



# Lithium-Ion Batteries

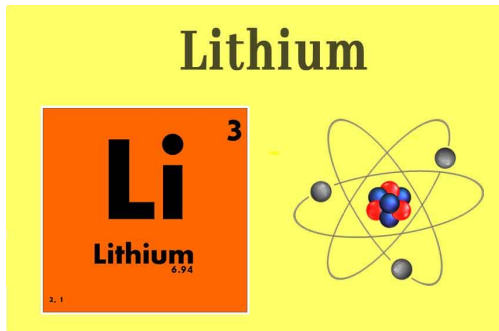
WHAT  
YOU  
NEED  
TO  
KNOW?



Jay Johnson  
Labelmaster Services

# Lithium

- Lithium comes from a Greek word **Lithos** meaning “stone”.
- Lithium metal come from lithium carbonate.
- Lithium is soft enough to be cut by knife.
- Lithium is corrosive and in contact with water emits flammable gasses.
- First lithium-ion battery commercial released in 1991.



# Lithium Battery Fires a New Problem?



Between 2002 – 2004 mobile phone batteries caused several fires and 1-out-of-4 Americans may have experienced an overheating scenario according one survey conducted back then.

CNET reported that “Bad batteries have made **2004 a year of living dangerously** with cell phones.”

U.S. Consumer Product Safety Commission reported that defective or counterfeit batteries have caused nearly all of the reported incidents.

# Back to the Future - Hoverboards

In December 2015, fears of fires grounded the popular hoverboards on airlines.

In July 2016, the U.S. Consumer Product Safety Commission had at least 60 reports of hoverboard fires totaling over \$2 million in property damage.



London Fire Brigade

# When lithium batteries go wrong...



# Definition of Dangerous Goods(DG)



Health



Safety



Property



Environment

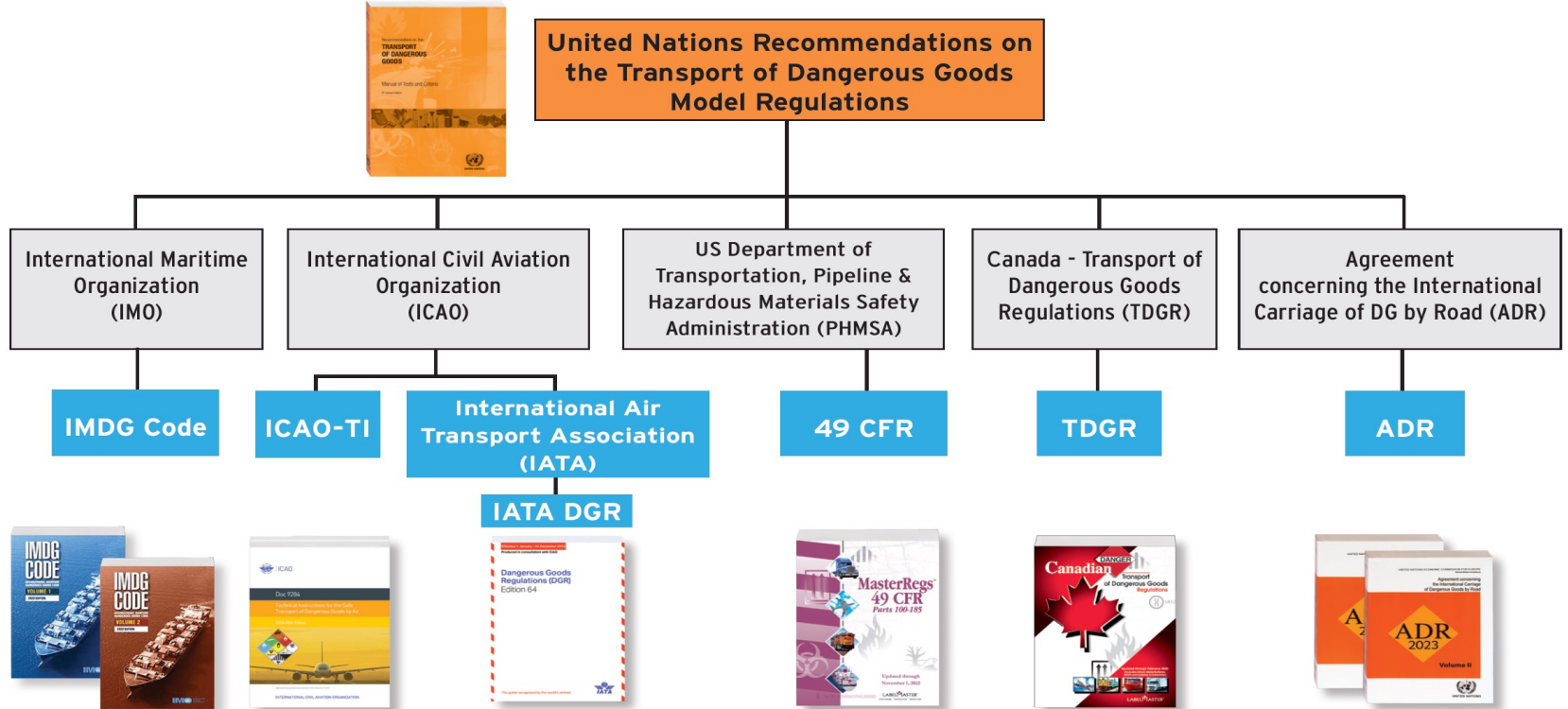
Dangerous Goods(DG) are articles or substances which are capable of posing a hazard to health, safety, property or the environment and which are shown in the list of dangerous goods in the regulations or which are classified according to the regulations.

# DG vs. Hazardous Materials



The U.S. is the only region to use the term **Hazardous Materials**.  
The rest of the world uses the term **Dangerous Goods**.

# Regulatory Standards





# International Maritime Dangerous Goods (IMDG) Code



## International regulations since 1965

Updated every two years. Consists of a transition year (*where two editions overlap and are both valid*) and a mandatory year (*where only one edition is valid*).

### Amendment 40-20 (2020 Version)

Voluntary 1 January, 2021  
Mandatory 1 January, 2022/2023



### Amendment 41-22 (2022 Version)

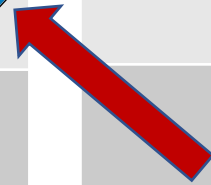
Voluntary 1 January, 2023  
Mandatory 1 January, 2024/2025



# Hazard Classes



Class 1	Explosives		Class 6	Toxic & Infectious Substances	 
Class 2	Gases	  	Class 7	Radioactive	  
Class 3	Flammable Liquids		Class 8	Corrosive	
Class 4	Flammable Solids & Reactives	  	Class 9	Miscellaneous	 
Class 5	Oxidizers & Organic Peroxides	 	Lithium	Lithium Battery	



# Why Lithium Batteries are Regulated



## Lithium batteries are hazardous because:

- Can overheat & self-ignite (contain flammable electrolytes)
- Once ignited, they burn at extremely high temperatures
- Overpressure resulting in “rapid disassembly”
- Venting of toxic gases

## Unique Hazard

- Lithium batteries provide both a potential **ignition source**
- as well as a **fuel** for a fire initiated by any source



# Lithium Battery Dangers



06-14-2016 Tue 11:00:36

Camera 01



#UMI2023

# Lithium Battery Basics



#IUMI2023

# UN Manual of Tests and Criteria

## Lithium Battery Classification - must meet the following provisions:


- ❖ **All lithium cells and batteries must be proven to pass the UN Manual of Tests & Criteria 38.3 tests.**
  - ❖ The 38.3 test runs the batteries thru Altitude simulation, Thermal, Vibration, Shock, External short circuit, Impact/Crush, Overcharge and Forced discharge Tests to ensure the batteries have no defects and can be transported safely.
- ✓ Cells and batteries incorporate safety venting device or designed to preclude a violent rupture
- ✓ Equipped with effective means to prevent short circuit
- ✓ Cells connected in parallel equipped with effective means to prevent reverse current flow
- ✓ Cells and batteries must be manufactured under a quality management program
- ❖ **Test Summary must be made available**



# 38.3 Test Reports

Lithium batteries must meet requirements of UN Manual of Tests & Criteria, Part III, Subsection 38.3

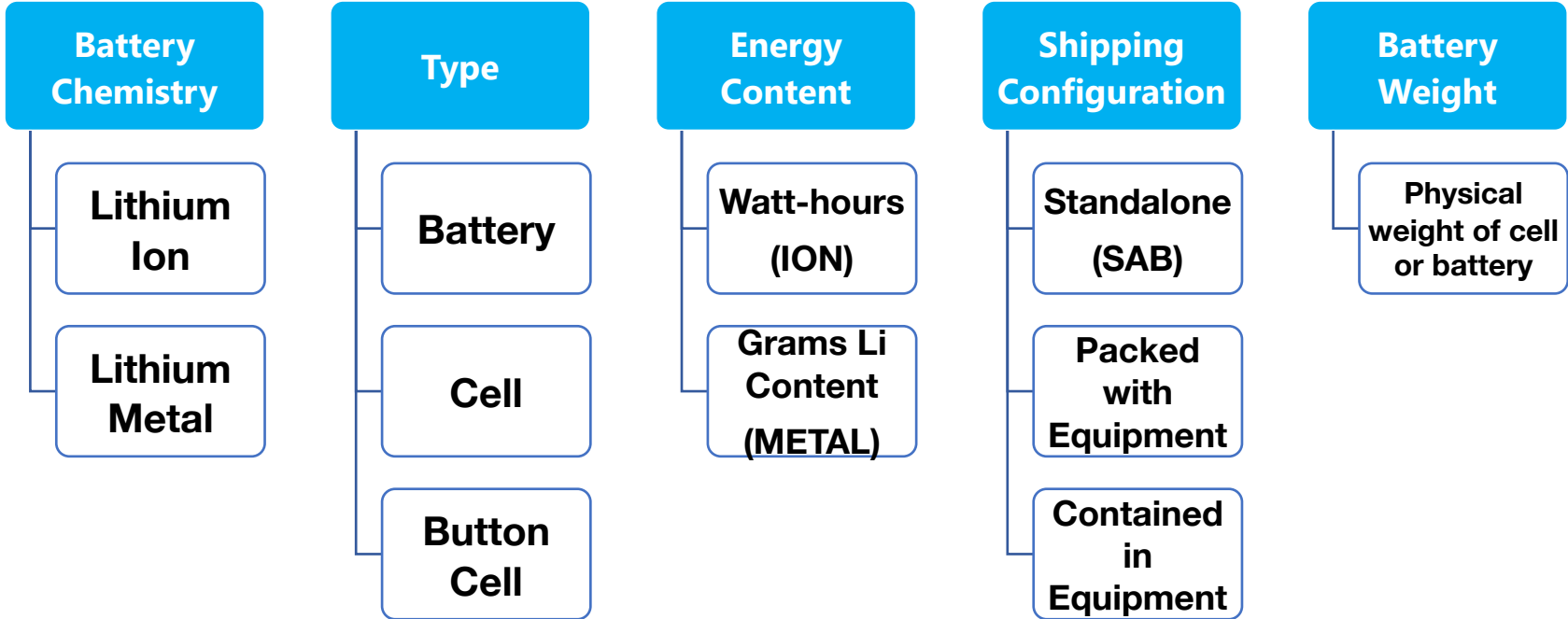
- Manufacturers must maintain test reports
- Downstream users/distributors **should** keep copies
- Ask for test reports before purchase

	Project No.: BCTC-FY180301592S
<b>UN 38.3 检测报告</b> <b>UN38.3 Test Report</b>	
产品名称: Product Name:	锂离子聚合物电池 Lithium Polymer Battery
委托单位: Consignor:	深圳市欣双洋数码科技有限公司 LIPol Battery Co., Ltd
委托单位地址: Address:	深圳龙华中梅路光浩国际中心B座18楼 B-18F, Guanghao Intention Center, Zhongmei Rd., Longhua, Shenzhen
产品型号: Product Type:	LP652730
检测日期: Tested Date:	2018-03-28-2018-04-13
发布日期: Issued Date:	2018-04-17
深圳市倍测检测有限公司 Shenzhen BCTC Testing Co., Ltd. 地址: 深圳市宝安区福永街道桥头社区福园一路鹏洲工业园 B栋东面1楼2楼及倍测大厦 BCTC Building & 1-2F, East of B Building, Pengzhou Industrial, Fuyuan 1st Road, Qiaotou Community, Fuyong Street, Bao'an District, Shenzhen, China 电话/Tel.:400-788-9558; 传真/Fax.:0755-33229357 网址/Web: www.bctc-lab.com.cn 邮件/Email: bct@bctc-lab.com.cn	
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# What Do I Need to Know?

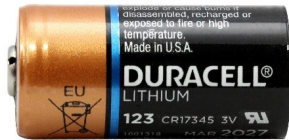
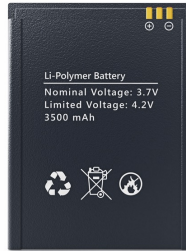


# Lithium Battery Chemistry

## Battery Chemistry

Lithium ion

Lithium metal



## Lithium ion cells/batteries

- “Secondary” batteries, rechargeable
- Lithium ion or lithium polymer

## Lithium metal cells/batteries

- “Primary” batteries, non-rechargeable (one-time use)
- Lithium metal (or alloy) as an anode

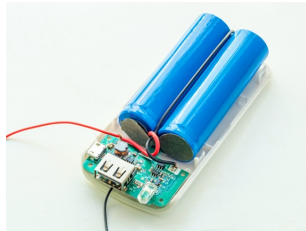
# Lithium Battery Types

## Type

Cell

Battery

Button  
cell



### Cell (single cell)

a single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals.

### Battery (multi-cell)

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

### Button cell (coin cell)

a small round cell when the overall height is less than the diameter.

## Energy Content

Watt-hours  
(ION)

Grams Li  
Content  
(METAL)

### Lithium Ion Cells & Batteries

- The energy content is measured in **Watt-hours (Wh)**
- Wh rating can be found on a product data sheet, SDS, Test Summary document, on the battery case, or calculated using:

$$\text{Volts} \times \text{Ampere Hours (Ah)} = \text{Watt-hours (Wh)}$$

### Lithium Metal Cells & Batteries

- The energy content is measured in **grams of lithium**
- Lithium content can be found on a product data sheet, SDS, Test Summary document, on the battery case, or calculated using:

$$\text{Ah per cell} \times 0.3 \text{ g} \times \text{number of cells} = \text{grams of lithium}$$

# Lithium Battery Thresholds

## Energy Content Thresholds - Small



Lithium **ion** batteries are regulated differently based on their energy content (Wh)

<u>Regulatory Category</u>	<u>US Ground/Rail</u>	<u>Air</u>	<u>Vessel</u>
<i>Fully Regulated (Large)</i>	Cell > 60 Wh Battery > 300 Wh	Cell > 20 Wh Battery > 100 Wh	Cell > 20 Wh Battery > 100 Wh
<i>Excepted (Medium)</i>	Cell > 20 Wh and ≤ 60 Wh Battery > 100 and ≤ 300 Wh	N/A	N/A
<i>Excepted (Small)</i>	Cell ≤ 20 Wh Battery ≤ 100 Wh	Cell ≤ 20 Wh Battery ≤ 100 Wh	Cell ≤ 20 Wh Battery ≤ 100 Wh



Lithium **metal** batteries are regulated differently based on their lithium content (LC)

<u>Regulatory Category</u>	<u>US Ground/Rail</u>	<u>Air</u>	<u>Vessel</u>
<i>Fully Regulated (Large)</i>	Cell > 5 g Battery > 25 g	Cell > 1 g Battery > 2 g	Cell > 1 g Battery > 2 g
<i>Excepted (Medium)</i>	Cell > 1 g and ≤ 5 g Battery > 2 g and ≤ 25 g	N/A	N/A
<i>Excepted (Small)</i>	Cell ≤ 1 g Battery ≤ 2 g	Cell ≤ 1 g Battery ≤ 2 g	Cell ≤ 1 g Battery ≤ 2 g



Note: optional "medium" exception for US Ground only



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# Lithium Battery Thresholds

## Energy Content Thresholds - Large

Lithium **ion** batteries are regulated differently based on their energy content (Wh)

<u>Regulatory Category</u>	<u>US Ground/Rail</u>	<u>Air</u>	<u>Vessel</u>
<b>Fully Regulated (Large)</b>	Cell > 60 Wh Battery > 300 Wh	Cell > 20 Wh Battery > 100 Wh	Cell > 20 Wh Battery > 100 Wh
<b>Excepted (Medium)</b>	Cell > 20 Wh and ≤ 60 Wh Battery > 100 and ≤ 300 Wh	N/A	N/A
<b>Excepted (Small)</b>	Cell ≤ 20 Wh Battery ≤ 100 Wh	Cell ≤ 20 Wh Battery ≤ 100 Wh	Cell ≤ 20 Wh Battery ≤ 100 Wh

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<u>Regulatory Category</u>	<u>US Ground/Rail</u>	<u>Air</u>	<u>Vessel</u>
<b>Fully Regulated (Large)</b>	Cell > 5 g Battery > 25 g	Cell > 1 g Battery > 2 g	Cell > 1 g Battery > 2 g
<b>Excepted (Medium)</b>	Cell > 1 g and ≤ 5 g Battery > 2 g and ≤ 25 g	N/A	N/A
<b>Excepted (Small)</b>	Cell ≤ 1 g Battery ≤ 2 g	Cell ≤ 1 g Battery ≤ 2 g	Cell ≤ 1 g Battery ≤ 2 g

Note: optional "medium" exception for US Ground only

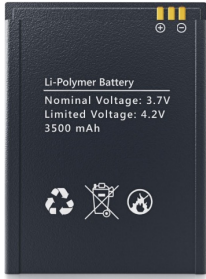
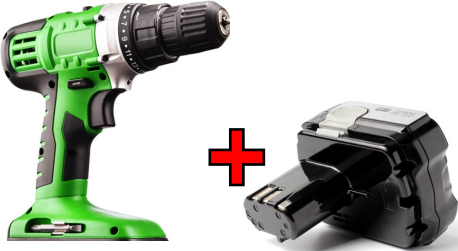

# Shipping Configuration

## Shipping Configuration

Standalone

Packed with Equipment

Contained in Equipment

Standalone	Packed With Equipment	Contained In Equipment
		
<p><b>Individual batteries, without equipment</b></p>	<p><b>Packed with, but not installed in, the equipment they operate</b></p>	<p><b>Installed in the equipment that they operate</b></p>

*\* Number of batteries limited to the minimum number required to power the equipment, plus two spares*



# Need to Know Summary

## Lithium Battery Classification

- ✓ Meets the requirements of 38.3 of the UN Manual of Test and Criteria
- ✓ Incorporates safety venting or designed to prevent violent rupture
- ✓ Equipped with a means to prevent short circuits
- ✓ Battery equip with a means of preventing reverse current flow
- ✓ Manufactured under a quality management program
- ✓ Test summary made available

## Battery Chemistry

- ✓ lithium ion, or
- ✓ lithium metal

## Type

- ✓ cells,
- ✓ batteries, or
- ✓ button cells (coin cells)

## Energy Content

- ✓ lithium content → lithium metal
- ✓ watt hours → lithium ion

## Shipping Configuration

- ✓ standalone,
- ✓ packed with, or
- ✓ contained in

## Battery weight

- ✓ Physical weight of cell or battery

WHAT  
YOU  
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TO  
KNOW?





# IMDG Dangerous Goods List

Part 3 – Dangerous Goods List, special provisions and exceptions



UN No.	Proper shipping name (PSN)	Class or division	Subsidiary hazard(s)	Packing group	Special provisions	Limited and excepted quantity provisions		Packing		IBC	
						Limited quantities (7a)	Excepted quantities (7b)	Instructions (8)	Provisions (9)	Instructions (10)	Provisions (11)
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.1.4	4.1.4
3090	LITHIUM METAL BATTERIES (including lithium alloy batteries)	9	-	-	188 230 310 376 377 384 387	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906	-	-	-
3091	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)	9	-	-	188 230 310 360 376 377 384 387 390	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906	-	-	-
3480	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	9	-	-	188 230 310 348 376 377 384 387	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906	-	-	-
3481	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	9	-	-	188 230 310 348 360 376 377 384 387 390	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906	-	-	-

Based on battery chemistry and shipping configuration, the six (6) hazmat descriptions for lithium cells and batteries are:

- UN 3090, Lithium **metal** batteries
- UN 3091, Lithium **metal** batteries *contained in equipment*
- UN 3091, Lithium **metal** batteries *packed with equipment*

- UN 3480, Lithium **ion** batteries
- UN 3481, Lithium **ion** batteries *contained in equipment*
- UN 3481, Lithium **ion** batteries *packed with equipment*

# Battery Powered Vehicle (UN3171)



Although they contain a lithium-ion battery, electric vehicles are classified as:

- **UN3171, Battery-powered vehicle**

IMDG in **Special Provision 360** clarifies that a Battery Powered Vehicle only applies to vehicles powered by lithium batteries that are transported with these batteries **installed**.

Note: If the batteries are removed from the vehicle it must be classified as UN3481 Lithium-ion batteries packed with equipment.



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# Small Lithium Batteries



## UN 38.3 testing

**Cells and batteries** must be a type proved to meet the requirements of each test in the Manual of Tests and Criteria, Part III, Section 38.3.

## Small Watt hour rating or Lithium content

Lithium ion cell  $\leq 20$  Wh **or**  $\leq 100$  Wh battery  
Lithium metal cell  $\leq 1$  g LC **or**  $\leq 2$  g LC battery

## Wh marking

**For batteries**, the Watt-hour rating must be marked on the outside of the battery case

# Small Haz Comm Requirements



With a few exceptions, packages containing small lithium cells and batteries must display the lithium battery mark

- The mark must contain the UN number (e.g., UN3481)
- The regulations allow the use of a smaller lithium battery mark when the box size does not accommodate the larger label.
- Use of the smaller label when it does not meet this requirement may result in frustrated shipments and additional labeling charges from forwarders



**The lithium battery mark with the phone number may continue to be used until 31 December 2026.**

*Dimensions:*

- Must be 100mm x 100mm
- For smaller packages may be reduced to 100mm x 70mm

# Small Haz Com Requirements



Each package must display the lithium battery mark, except when:

- a package contains button cell batteries installed in equipment (including circuit boards), **or**
- no more than four (4) cells or two (2) batteries contained in the equipment, where there are not more than two (2) such packages in a consignment
  - Consignment: One or more packages of dangerous goods accepted by an operator (FedEx) from one shipper (You) at one time and at one address, receipted for in one lot and moving to one consignee at one destination address.

**One Consignment -  
2 packages or less (e.g., 2 laptops each)  
(≤ 4 cells or 2 batteries contained in equipment)**



**One Consignment -  
3 or more packages (e.g., 2 laptops each)  
(≤ 4 cells / 2 batteries contained in equipment)**

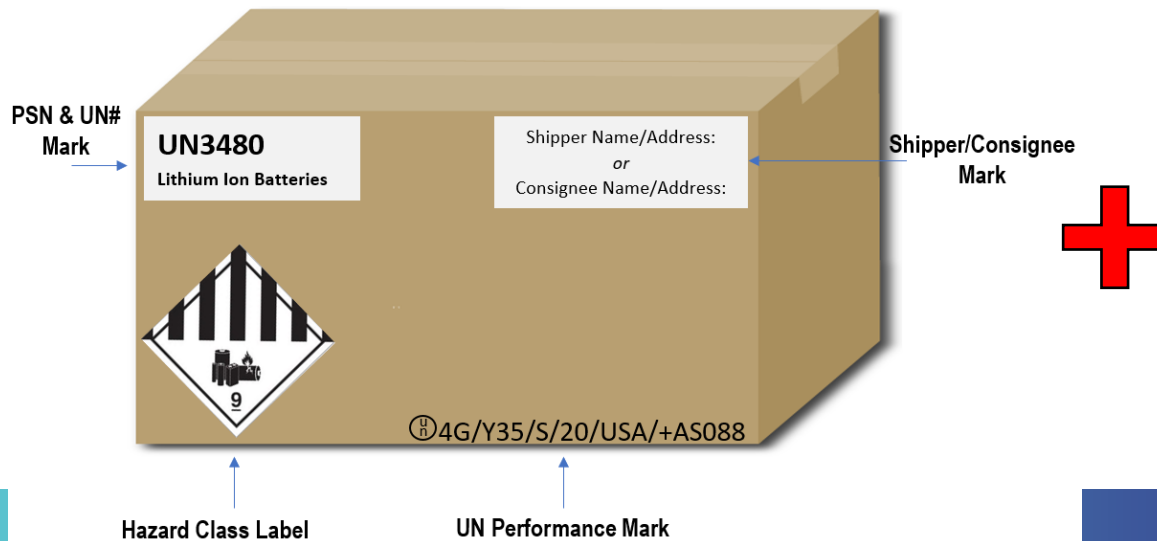




# Fully Regulated Non-Bulk

Shipments will require:

- ✓ Proper Shipping Name (PSN) and UN Number mark
- ✓ Class 9 hazard class label
- ✓ UN Performance Packaging (standalone & packed with)
- ✓ Shipper or Consignee Name and Address
- ✓ Shipping papers

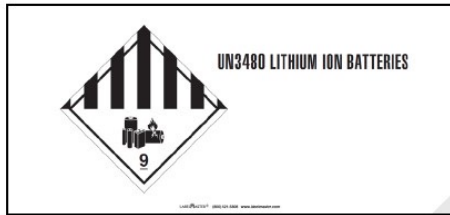


MULTIMODAL DANGEROUS GOODS FORM

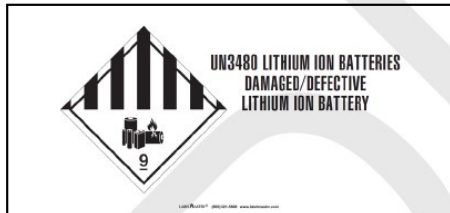
# Fully Regulated Large Package

## Example Package Containing Large (Fully Regulated) Lithium Batteries

The Class 9 hazard label as well as the UN number and proper shipping name must be displayed on two opposite sides of the crate.



Or



# Transport Canada Evaluation of UN 38.3 Testi



Transport  
Canada

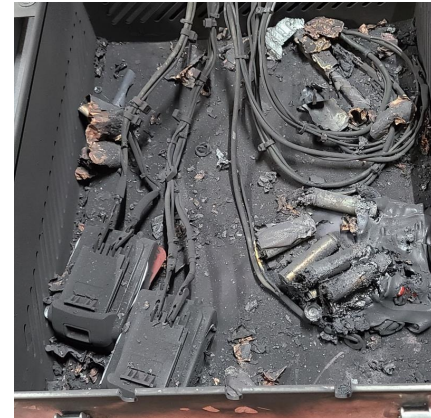
Transports  
Canada



- All Original Equipment Manufacturer OEM batteries passed (4 of 4).
- Many (10 of 20) third-party batteries failed:
  - Seven (7) failures during vibration testing (T3) mostly due to loss of voltage;
  - Six (6) failures during short circuit or overcharge testing (T5, T7); and
  - Four (4) of 20 third-party batteries had “severe” failures with fire/explosion.



RDIMS: 19385371 / SGDDI: 19401682







# How Are We Doing?

There are lots of concerns about lithium battery transport, but it is NOT just a DG thing. **The problems are coming from damaged, defective or counterfeit batteries.**

Remember what was said back in 2004 –

**U.S. Consumer Product Safety Commission reported that defective or counterfeit batteries have caused nearly all of the reported incidents.**

Comment from the International Union of Marine Insurance (IUMI) on Aug 10, 1023

**No fire onboard a Roll-on/Roll-off (RORO) or Pure Car and Truck Carrier (PCTC) has been proven to have been caused by a factory-new EV.**



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# Questions?

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