

# Applicability of Nail Initiation for Thermal Propagation Test

19<sup>th</sup> EVS-GTR IWG\_ December, 2019

JASIC

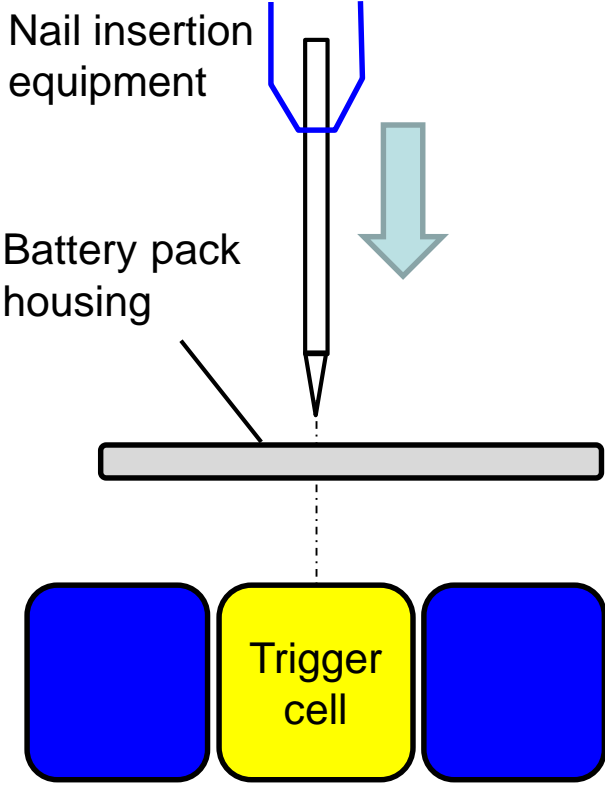
With some considerations and devised test jigs, nail method is effective and valid as one of the thermal runaway initiations.

- No additional energy input and short test time period.
- Robustness against test condition deviations.
- In some cases, remodeling of modules is unnecessary for the nail test.
  - Vehicle manufacturers can conduct the test on their own.

## ■ Merit and Issues on Nail Method

Nail Method		
Merits	<ul style="list-style-type: none"><li>• Modification of module is unnecessary.</li><li>• No additional energy input.</li><li>• Short and clear test time period.</li></ul>	
Issues	• Accuracy of nail prick point on the cell	} <u>Presentation</u>
	• Gas leakage from nail prick hole on battery housing	
	• Impact of deviations on test conditions	} Test data
	• Limited direction of nail prick	} Test data

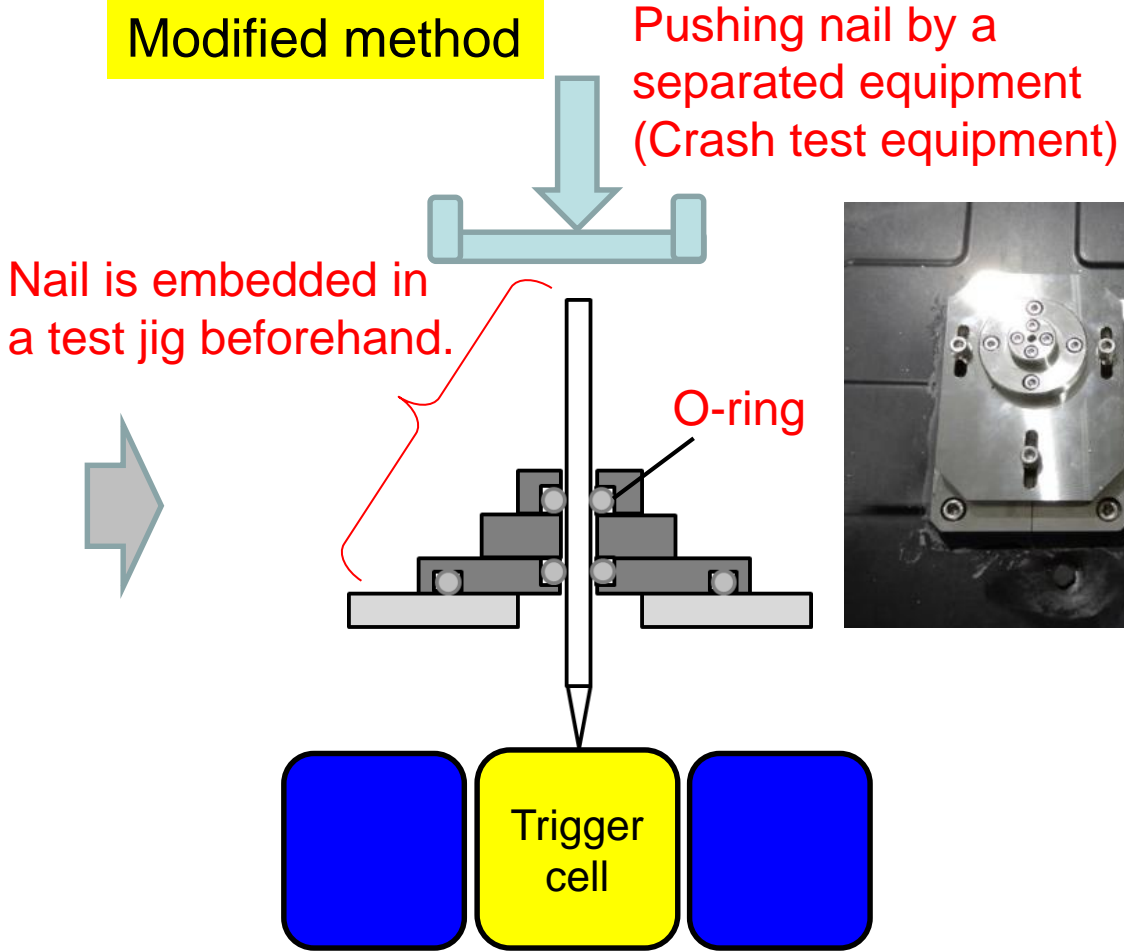
Conventional method



<Issue>

- Accurate relative positioning of battery pack and nail test equipment is difficult.
- Gas and flame discharge from the nail hole needs to be managed.

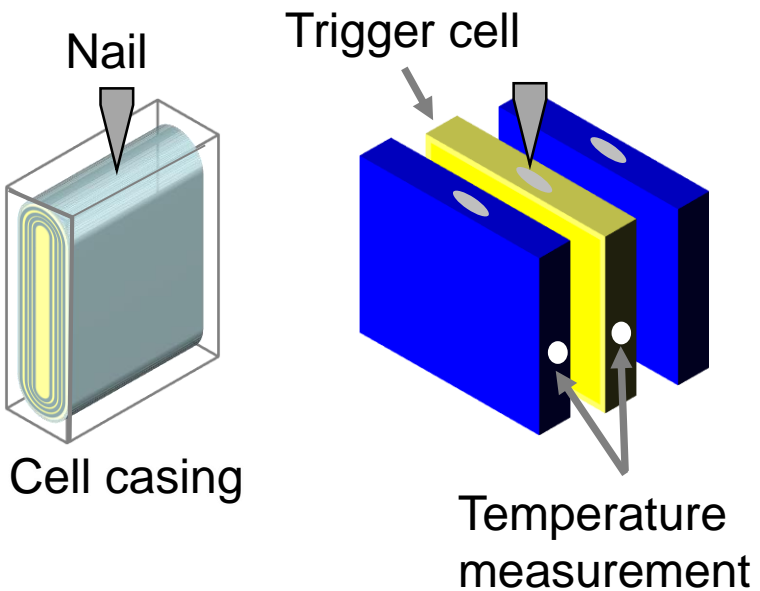
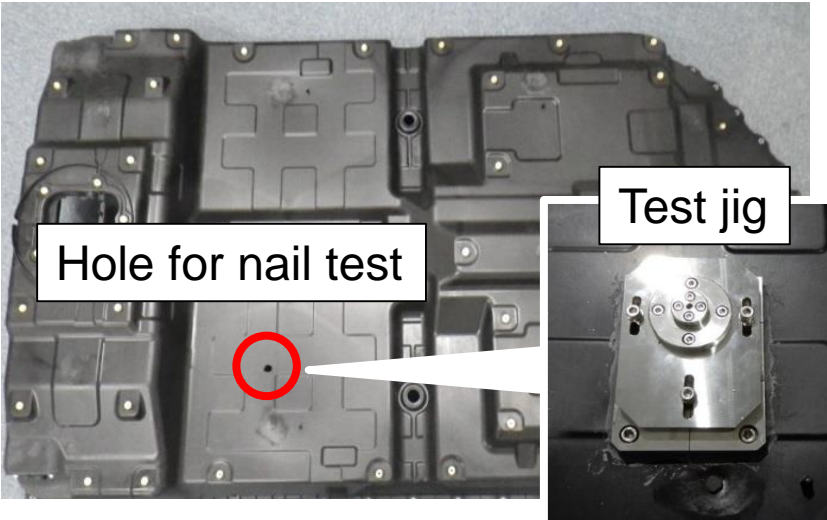
Modified method



<Modification point>

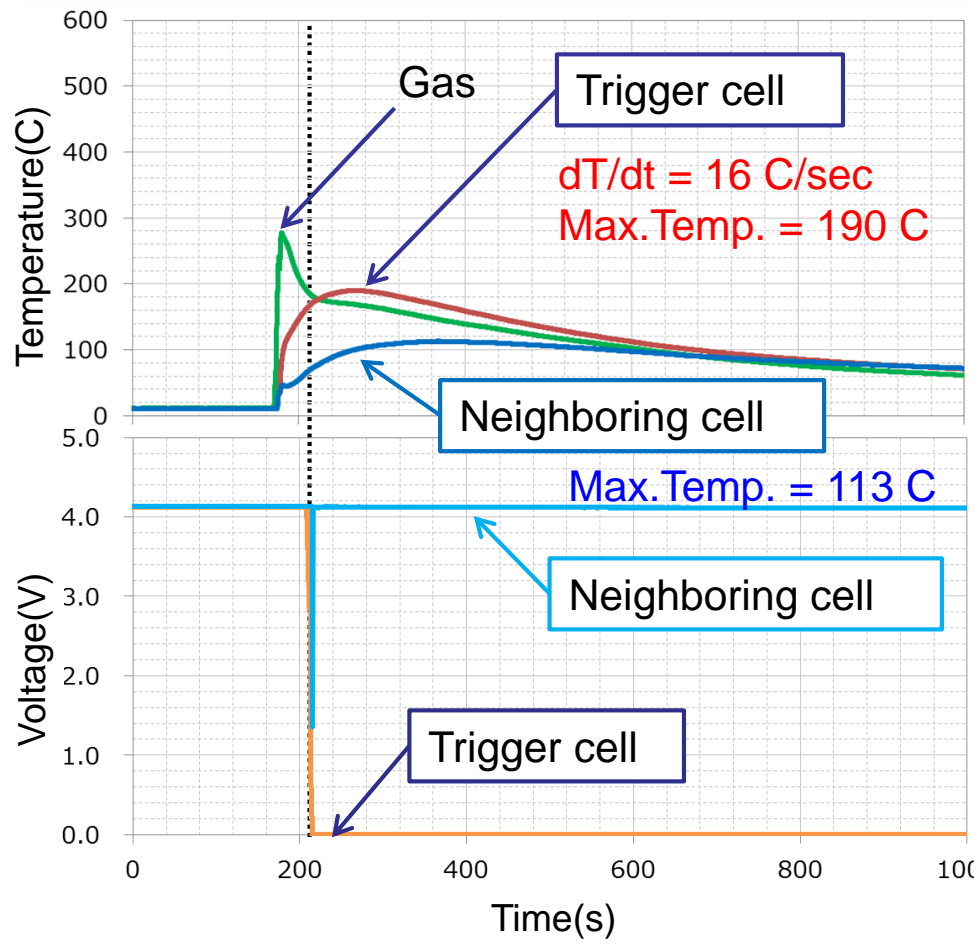
- A target point on a cell can be aimed at accurately.
- O-rings prevent gas from leaking.

■ Test setting and results

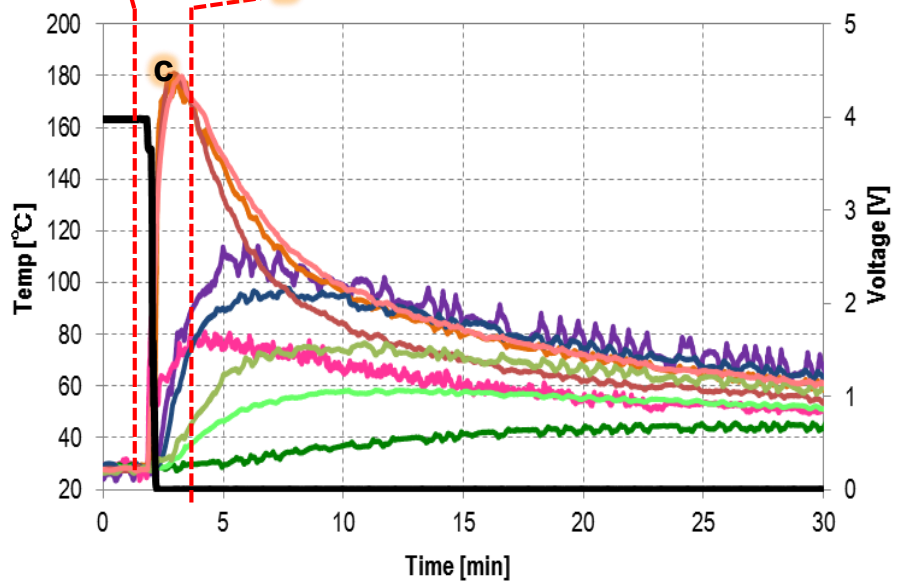
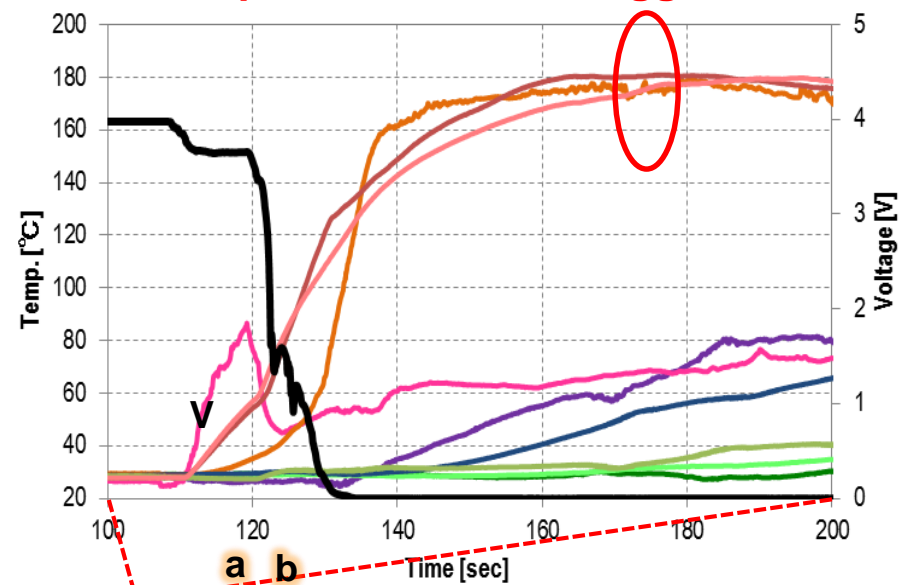


Test condition

- Nail material : Steel
- Diameter : 3 mm
- Tip angle : 30 degree
- Nail speed : 5 mm/sec



Temperature rises of trigger cell



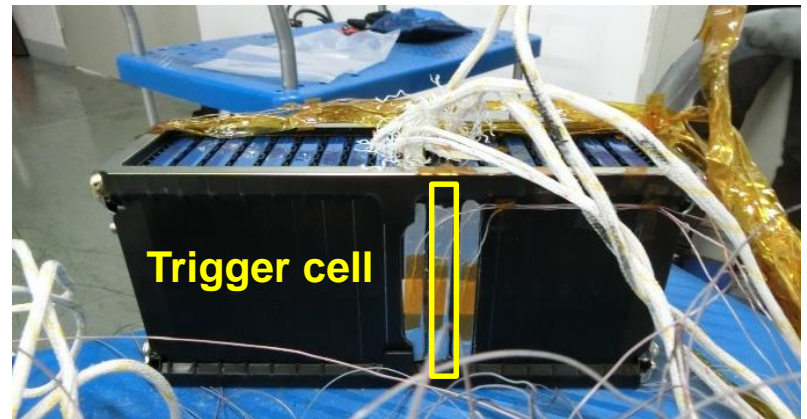
<Results>

- Trigger cell thermal runaway
- No fire, no thermal propagation

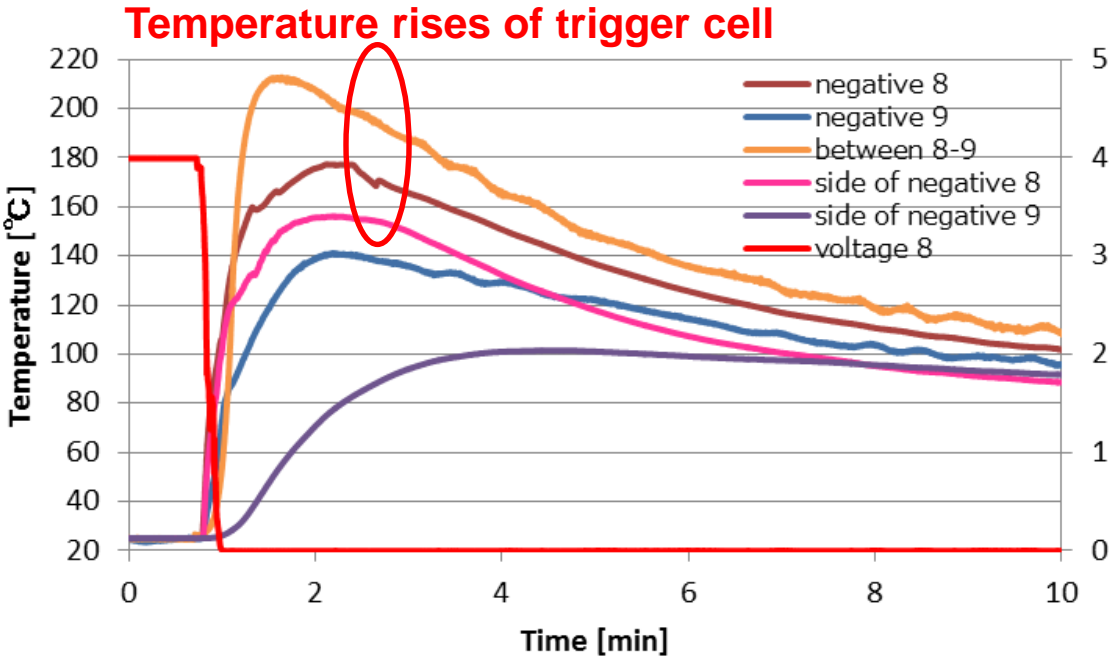
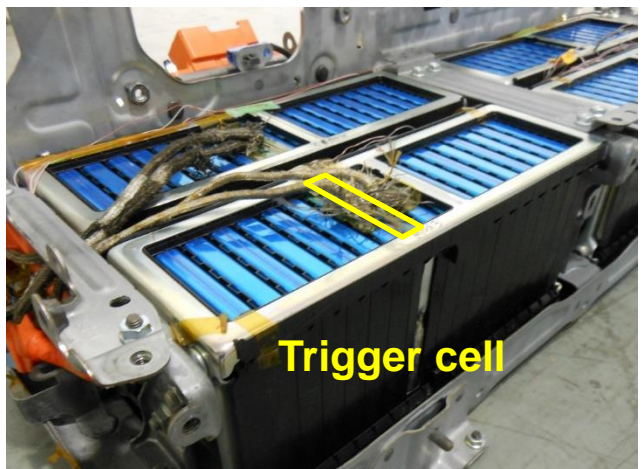
Voltage drop	Max. Temp.	dT/dt	Thermal runaway	Thermal propagation
to 0 V	180 C	10.5 C/sec	Yes	No

Test condition

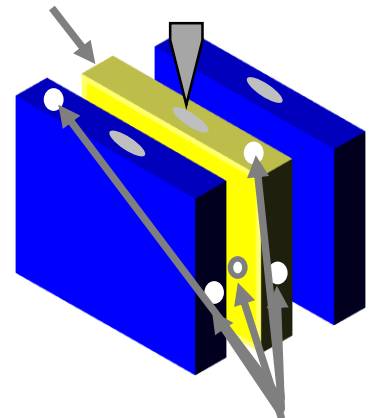
- Nail material : Steel
- Diameter : 5 mm
- Tip angle : 30 degree
- Neil speed : 10 mm/sec



- <Results>
- Trigger cell thermal runaway
  - No fire, no thermal propagation



Trigger cell (No.8 of 16cells module)

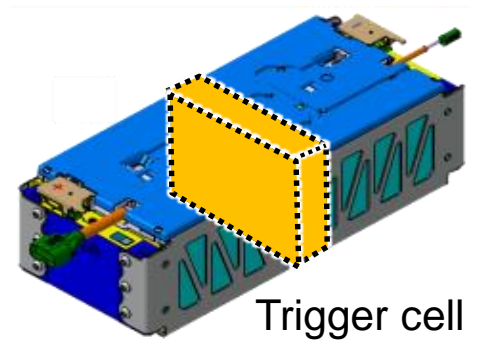
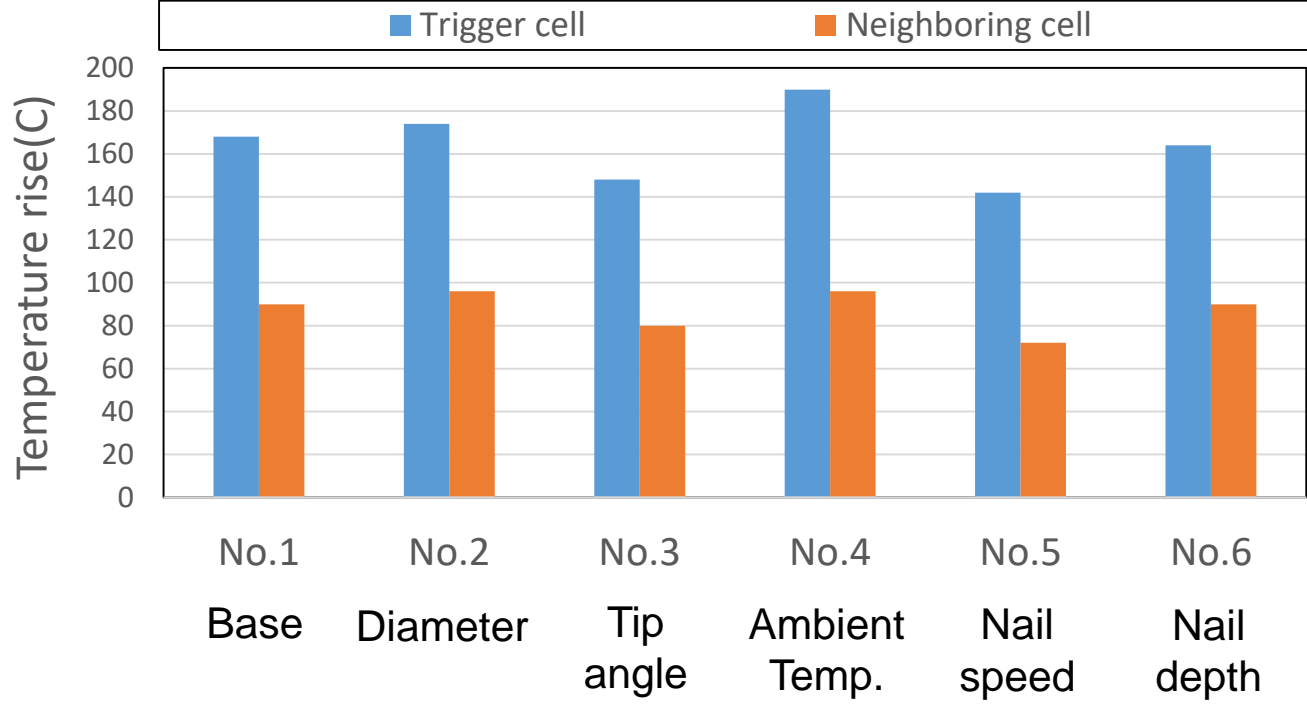


Temperature measurement

Voltage drop	Max. Temp.	dT/dt	Thermal runaway	Thermal propagation
to 0 V	210 C	7.0 C/sec	Yes	No

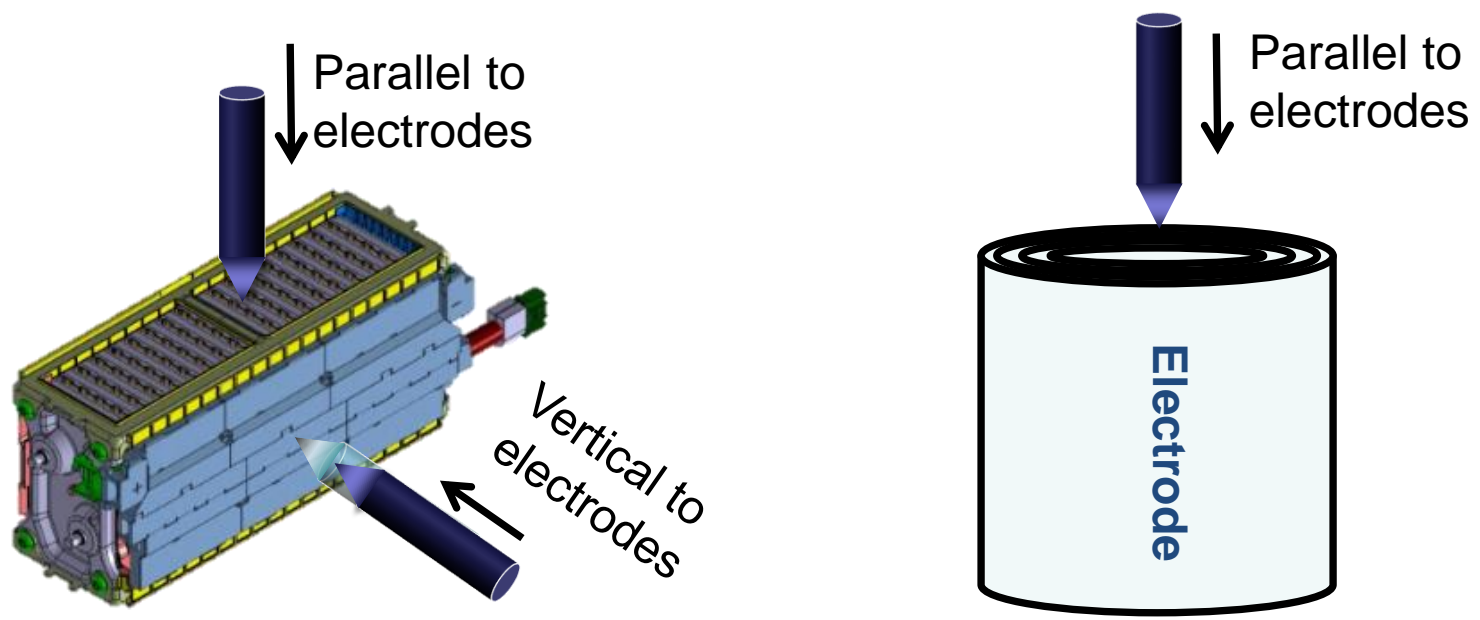
Nail test has robustness against test condition deviations.

		No.1	No.2	No.3	No.4	No.5	No.6
		Base	Diameter	Tip angle	Ambient temp.	Nail speed	Nail depth
Diameter [mm]		3	4	3	3	3	3
Tip angle [°]		30	30	60	30	30	30
Ambient temp. [°C]		20	20	20	40	20	20
Nail speed [mm/sec]		5	5	5	5	10	5
Nail depth [mm]		20	20	20	20	20	15
Results	Propagation	No	No	No	No	No	No
	DT/Dt [C/sec]	15.4	13.0	10.7	11.3	12.0	11.7





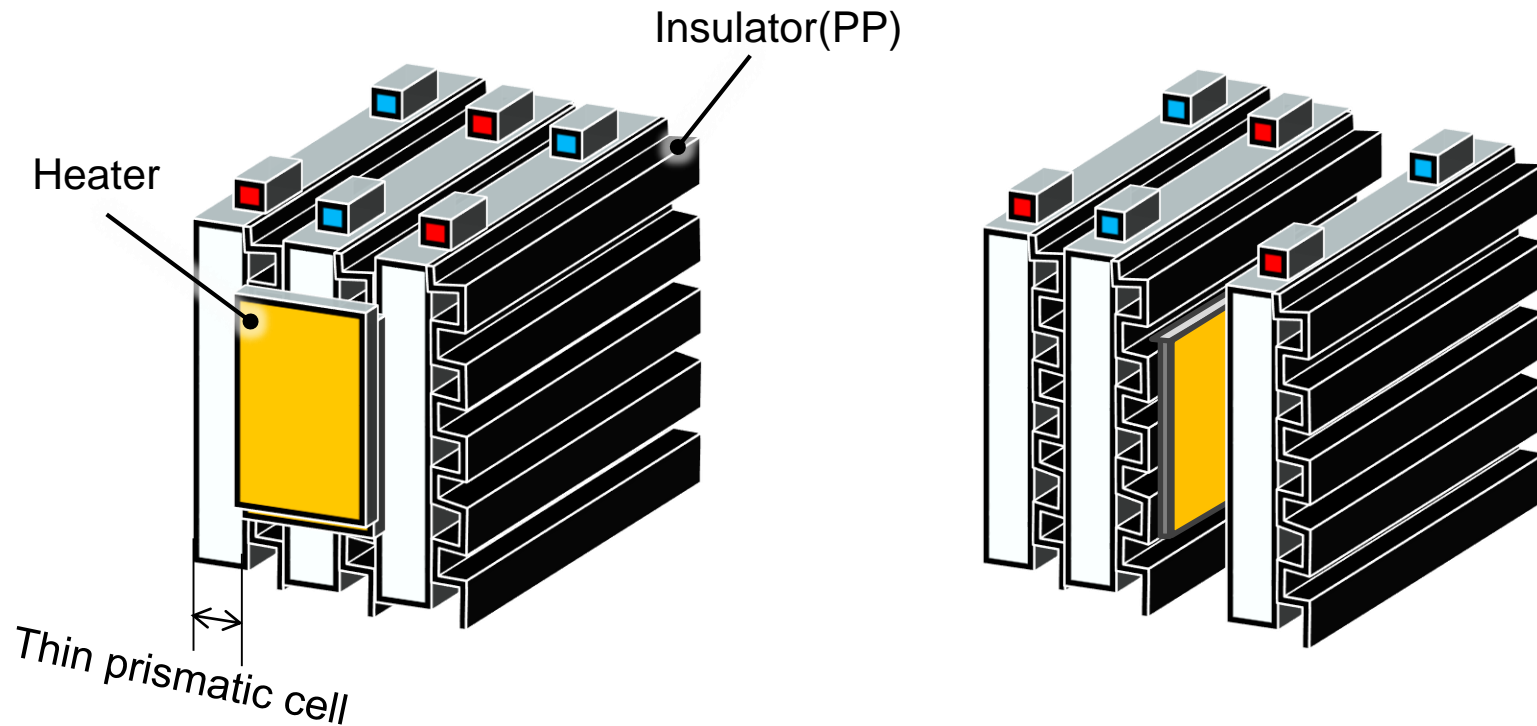
Nail directions need to be limited to get valid results.



	Nail direction	Validity	Voltage drop	Max. Temp.	dT/dt
NO.1	Vertical to electrode	○	to 0 V	180 C	10.5 C/sec
NO.2	Parallel to electrode	×	No	25 C	-

Nail method has possibility to avoid issues on conducting tests.

- Temperature rise of neighboring cells
- Melting and/or ignition of adjacent resin parts

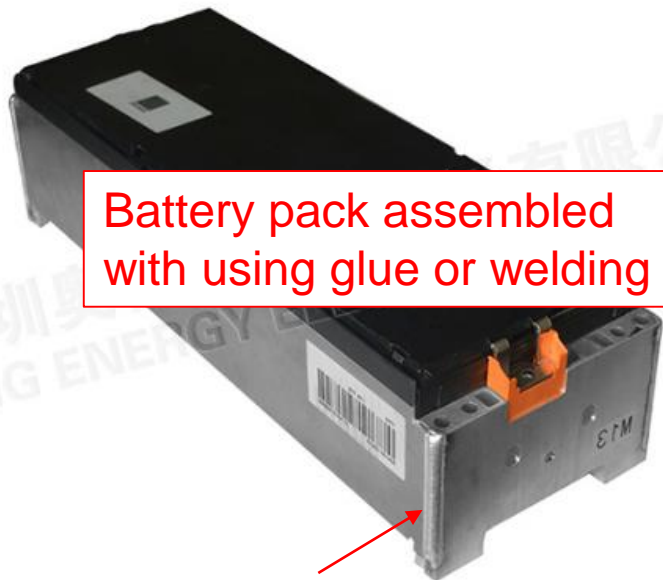


When Heater temperature > Ignition temperature (polypropylene :450 C)

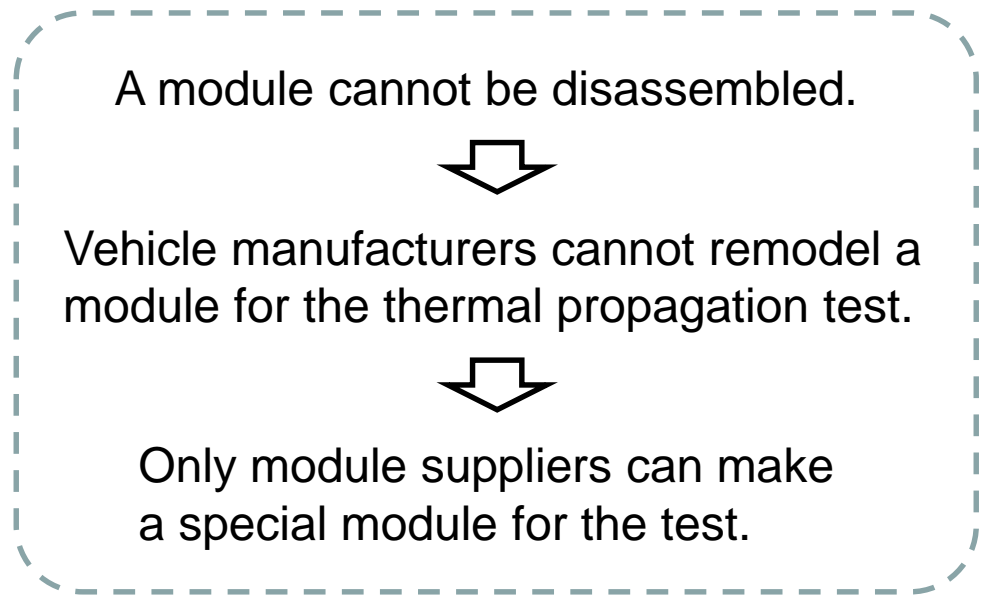
→ Resin parts ignite and thermal propagation criteria cannot be evaluated.

Nail method has possibility to avoid issues on conducting tests.

Making a special module for the test may be possible only by a module supplier.



Welded battery casing



In some cases, remodeling of modules is unnecessary for the nail test.

→ Vehicle manufacturers can conduct the test on their own.