metal battery.

– For lithium ion cells/batteries, the equivalent lithium content can be no more than 5 g (60 Wh) per lithium ion cell or 25 g (300 Wh) per lithium ion battery.

– The outside of each package must be marked “LITHIUM BATTERIES-FORBIDDEN FOR TRANSPORT ABOARD AIRCRAFT AND VESSEL.”

– A written report must be submitted to Pipeline and Hazardous Materials Safety Administration (PHMSA) if the cell or battery or a battery powered device are involved in an incident resulting in fire, violent rupture, explosion or dangerous evolution of heat.”
EXCEPTED SP 189

- The requirements vary depending on how many batteries or cells are in the package. If you have no more than 24 cells or 12 batteries (except for contained in), you only need to meet the general requirements outlined on the previous slide.
- If you exceed 24 cells or 12 batteries, you must meet requirements below in addition to those on the previous slide.

<table>
<thead>
<tr>
<th>LITHIUM ION OR METAL - MORE THAN 24 CELL OR 12 BATTERIES</th>
<th>Standalone</th>
<th>Packed with</th>
<th>Contained In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>1.2 m drop test</td>
<td>1.2 m drop test</td>
<td>No additional requirements</td>
</tr>
<tr>
<td>Markings</td>
<td>Lithium Battery Marking (slide 10)</td>
<td>Lithium Battery Marking (slide 10)</td>
<td>No marking requirement</td>
</tr>
<tr>
<td>Documentation</td>
<td>Document indicating contents and special procedures if damaged (slide 11)</td>
<td>Document indicating contents and special procedures if damaged (slide 11)</td>
<td>No documentation requirement</td>
</tr>
<tr>
<td>Weight requirement</td>
<td>Gross package weight cannot exceed 30 kg</td>
<td>No weight requirement</td>
<td>No weight requirement</td>
</tr>
</tbody>
</table>
Shipping by 49 CFR

- 173.185 – Regulated lithium battery shipments
  
  (a) Cells and Batteries
  
  (1) Pass UN Testing Criteria
  (2) Incorporate safety venting device
  (3) Effective means to prevent reverse current flow if in parallel
  (4) Combination packaging PGII performance standard
    Secured within inner packagings to prevent short circuits
    within listed outer packagings
  (5) Effective means to prevent external short circuit
  (6) Special conditions for sulfur dioxide and other chemistries
Each consignment must be accompanied with a **document** with an indication that:

- the package contains lithium 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;
- a telephone number for additional information; and
- the words “lithium ion batteries” or “lithium metal batteries”, “not restricted” and “Plxxx” (Packing Instructions number) must be placed on the air waybill.
DAMAGED BATTERIES

• Air – Forbidden
• Ground –
  – 49 CFR Section 173.185(f)
    • Permitted with an approval
  – ADR Special Provision 661
    • Approvals have been issued.

• Vessel – Previously Forbidden but E&T adopted provisions for IMDG Code Amdt 37-14 last week
HM-224F

- Should align with ICAO TI –scheduled to be published this year
RECENT PENALTIES

McKesson Medical-Surgical Swedesboro NJ (Shipper)
Offered lithium battery, 9, as consumer commodity ORM-D and failed to ship the battery as an item of class 9 or alternatively marking the package in accordance with special provision number 188, thereby misclassifying the material; offered ethyl chloride, 2.1, and isopropyl alcohol, 3, in UN standard packaging and failed to conduct design qualification testing. [173.22(a)(2); 173.202(a); 173.322; 172.102(c)(1); 173.4(d); 173.22(a)(1) and (2); 173.24(c)(1); 173.185(a)(4);173.22(a)(2); 173.24; 178.601] Case No: 10-0175-SB-EA
$ 19,580

Braille Battery Sarasota FL (Lithium Battery Mfg/Shipper)
Offered lithium batteries, 9, that have been assembled from tested cells, but had not been tested as required in the UN Manual of Tests and Criteria, IBR 171.7. [171.2(a), (b) and (e); Special Provision 189.] Case No: 11-0095-BAT-SO
$ 7,650

BionX International Corporation Aurora, Ontario, Canada XX (Lithium Battery Mfg/Shipper)
Offered lithium batteries packed with equipment, 9, in a packaging which was not subjected to UN-standard testing; offered lithium batteries packed with equipment, 9, when the materials were not identified as hazardous on the shipping papers; the package was not marked and labeled and the emergency response information, including an emergency response telephone number, was not provided therefore, shipping the material undeclared. [172.200(a), 172.300(a), 172.400(a)(1); 172.600(c), 173.22(a)(1); 173.22(a)(2); 173.185(a)(4)] Case No: 11-0147-BAT-EA
$ 18,000
Angel Island Company, LLC    San Rafael CA (Lithium Battery Mfg/Shipper)
Offered lithium batteries, 9, in a combination packaging which was not subjected to UN-standard testing; offered lithium batteries, 9, when the materials were not identified as hazardous on the shipping papers when the package was not marked and labeled, thereby failing to declare the materials as hazardous; failed to provide employees with hazardous materials general awareness, function-specific, safety, and security awareness training. [172.101(h); 173.22(a)(2); 173.185(a)(4); 172.702(a); 172.704(a)(1), (2), (4) and (d); 172.200; 172.201; 172.204; 172.300; 172.301; 172.304; 172.400; 172.406; 172.407; 172.446; 172.600; 172.602; 172.604; 173.22(a)(1)] Case No: 11-0063-SB-EA
$ 16,350

Battery Specialties, Inc.    Costa Mesa CA (Shipper)
Offered lithium batteries, 9, in combination packagings which exceeded the gross mass to which the package certified, and which were not subjected to UN-standard testing in the configuration used for shipping, therefore shipping in unauthorized packagings. [173.22(a)(2), 173.185(e)(4)] Case No: 07-0134-SB-EA
$ 10,870.58

Schnarr’s Hardware Company    St. Louis MO (Lithium Battery Mfg/Shipper)
Offered lithium batteries, 9, when the materials were not identified as hazardous materials on the shipping papers, the package was not marked and labeled, the emergency response information, including an emergency response telephone number, was not provided, thereby failing to declare the materials as hazardous; offered lithium batteries, 9, in a combination packaging which was not subjected to UN-standard testing; failed to provide general awareness, function-specific, safety, and security awareness training. [173.22 (a)(1); 172.200; 172.201; 172.204; 172.300; 172.301; 172.304; 172.400; 172.406; 172.407; 172.446; 172.600; 172.602; 172.604; 173.22(a)(2); 173.185(a)(4); 172.702(a); 172.704 (a)(1)-(4); 172.704 (d)] Case No: 11-0128-SB-EA
$ 11,495
NEED COMPLIANCE ASSISTANCE?

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Labelmaster Services

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