‘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

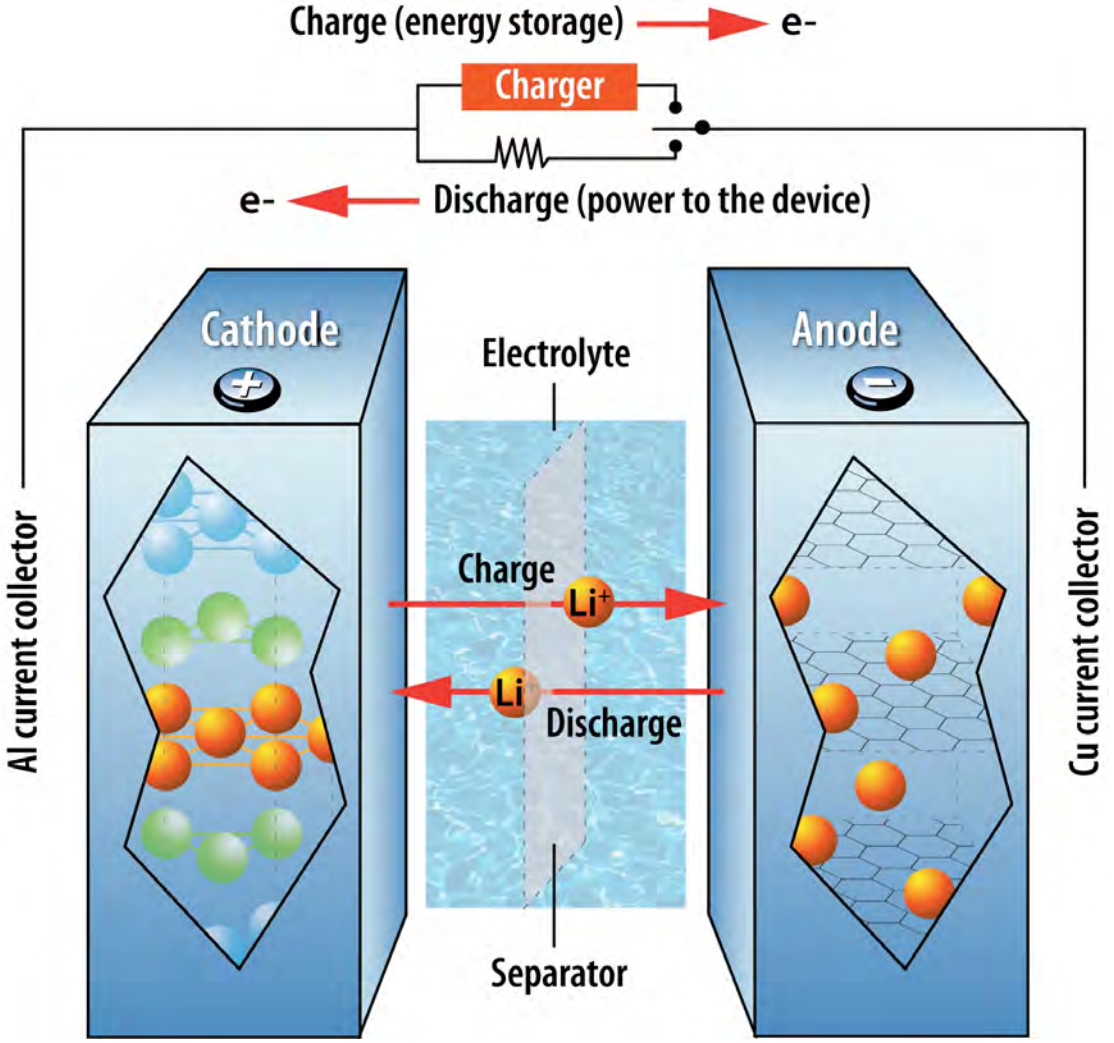
Lithium Batteries

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 recover 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.

Photo credit:
Cascade Asset Management
2018-2019

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

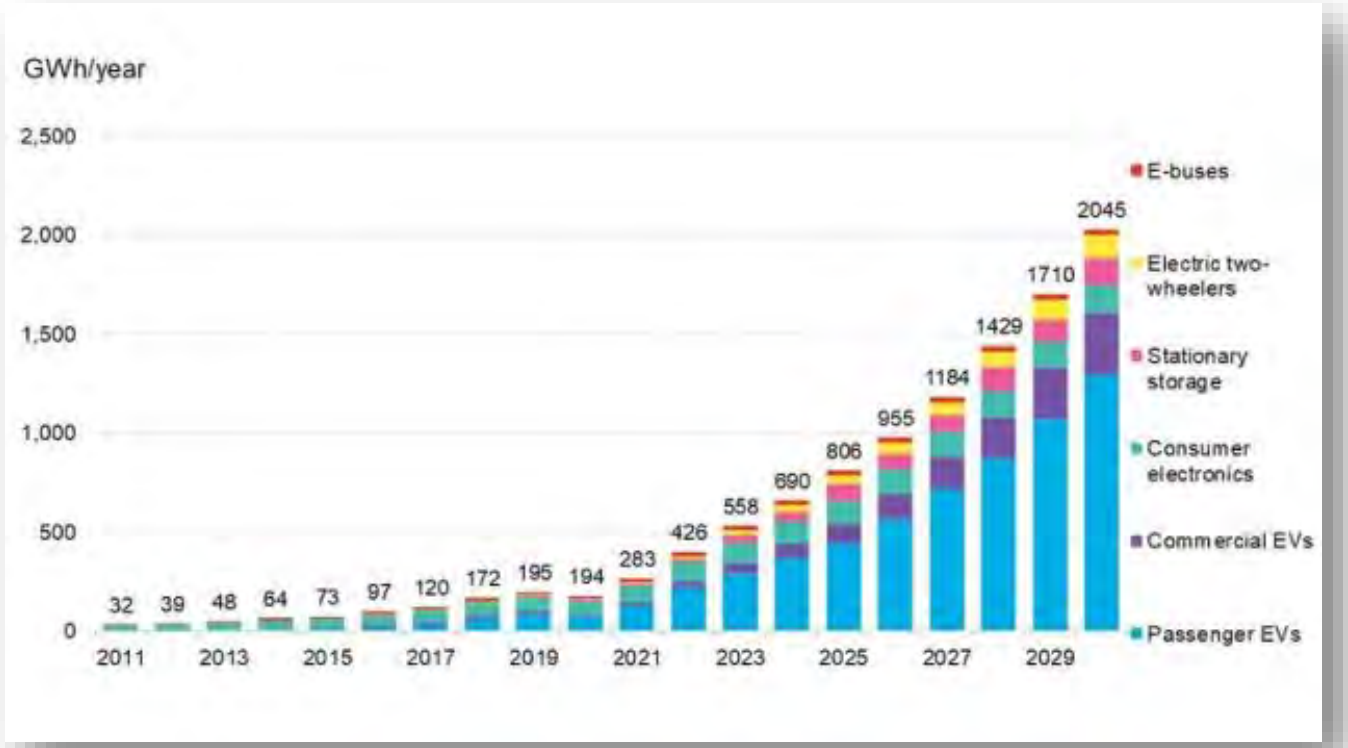
Safety Issue:

- 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)

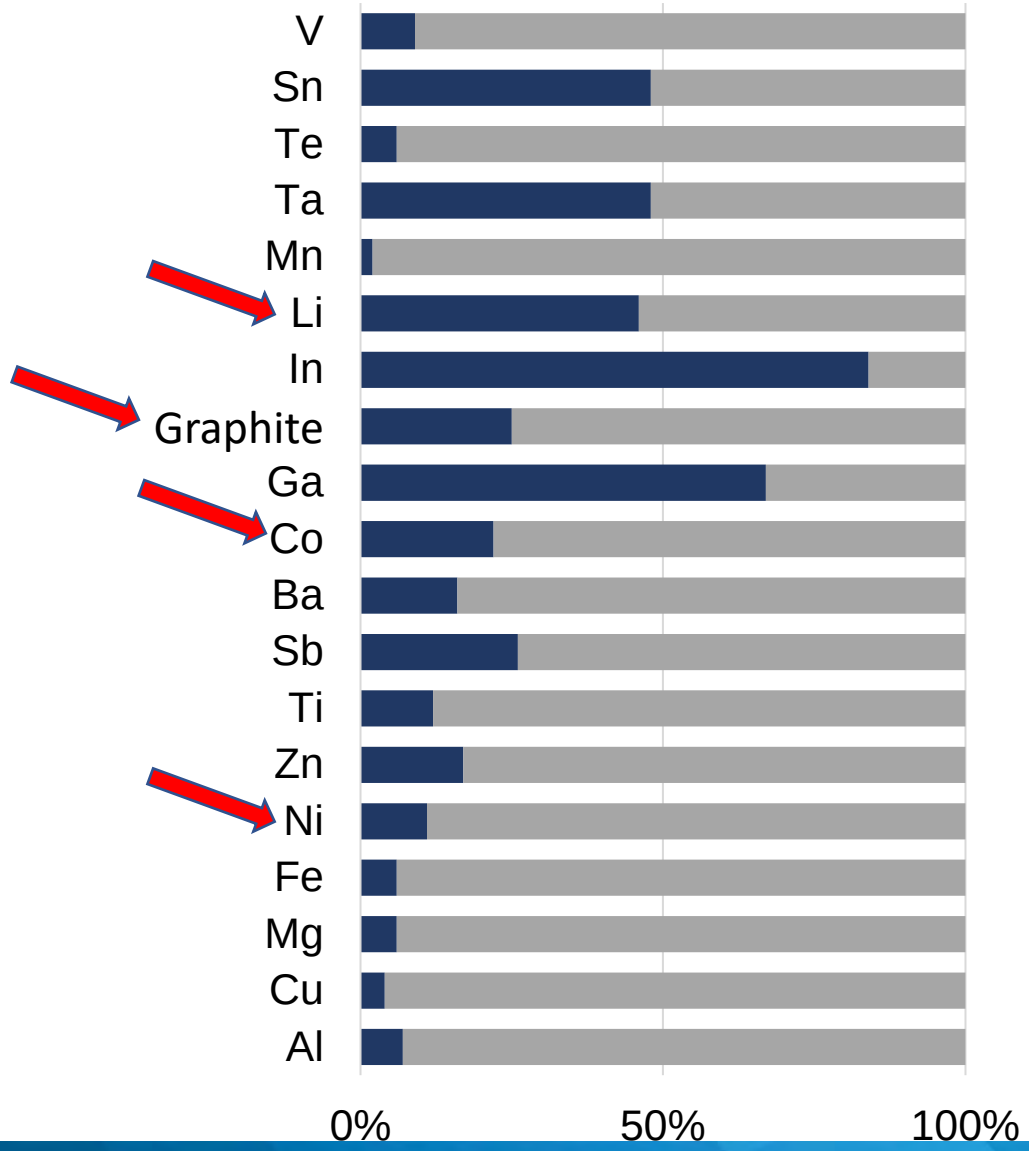
Battery Production Volume is Expected to Increase

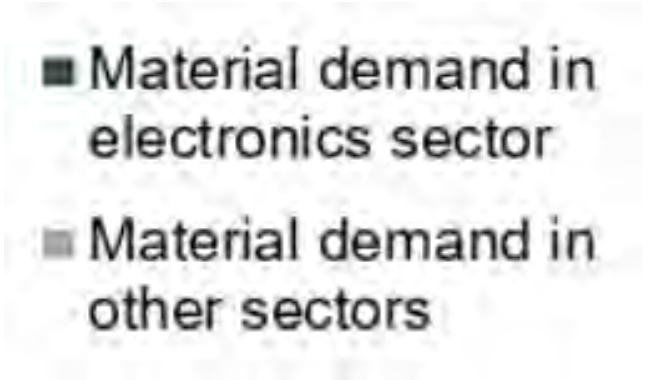
- The volume of installed lithium-ion batteries is expected to increase:
  - 32 GWh installed in 2015
  - 2045 GWh in 2045
- Applications continue to expand:
  - Personal and public transportation
  - Portable electronics and tools
  - Energy storage
- Demand for crucial materials will increase.



Source BloombergNEF

Future Availability: Competition from Other Sectors





- Automotive
- Energy
- Industrial

From: Althaf, S., Babbitt, C.W. Madaka, H., Gaustad, G., Flynn, C. 2019. "Sustainable Materials Management Metrics to Assess Consumer Technology – Phase 3. A report to the Staples Sustainable Innovation Lab and the Consumer Technology Association

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)

Cascade Asset Management

RCRA Regulation of Used Batteries

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

Universal Waste Frequent Questions: https://www.epa.gov/hw/frequent-questions-about-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

For more information:

- Contact:
  - Chris Newman
    - EPA Region 5
    - newman.christopherm@epa.gov
  - Kathy Lett
    - EPA Office of Resource Conservation and Recovery
    - 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

Thermal Runaway

Houston, TX – 2017

Workshop Agenda

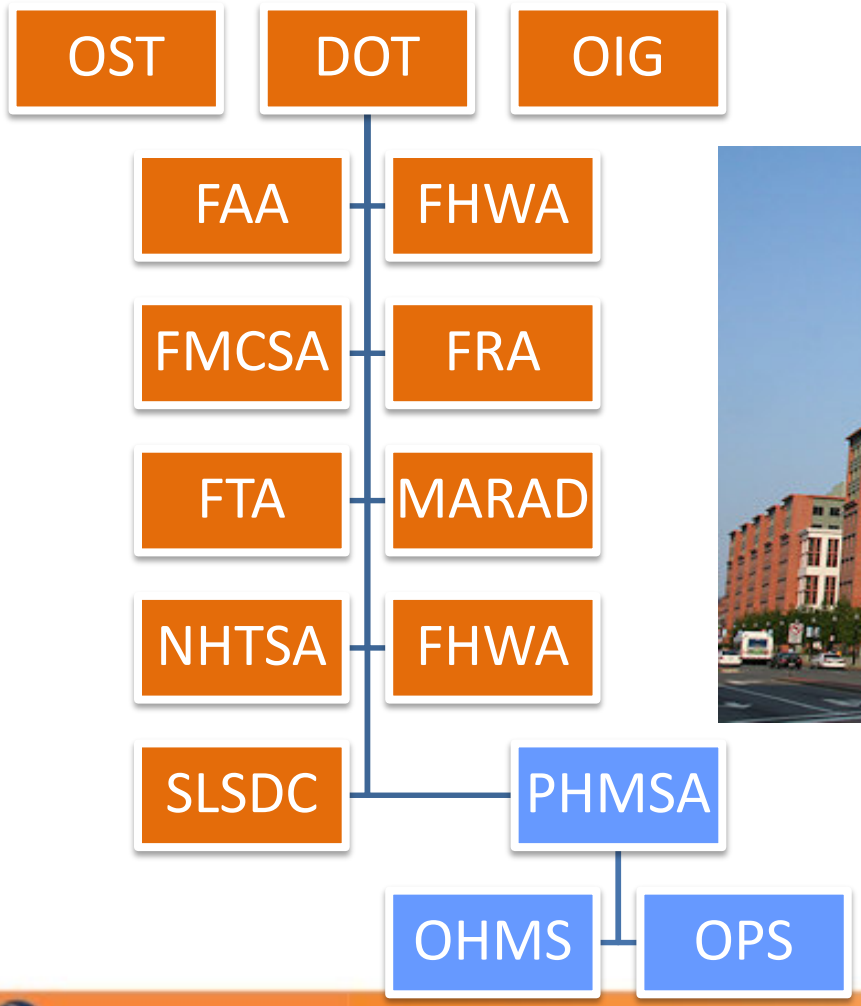
Workshop Agenda

- **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

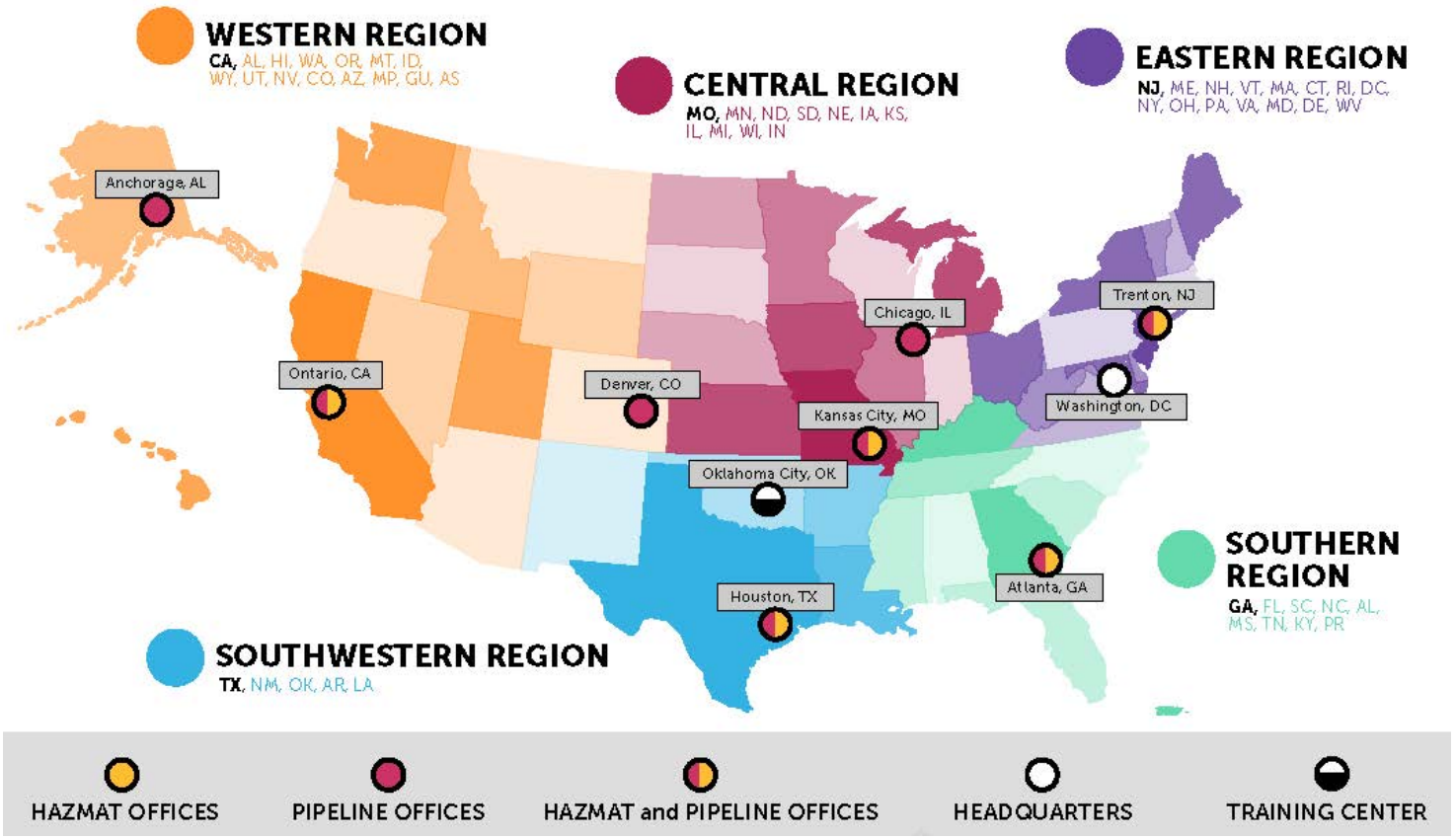
Overview of DOT/PHMSA

DOT Operating Administrations



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"

Federal Hazmat Law

- "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

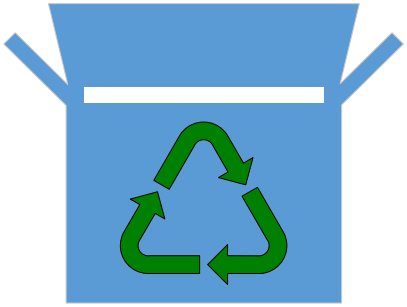
Part II:
DOT/PHMSA's Role in the Supply Chain

DOT in the Supply Chain

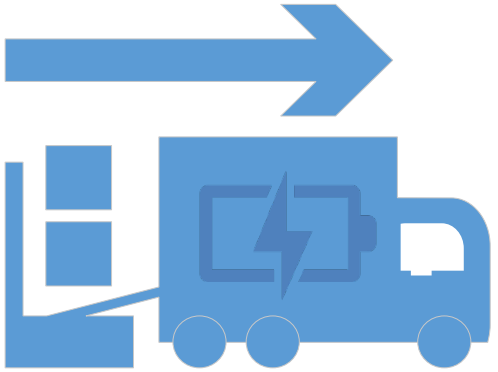
Oversight Over the Transportation Process

Identification and Classification (collection/ sorting)

Packaging and Hazard Communication



Movement



Part III:
How DOT/PHMSA Regulations Work

Hazardous Materials Regulations (HMR)

- 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 of the HMR

- 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)

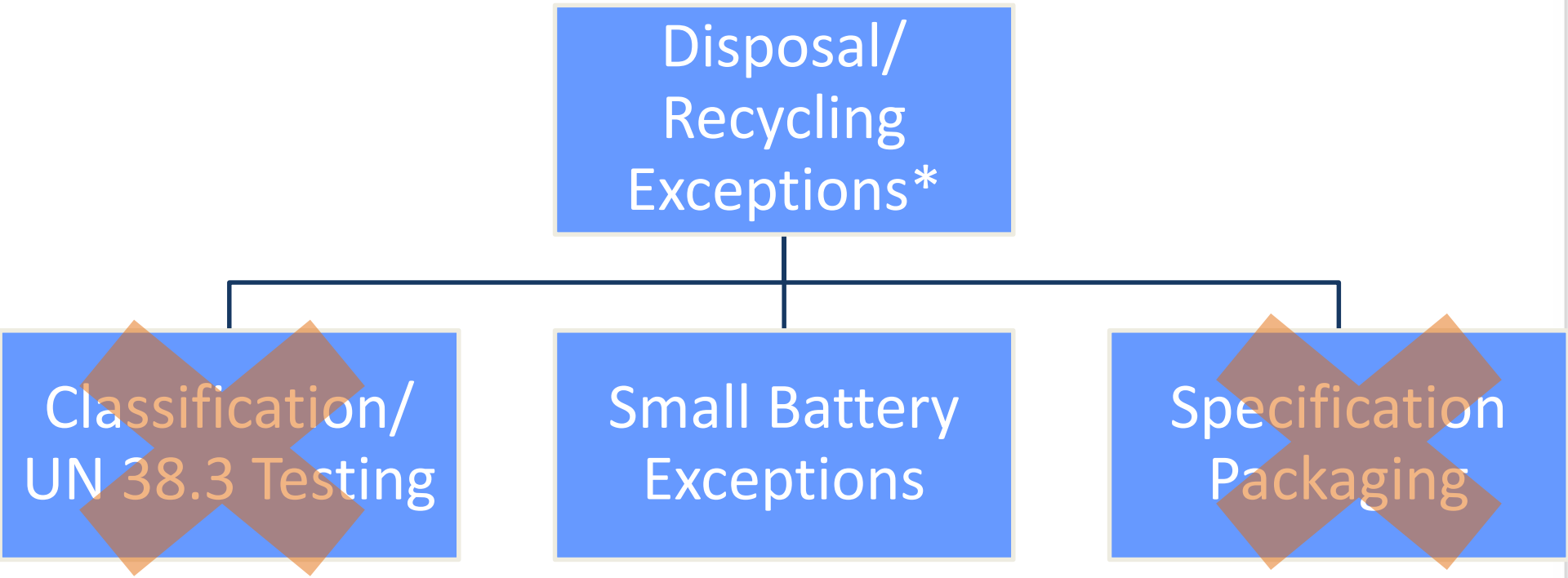
2. Packaging
Paragraph (b)

3. "Small" battery exceptions
Paragraph (c)

4. Disposal/ Recycling Exceptions
Paragraph (d)

5. Damaged, Defective, Recalled (DDR) Requirements
Paragraph (f)

Disposal/Recycling Exceptions



***For motor vehicle transportation ONLY**

49 CFR § 173.185(d)

Batteries for Reuse

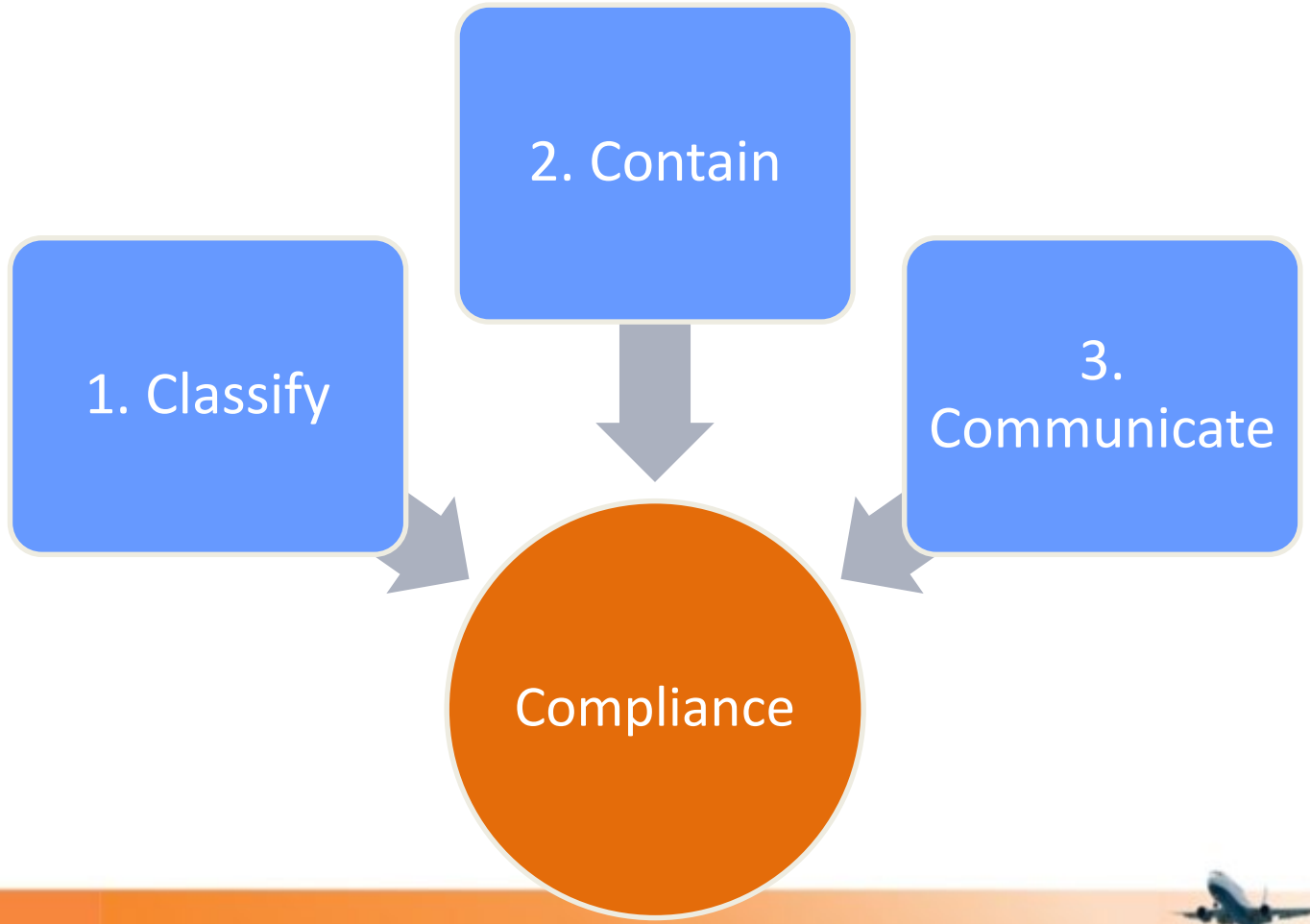
~~Disposal/ Recycling Exceptions~~

Classification/ UN 38.3 Testing

Small Battery Exceptions

Specification Packaging

Three Major Components



1. Classify the Hazard – Hazard Classes

Explosives

Gases

Flammable Liquids

Flammable Solids

Oxidizers and Organic Peroxides

Poison and Infectious Substances

Radioactive

Corrosive

Miscellaneous

Class 9 Lithium Battery

1. Classify the Hazard – Identification and Classification

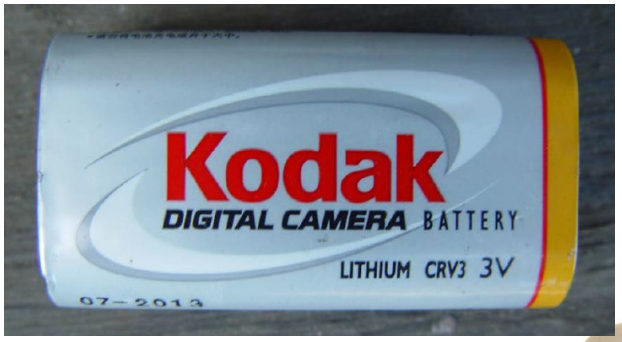
- Battery markings
- Physical characteristics
- Isolate DDR batteries

Battery identification and classification is done during the sorting process

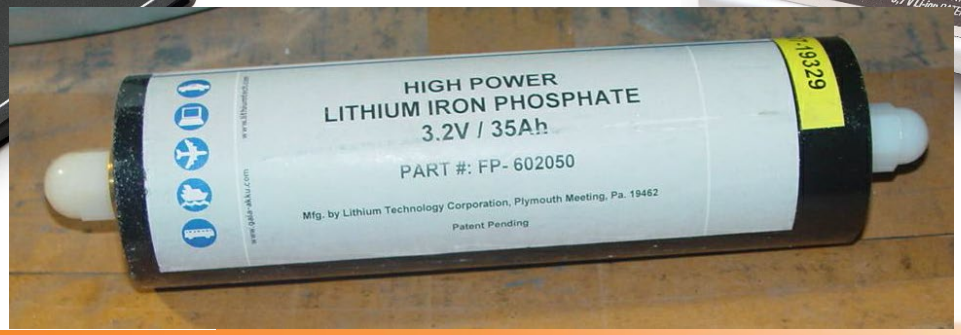
1. Classify the Hazard – Type of Lithium Batteries

- 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

UN3480	• Lithium Ion Batteries
UN3481	• Lithium Ion Batteries Contained in/Packed with Equipment
UN3090	• Lithium Metal Batteries
UN3091	• Lithium Metal Batteries Contained in/Packed with Equipment

1. Classify the Hazard – Energy Capacity

- 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)	Lithium Metal (Smaller Batteries)
• ≤ 100 Wh • ≤ 300 Wh ground only*	• ≤ 2 g • ≤ 25 g ground only*

* Additional hazard communication is required

1. Classify the Hazard – Energy Capacity

^ Under 100 Wh and qualifies for "Small" battery exception

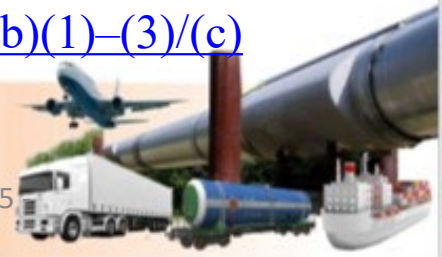
- Watt-hour (Wh) = Ampere-hours (Ah) x Volts (V)
- In the case of milliampere hour (mAh), divide by 1000

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

Increased Regulation

- 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

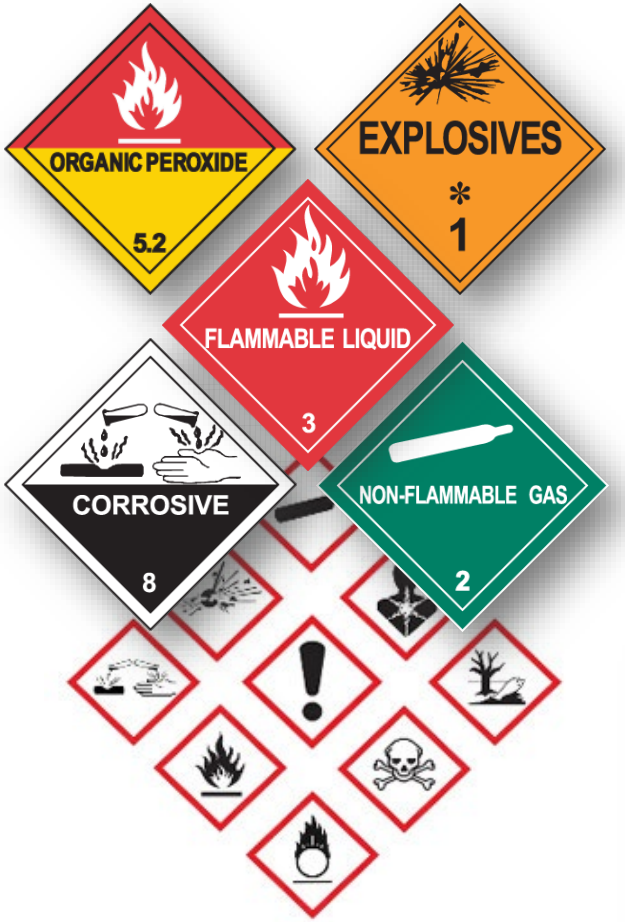
Not permitted for passenger aircraft (Cargo Aircraft requires Approval by AA)

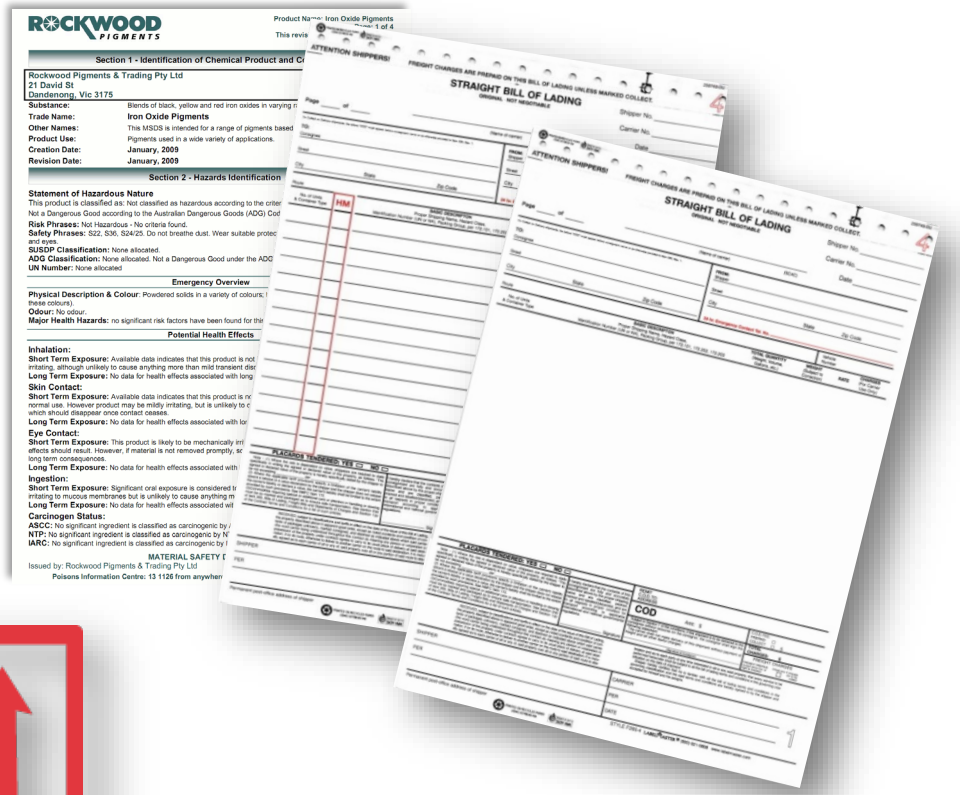
May be packed:

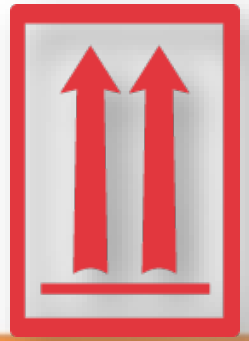
- In "strong outer packagings"
- In protective enclosures (e.g., crates)
- On pallets

49 CFR § 173.185(b)(5)
or
49 CFR § 173.185(d)

3. Communicate the Hazard – Hazard Communication

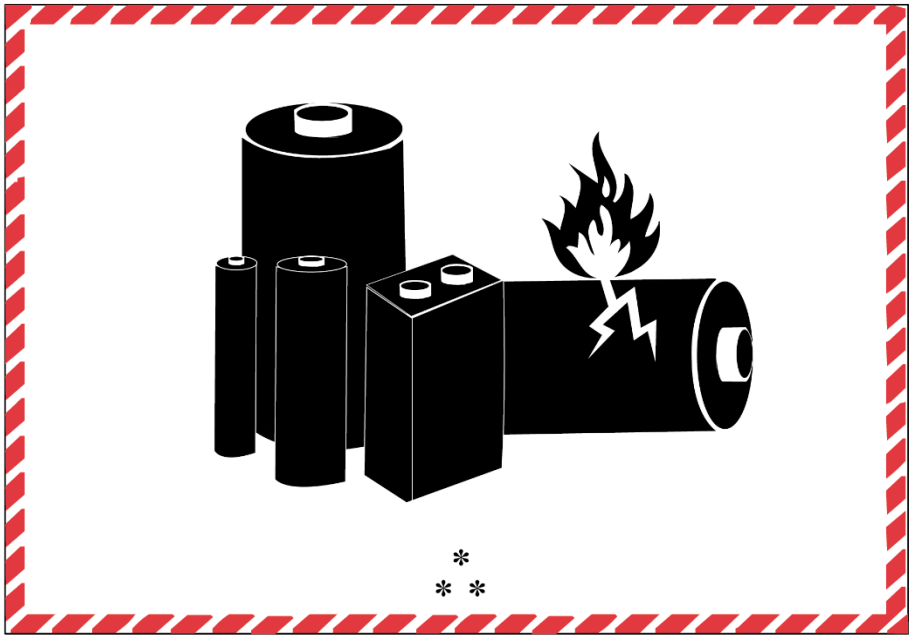






3. Communicate the Hazard – Lithium Battery Handling Mark

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



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

49 CFR § 173.185(c)(3)

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

Cargo Aircraft Only Label (DOT)

Universal Waste Label OR Marking (EPA)

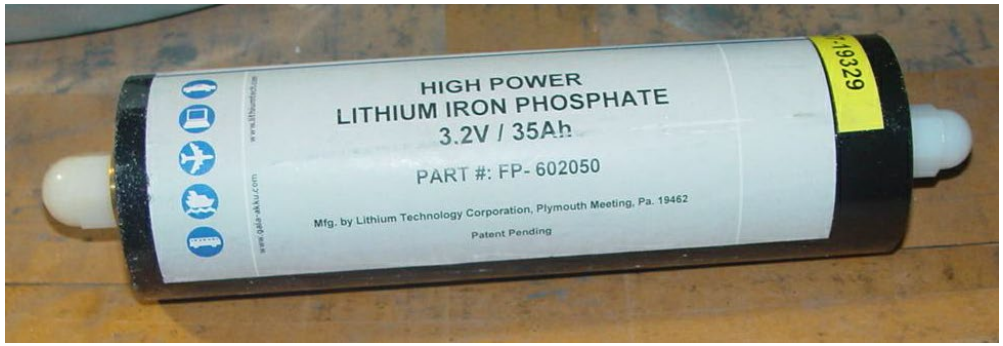
Lithium Battery Handling Mark (DOT)

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)

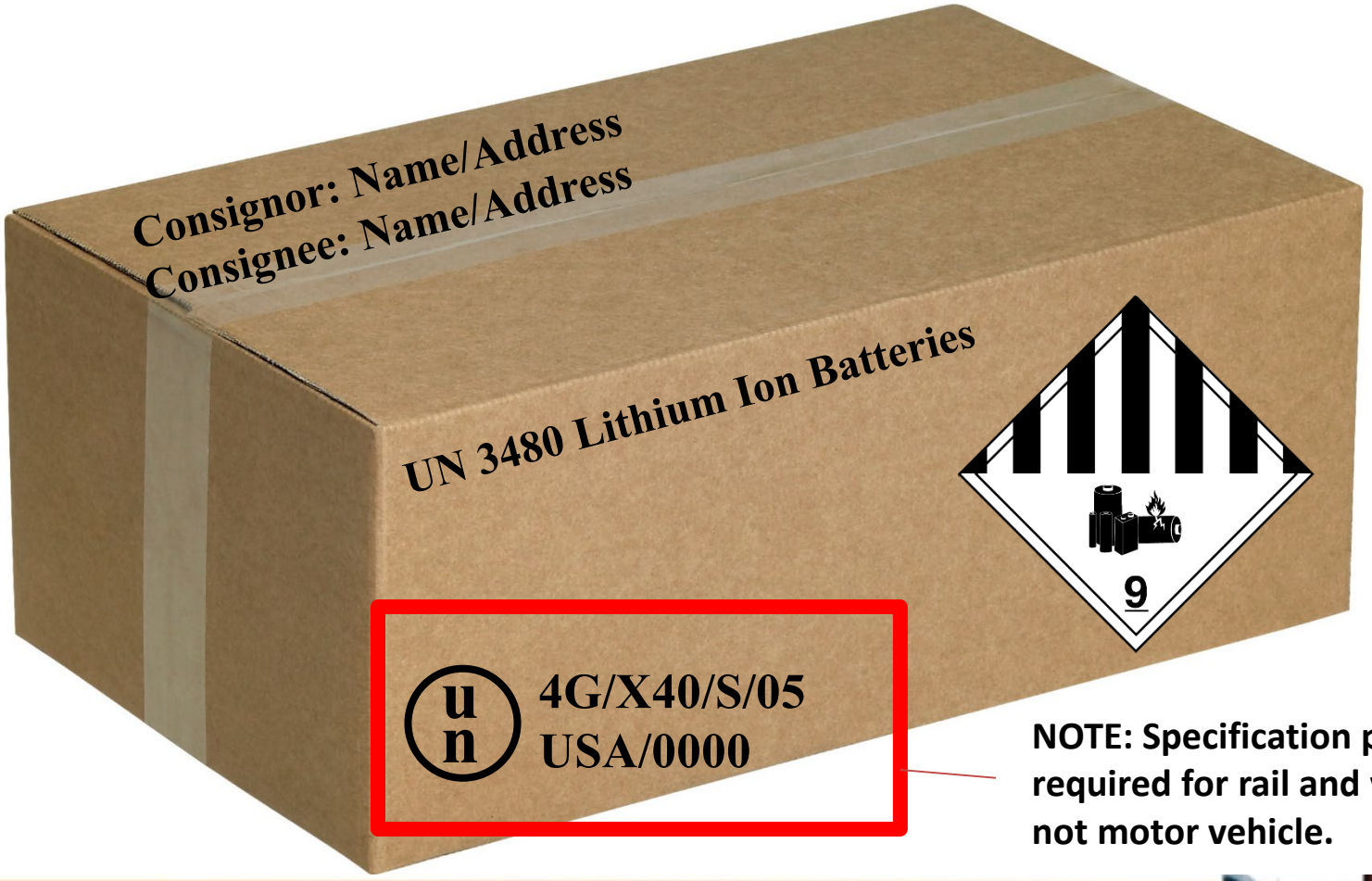
Communicate the Hazard – Larger Batteries and Quantities (All Modes)

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

49 CFR § 173.185(f)

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

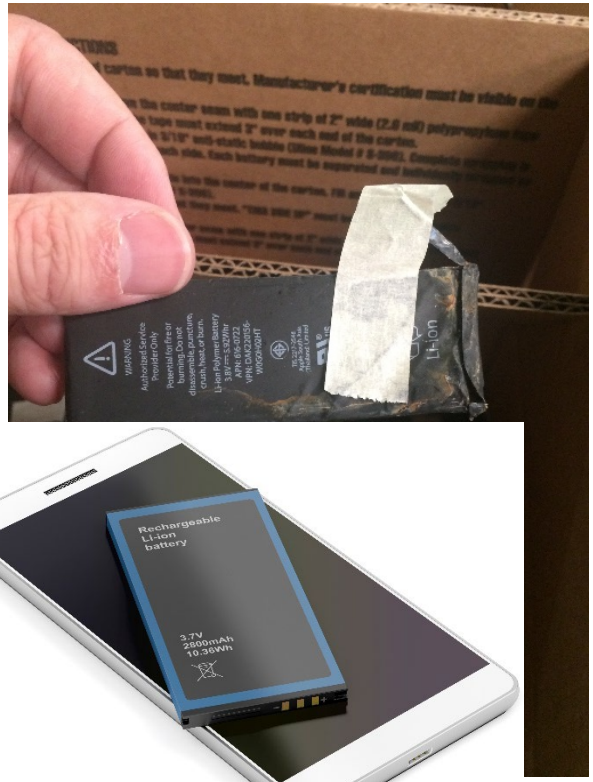
Classify the Hazard - DDR

- 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



2. Contain 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

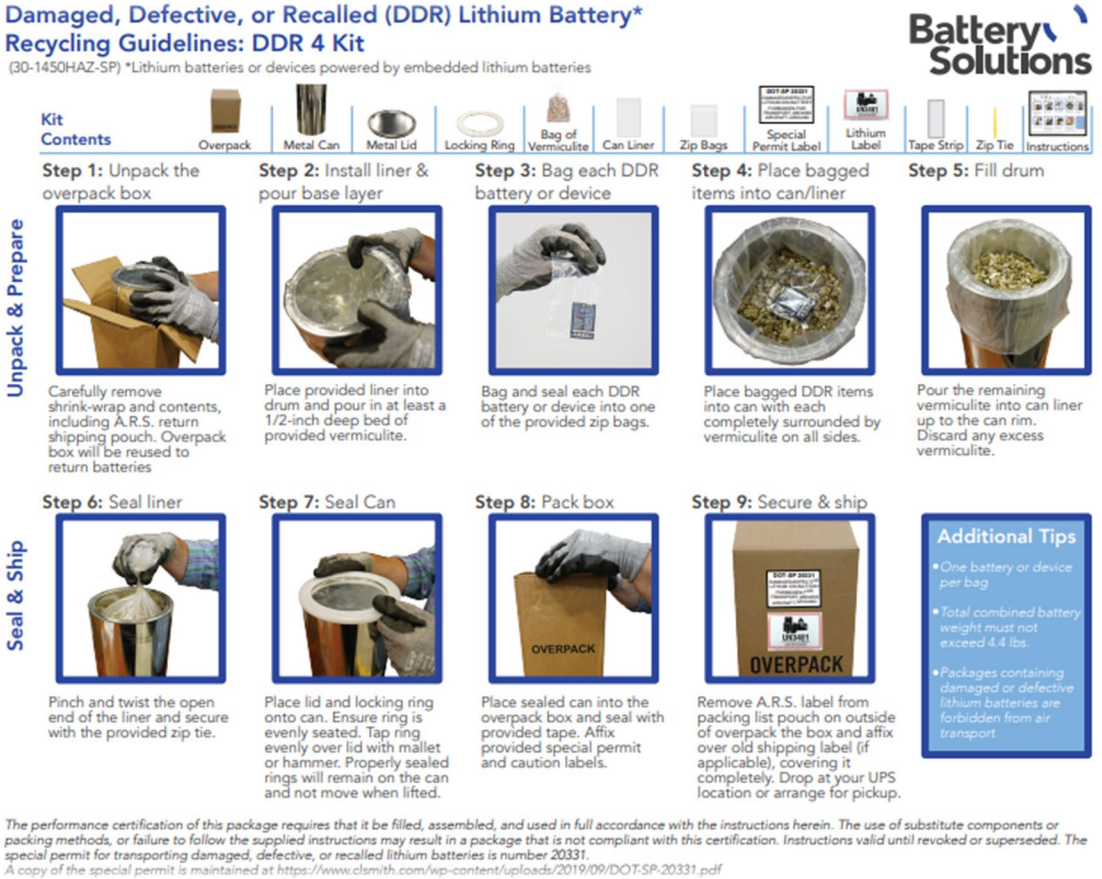
Example DDR Kits

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

DDR Kits

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

Compliance assistance to industry (Outreach and Engagement)

- Emergency Response Guidebook (ERG)

Locating DOT-SPs

PHMSA Training Modules

Sign-Up for Email Alerts | Newsroom

PHMSA
Pipeline and Hazardous Materials Safety Administration

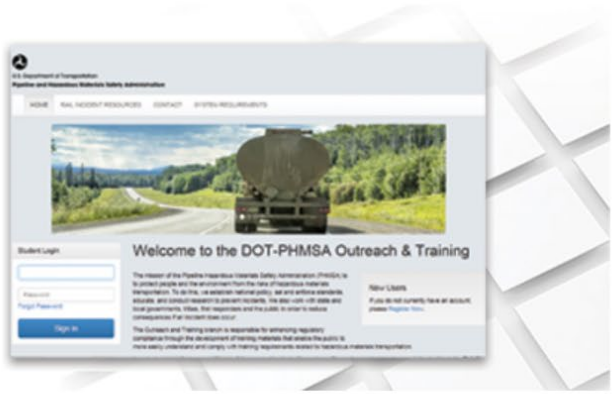
Search PHMSA site

ABOUT PHMSA | SAFETY | REGULATIONS AND COMPLIANCE | RESOURCES

Home » Training » Hazmat

- Hazardous Materials Outreach & Engagement
- Training Requirements for Industry
- Emergency Response Guidebook (ERG)
- Webinars and Workshops
- Hazardous Materials Safety Assistance Team (HMSAT)
- Publications
- Training Modules
- Videos and Mobile Apps
- Contact Us

Training Modules



Related Links

- Hazardous Materials Training Modules

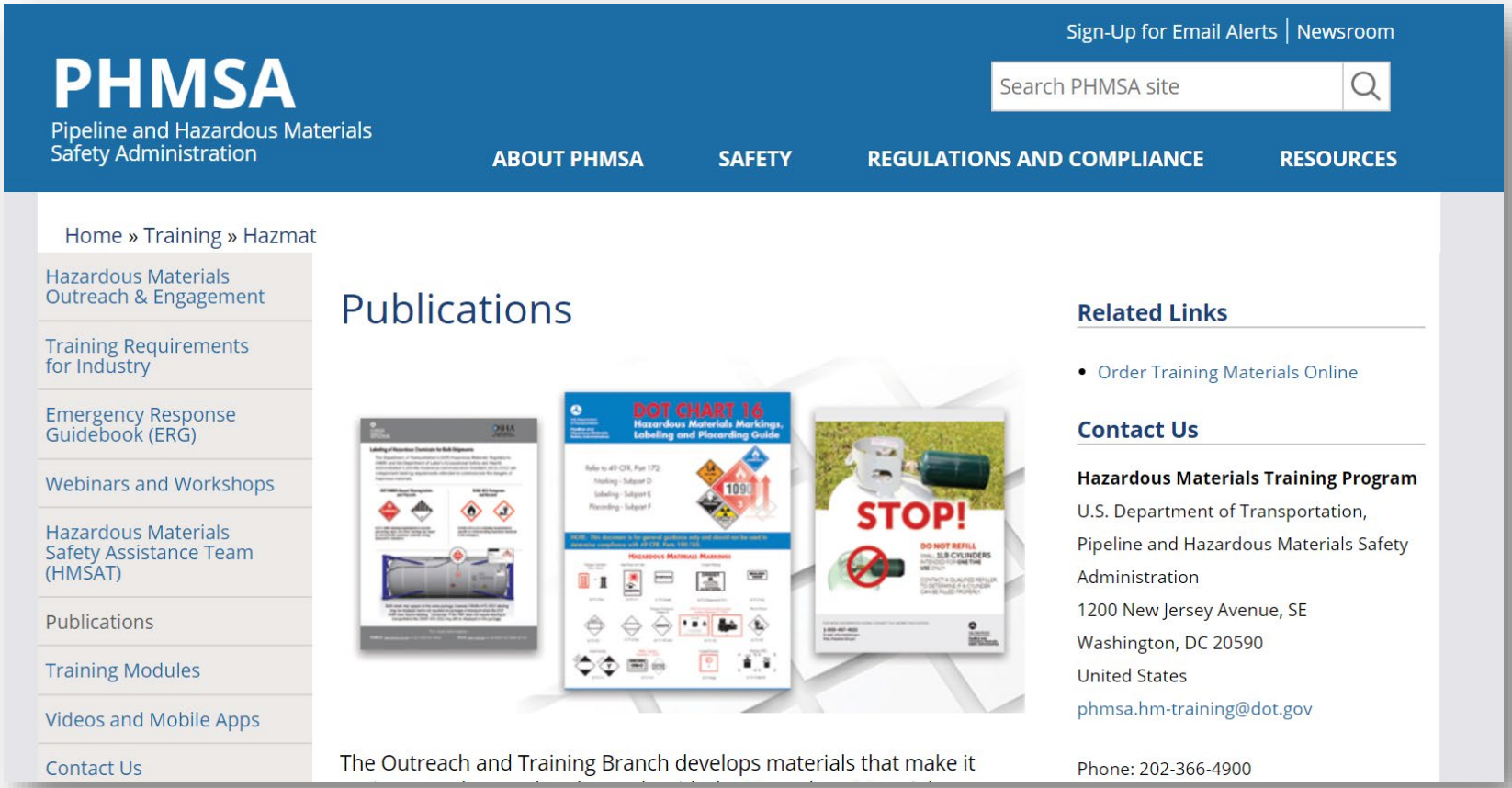
Contact Us

Hazardous Materials Training Program
U.S. Department of Transportation,
Pipeline and Hazardous Materials Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590
United States
phmsa.hm-training@dot.gov

Phone: 202-366-4900

Hazardous Materials Transportation

PHMSA Training Publications



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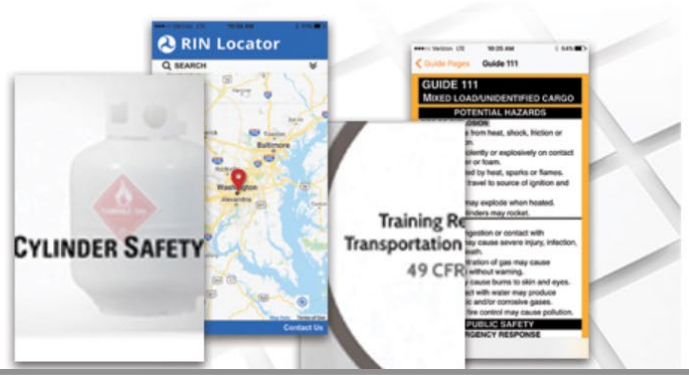

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U.S. Department of Transportation,
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1200 New Jersey Avenue, SE

HMSAT

PHMSA Hazmat Transportation Webinars: https://www.phmsa.dot.gov/hazmat/seminars/webinars

Hazardous Materials Information Center

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Acknowledgements

Alex Armstrong (*PHMSA, HQ*)

Tristan Brown (*PHMSA, HQ*)

Kim Charick (*EPA, Region 4*)

Elina Chen (*Eastern Research Group*)

Joe Day (*Terracycle*)

Harlan Dalzell (*PHMSA, HQ*)

Steve Drueke (*Environmental Restoration*)

Eric Fredrickson (Call2Recycle)

Shelby Geller (*PHMSA, HQ*)

Kathryn Harrison (*Eastern Research Group*)

Peter Heitzmann (*PHMSA, HQ*)

Kenetha Hillman (*PHMSA, HQ*)

John Katz (*EPA, Region 9*)

George Kerchner (*Wiley Rein LLP*)

Elizabeth Ladow (*PHMSA, Southern*)

Wayne Lalicon (*PHMSA, Eastern*)

Kevin Leary (*PHMSA, HQ*)

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