# Results of Thermal Propagation Tests of HEV Batteries

12 – 14 March , 2024

3rd meeting of SIG on Thermal Propagation

JAPAN AUTOMOBILE STANDARDS INTERNATIONALIZATION CENTER

# Details of the Tests Conducted

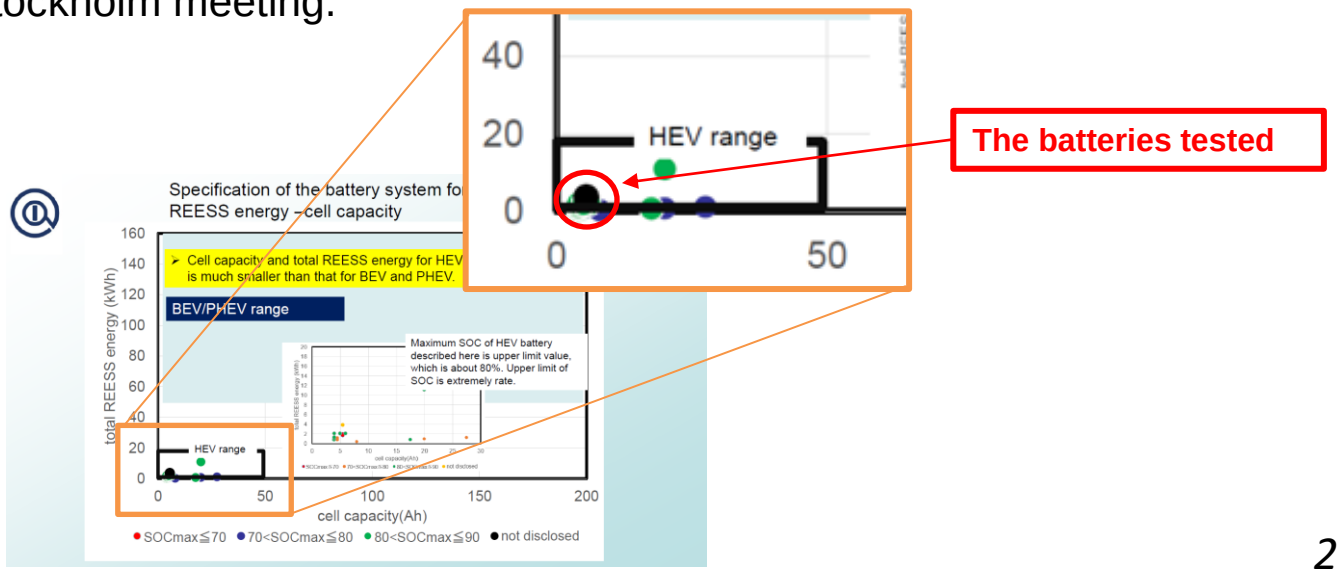
## Introduction

Battery systems for HEVs differ from those for BEVs in their required characteristics: theoretically, they have a lower risk of undergoing thermal runaway and Thermal propagation due to their smaller cell and pack capacities and lower SOC for normal use.

Japan conducted thermal propagation tests of battery systems for HEVs using the external heating method, which is defined as “main method” in SIG on TP, and studied whether the Thermal propagation test discussed in the SIG (UNR100) should be required for battery systems for HEVs.

## Test Conditions

On January 25 and 26, 2024, the Japan Automobile Research Institute (JARI) conducted Thermal propagation tests using two types of battery systems for HEVs that fall in the HEV range as explained by OICA at the Stockholm meeting.



# Summary of the Test Results

Battery pack A for HEVs

✓ At the specified additional energy rate (20%), the triggered cell did not start thermal runaway.
✓ The thermal runaway of the triggered cell was confirmed at an additional energy rate of 67%.
✓ The thermal runaway of the triggered cell did not provoke thermal propagation to adjacent cells.

Battery pack B for HEVs

✓ The thermal runaway of the triggered cell was confirmed at an additional energy rate of 13%.
✓ The thermal runaway of the triggered cell did not provoke thermal propagation to adjacent cells.

**MD: Module**

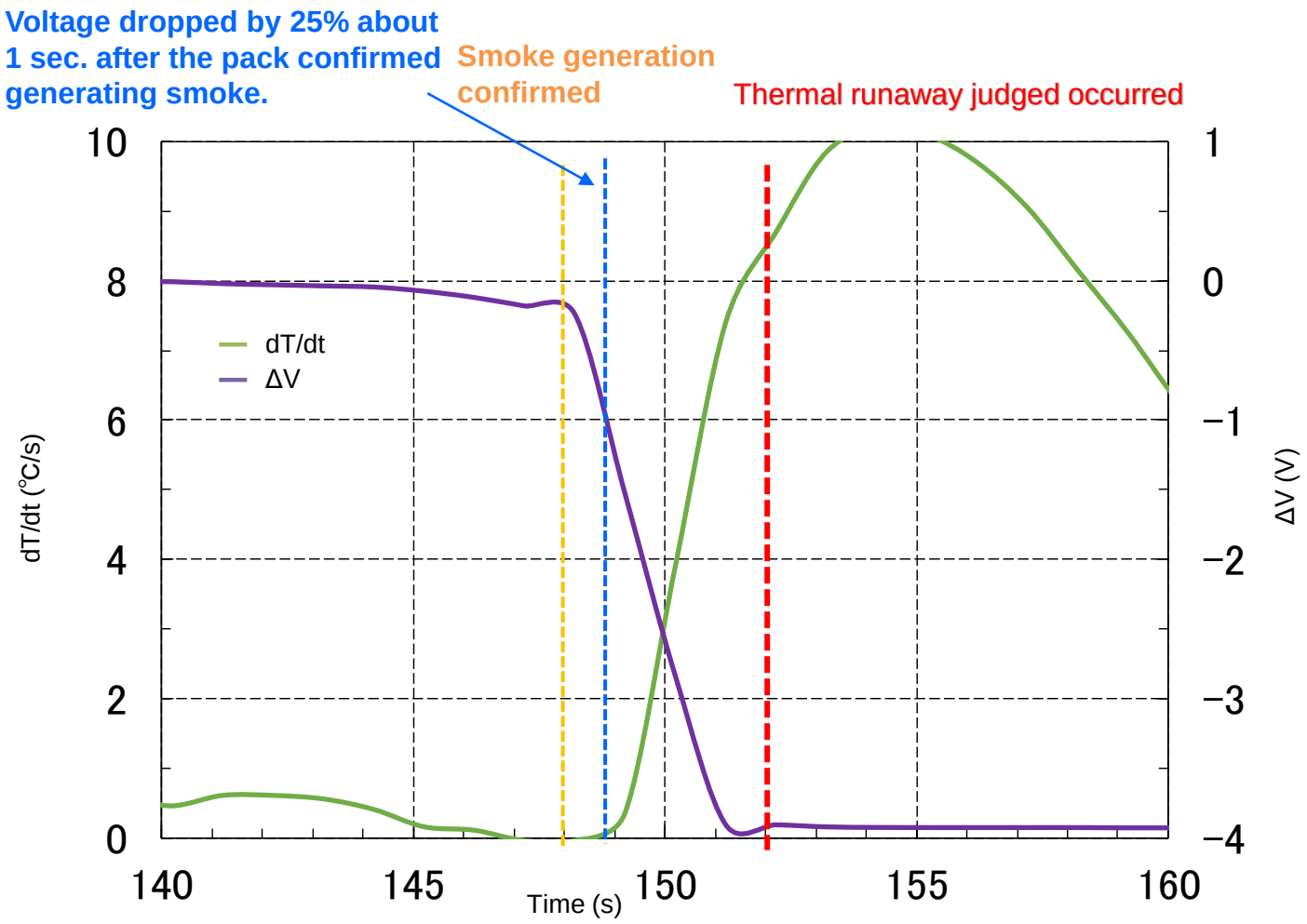
| | Battery pack A 1.1kWh* | Battery pack B 1.5kWh* | Reference ISO |
|---|---|---|---|
| Pack configuration | 2MD, 36 cells/MD (Pack: 72s) | 4MD, 20 cells/MD (Pack: 80s) | |
| Test SOC (%) | SOC around 80%* | SOC around 80%* | |
| Thermal runaway of the triggered cell | Occurred | Occurred | — |
| Thermal propagation | Not occurred | Not occurred | — |
| Additional energy rate (%) | 67 | 13 | 20% or less |
| Heater temperature rising speed (ºC/s) | 16 | 17 | 10 - 25 |

*Estimated values from publicly available information

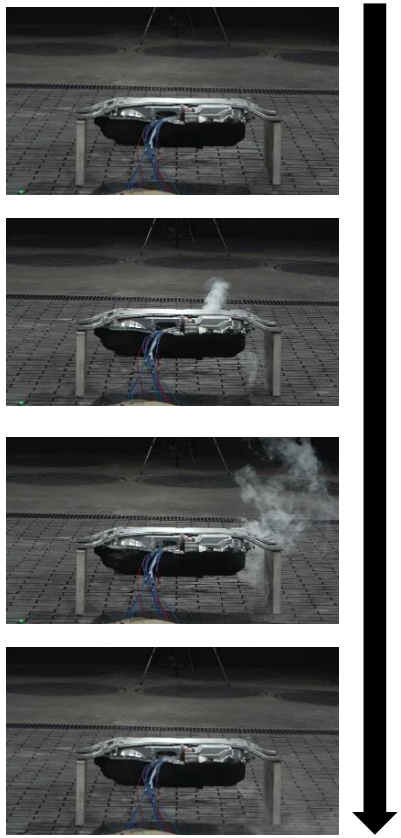
# Test Results for Battery Pack A for HEVs

**Thermal runaway was judged occurred when: dT/dt ≥ 1° C/s continued for 3 seconds and the voltage dropped by 25%**

- ✓ **Thermal runaway judged occurred about 4 seconds after the pack started generating smoke**
- ✓ **No thermal runaway observed in adjacent cells. No Thermal propagation confirmed, either**



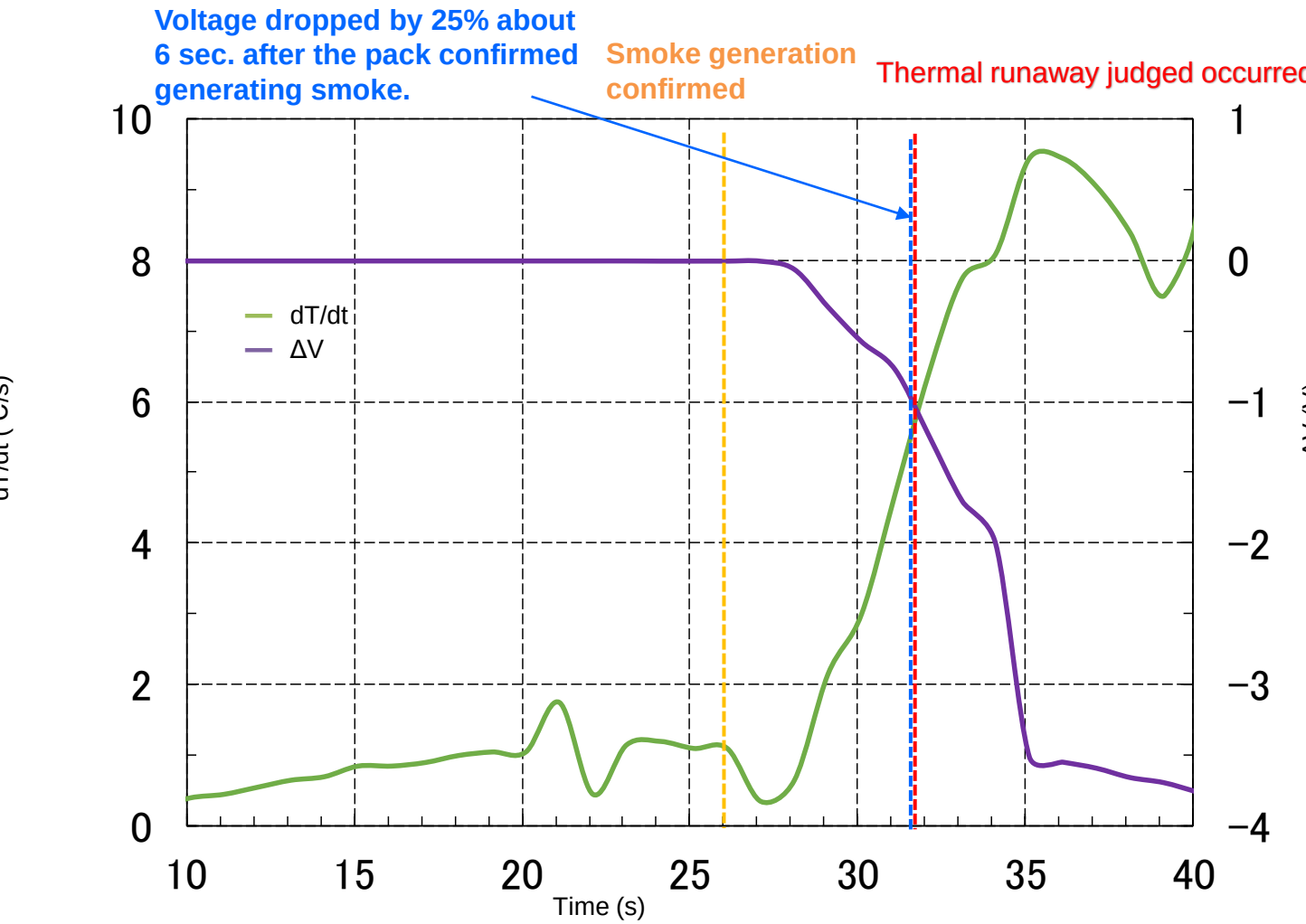

**Test scenes**



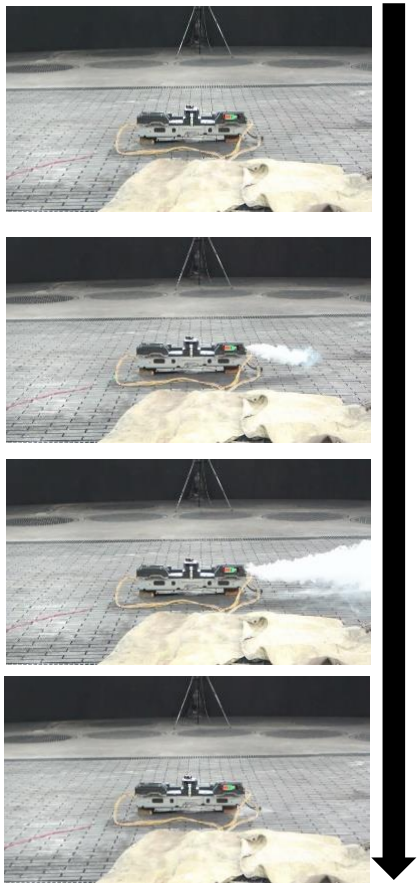
# Test Results for Battery Pack B for HEVs

**Thermal runaway was judged occurred when: dT/dt ≥ 1° C/s continued for 3 seconds and the voltage dropped by 25%**

- ✓ **Thermal runaway judged occurred about 6 seconds after the pack started generating smoke**
- ✓ **No thermal runaway observed in adjacent cells. No Thermal propagation confirmed, either**




**Test scenes**



# Test Conditions

| Items | This test | ISO 6469-1 amd. | UNR100 (draft) |
|---|---|---|---|
| | | Conditions | Conditions |
| **Product under test** | Two types of HEV battery packs<br>Packs A and B (both rectangular cells) | Rectangular, cylindrical, or pouch | Rectangular, cylindrical, or pouch |
| **Heater material** | Aluminum nitride<br>(WALN-1H by Sakaguchi Electric Heaters) | Insulation coated Ni-Cr or other suitable resistance heating materials | Insulation coated Ni-Cr or other suitable resistance heating materials |
| **Thickness (mm)** | 2.5 | <5 | <5 |
| **Area ratio** | Battery pack A: approx. 8%<br>Battery pack B: approx. 9%<br>(Heater: 25 x 25 mm) | As small as possible, not exceeding 20% of the installation surface | As small as possible, not exceeding 20% of the installation surface |
| **Temperature rising speed(°C/s)** | → | ≥15 | ≥15 |
| **Maximum heater temperature (°C)** | 550，500°C | Heater set at >100 | Heater set at >100 |
| **Heater location** | Battery pack A: between cells<br>Battery pack B: between cells and the end plate | Between cells or between adjacent cells and the end plate | |
| **End of test** | → | In case a thermal runaway occurs, 1 hour after the temperature drops to 60°C; in case no thermal runaway happens, 1 hour after heating ended (over 20% additional energy rate by the heater) | (i)The initiation is stopped in accordance with the subparagraph (h) above followed by an observation period of [1 hour], or<br>(ii)at least 5 minutes elapse after the activation of the warning indication.<br>If TR has occurred in the initiation cell, but no TP ensued, the observation period of [1 hour] is applied to Tested-Device.] |

# Summary

- No thermal propagation reactions occurred in either of the two HEV battery systems tested in this study, which is consistent with the tendency of the test results reported by OICA at the Stockholm meeting.

- Therefore, in the battery systems for HEVs in the HEV range indicated by OICA, even if thermal runaway occurred in the triggered cell by the external heating method defined as “main method”, it is likely that thermal propagation will not occur in adjacent cells.

- Japan expects that further tests conducted on battery systems for HEVs would only show similar results predictable in advance. Considering the burden to be increased on certification bodies, testing organizations, etc. when thermal propagation tests begin, we find it appropriate to maintain the documentation requirements as currently specified in UNR100 for battery systems for HEVs.