‘Watt’s’ the Buzz About Lithium Batteries

Background and Recycling Information
Agenda

• Overview of Batteries
• How the Environmental Protection Agency became involved
• Challenges of end-of-life batteries
• Other federal activities
• Pipeline and Hazardous Materials and Safety Administration battery shipping training
Background

- Batteries power a world without wires
- Consumers want smaller, more portable devices
- New battery chemistries mean smaller, more powerful, batteries
- More batteries are being used in more applications
Lithium Batteries

There are two types of lithium batteries:
- Primary batteries, non-rechargeable that use lithium metal; often in an AA, 9V, or coin cell format.
- Secondary batteries, rechargeable lithium-polymer cells use an electrolyte and thin porous membrane that allows Li-ions to pass between the anode and cathode; come in various shapes and sizes.

Compared to other batteries types, lithium batteries offer:
- Higher energy, densities,
- Lighter weights,
- Higher voltages;
- And Li-Poly batteries may still have a 30% state of charge, even though the device won’t operate.

Rechargeable Lithium Polymer Cell - Argonne National Lab
Lithium Batteries are Different

• They can have higher energy densities and voltages
• A lithium-ion may still have some charge in a ‘dead’ product
• The electrolyte is flammable when it meets air
• They can be hard to access or identify in products
How did batteries get EPA staff’s attention?

• Batteries were identified as limiting the reuse and recycling of electronic products.
• Justified product safety concerns were impacting end-of-life management.
• Batteries are showing up in more products and smaller packages than ever.
• Do consumers know what to do with used batteries?
How did batteries get EPA staff’s attention?

• Electronics recyclers mentioned problems removing batteries and an increase of fires at their facility.

• EPA staff learned that lithium batteries are affecting multiple industries: electronics recycling, material recovery facilities, C&D recyclers, auto shredding, and transportation providers.

• Examples:
  • A battery-initiated fire led to a multimillion-dollar recovery effort at a California material recovery facility
  • A battery explosion on a freight train in Houston made headlines
  • Chicago area C&D recycler shreds a battery and starts a major fire
Thermal Events at Electronics Recyclers

• Removing glued/imbedded batteries can damage the battery.
• Thermal events happen during repair, reuse, or recycling, or during shredding if the battery is not removed.
• In this example a worker was opening a tablet computer.
• Workers are trained to respond when an event happens.
Lithium Battery - a Safety and Sustainability issue

**Sustainability Issue:**
- If the batteries are not able to be removed:
  - Reuse of electronics products decreases
  - Recycling/recovery (e.g., can’t shred) decreases

**Safety Issue:**
- May become a fire hazard to the facility, vehicles, and a safety issue to the workers.
- Identification of lithium batteries and proper handling could reduce the risk of incidents.
- Workers across the supply chain are being trained.

(November 2006 truck fire in Galesburg, IL)
Battery Production Volume is Expected to Increase

• The volume of installed lithium-ion batteries is expected to increase:
  • 32 GWh installed in 2015
  • 2045 GWh in 2045
• Applications continue to expand:
  • Personal and public transportation
  • Portable electronics and tools
  • Energy storage
• Demand for crucial materials will increase.

Source BloombergNEF
Future Availability: Competition from Other Sectors

- Automotive
- Energy
- Industrial

How do batteries get recycled?

- Collection points receive used batteries:
  - Retail or HHW – for public collection of rechargeable batteries or certain devices with rechargeable batteries
  - Private collection bins - for commercial generators of rechargeable batteries
  - Electronics recyclers – are removing batteries from devices
- Batteries are properly packed and shipped to a sorting facility or a processor
- There are two main processes used to recover materials
  - Pyro-metallurgical (using high temperatures)
  - Hydro-metallurgical (using acids to dissolve materials)
Depending on their specific chemistry, used batteries can exhibit one or more of the characteristics of hazardous waste per 40 CFR part 261 Subpart C.

Hazardous waste batteries may be regulated as “universal waste” per 40 CFR part 273.

**Household batteries** are exempt from the hazardous waste standards and are not affected by the universal waste regulations. Batteries from facilities with **very small quantity generator status** are also not affected by the universal waste regulations.

EPA’s Universal Waste Website: [https://www.epa.gov/hw/universal-waste](https://www.epa.gov/hw/universal-waste)

Lithium-ion Battery: Federal Government Activities

• **U.S. Environmental Protection Agency:**
  • Webinars: SMM Web Academy and Solving the Ewaste Problem (StEP)
  • Domestic and international presentations, panels and other industry engagement
  • New webpages: [general batteries](#) and [lithium-ion batteries](#)

• **U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration:**
  • DOT/EPA are working together to inform electronics and battery recyclers on packaging, labeling and transportation.
  • DOT regulatory/enforcement activities

• **U.S. Department of Energy, National Renewable Energy Lab and the Office of Energy Efficiency & Renewable Energy:**
  • Lithium-Ion Battery Recycling Prize
  • Research, development and verification of new battery formulations and recycling techniques

• **U.S. Consumer Product Safety Commission**
  • Participating in voluntary standard activities related to batteries in consumer products
  • Receives consumer complaints and manufacturer and retailer reports involving hazards associated with batteries and battery chargers
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    • lett.kathy@epa.gov
Lithium Battery Recycling and Reuse
Presented by the Pipeline and Hazardous Materials Safety Administration (PHMSA)
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Disclaimer: These slides are informational and DOT always advises you use the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) when determining compliance.
Why Is This Important?
Why Is This Important?

- High energy densities
- Potential short circuiting leading to thermal runaway
- Past recycling-related incidents
- Expected exponential increases volumes
Implications of High Energy Density

Video courtesy of the University of Michigan College of Engineering
Houston, TX – 2017
Workshop Agenda
Workshop Agenda

- Part I: Overview of DOT/PHMSA
- Part II: DOT/PHMSA’s Role in the Supply Chain
- Part III: How DOT/PHMSA Regulations Work
- Part IV: Special Topics
- Part V: Compliance Resources
Part I: Overview of DOT/PHMSA
Overview of DOT/PHMSA

DOT Operating Administrations

OST  DOT  OIG

FAA  FHWA

FMCSA  FRA

FTA  MARAD

NHTSA  FHWA

SLSDC  PHMSA

OHMS  OPS

U.S. Department of Transportation Headquarters – Washington, DC
PHMSA Regional Offices

https://www.phmsa.dot.gov/about-phmsa/offices
PHMSA Mission

- “Our mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives”
“Protect against the risks to life, property, and the environment which are inherent in the transportation of hazardous materials in intrastate, interstate, and foreign commerce”

49 U.S.C. Section 5101 et seq.
PHMSA Responsibilities

**Regulations**
- Rulemakings
- Letters of Interpretation

**Special Permits and Approvals**
- Approvals for Fireworks or Self- Reactive materials
- Special Permits for packaging

**Enforcement**
- Inspections
- Multi-Agency Strike Force Operations

**Outreach and Engagement**
- Publications
- HMSAT
- Workshops or conferences
Part II: DOT/PHMSA’s Role in the Supply Chain
DOT in the Supply Chain

Oversight Over the Transportation Process

- Identification and Classification (collection/sorting)
- Packaging and Hazard Communication
- Movement

PHMSA: Your Safety is Our Mission
Part III:
How DOT/PHMSA Regulations Work
The HMR govern the packaging and safe transportation of hazardous materials by highway, air, rail, and water.

Covers
- Identification and Classification
- Hazard Communication
- Packaging Requirements
- Operational Rules
Section 173.185 in the HMR addresses requirements for lithium batteries, including the exceptions for recycling lithium batteries:

1. Classification/ UN 38.3 Testing Paragraph (a)
2. Packaging Paragraph (b)
3. “Small” battery exceptions Paragraph (c)
4. Disposal/ Recycling Exceptions Paragraph (d)
5. Damaged, Defective, Recalled (DDR) Requirements Paragraph (f)
Disposal/Recycling Exceptions

*Classification/UN 38.3 Testing
*Small Battery Exceptions
*Specification Packaging

*For motor vehicle transportation ONLY

49 CFR § 173.185(d)
Batteries for Reuse

Disposal/Recycling Exceptions

Classification/UN 38.3 Testing

Small Battery Exceptions

Specification Packaging
Three Major Components

1. Classify
2. Contain
3. Communicate
1. Classify the Hazard – Hazard Classes

- Explosives
- Gases
- Flammable Liquids
- Flammable Solids
- Oxidizers and Organic Peroxides
- Poisons
- Poisonous Substances
- Radiological Materials
- Class 9 Lithium Battery
- Corrosive
- Miscellaneous
1. Classify the Hazard – Identification and Classification

- Battery markings
- Physical characteristics
- Isolate DDR batteries

Battery identification and classification is done during the sorting process.
1. Classify the Hazard – Type of Lithium Batteries

- **Lithium Metal**
  - Metallic lithium or alloy
  - Size measured in grams
  - Generally not rechargeable (single-use)
  - Typical configurations: coin cell, cylindrical, and rectangular
  - Examples: watches, thermometers

- **Lithium Ion**
  - Lithium compound
  - Size measured in Watt-hours (Wh)
  - Generally rechargeable
  - Typical configurations: cylindrical, rectangular, and pouch packs
  - Examples: laptops, tablets, cell phones, power tools
1. Classify the Hazard – Lithium Metal
1. Classify the Hazard – Lithium Ion
1. Classify the Hazard – UN ID Numbers

<table>
<thead>
<tr>
<th>UN3480</th>
<th>• Lithium Ion Batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN3481</td>
<td>• Lithium Ion Batteries Contained in/Packed with Equipment</td>
</tr>
<tr>
<td>UN3090</td>
<td>• Lithium Metal Batteries</td>
</tr>
<tr>
<td>UN3091</td>
<td>• Lithium Metal Batteries Contained in/Packed with Equipment</td>
</tr>
</tbody>
</table>

The energy capacity of the lithium battery is an important consideration – larger batteries and quantities are subject to increased regulation. Thresholds:

- **Lithium Ion (Smaller Batteries)**
  - $\leq 100 \text{ Wh}$
  - $\leq 300 \text{ Wh ground only}$*

- **Lithium Metal (Smaller Batteries)**
  - $\leq 2 \text{ g}$
  - $\leq 25 \text{ g ground only}$*

* Additional hazard communication is required
1. Classify the Hazard – Energy Capacity

- Watt-hour (Wh) = Ampere-hours (Ah) x Volts (V)
- In the case of milliampere hour (mAh), divide by 1000

^ Under 100 Wh and qualifies for “Small” battery exception
2. Contain the Hazard – Packaging
2. Contain the Hazard – “Small” Consumer Lithium Batteries

- General Requirements
  - Prevent short circuits
  - Prevent damage caused by shifting
  - Prevent accidental activation
  - Prevent release of contents
  - Packaging requirements are performance-based

- Basic Configuration
  - Inner packaging
  - Cushioning material
  - Outer packaging

49 CFR § 173.185(b)(1)–(3)/(c)
2. Contain the Hazard – Inner Packaging

- **Requirements**
  - Non-metallic
  - Completely enclose the battery and terminals
  - Separate batteries from contact with any electrically conductive material

- **Examples**
  - Plastic bags
  - Tape enclosures
  - ANY method meeting performance requirement of protecting terminals and preventing short circuit is acceptable

49 CFR § 173.185(b)(3)(i)
2. Contain the Hazard – Inner Packaging

Inner package did not protect from short circuits
2. Contain the Hazard – Inner Packaging
2. Contain the Hazard – Cushioning Material
2. Contain the Hazard – Outer Packaging
2. Contain the Hazard – “Larger” Batteries and Quantities

- Batteries over 300 Wh rating (Lithium Ion) or 25 g (Lithium Metal)
- Packages over 66 lbs gross weight

UN Specification Packaging (ONLY Rail/Vessel)

1A2/X40/S/05 USA/0000

49 CFR § 173.185(b)(3)
2. Contain the Hazard – Electric Vehicle or Electric Storage Batteries

Alternative packaging

- Batteries that weigh over 12 kg (26.5 lbs)
- Must have strong, impact-resistant outer casing

May be packed:
- In “strong outer packagings”
- In protective enclosures (e.g., crates)
- On pallets

Not permitted for passenger aircraft (Cargo Aircraft requires Approval by AA)

49 CFR § 173.185(b)(5)
or
49 CFR § 173.185(d)
3. Communicate the Hazard – Hazard Communication

PHMSA: Your Safety is Our Mission
3. Communicate the Hazard – Lithium Battery Handling Mark

- “*” = the applicable UN ID number
- “**” = telephone number for information about the shipment

49 CFR § 173.185(c)(3)

120mm width (~4.8 inches)/110mm height (~4.3 inches); May be reduced to 105mm width (~4.1 inches) / 74mm height (~2.9 inches) should the package be too small for the larger mark.
3. Communicate the Hazard – Cargo Aircraft Only

- “LITHIUM METAL/ION BATTERIES—FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT”

NOTE: You must include this mark or label for all transportation modes, under the small battery exceptions

Cargo Aircraft Only Label

120mm width (~4.8 inches)/110mm height (~4.3 inches)

49 CFR § 173.185(c)(1)(iii)
3. Communicate the Hazard - Package

- Universal Waste Label OR Marking (EPA)
- Cargo Aircraft Only Label (DOT)
- Lithium Battery Handling Mark (DOT)

49 CFR § 173.185(c)(3) & 40 CFR §§ 273.14, 273.34
3. Communicate the Hazard – Batteries > 100, Wh, but ≤ 300Wh

- Additional package marking requirement:

“LITHIUM BATTERIES—FORBIDDEN FOR TRANSPORT ABOARD AIRCRAFT AND VESSEL.”

49 CFR § 173.185(c)(1)(iv)
Communicate the Hazard – Larger Batteries and Quantities (All Modes)

Increased Regulation

- Batteries over 300 Wh rating (Lithium Ion) or 25 g (Lithium Metal)
- Packages over 66 lbs gross weight

Shipping Papers
Emergency Response Information
Marks
Labels
Communicate the Hazard – Larger Batteries and Quantities

NOTE: Specification package required for rail and vessel – not motor vehicle.
DOT Training Requirements

- General Awareness/Familiarization
- Function-Specific
- Safety
- Security Awareness

49 CFR § 172.700-704
Part IV: Special Topics – Damaged, Defective, or Recalled (DDR) Batteries
1. Classify the Hazard – DDR

- Identify and separate batteries that pose an increased risk of producing a dangerous evolution of heat, fire, and short circuit
Batteries to Look For:

- Defective
- Leaked or vented
- Sustained physical or mechanical damage
- Cannot be diagnosed (i.e., cannot say for sure they are not damaged)

Consider:

- Risk of acute hazards (e.g., gas, fire, electrolyte leaking)
- Known misuse of the battery
- Signs of physical damage
- Damage to safety features, components, or short circuit protection

Source: 21st Revised Edition of the UN Model Regulations 3.3.1, Special Provision 376
1. Classify the Hazard - DDR
Batteries must be **individually** packaged as follows:

- Non-metallic, inner packaging that completely encloses the battery
- Inner packaging surrounded by non-combustible, non-conductive, and absorbent cushioning material
- Single inner packaging must be placed in *performance-oriented* packaging at the Packing Group I performance level.
2. Contain the Hazard – DDR

Photos courtesy of Cascade Asset Management
2. Contain the Hazard - DDR

- Performance-oriented packaging at the Packing Group I performance level means:
  - Designed and tested to a specific performance standard by packaging manufacturer
  - You **MUST** follow the packaging manufacturer’s instructions **EXACTLY**, including the use of any specific packaging components specified (e.g., cushioning, tape)
3. Communicate the Hazard - DDR

- Requires the same hazard communication as a larger, fully-regulated lithium battery (e.g., marks, labels, shipping paper)

- “Damaged/defective lithium ion battery” and/or “Damaged/defective lithium metal battery” as appropriate.
3. Communicate the Hazard - DDR

NOTE: If using DOT Special Permit packaging, the mark “DOT-SP” following by the permit number must be on the package.
Part IV (cont’d): Special Topics – DOT Special Permits (DOT SPs)
What are Special Permits?

- DOT special permits (SPs) are an extension of the regulations and offer alternative provisions.
- There are two types of SPs:

  Manufacture, mark, and sell (MMS) packaging

  Offer
What are examples of DOT SPs?

Disclaimer: images are examples of DOT Special Permit packaging and not an endorsement of any particular product or company.
Example DDR Kits

Disclaimer: images are examples of DOT Special Permit packaging and not an endorsement of any particular product or company

Pictured L-R: DOT-SP 20549, DOT-SP 20432, DOT-SP 20910
Disclaimer: images are examples of DOT Special Permit packaging and not an endorsement of any particular product or company

Pictured: DOT-SP 20331
Part V: Compliance Resources
PHMSA Resources

- Outreach materials
- Training materials
  - Emergency Response Guidebook (ERG)
  - Compliance assistance to industry (Outreach and Engagement)
Locating DOT-SPs

PHMSA Approvals and Permits

Overview
The Pipeline and Hazardous Materials Safety Administration (PHMSA) issues special permits and approvals for hazardous materials. Special permits authorize a person to perform a function required under the PHMSA regulations. Approvals authorize installation, use, or operation (i.e., explosives) or the performance of a designated function currently required under the PHMSA regulations. Use the menu on the left to search for hazardous materials and pipelines.

Hazardous Materials Safety
PHMSA has the primary responsibility for the enforcement of the Hazardous Materials Regulations (HMR). A special permit authorizes a person to perform a function that is not currently authorized under the authority granted in the HMR (for example, chemical oxygen generators).
NEW: 7 Useful Tips to Help You Ship Hazardous Materials Safely in Commerce, a quick e-resource guide
Videos and Mobile Apps
PHMSA's Online CFR (oCFR)

The oCFR tool is an interactive web-based application that allows users to navigate with a single click between all content connected to a HMR citation. The oCFR includes tools to sort, filter, and export search results. Besides providing the regulated community with a new way to access documents, the system also provides additional tools to make it easier to understand the status of documents and identify recent rulemakings which may have impacted the documents.

Also, the oCFR tool includes a separate tab for the Hazardous Materials Table (HMT) and Appendixes. This tab provides PHMSA's first database version of the HMT as well as tables of hazardous substances in
Hazardous Materials Safety Assistance Team (HMSAT)

About HMSAT

PHMSA's Hazardous Materials Safety Assistance Team (HMSAT) is responsible for face-to-face outreach and field compliance assistance on the Hazardous Materials Regulations (HMR). HMSAT's goal is to improve hazardous materials transportation safety and security through increased communication and education. HMSAT members are assigned to each of PHMSA's regional offices and are available to help businesses comply with the hazardous materials transportation regulations through educational and technical assistance. HMSAT also provides compliance assistance to federal, state, and local governments.

PHMSA Hazmat Transportation Webinars: https://www.phmsa.dot.gov/hazmat/seminars/webinars
Hazardous Materials Information Center

1-800-HMR-4922
1-800-467-4922
202-366-4488
infocntr@dot.gov

Have a question about transporting hazardous materials? Need clarification on an entry in the Hazardous Materials Regulations? PHMSA's Hazmat Information Center provides live, one-on-one assistance Monday through Friday from 9 a.m. - 5 p.m.

Call the Info Center:

- for help with use of the Hazardous Materials Regulations (49 CFR

Contact Us

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