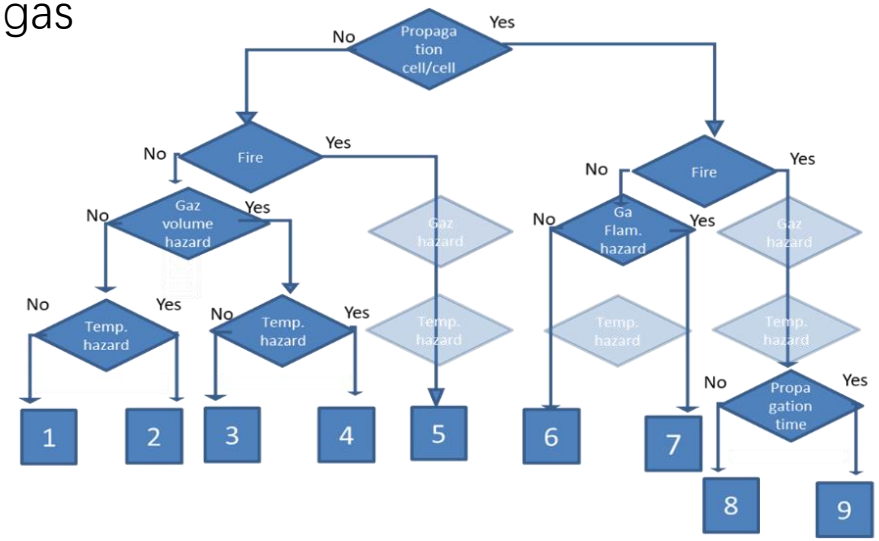
UN TDG IWG_Tests Responding to the Latest Draft Testing Protocol

China

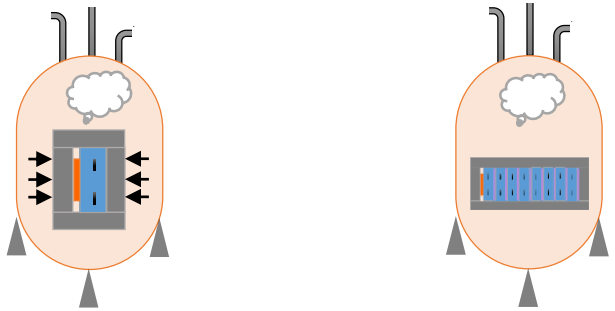
Background

- Intrinsic hazards of lithium cells/batteries can be represented by the capability of:
  1. thermal runaway to propagate from cell to cell
  2. generating fire
  3. generating significant quantities of toxic/flammable gas
  4. producing high temperature



- Required Test 1: Thermal Propagation
  - ☐ Cell Level
  - ☐ Module Level

- Required Test 2: Cell Gas Volume Determination
  - ☐ Cell Level
  - ☐ Module Level



Hazard Level	1	2	3	4	5	6	7	8	9
Characteristics	No TP					TP			
	No Fire				Fire	No Fire		Fire	
	Less Venting		More Venting			Non-flammable	flammable	Slow TP	Fast TP
	Low Temp.	High Temp.	Low Temp.	High Temp.	High Temp.	High Temp.			

Concern & Proposal

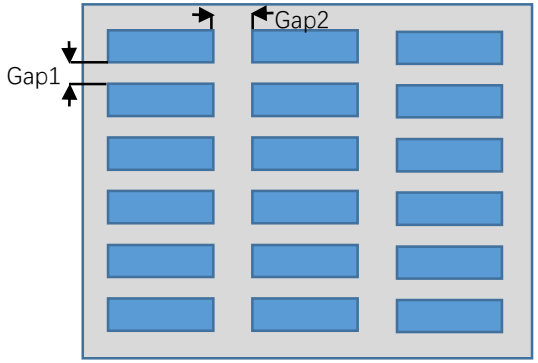
Issue ID#	Page #	Clause/ Subclause	Text	Comment	Proposal
Issue1: **Cell Propagation Test - Gap between Cells**	4	38.3.6.1.2	The propagation test is conducted by placing 4 of the same cells inside a thermally insulated test fixture designed to tightly maintain the 4 cells in a row	➢ Gap between shipping cells relies on packing condition of the supplier ➢ Not all cells under transportation sticks close to each other • The gap between cylindrical batteries in transportation can be up to 8mm • The gap between prismatic batteries in transportation is at least 20mm	The propagation test is conducted by placing 4 of the same cells in a row as arranged under transportation condition inside a thermally insulated test fixture
Issue2: **Test SOC**	4	38.3.6.1.2	The SOC shall be verified at 100% SOC or undischarged primary cells or batteries	➢ Cell/module on market is not shipped at a uniform SOC such as 100% SOC ➢ Hazards of cells in varied SOC have unneglectable differences	The SOC shall be verified at transport SOC
Issue3: **Heater Parameter**	4	38.3.6.1.2	The size of the heater contact area shall be 20% of the cell surface or smaller	➢ In some cases, the small heater fails to trigger the large prismatic cells into thermal runaway	Follow the regulation of initiation methods in ISO 6469-1 AMD
Issue4: **Cell Gas Volume Determination**	6	38.3.6.2.3	The result could be expressed as: • no gas volume measured; or • gas volume below [XX] liters; or • gas volume above [XX] liters.	➢ When comparing the venting gas of cells with different capacities, it is suggested to be demonstrated in L/Ah	The result could be expressed as: • no gas volume measured; or • gas volume below [XX] liters/Ah; or • gas volume above [XX] liters/Ah.

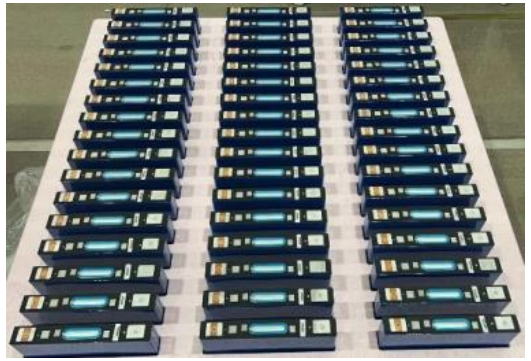
1. Cell Propagation Test – Gap between Cells

➢ Typical Packaging for Cell/Module

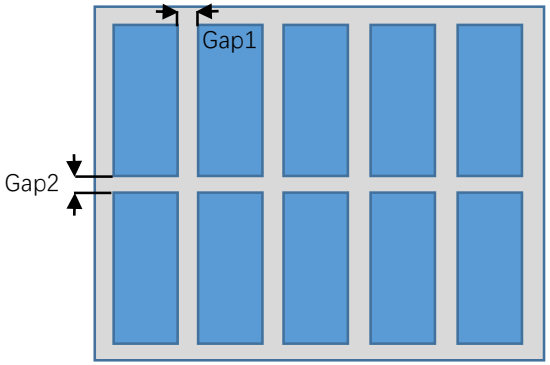
- Gap between shipping cells relies on packing condition of the supplier
- Not all cells under transportation sticks close to each other
- For example, gap between cylindrical batteries in transportation can be up to 8mm.
  Gap between prismatic batteries in transportation may be larger than 20mm

☐ Cell layout for single layer





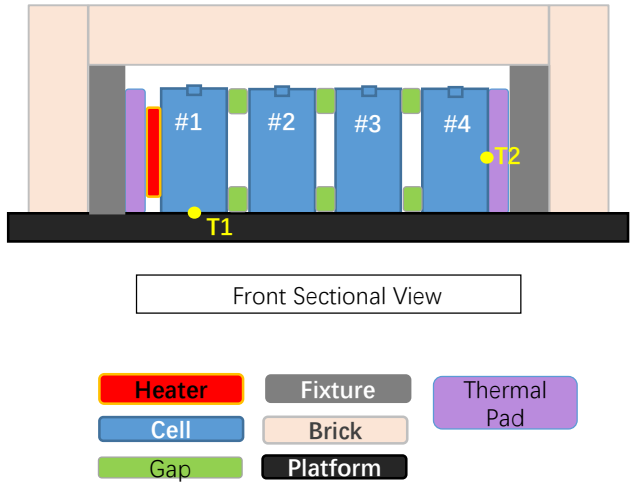
☐ Module layout for single layer



1. Cell Propagation Test – Gap between Cells

➢ Cell propagation test results with/without a cell gap vary markedly

- Test object: 4 identical cells (100%SOC) in a row with gap in between
- Test condition: to maximize heat containment
- Initial method: external heating



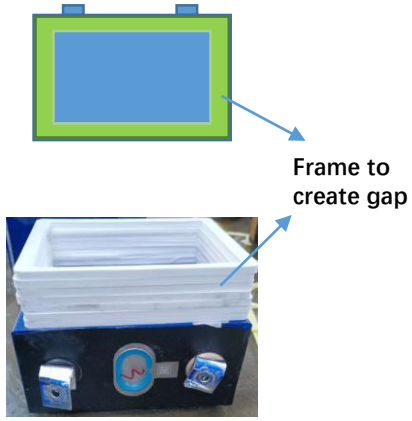
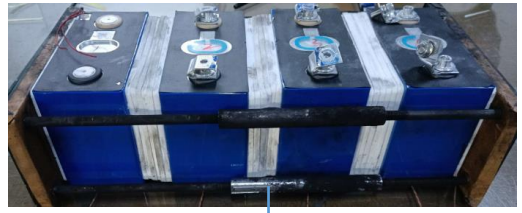


Table 1: Thermal Propagation Results with Different Gaps

DUT	Cell Information	Gap [mm]	Bottom Temp [℃]		Cell #2
			T1	T2	
1	NCM-1: 629Wh, 70*148*110	**0**	571	779	**TR @ 1min32s**
2		**10**	507	783	**TR @ 8min35s**
3		**20**	484	28	**No TP**

* Cell #1 TR considered as 0s



Proposal 1:

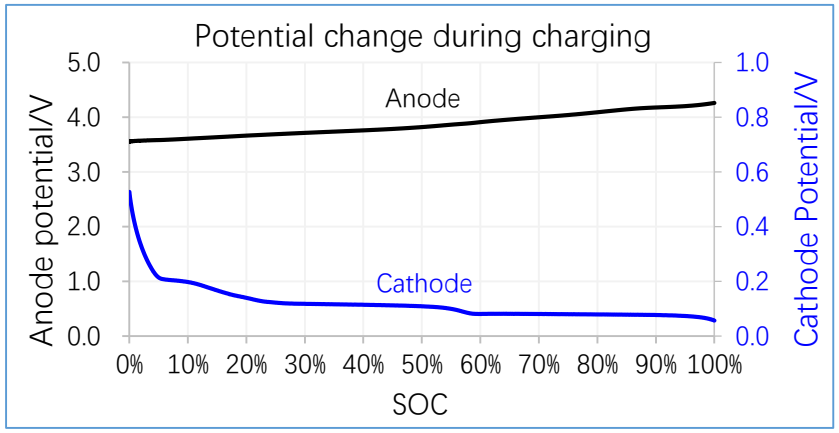
It is suggested that arrangement of the 4 cells follows transportation condition

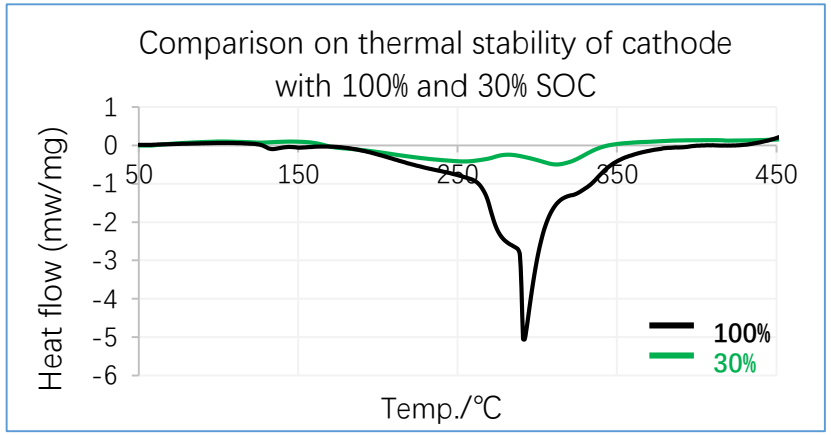
2. Test SOC vs. Transport SOC

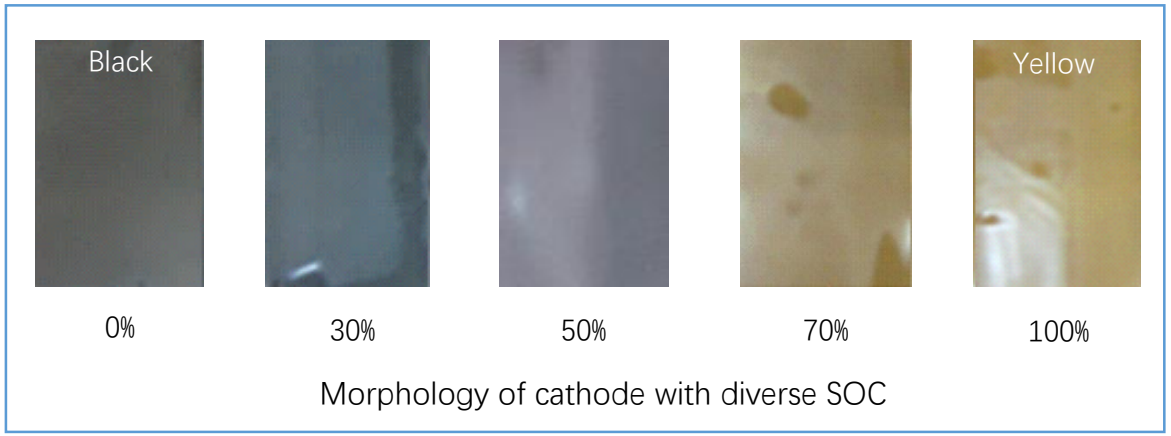
- Cell/module on market is not shipped at a uniform SOC, such as 100% SOC

Source of the Product	Shipping SOC
OEM-1	30~40%
OEM-2	55~70%
OEM-3	40~50%

① Battery stability decreases along with SOC increasing on material level





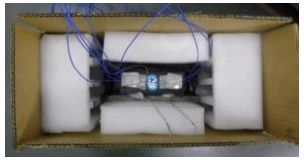


2. Test SOC vs. Transport SOC

② Hazards of cells in varied SOC have unneglectable differences at required testing 1&2

I. TR at certain SOC shows distinct phenomena

- Test object: 1 cell with fixture, forced into TR, 2 repetitions
- Test condition: wrapped with foam in a carton (packing condition)
- Initial method: external heating



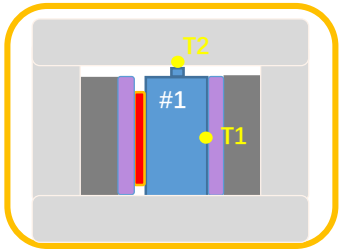


Table 2: Thermal Runaway Results at Different SOC

DUT	Cell Information	SOC	Temp. @Surf. Center	Temp. @Vent	Result
			T1	T2	
1	NCM-1: 629Wh, 70*148*110	**100%**	720	835	**Fire**
2		**40%**	513	486	**Smoke Only**
3	NCM-2: 431Wh, 52*148*103	**100%**	670	812	**Fire**
4		**40%**	477	453	**Smoke Only**
5	LFP-1: 902Wh, 71*204*173	**100%**	279	330	**Smoke Only**
6		**40%**	210	163	**Slow Smoke**

* Cell #1 TR in all cases

II. Quantity of venting gas varies as SOC of battery changes

Table 3: Cell Gas Volume of NCM-1 at Different SOC

DUT	SOC	Total Volume / L	Unit Volume / (L/Ah)
1	100%	340	2.01
2	40%	218	1.29

- 100% SOC TR Process(NCM):

- 40% SOC TR Process(NCM):

Proposal 2:

It is suggested that all the testing shall be conducted at transport SOC

3. Heater Parameter

- In some cases, the small heater fails to trigger the large prismatic cells into thermal runaway because heater failed itself

- Cell Info.: NCM-2, 100% SOC
- Surface Area Ratio (Heater to Cell): about 24%

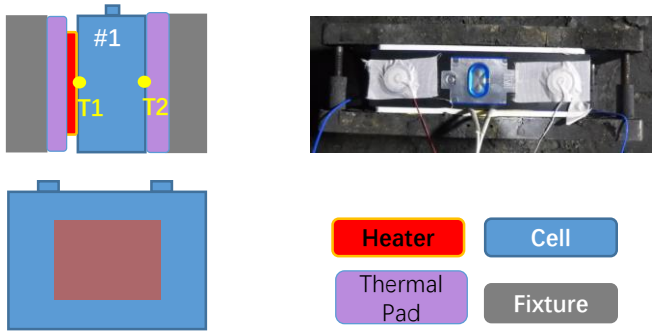
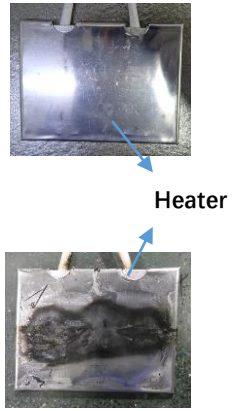


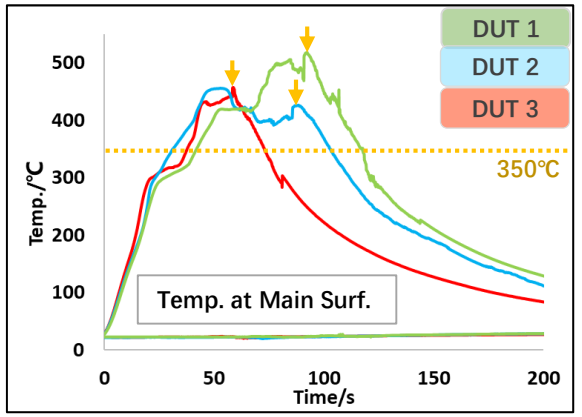
Table 3: Thermal Runaway Results using Different Heater Parameters

DUT	Heater Information		Time to Heater Failure (Baseline: 350℃)
	Properties	Power [w]	
1	Size: 60*80 mm^2	500	After ~50s
2		600	After ~50s
3	Heating Rate: 5~13 ℃/s	700	After ~20s

* Cell #1 No TR in all cases

- On the other hand, small heater with high power may result in localized cell surface damage
- Heater determination requires a lot of trials and errors in finalizing heater dimension and power





Proposal 3:

- It is suggested to follow the regulation of initiation methods in ISO 6469-1 AMD

Conclusion

- **Issue1: Cell Propagation Test - Gap between Cells**
- Proposal 1: layout of the 4 cells to be tested follows transportation condition

- **Issue2: Test SOC**
- Proposal 2: all the testing is carried out at transport SOC

- **Issue3: Heater Parameter**
- Proposal 3: follow the regulation of initiation methods in ISO 6469-1 AMD

- **Issue4: Cell Gas Volume Determination**
- Proposal 4: demonstrated in L/Ah on account of cells with varied ranges of capacities

Thank you