TF5： Cell/module/system test

March 17th, Paris, France

- Definition of internal short circuit
- Proposal for thermal runaway / ISC test
- Proposal for thermal propagation test
- Something to discuss

Definition of internal short circuit (ISC)：

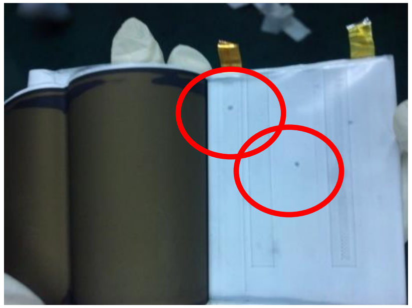
The phenomena of ISC between the anode and cathode electrodes is mainly caused by the flaw in production process, or lithium dendrites formation, or usage in the complex operation environment.

ISC can directly result in the thermal runaway on the level of cell and also the phenomena of thermal propagation in the whole battery system.

Reasons for formation of ISC

1. QC of material and production process give rise to the flaw

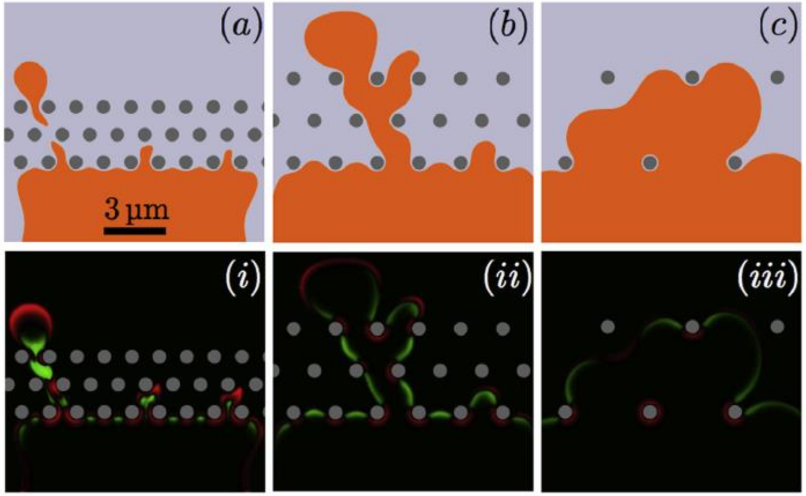
- Even on the level of 6 SIGMA QC, the cell failure rate（include ISC） is within 3.4 ppm



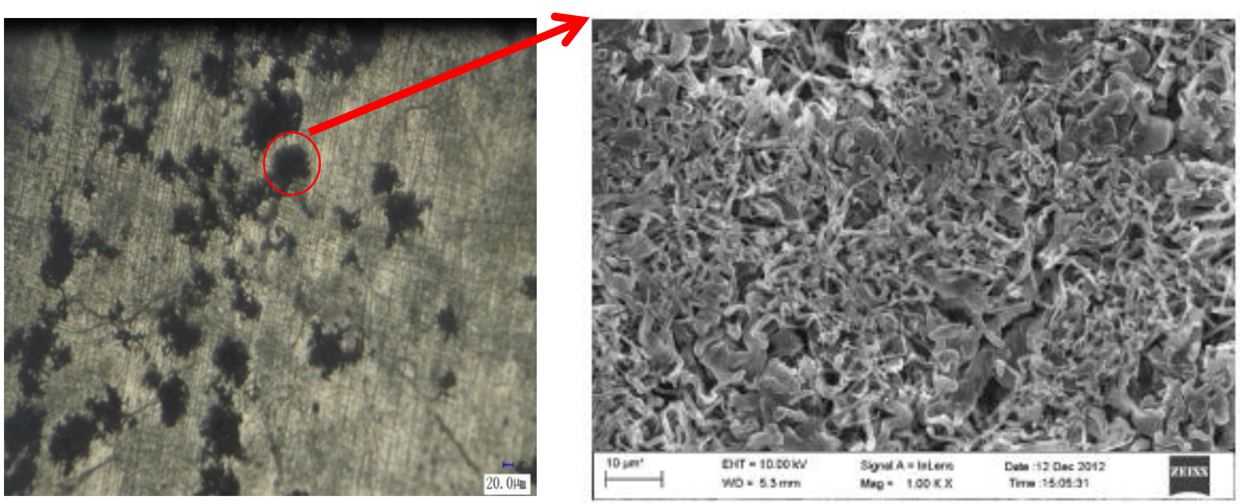
Reasons for the formation of ISC

2. Lithium dendrite growth

- Lithium may deposit on the anode surface and form lithium dendrite.
- The dendrite grows during cell cycling.
- The dendrite may pierce the separator and cause ISC after growing to a significant height [1].



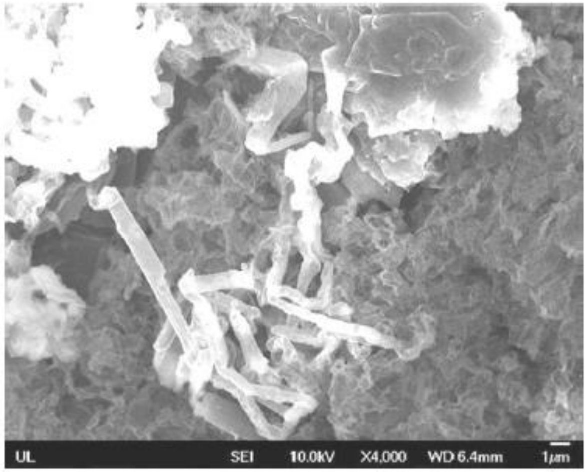
[1] A. Jana, D.R. Ely, R.E. Garcia. Dendrite-separator interactions in lithium-based batteries. J. Power Sources, 2015, 275: 912-921.



Reasons for formation of ISC

3. Complex operation environment

- The phenomena of ISC maybe cause Boeing 787 fire.



[1] Japan Transport Safety Board, Aircraft serious incident investigation report. Sept. 25, 2014.

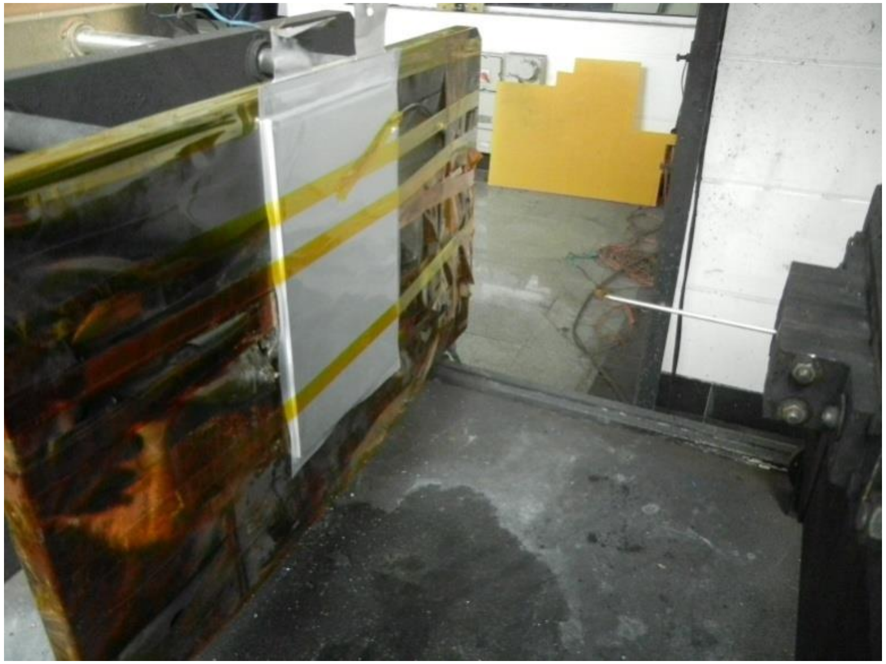
Proposal for thermal runaway/ISC test

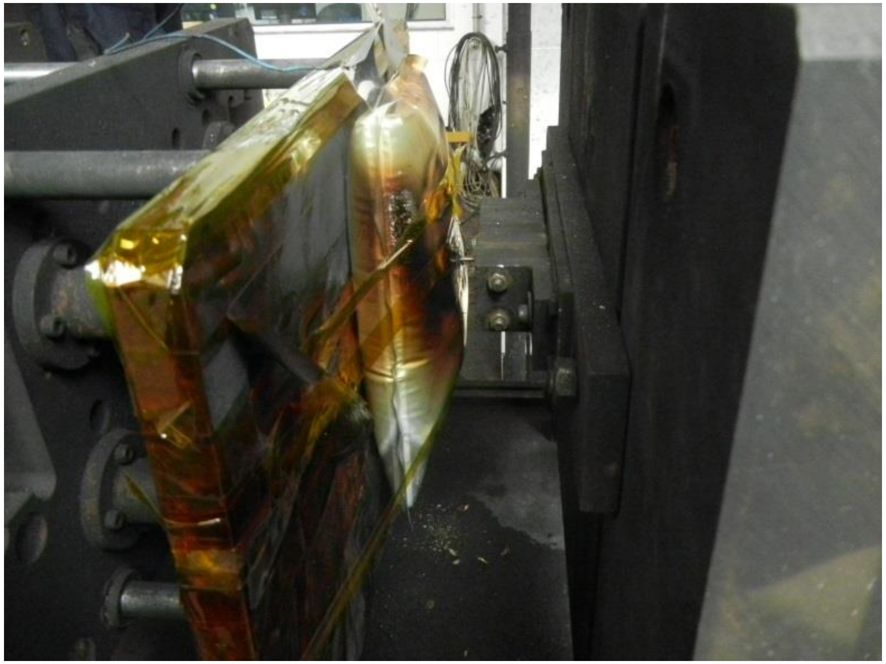
1. Nail penetration

- full Penetration
- Partial penetration

Proposal for thermal runaway/ISC test

1. Nail penetration





Proposal for thermal runaway/ISC test

1. Nail penetration

Proposal for thermal runaway/ISC test

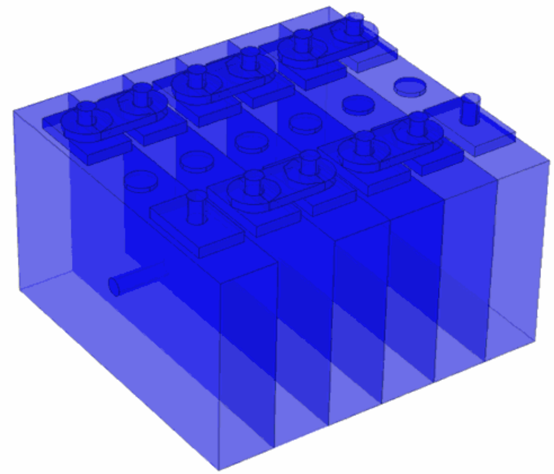
2. Oven

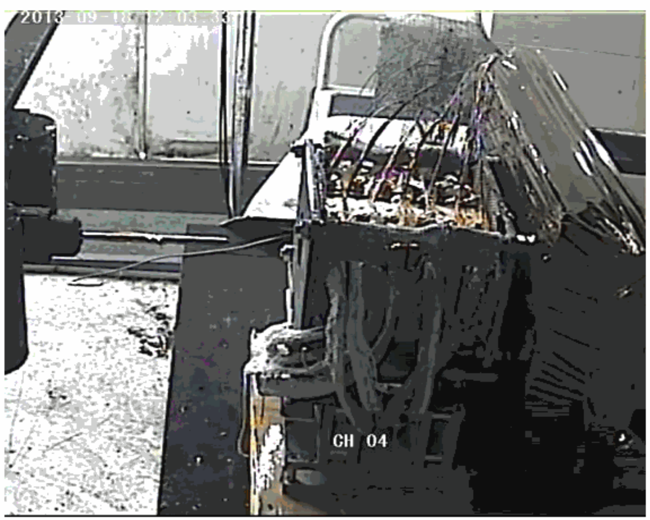
Room temperature-80℃，5K/min, 80 ℃ -200 ℃,2k/min

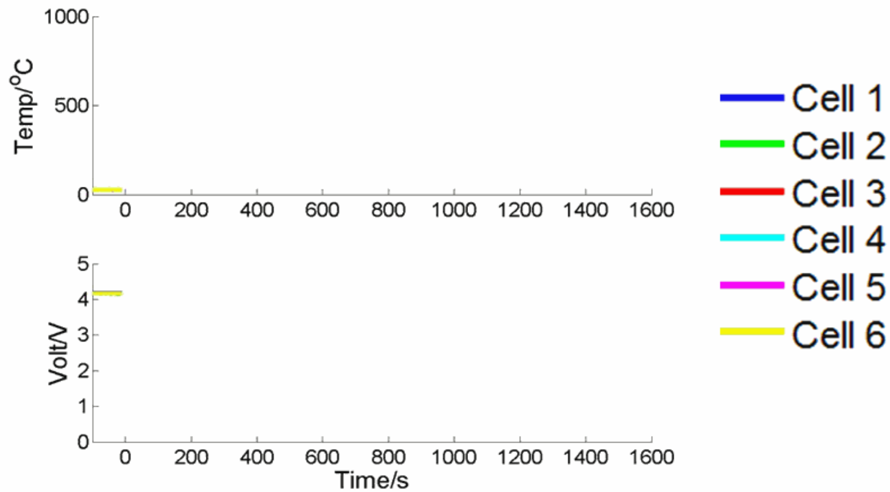
Proposal for thermal propagation test

1. Nail penetration

Penetrate one cell in system/sub-system to trigger the phenomena of thermal runaway.



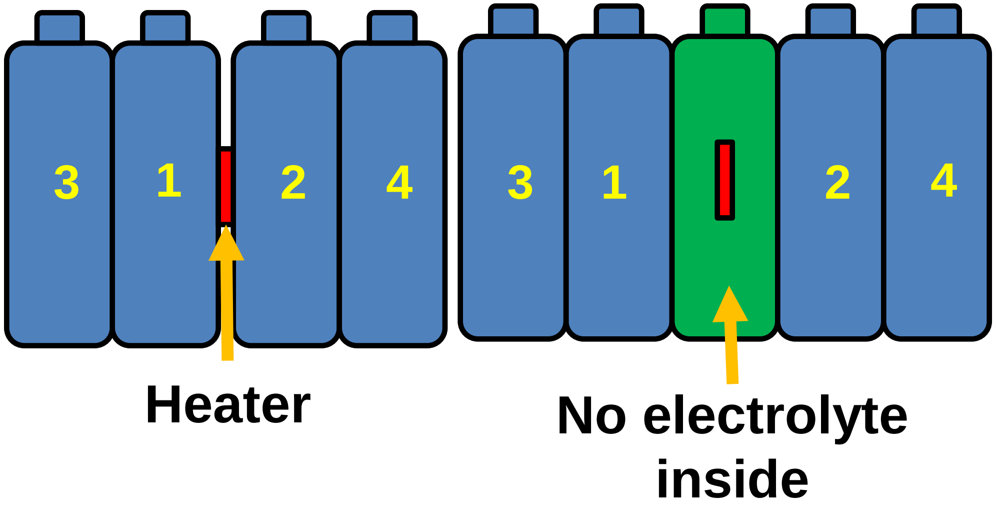




Proposal for the thermal propagation tests

2. Heating

Heat inside one cell or directly with the heating plate

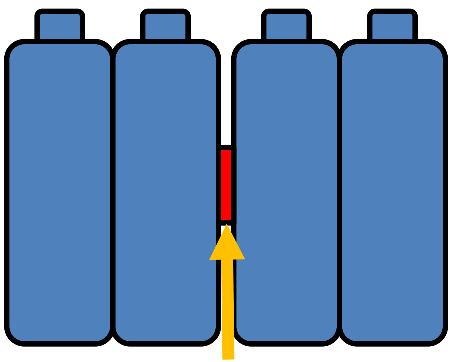


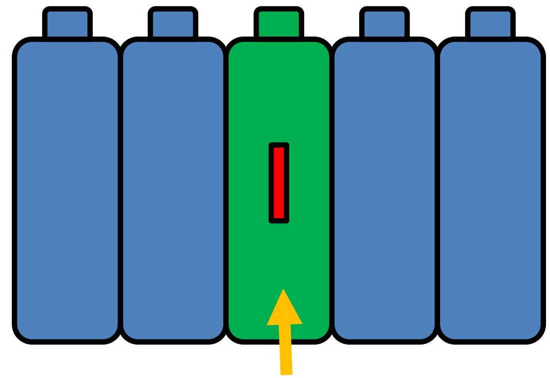
➢ **In the model:**

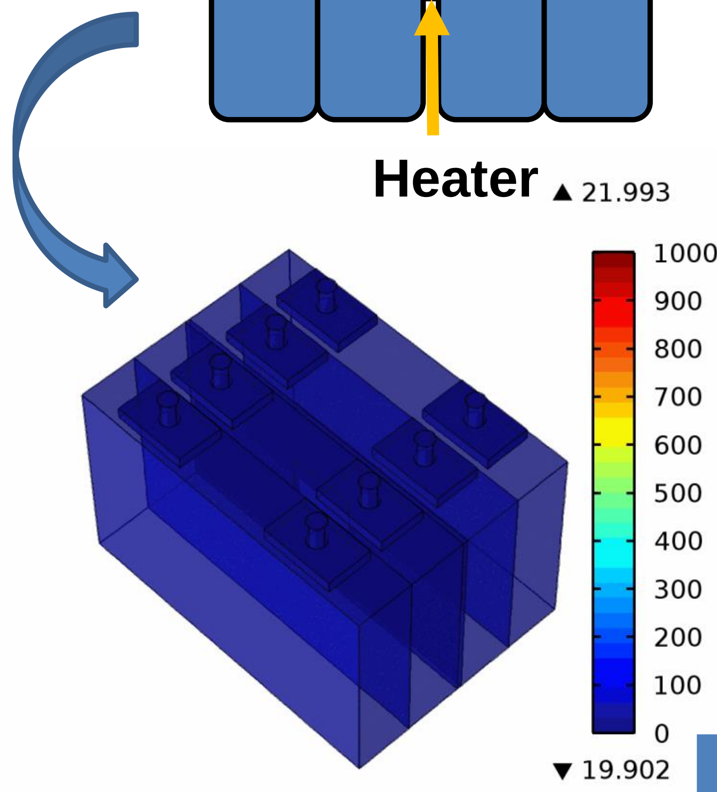
- Initial temperature: 20^{o}C
- Heating power = 400W
- Thermal runaway temperature = 170^{o}C
- No additional thermal insulation around adjacent cells, but the thermal resistance of pouch is included in the model.

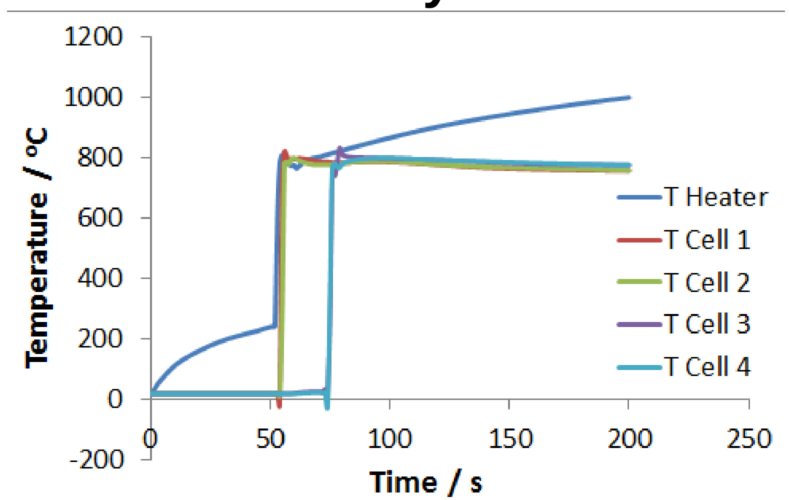
Proposal for the thermal propagation tests

2. Heating





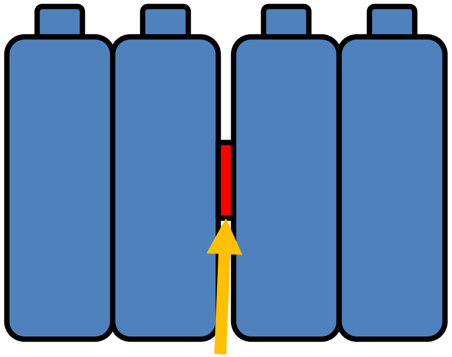




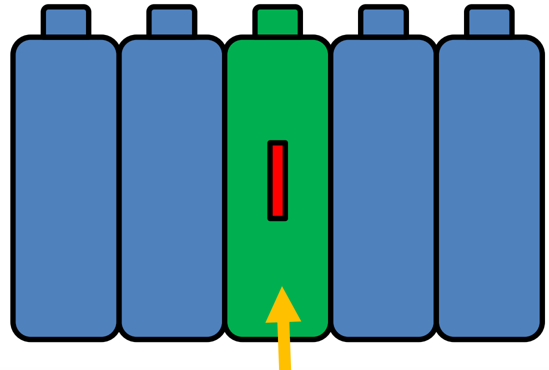
Heating time=53s	Cell 1	Cell 2	Cell 3	Cell 4
TR time /s	53	53	73	73

Proposal for the thermal propagation tests

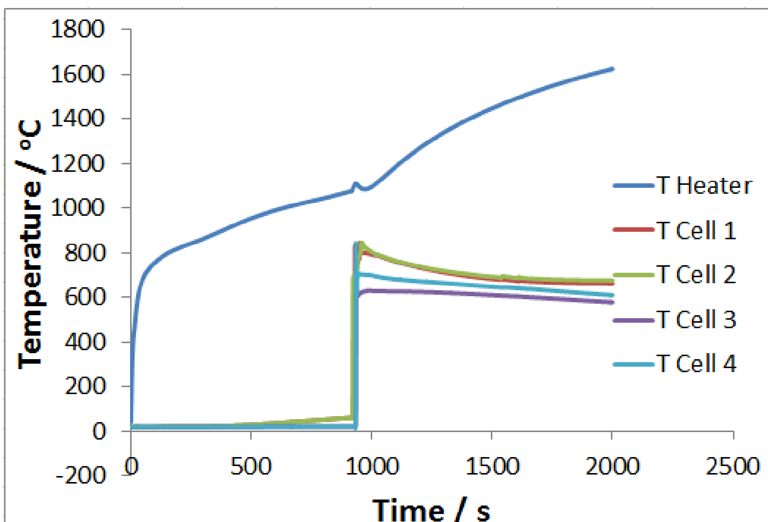
2. Heating

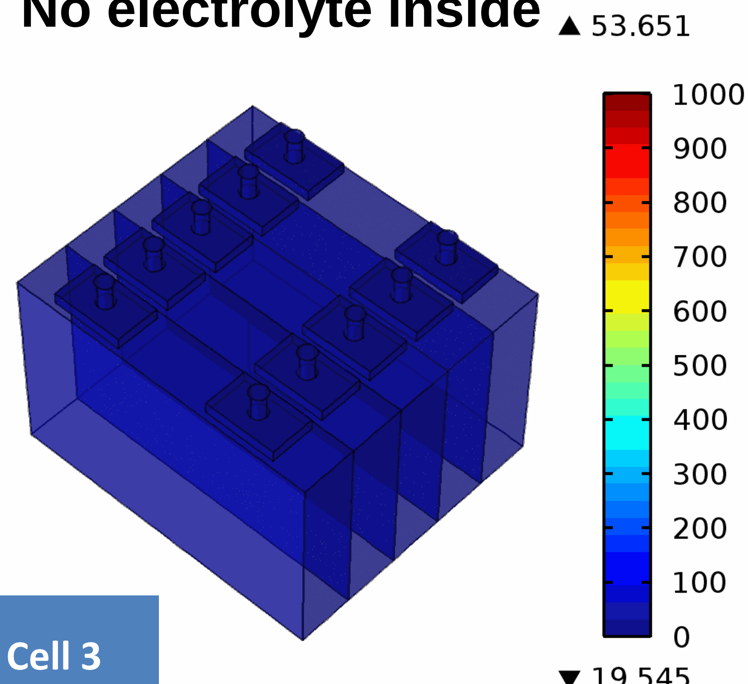


Heater



No electrolyte inside





Heating time=920s	Cell 2	Cell 1	Cell 4	Cell 3
TR time /s	920	925	931	932

Proposal for thermal propagation test

2. Heating

Key issues to be determined:

1) The judgment condition for pass or not: no thermal runaway propagation to cell 2&4?
2) The power of the heater (400W in the shown model)
3) The geometry of the heater (0.03m*0.03m in the model), should it change with the different cell capacity?
4) The maximum temperature allowed for the heater to reach
5) The thermal runaway trigger method for the first cell
6) The contact of cell 1&3 and cell 2&4, should it be the same as the battery pack design in actual application?
7) The heating time in the test, the left one（with heater） has much shorter test time.

something to discuss

- Which is the acceptable way to test ISC?
- Which is the acceptable way to test thermal runaway?
- Agenda for TF5 before next EVS-GTR meeting

Thanks！