Nov. 11, 2008

Activities for Safety of Li-ion batteries

Battery Association of Japan

1. Introduction

History of developments for safety technologies of Lithium-ion batteries in Japan

2006. 11 Establishment of Safety Committee in BAJ

12 Analysis of incidents (Failure mode analysis etc.)

2007. 4 Publication of a Guideline

"A Guide to the Safe Use of Secondary Lithium Ion Batteries in Notebook-type Personal Computers "

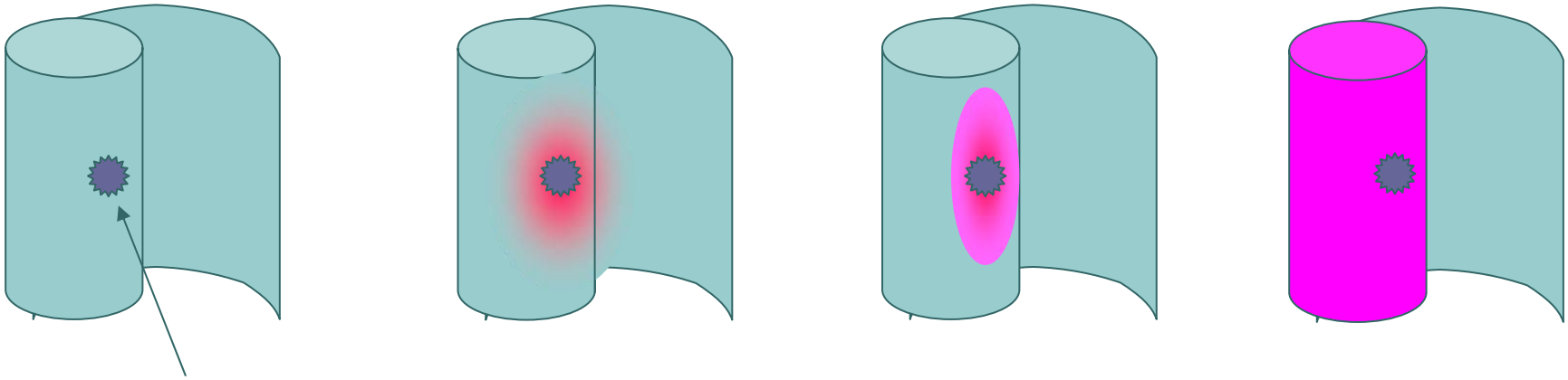
6 Establishment of Product Safety Committee under the direction of METI (Japan)

11 The publication of JIS C8714

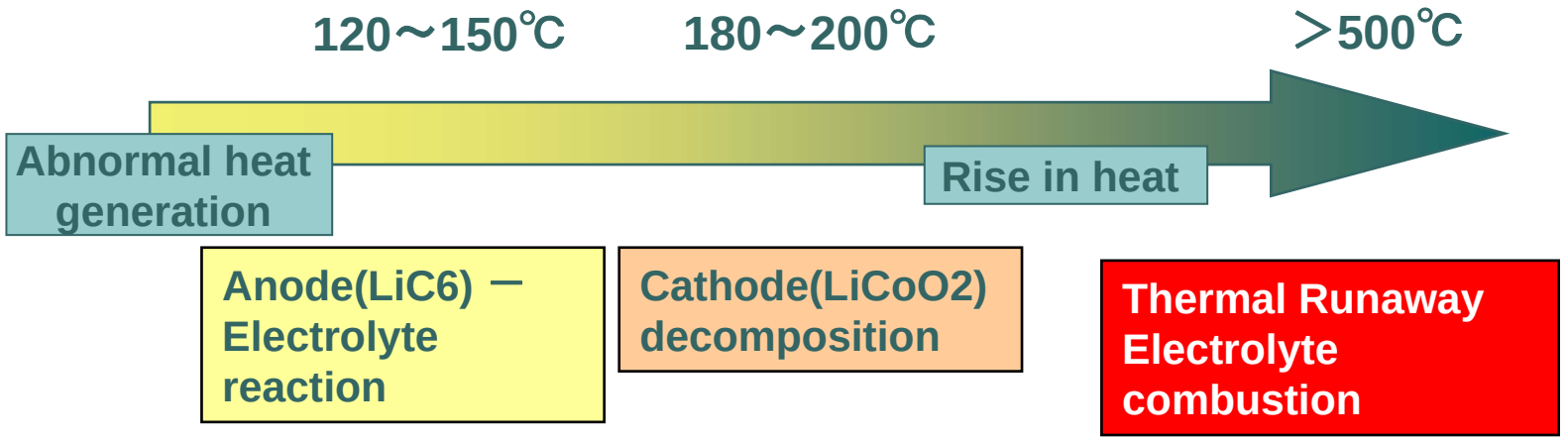
2008. 4 The release of the 1st CD (Committee Draft) of the revised IEC 62133

5 The revision concerning Lithium Ion Batteries in Enforcing Rules for the Electrical Appliance and Material Safety Law (Japan) (Effectively from Nov. 2008 in Japan)

Mechanism of Serious Accident



The trigger of the accident is the internal short-circuit between the positive electrode and negative electrode



Requirement for new testing methods

To evaluate safety level of cell design of Li-ion batteries

- **Simulation of the fire incidents**
- **Reliability of the testing method**
- **Reproducibility of the testing method**

Essence of JIS C8714

Serious fire incidents occurred under the conditions complying JIS C8712.

↓ ***Added the new testing method***

1. Simulation of the fire incidents
   ⇒**Forced internal short-circuit test**
2. The accordance with the real use
   ⇒**Cell Operating Region**
   Upper limited charging voltage

↓ ***Prevention of Fire incidents***

The points in the 1st CD (Committee Draft) of the revision of IEC 62133

In addition to IEC62133 (same as JIS C 8712) , Additional tests (①、②) are added.

IEC62133 (JIS8712)

Test item
（Ambient Temperature）

Crush
External short-circuit
Thermal test

+

Drop
Vibration
Impact
etc

Additional test ①

At upper and lower temperature in the standard temperature range, the cell is charged by the maximum current until the upper limit charging voltage. And then, Crush, External short-circuit, and Thermal test are carried out.
(Pass criteria: No explosion, No fire)

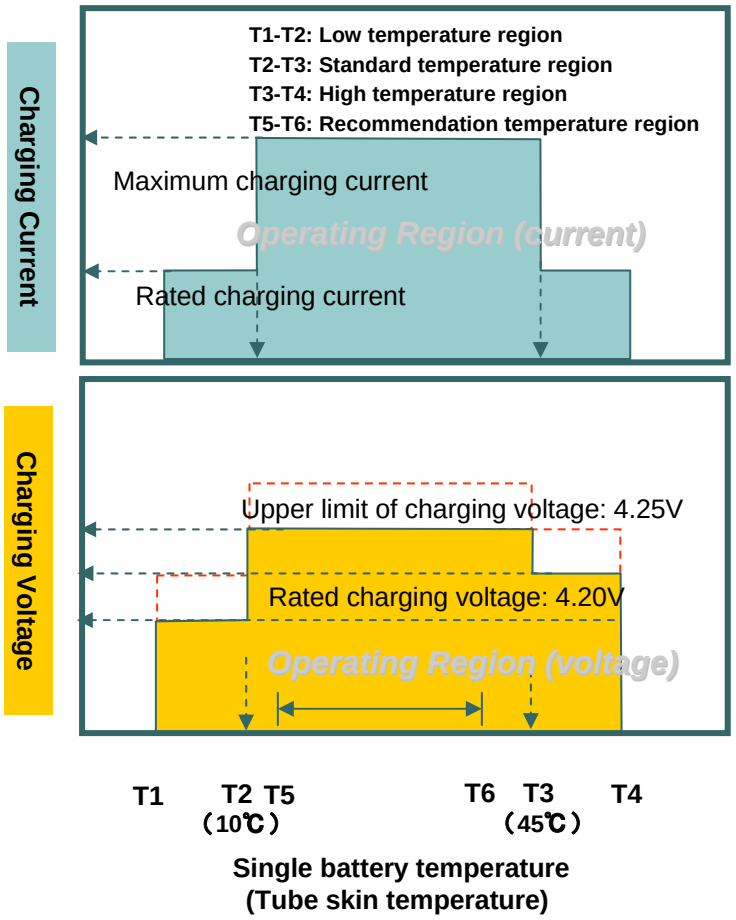
For the common "Carbon anode - Co base cathode",
The upper limit charging voltage : 4.25 V
The maximum current : 0.7 It
The standard temperature range –
Upper temp.: 45 degree C, Lower temp : 10 degree C

Additional test ②
New testing method for internal short-circuits
(Forced internal short-circuit test)

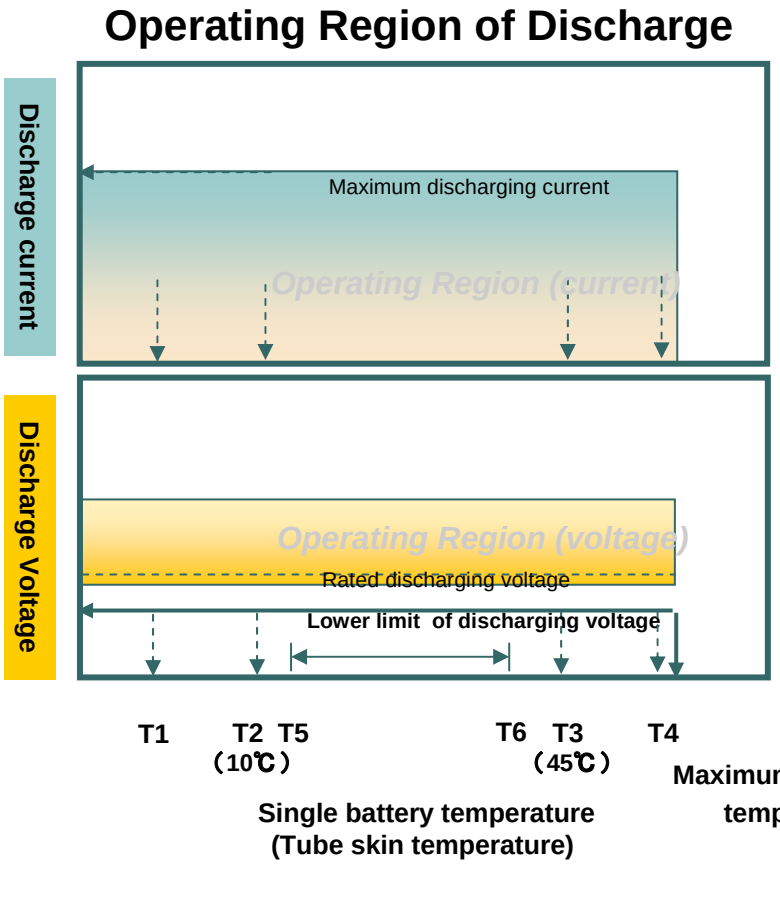
Key point 1

Cell Operating Region of Li ion batteries

Operating Region of Charge



Operating Region of Discharge

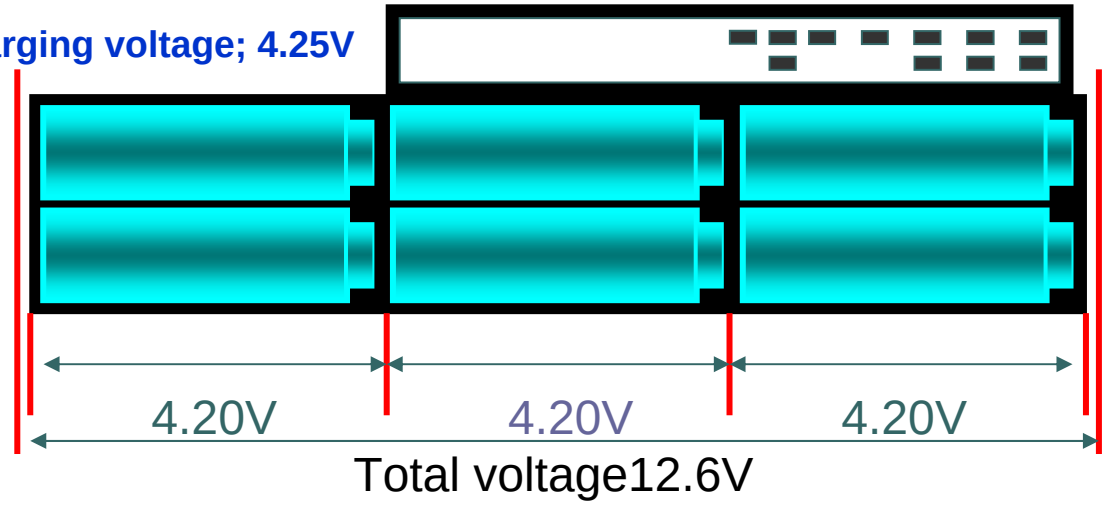


Over-charge protection of batteries

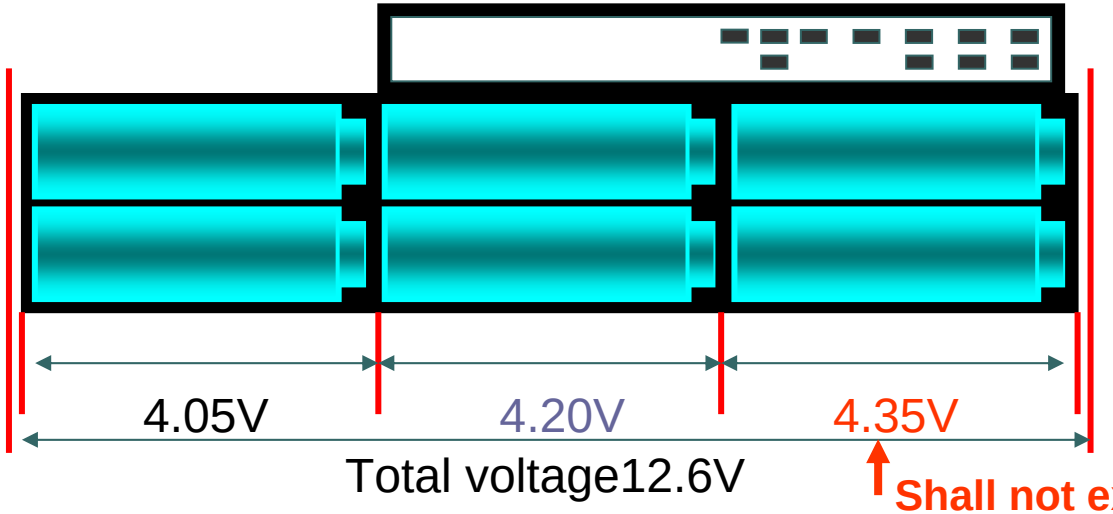
Examples ;

In case of the upper limit charging voltage; 4.25V

Ideal condition of fully charged cells in a battery pack



A bad example; Capacity-imbalance is occurred with no protection

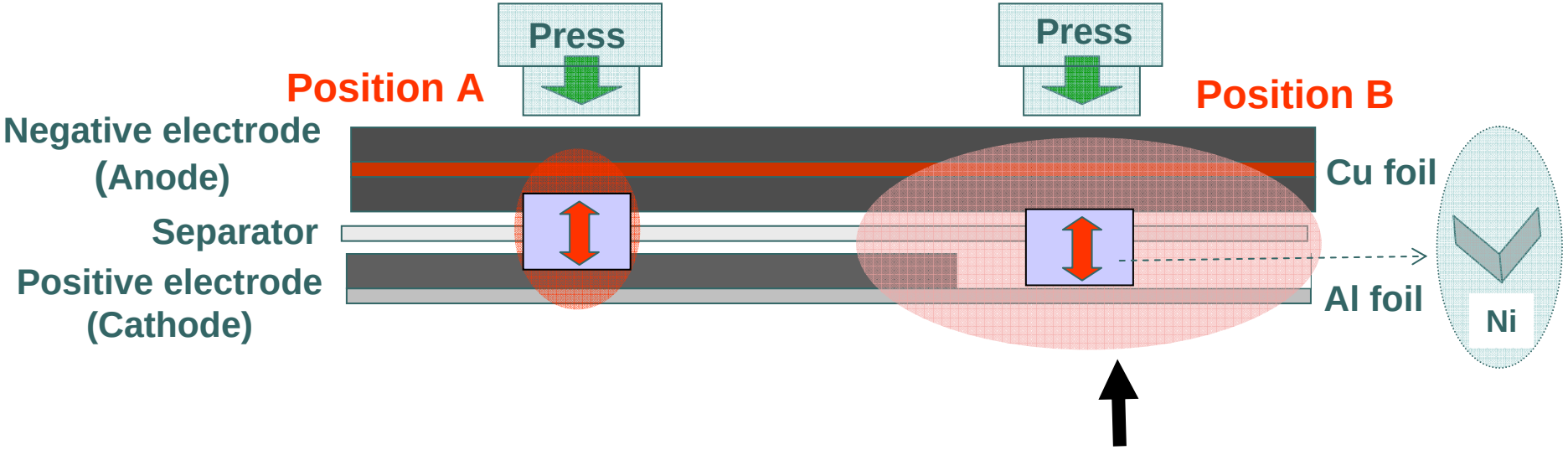


Requirement : Cell or Cell block voltage shall not exceed the upper limit charging voltage.

Key point 2

A new testing method

Forced internal short-circuit test



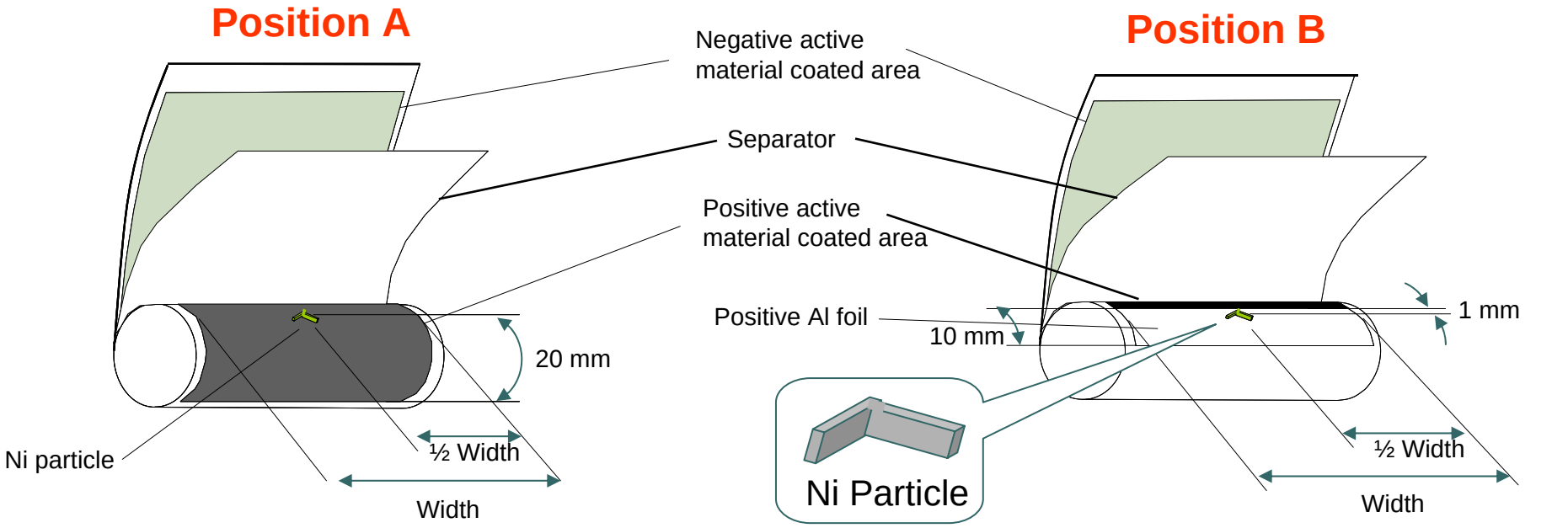
The critical area;
Bare Aluminum foil facing
the Negative active material.
Short-circuit in the area leads to fire easily.

Procedure of the Forced Internal short-circuit test

1. **Charge the cell up to the upper limit charging voltage (e.g. 4.25V)**

2. **Disassemble the cell and take out the winding core.**

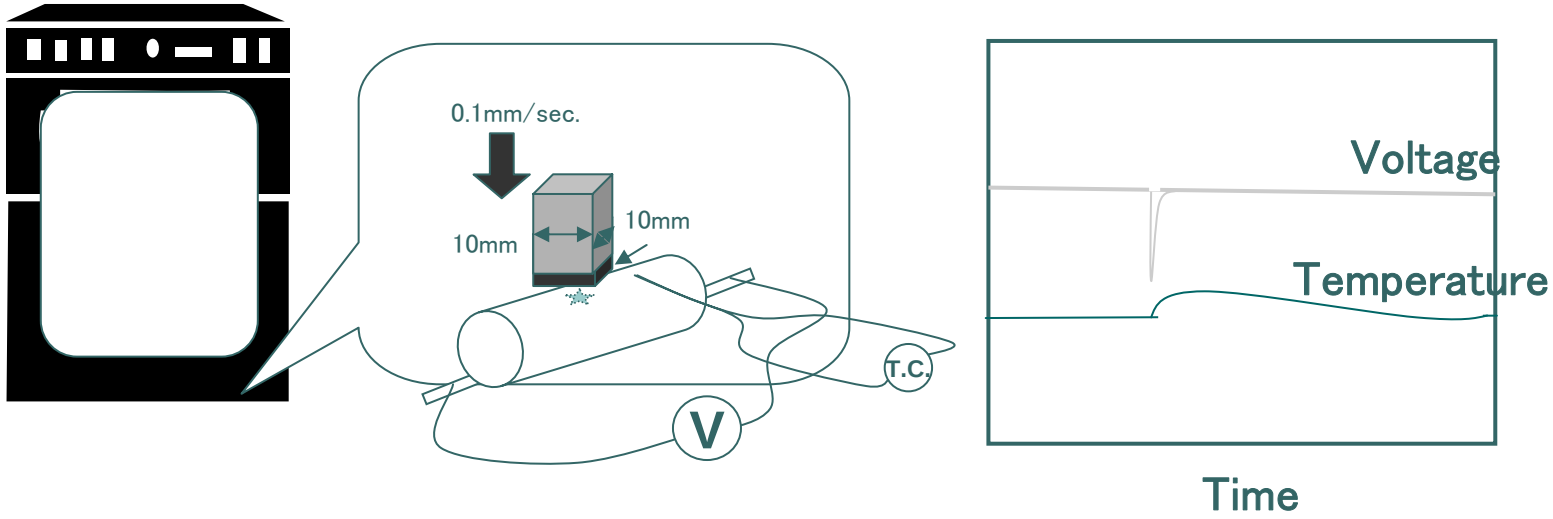
3. **Insertion a Nickel particle to the core.**



Between Positive and Negative active material

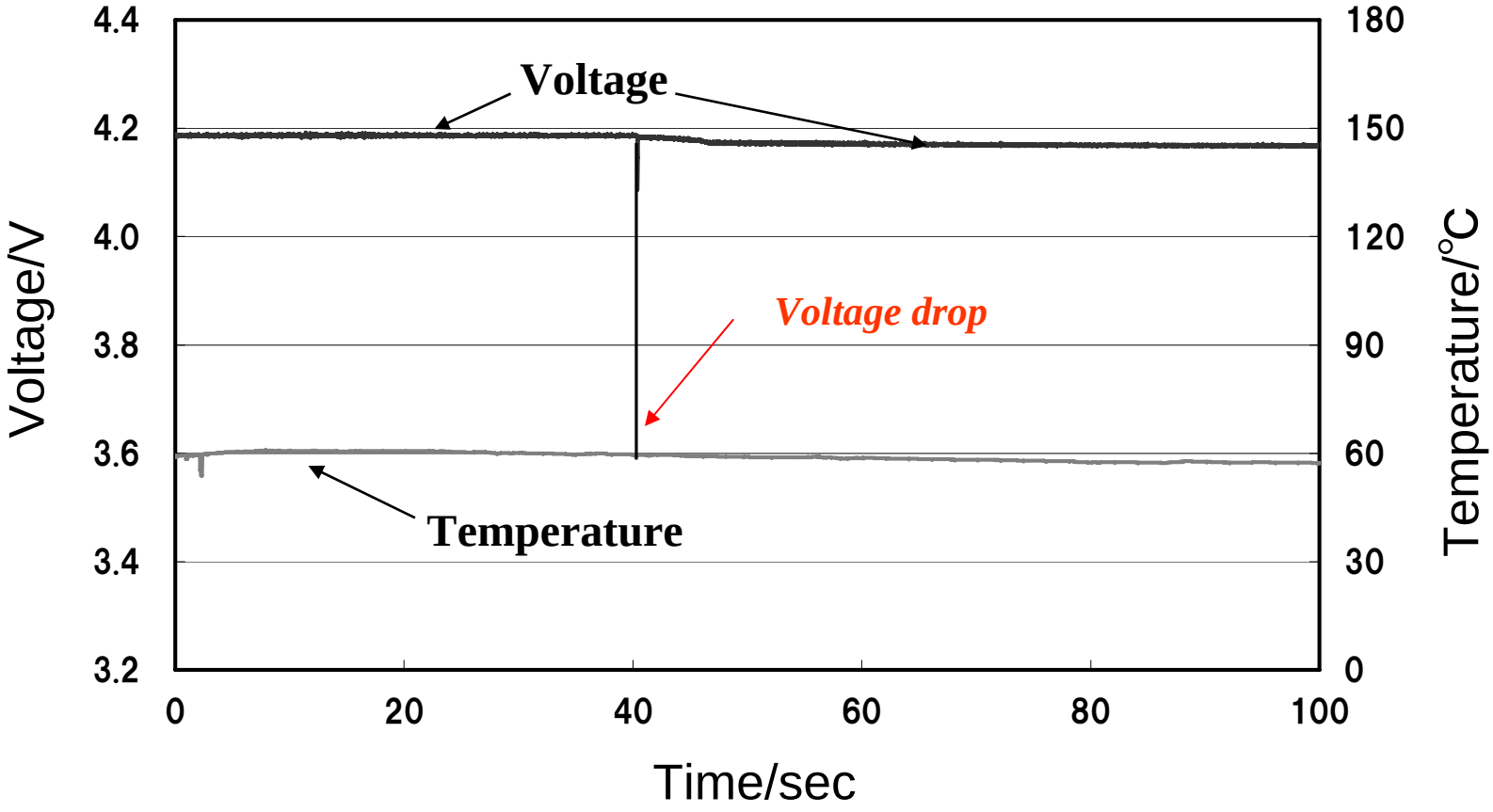
Between uncoated Al foil and Negative active material

Procedure of the Forced Internal Short-circuit Test



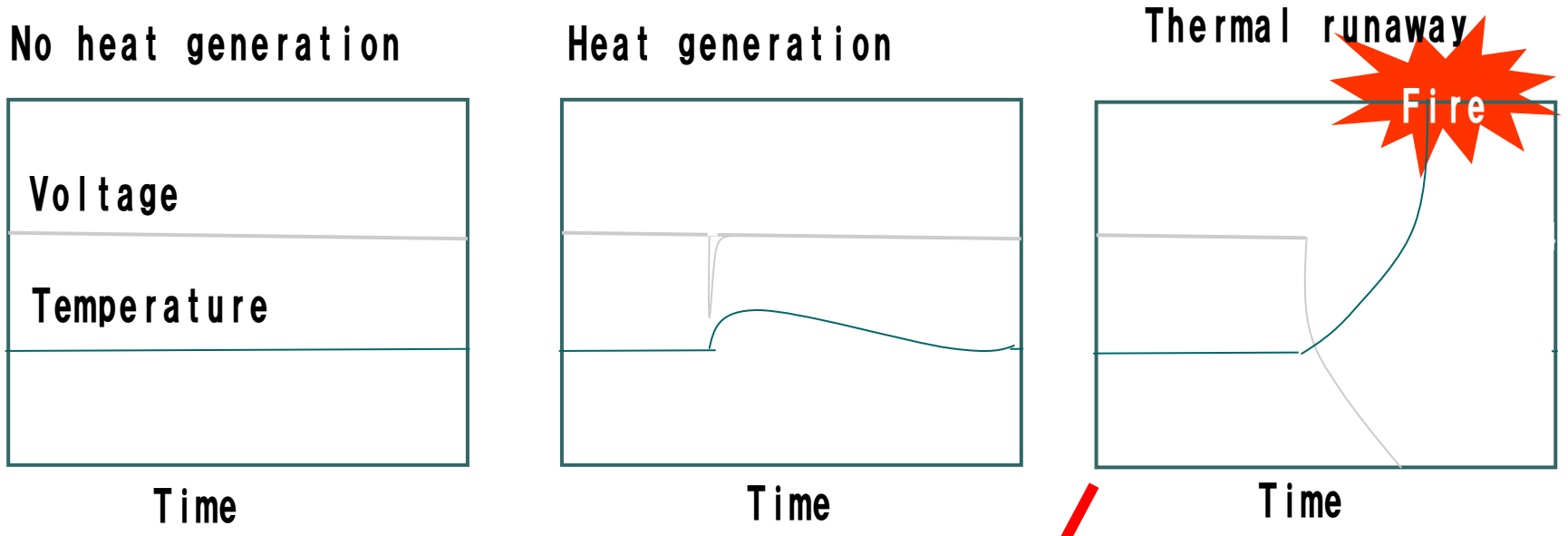
Voltage should be recorded
Confirm no fire when the voltage drops.

Typical behavior of Voltage and temperature in the Forced internal short-circuit test



Voltage drop shows occurrence of short-circuit

The typical behaviors of the Forced internal short-circuit test



Not safe design, or
Not safe charging

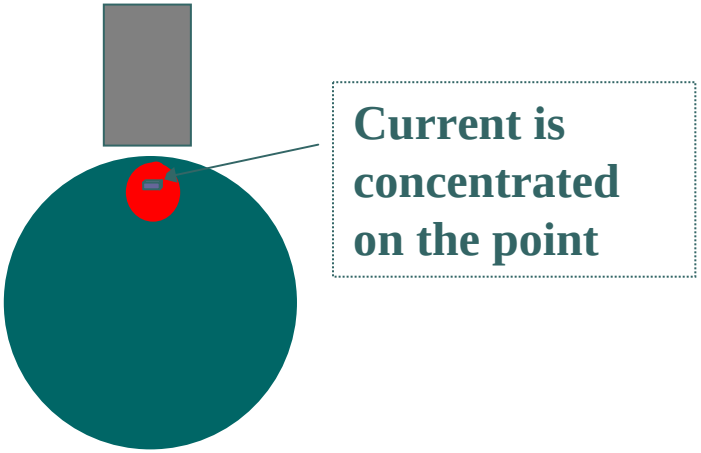
Comparison of other testing methods

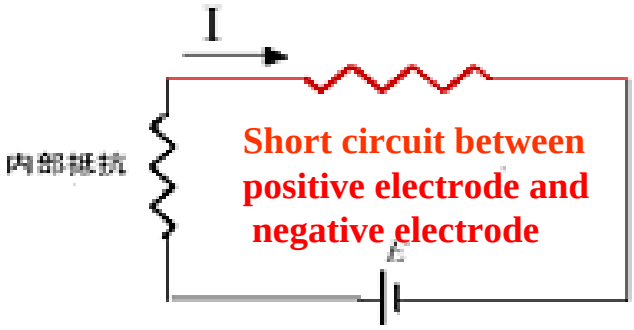
	Behavior				
	Internal Short-circuit	Deforma-tion of cell casing during short circuiting	Identification of the short-circuited point	criteria	Meaning of Fire in the test
The Forced internal short-circuit test	Single layer	No	Yes	Fire	The cell design is not safe.
Nail penetration	Multi layer	Yes	No	Fire	These criteria have no accordance with safety level required in the market
Crush	Large area	Yes	No	Fire	

The Forced internal short-circuit test is to evaluate safety level of the cell design (simulation of cell internal short-circuit that leads to fire incident).

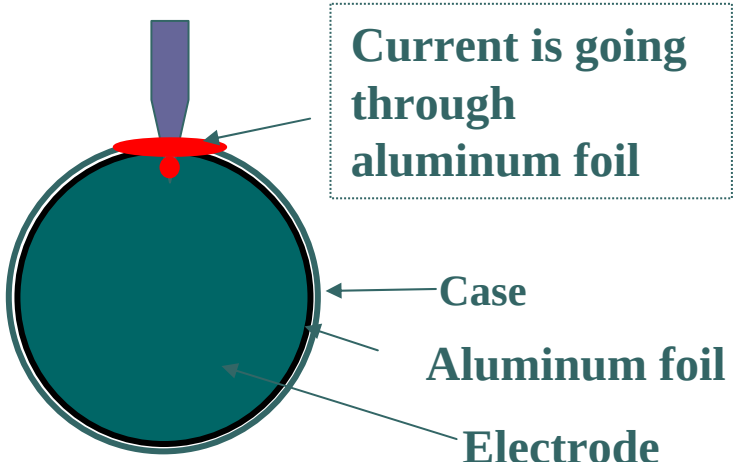
Comparison between Forced internal short-circuit test and Nail Test

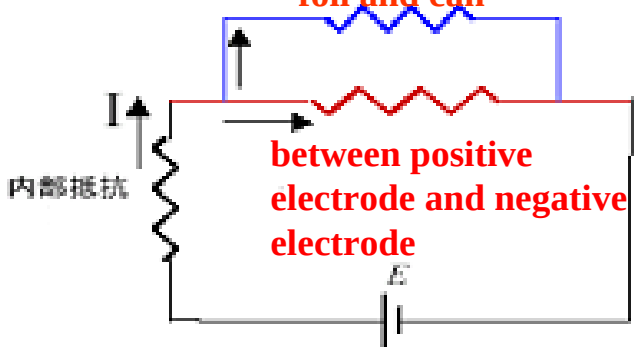
Forced internal short-circuit test





Nail test





Reproducibility of the forced internal short-circuit test

	Safe cells			Unsafe cells		
	Person A	Person B	Person C	Person A	Person B	Person C
Cell A	OK(0/5)	OK(0/5)	OK(0/5)	NG(3/5)	NG(4/5)	NG(4/5)
Cell B	OK(0/5)	OK(0/5)	OK(0/5)	NG(3/5)	NG(4/5)	NG(4/5)
Cell C	OK(0/5)	OK(0/5)		NG(3/5)	NG(2/2)	

OK or NG（Numbers of Fire / Numbers of tested cell）
Criteria：OK(0/5), NG(1/5 ~ 5/5)

	Safe cell conditions			Unsafe cell conditions		
	Position of internal shot-circuit	Charging voltage	Charging temperature	Position of internal shot-circuit	Charging voltage	Charging temperature
Cell A	positive active material - negative active material	4.25V	25℃	aluminum foil - negative active material	4.35V	45℃
Cell B	positive active material - negative active material	4.25V	25℃	aluminum foil - negative active material	4.40V	45℃
Cell C	positive active material - negative active material	4.25V	50℃	aluminum foil - negative active material	4.25V	50℃