Hazard-based Classification System for lithium batteries

Ting XU, Honghui WANG

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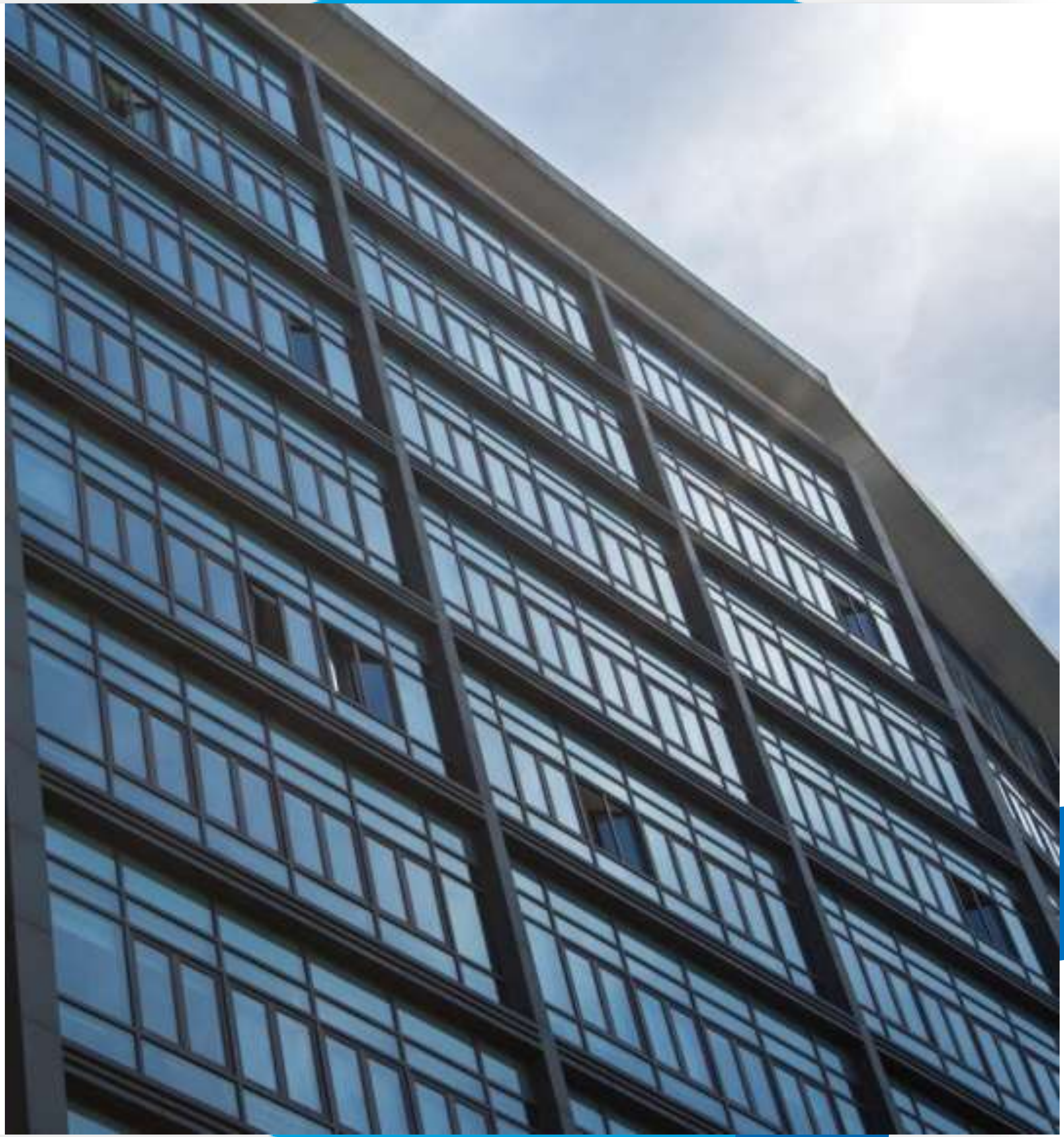
Shanghai Institute of Chemical Industry Testing Co. Ltd.

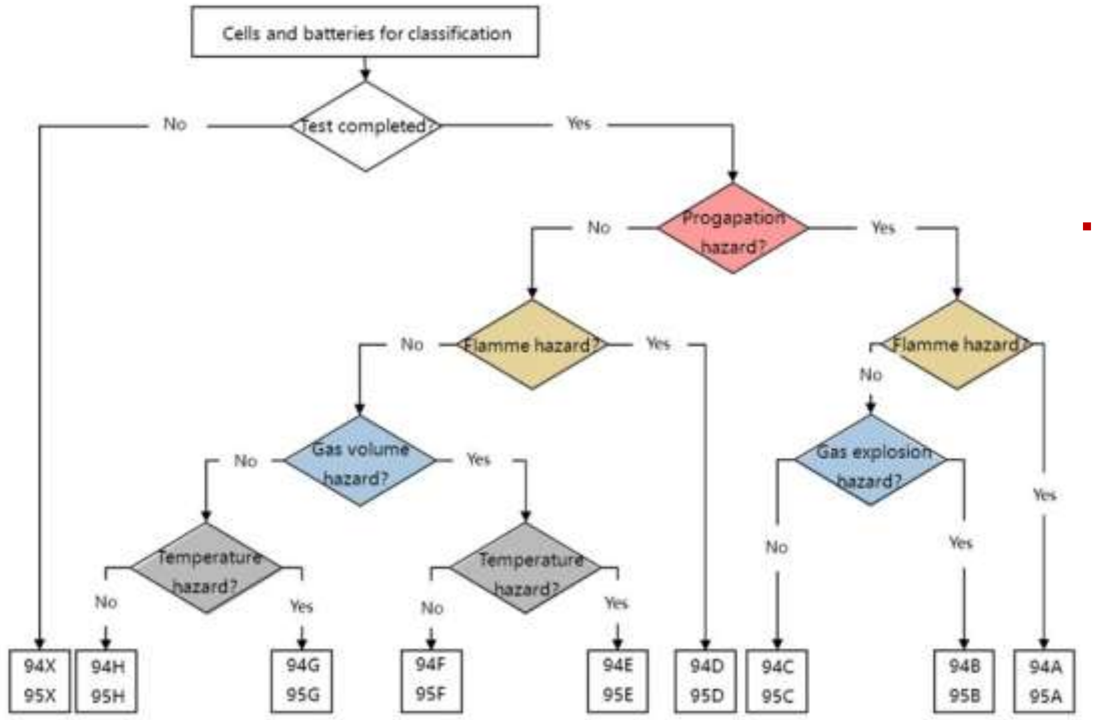


1. Classification

Thermal propagation (TP) is typically accompanied by hazards such as flame, gas release and high temp. Therefore, **the extent of TP** should be regarded as a **crucial criterion** for classification.

The classification system is **highly complex.**

It requires an additional **5 tests**, as well as the consideration of **4 key factors.**



① Test T.9: Cell propagation test

② Test T.10: Cell gas volume determination

③ Test T.11: Battery propagation test

④ Test T.12: Battery gas volume determination

⑤ Test T.13: Cell gas flammability determination

- Propagation hazard: speed?
- Flame hazard: flame generated?
- Gas hazards: volume, flammability?
- Temperature hazard: High temp.?

Experts from Belgium, France, RECHARGE on behalf of the IWG. Hazard-based system for classification of lithium batteries. ST/SG/AC.10/C.3/2024/13, 2024-4-9.

1. Classification

Thermal propagation (TP) is typically accompanied by hazards such as flame, gas release and high temp. Therefore, **the extent of TP** should be regarded as a **crucial criterion** for classification.

A new proposed classification system is based solely on the **extent of cell TP**.

- ✓ Reduced Test Items:

  Only T.9 (Cell Propagation Test) is required, reducing the number of tests from 5 to 1.

- ✓ Simplified Criteria:

  Only the **extent of cell TP** is considered, reducing the criteria from 4 to 1.

Test items **(5):**

T.9, T.10, T.11, T.12, T.13

Test criteria **(4)**:

① Propagation hazard

② Flame hazard

③ Gas hazards

④ Temperature hazard

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Test item **(1)**:

T.9: Cell propagation test

Test criteria **(1)**:

① **Propagation hazard dimension**:

The extent are affected by thermal propagation.

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Thermal runaway (TR)

Uncontrollable rise in temperature of a cell driven by inside exothermic chain reaction, usually accompanied by exhaust, smoke, fire or explosion.

Note 1: The temperature at which thermal runaway occurs is considered as the critical point;
Note 2: Generally, “uncontrollable” means the maximum temperature rising rate exceeds 10 ℃/min;
Note 3：For battery, module or battery pack, the occurrence of thermal runaway at the cell level is considered to be the occurrence of thermal runaway of the entire unit.

Reference :

IEC 62619-2022：Uncontrolled intensive increase in the temperature of a cell driven by exothermic reaction.

UL 2596-2023, UL 9540A-2018, (UL1973-2022)：The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell’s generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion, and gas evolution (gassing).

GB 38031-2020 ：电池单体放热连锁反应引起电池温度不可控上升的现象。The phenomenon of uncontrollable temperature rise caused by the exothermic chain reaction of a cell.

Thermal propagation (TP)

Thermal runaway spread consecutively from one cell to nearby cell(s).

Note 1: Also known as thermal runaway propagation.

3. TP Hazard Index

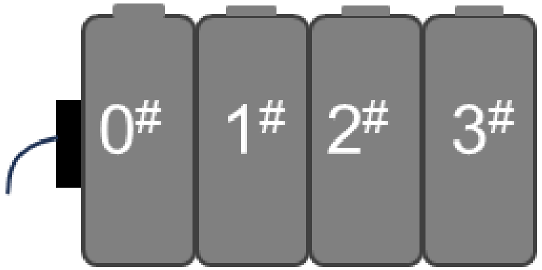
How to measure the extend of the thermal propagation(TP)?

TP hazard Index divided the test results into **3 hazard levels**.

Level I: $3^{\#}$ cell (target cell, the farthest cell) run thermal runaway, which is considered as severe case.

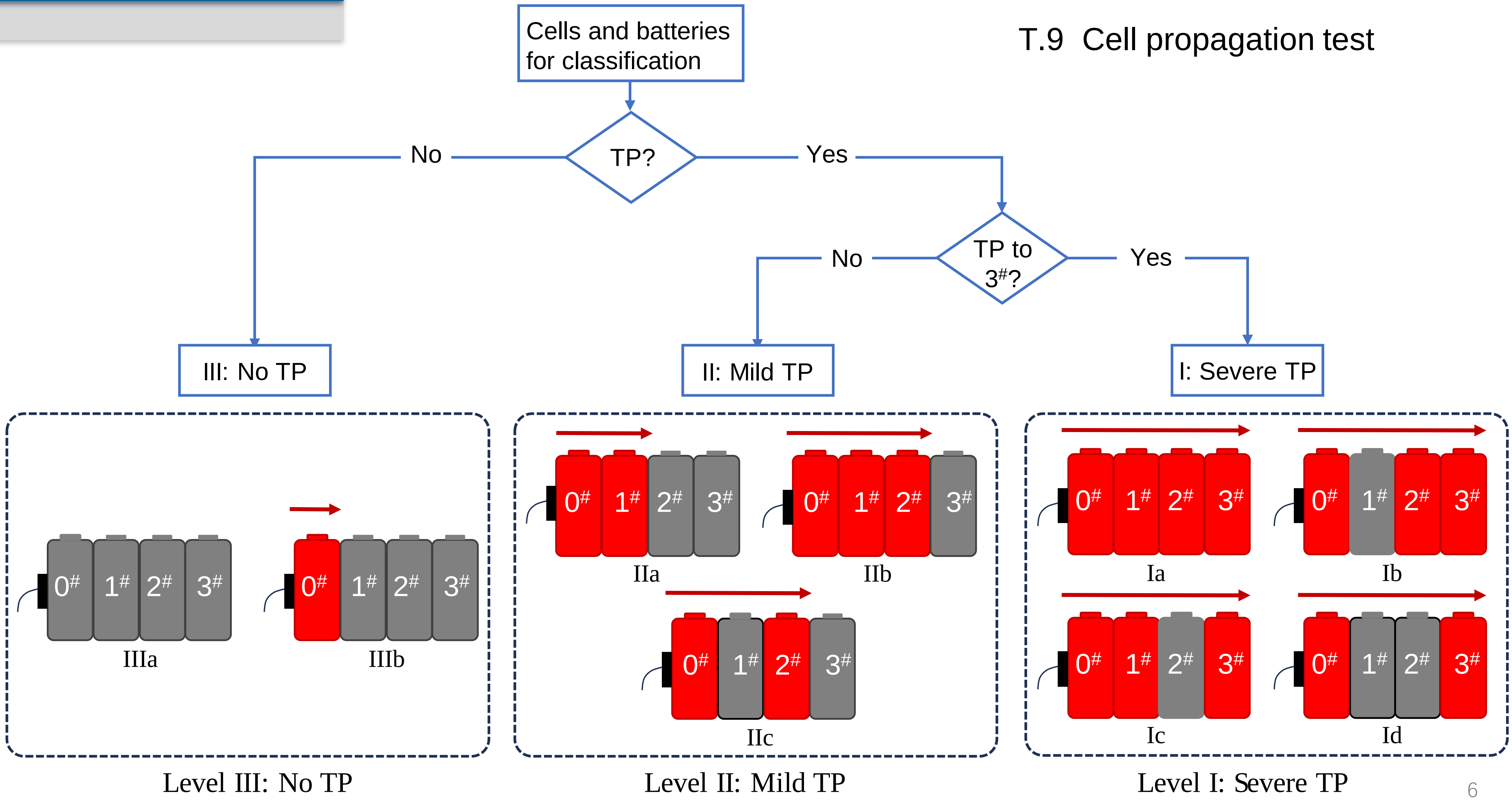
Level II: $3^{\#}$ cell did not run thermal runaway, but the $1^{\#}$ or $2^{\#}$ cell(s) run thermal runaway, which is considered as moderate case.

Level III: $1^{\#}$-$3^{\#}$ cells did not run thermal runaway, no matter $0^{\#}$ cell (trigger cell) thermal runaway or not, which is considered to be relatively safe.



3. TP Hazard Index

T.9 Cell propagation test



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4. Packing Instruction

According to the UN Model Regulations and the current packaging of lithium batteries, the packaging is simply divided into four levels.

From P4 to P1, the requirements for packaging are becoming increasingly strict.

Lithium battery Packing Group	Test items	Packing Instruction
UN specification PG II	drop test stack test ……	P908 P909 P910
UN specification PG II	drop test stack test	P903
Common packaging	1.2m drop test	SP188

P1

P2

P3

P4

5. Application

The 3-levels hazard index matched with 4 packing groups applied well into current Regulations.

Hazard Level \ Energy	E_1	
Level I	**Add UN 4001/4002** UN PG =P2	P1 / P2
Level II	UN 3090/3480 UN PG II=P3	P3
Level III	Unrestricted goods Common packaging=P4	P4

Stricter, need to add 2 UN numbers (4001/ 4002) and special packaging for UN PG =P2. (Passed T.1-T.8 & [T.9(L-I) or No T.9)]

Same to current classification strategy, UN 3090/3480 with PG II =P3. (Passed T.1-T.9(L-II))

Less strict, more safer cells or batteries could be shipped as Unrestricted goods with a special provision. (Passed T.1-T.9(L-III))

E_1: means small energy cell or battery;
for a lithium metal or lithium alloy cell or battery, the lithium content is not more than 1 g or 2 g;
for a lithium ion cell or battery, the watt-hour rating is not more than 20 Wh or 100 Wh.

5. Application

The 3-levels hazard index matched with 4 packing groups applied well into current Regulations.

Hazard Level \ Energy	E_2	
Level I	**Add UN 4003/4004 or by the SP of 4001/4002** UN PG =P1	P1
Level II	**Add UN 4001/4002** UN PG =P2	P2
Level III	UN 3090/3480 UN PG II=P3	P3
		P4

E_2: means large energy cell or battery; which lithium content or nominal energy over E_1.

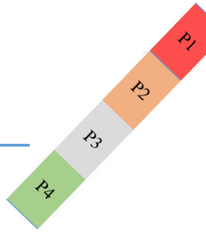
Strictest, need to add 2 UN numbers or by the special provisions of UN 4001/4002.
(Passed T.1-T.8 & [T.9(L-I) or No T.9)]

Stricter, need to add 2 UN numbers (4001/4002) and special packaging for UN PG =P2.
(Passed T.1-T.9(L-II))

Same to current classification strategy, UN 3090/3480 with PG II =P3.
(Passed T.1-T.9(L-III))

5. Application

The 3-levels hazard index matched with 4 packing groups applied well into current Regulations.



Hazard Level	E_1	E_1 **Compare with current rules (PI)**	E_2	E_2 **Compare with current rules (PI)**
Level I	**Add UN 4001/4002** **PI 91X** UN PG =P2	**Stricter**	**Add UN 4003/4004 or by the SP of 4001/4002** UN PG =P1	**Strictest** **Add PI 91Y**
Level II	UN 3090/3480 UN PG II=P3	Almost no change	**Add UN 4001/4002** **PI 91X** UN PG =P2	**Stricter**
Level III	Unrestricted goods SP 188 Common packaging=P4	**Less strict** **Add special provisions**	UN 3090/3480 UN PG II=P3	Almost no change

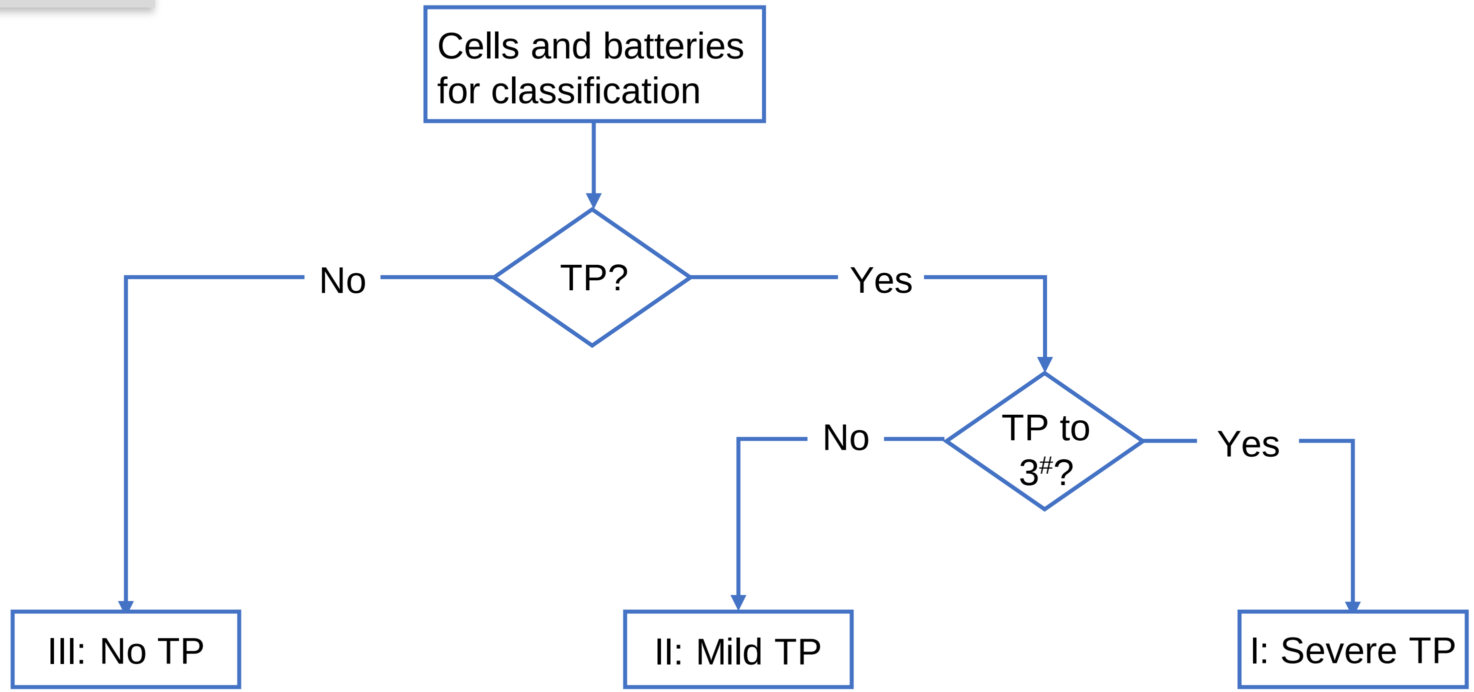
E_1: means small energy cell or battery;

for a lithium metal or lithium alloy cell or battery, the lithium content is not more than 1 g or 2 g;

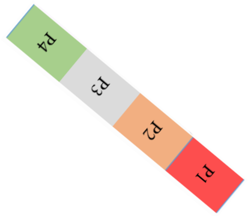
for a lithium ion cell or battery, the watt-hour rating is not more than 20 Wh or 100 Wh;

E_2: means large energy cell or battery; which lithium content or nominal energy over E_1.

5. Application



	III: No TP	II: Mild TP	I: Severe TP
E_1	Cells ≤20Wh or 1g Li Batteries ≤100Wh or 1g Li Unrestricted goods **P4**	Cells ≤20Wh or 1g Li Batteries ≤100Wh or 1g Li UN 3480/3090 **P3**	Cells ≤20Wh or 1g Li Batteries ≤100Wh or 1g Li UN 4001/4002 **P2**
E_2	Cells >20Wh or 1g Li Batteries >100Wh or 1g Li UN 3480/3090 **P3**	Cells >20Wh or 1g Li Batteries >100Wh or 1g Li UN 4001/4002 **P2**	Cells >20Wh or 1g Li Batteries >100Wh or 1g Li **Add 2 UN numbers** **P1**



6. Summarize

- ✓ We focused on the Thermal Propagation (TP) because it is typically accompanied by hazards such as flame, gas release and high temp.

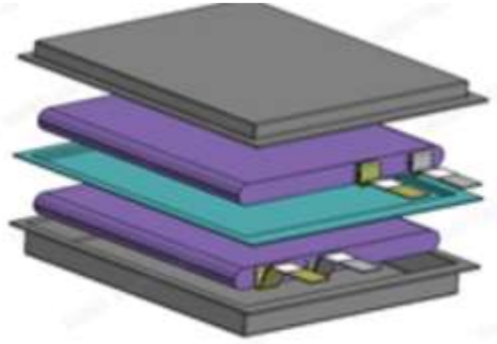
- ✓ We have proposed two definitions for Thermal Runaway (TR) and Thermal Propagation (TP) .

- ✓ The Thermal Propagation (TP) hazard Index was proposed to measure the extend of the Thermal Propagation(TP).

- ✓ Four different Packing Groups(P4-P1) were introduced to correspond with the Thermal Propagation (TP) hazard Index.

The 3-levels hazard index matched with 4 packing groups， fits well within the current regulatory framework.

7. Another Question



Is it a cell or battery?

Case 1： cell or battery

The purple part is an independent cell, which is covered with a casing to form a unit, but it has four independent terminals and no electrical connection between the four terminals.

Case 2： cell or battery

The purple part is a jerry roll. The two purple parts share the same electrolyte in the case. It has four independent terminals and no electrical connection between the four terminals.

Cell means a single encased electrochemical unit(one positive and one negative electrode) which exhibits a voltage differential across its two terminals, and may contain protective devices.

Battery means two or more cells or batteries which are electrically connected together and fitted with devices necessary for use, for example, case, terminals, marking or protective devices.

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Thanks for your listening!

Ting XU   xt@ghs.cn

15800616132