Seminar on Safe Transport of Lithium Battery by Air

Lithium battery knowledge

12 December 2008
At Cathay City's Auditorium

Battery Association of Japan（BAJ）

Seminar on Safe Transport of Lithium Battery by Air

1. What is the Lithium metal battery and Lithium ion battery?
2. What kind of the features the batteries have?
3. What is the safety concept for the batteries?
4. What is the results of safety testing to the batteries?
5. In where are the batteries used?

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1. **What is the Lithium metal battery and Lithium ion battery?**
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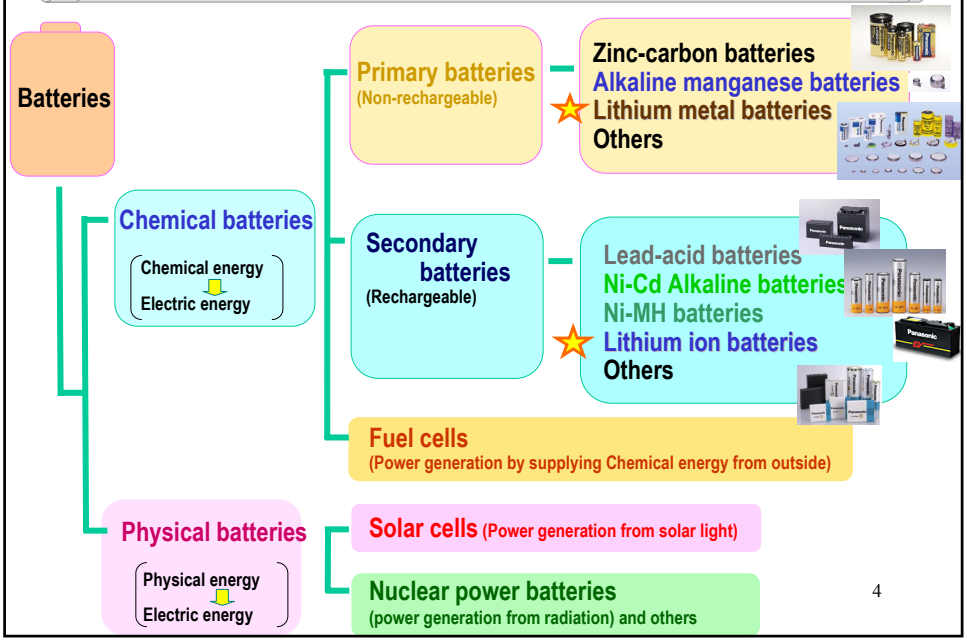
1-1. Battery types



1-2. UN Number of Battery type

UN2794	Batteries, wet, filled with acid	**Battery/Batteries**
UN2795	Batteries, wet, filled with alkali	**Battery /Batteries and Equipment)**
UN2796	Battery fluid, acid	
UN2797	Battery fluid, alkali	
UN2800	Batteries, wet, non spillable	
UN3028	Batteries, dry, containing potassium hydroxide solid	
★ UN3090	Lithium metal batteries	
★ UN3091	Lithium metal batteries contained in equipment Lithium metal batteries packed with equipment	
★ UN3480	Lithium ion batteries	
★ UN3481	Lithium ion batteries contained in equipment Lithium ion batteries packed with equipment	
UN3171	Battery-powered vehicle Battery-powered equipment	
UN3292	Batteries, contained sodium	

★ **Changed the battery type or New UN Number**

1-3. Naming of Lithium Batteries

- **Lithium metal battery**

Lithium primary battery
Lithium metal primary battery

- **Lithium ion battery**

Lithium rechargeable battery
Lithium ion rechargeable battery

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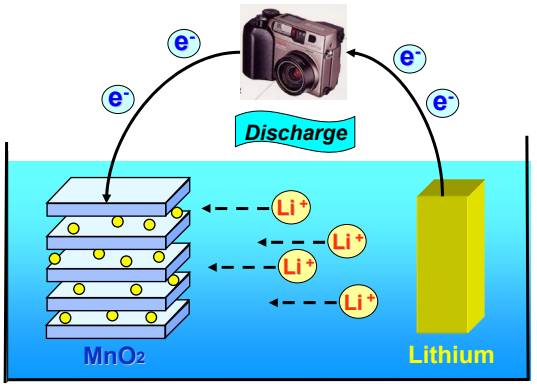
2-1. Chemical Reaction of Lithium metal cell (UN3090)

- *Positive Electrode Reaction* $Mn^{IV}O_2 + Li^+ + e^- \xrightarrow{Discharge} Mn^{III}O_2(Li^+)$
- *Negative Electrode Reaction* $Li \xrightarrow{Discharge} Li^+ + e^-$
- *Total Reaction* $Mn^{IV}O_2 + Li \xrightarrow{Discharge} Mn^{III}O_2(Li^+)$

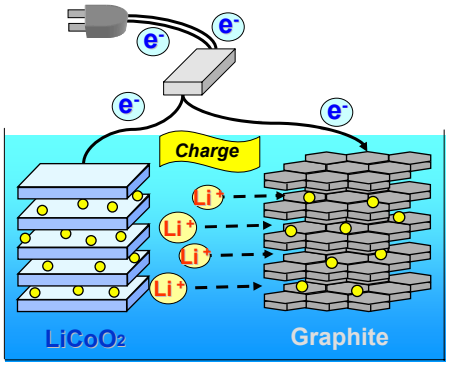


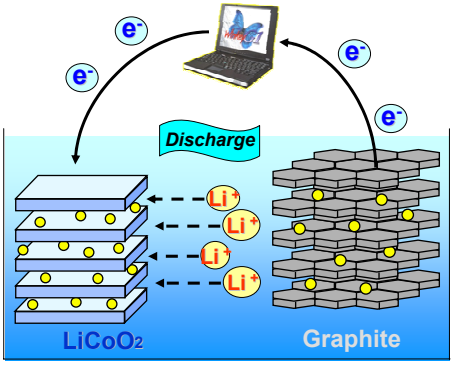
2-2. Chemical Reaction of Lithium ion cell (UN3480)

- *Positive Electrode Reaction* $LiCoO_2 \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} Li_{1-x}CoO_2 + xLi^+ + xe^-$

- *Negative Electrode Reaction* $C_y + xLi^+ + xe^- \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} C_yLi_x$

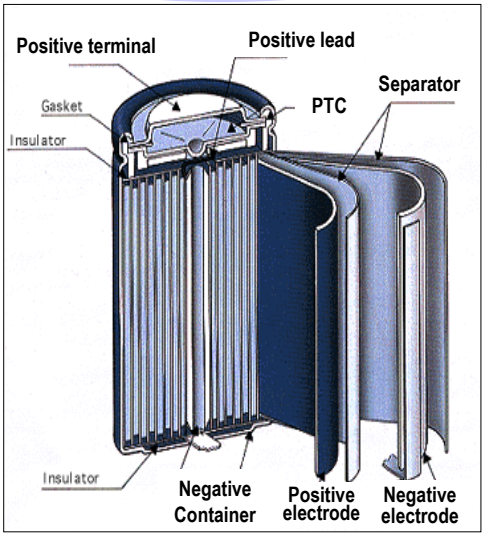
- *Total Reaction* $LiCoO_2 + C_y \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} Li_{1-x}CoO_2 + C_yLi_x$



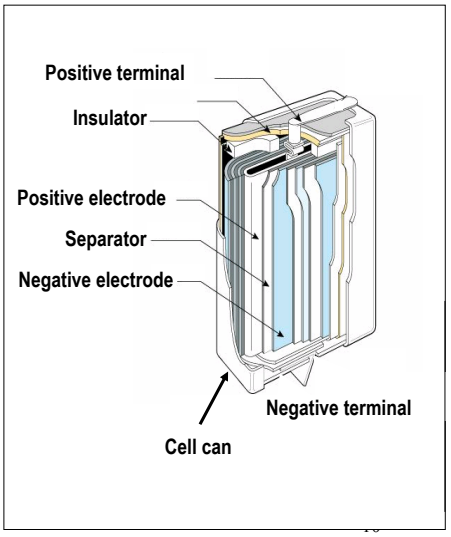


2-3. Structure of Lithium ion cells (UN3480)

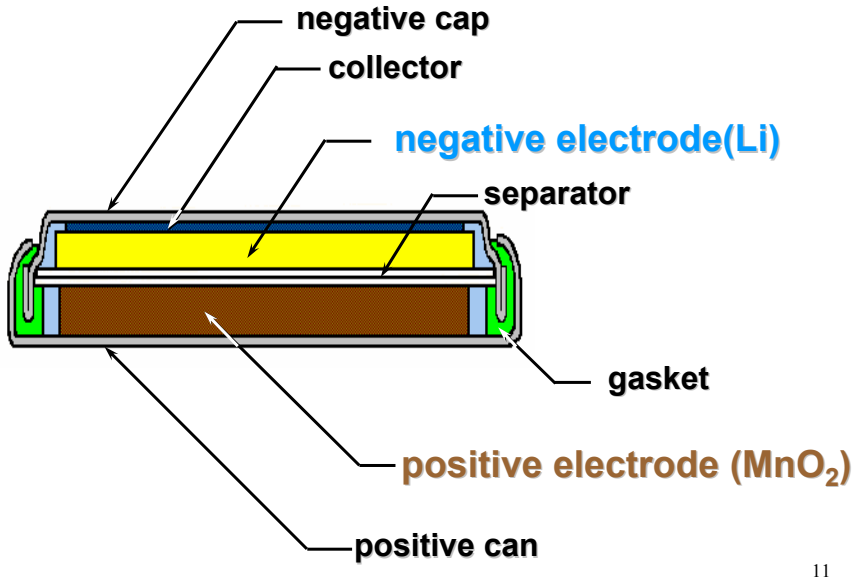
Cylindrical



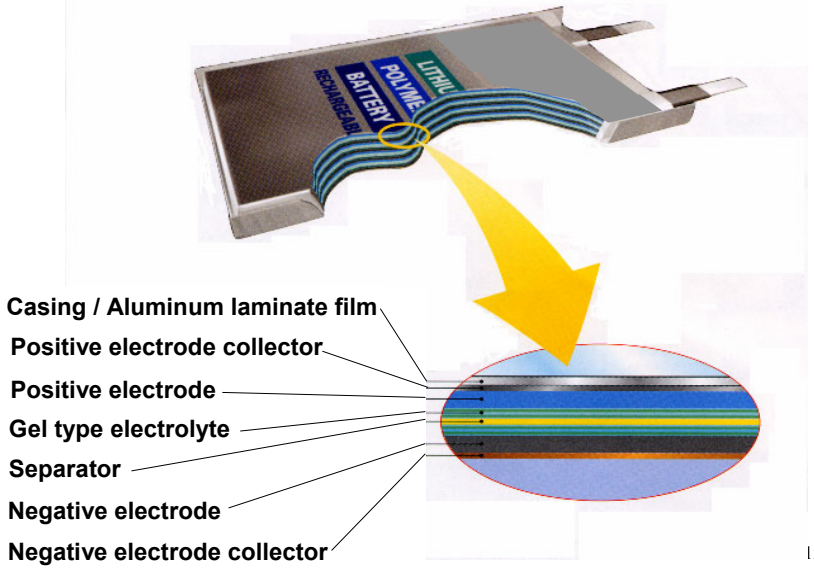
Prismatic



2-4. Structure of Lithium metal cell UN3090 (Coin Type)



2-5. Structure of Lithium ion UN3480 (Polymer type)



2-6. Major Constitution of Lithium metal batteries (UN3090)

Manganese Dioxide lithium battery (CR)

(IEC Designation :CR)

Positive Electrode : Manganese Dioxide (MnO_2)
Negative Electrode : Lithium Metal
Electrolyte : Propylene Carbonate - Solvent
1,2-Dimethoxyethane - Solvent
Lithium Triflate - Salt or Lithium Perchlorate - Salt
Separator : Polyethylene , Polypropylene

Carbon Monofluride lithium battery (BR)

Positive Electrode : Carbon Monofluoride $(CF)_n$
Negative Electrode : Lithium Metal
Electrolyte : γ -Butyrolactone - Solvent
1,2-Dimethoxyethane - Solvent
Lithium Tetrafluroborate - Salt
Separator : Polypropylene

2-7. Major Constitution of Lithium metal batteries (UN3090)

Thionyl Chloride lithium battery (ER)

Positive Electrode : Thionyl Chloride ($SOCL_2$)
Negative Electrode : Lithium Metal
Electrolyte : Thionyl Chloride

Sulfur Dioxide lithium battery

Positive Electrode : Sulfur Dioxide (SO_2)
Negative Electrode : Lithium Metal
Electrolyte : Sulfur Dioxide
Acetonitrile Lithium Bromide - Salt

2-8. Major Constitution of Lithium ion batteries (UN3480)

Lithium ion battery

Positive Electrode : Lithium cobalt oxide $LiCoO_2$ (IEC Designation:ICR, ICP)
Lithium nickel oxide $LiNiO_2$
Lithium manganese oxide $LiMn_2O_4$ (IEC Designation:IMR, IMP)

Negative Electrode : Cylindrical, Prismatic & coke, hard carbon, graphite
Electrolyte : Ethylene carbonate, Propylene carbonate - Solvent
Hexafluoro lithium phosphate - salt
Lithium per chlorate - salt
Separator Polyethylene

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3-1. UN Classification according to content of lithium

TRANSPORT OF DANGEROUS GOODS Model Regulations

UNITED NATIONS

Note:
Cell: Manufacturer semi-product
Battery: Consumer product

Classification			Transportation	
	Lithium Content		Test	Requirement
Small	Cell	≦ 1 g (Metal UN3090)	UN38.3	Non Dangerous Goods Transportation
		≦ 1.5g (Ion UN3480) 20Wh	Yes	
	Battery	≦ 2 g (Metal UN3090)		
		≦ 8 g (Ion UN3480) 100Wh	1 Jan.2009~	
	Cell	≦ 12 g (Metal UN3090) (Ion UN3480)	UN38.3	Class 9 DG
	Battery	≦ 500 g (Metal UN3090) (Ion UN3480)	Yes	
Large	Cell	> 12 g (Metal UN3090) (Ion UN3480)	Yes	Class 9 DG
	Battery	> 500 g (Metal UN3090) (Ion UN3480)	Yes	

3-2. Watt hour formula (Wh)

Lithium metal and Lithium ion batteries

Wh=Rated Capacity(Ah) x voltage (V)

3-3. UN Tests and Requirements 38.3

Test Item	Test Condition
Test 1. Altitude simulation	11.6 kPa, 6hours
Test 2. Thermal Test	+75 deg.C ~ - 40 deg.C,6hours,10 Times
Test 3. Vibration	7 Hz ~ 200 Hz, 3 hours,12 Times
Test 4. Shock	Peak acceleration : 150 gn, Pulse duration : 6 msec.
☆ **Test 5. External Short Circuit**	0.1 ohm , 55 deg.C, 6hours
☆ **Test 6. Impact** **(Internal Short Circuit)**	R15.8 mm rod is placed on the battery, A 9.1 kg mass is to be dropped from 61 cm.
☆ **Test 7. Overcharge**	2 times the max. charge voltage or 22 V
Test 8. Forced Discharge	12 V

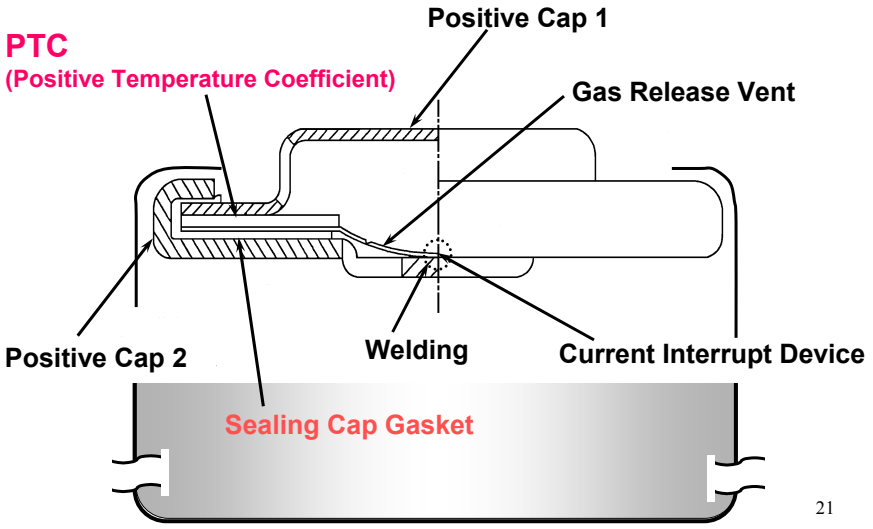
☆: Serious Test (no gas, no fire, no explode)

3-4. Safety Concept – Safety Features within a Cell

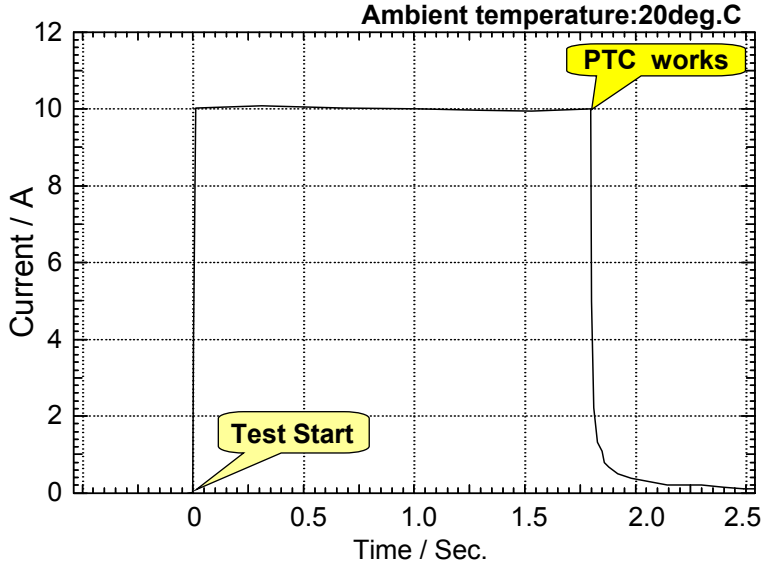
- **First level (PTC)**
  - **Reversible protector operation**
  - **No damage remain**
- **Second level (Gasket & Separator)**
  - **Ultimate emergency activation**
  - **'Fail-safe' operation**

3-5. PTC and Gasket Device (Current Interrupt)

Positive Cap with Current Shutdown Mechanism

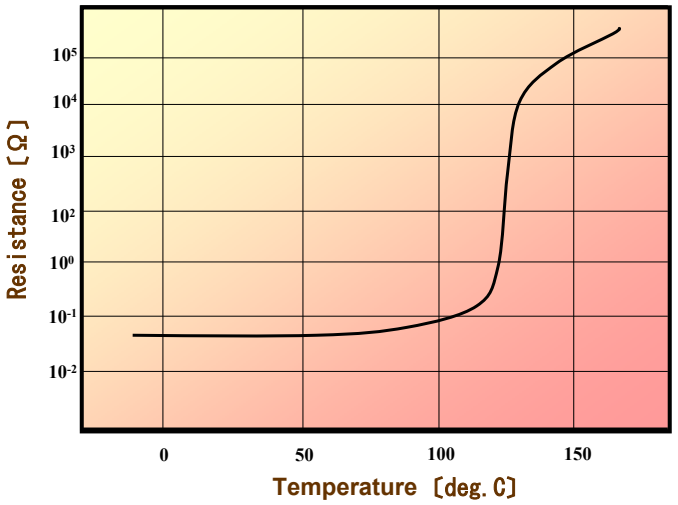


3-6. First Level Safety - PTC Operation Test



3-7. First Level Safety - Characteristics of PTC

The Relation between Resistance and Temperature

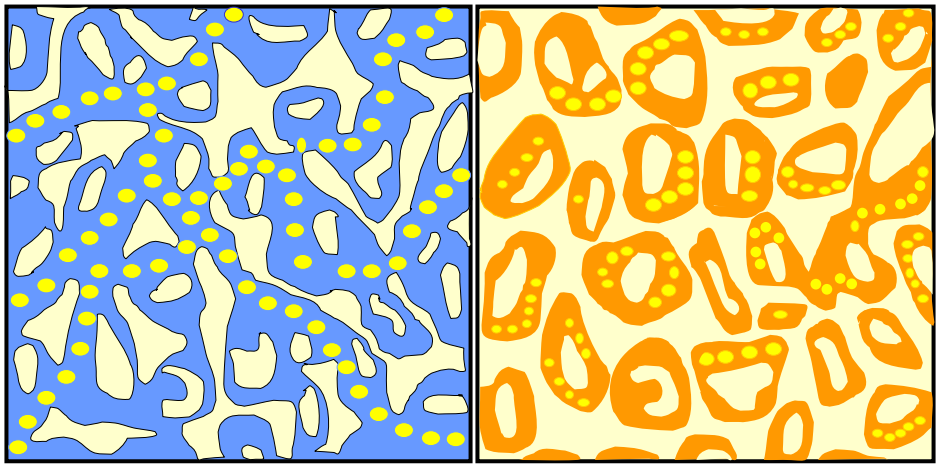


3-8. First Level Safety - PTC Mechanism

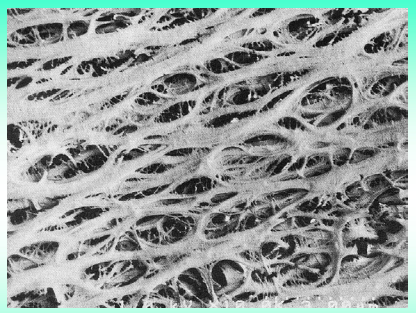
(a) Normal Temp.

Dotted line:pass

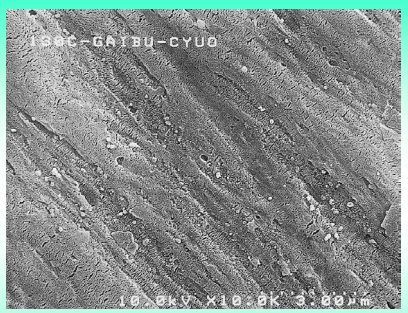
(b) Hot Temp.



3-9. Second Level Safety within a Cell –
SEM photographs of PE separator



Before short-circuit test

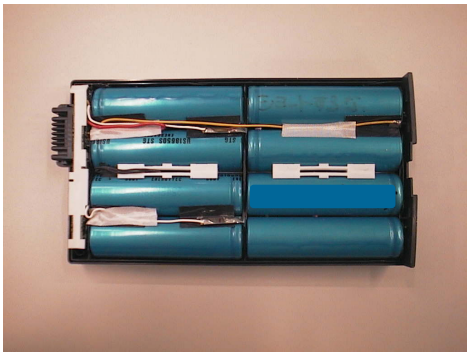


After short-circuit test

SEM : Scanning Electron Microscope

PE : Polyethylene

3-10. Additional Safety Features for Batteries (>= 1 cell)-
Safety unit mount of Lithium ion battery (UN3480)



Top view

Safety unit part

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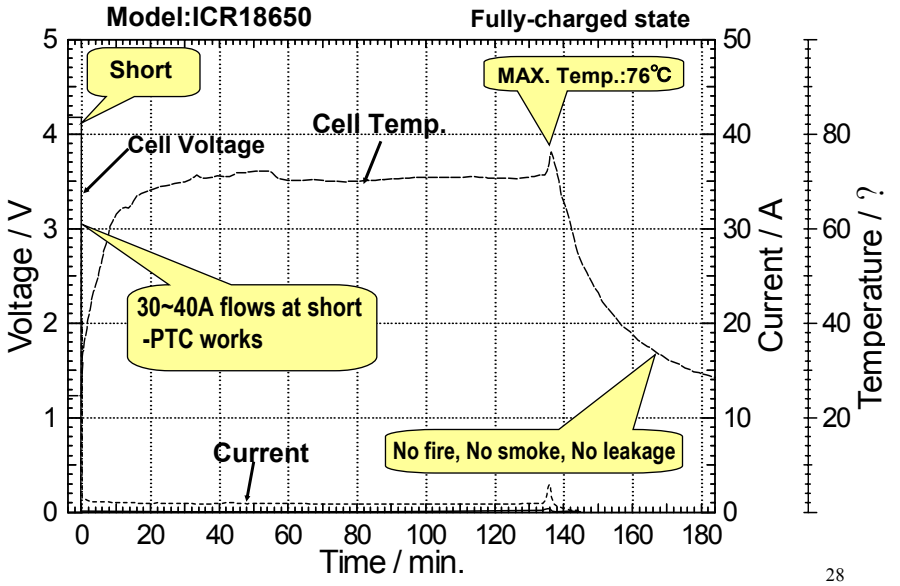
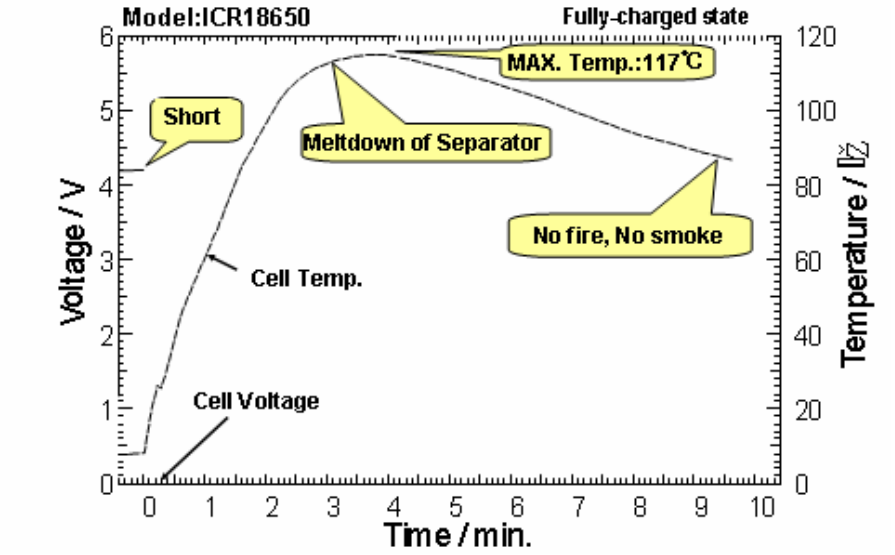
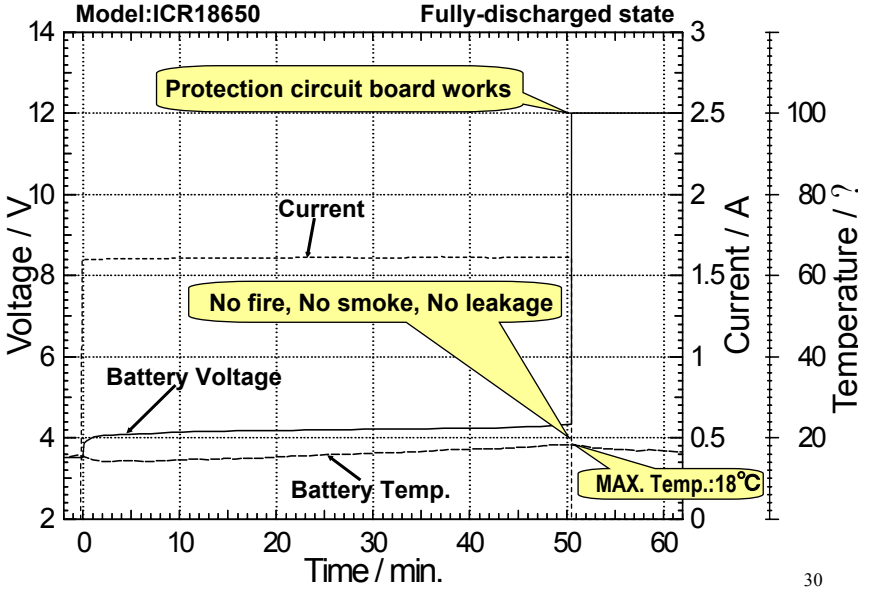
4-1. External short circuit test of UN38.3 test 5



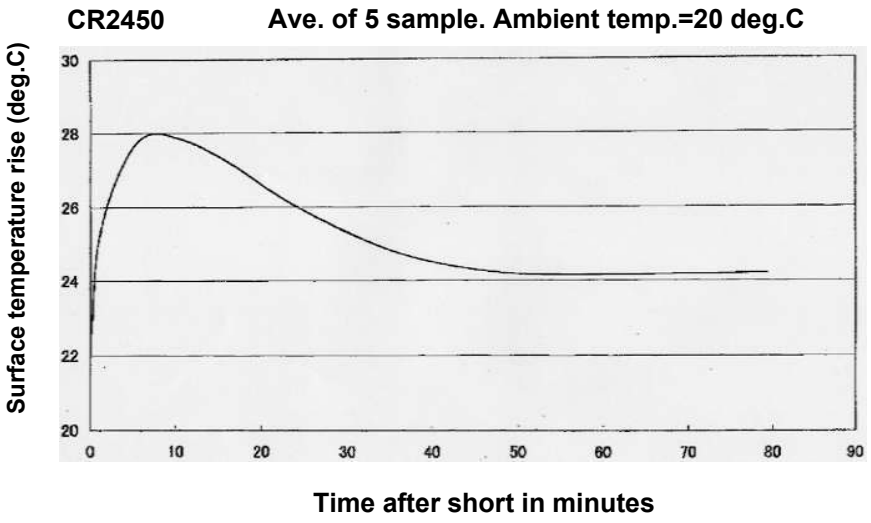
4-2. Internal short circuit test of UN38.3 test 6 (Battery)



4-3. Over charge test of UN38.3 test 7



4-4. External short test of UN38.3 Test 5 (coin type)



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5-1. Application of Lithium metal batteries UN3090 (Coin Type)

Caluculator(CR2016,CR2032)

Personal computer(CR2430)

Copy machine(CR2450)

Camera(remote control unit
CR1220,CR2016,CR2025)

5-2. Application of Lithium metal batteries UN3090 (Cylindrical Type 1)

(Spiral structure)

Camera (CR123A)

DSC (CR-V3)

Auto hand washer (2CR5)

APS Camera (CR2)

5-3. Application of Lithium metal batteries UN3090 (Cylindrical Type 2)

(Bobbin structure)

Personal computer
(CR12600SE, CR14250SE)

Water meter (CR17335SE, CR17450SE)

NCU (CR17335SE, CR17450SE)

5-4. Application of Lithium ion batteries UN3480

Digital Video Camera

(Camcorder)

Lithium ion batteries are suitable for mobile products.

<Feature>

- High energy density
- High voltage(three times higher than Ni-Cd and Ni-MH)
- Light weight
- No memory effect

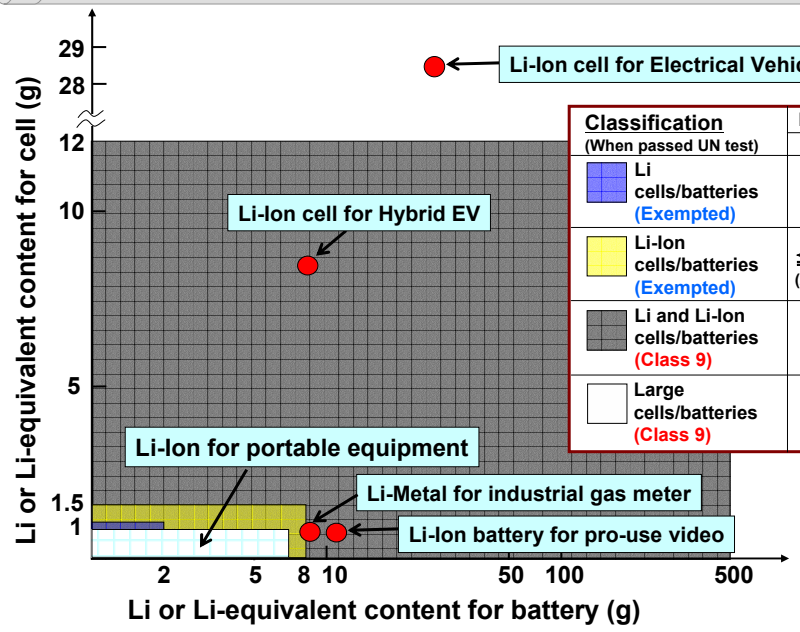
Mobile Phone

Mobile DVD

Mobile PC

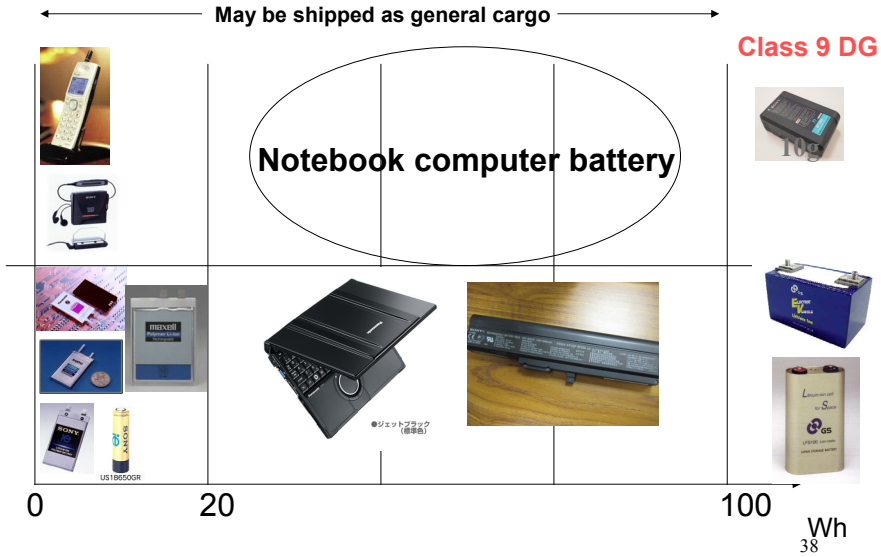
Digital Still Camera

5-4. Class 9 DG or Not ?

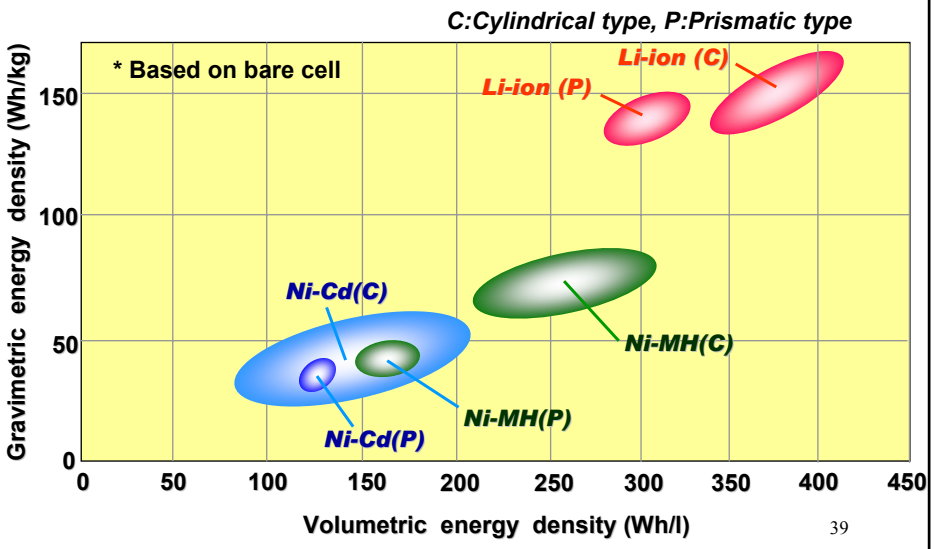


Classification (When passed UN test)	Li content(g) cell	battery
Li cells/batteries (Exempted)	≦1	≦2
Li-Ion cells/batteries (Exempted)	≦1.5 (20Wh)	≦8 (100Wh)
Li and Li-Ion cells/batteries (Class 9)	≦12	≦500
Large cells/batteries (Class 9)	12＜	500＜

5-5. Lithium ion battery UN3480 (Watt hour overview)



5-6. Comparison of energy density



謝謝

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