Proposal for IWG on Hazard-based Classification for Battery

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Toyota Motor Cooperation

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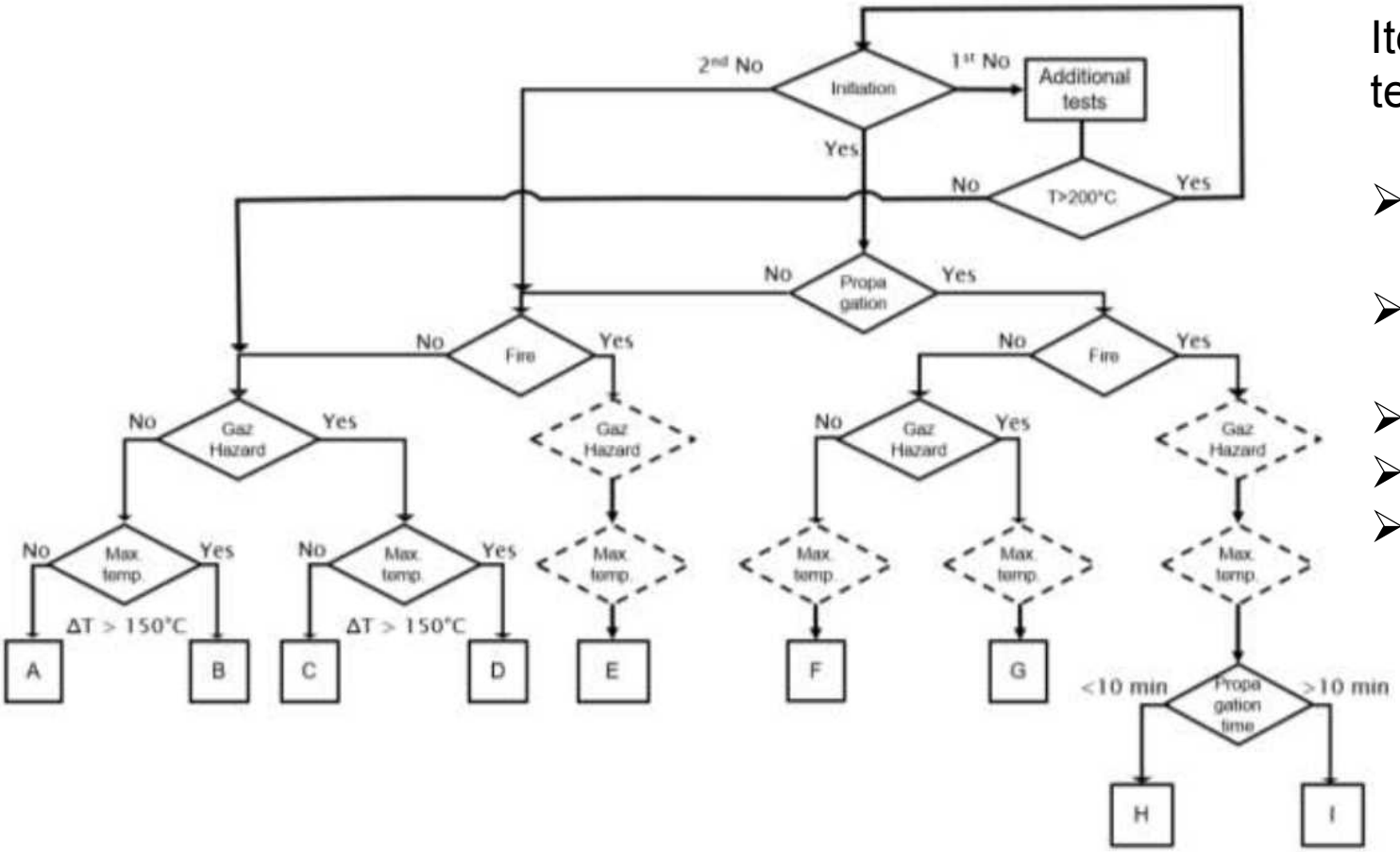
1. Introduction

- The IWG has been discussing hazard-based classification of lithium cell since 2017.
- Based on hazard of the cell, it is considered to classify the cell according to whether or not heat propagation, ignition, gas hazard occur.
- For batteries, there are various designs and products with regard to sizes and mass. Classification for batteries needs to be determined depending on the test results of cells and batteries.
- The methodology of classification for batteries should be discussed specifically in the IWG from now.

Proposal on hazard-based classification for lithium ion cell

Proposals for a hazard-based classification for Li-ion cells

5. Actualized proposition of classification for Li-ion cells:



Items examined in testing

- Thermal runaway
- Thermal propagation
- Fire
- Gas hazard
- Max temperature

Referred from **UN/SCETDG/54/INF.42**

Discussion on Batteries

Discussion on batteries

56. The working group discussed how cell propagation relates to battery propagation. Is it necessary to retest a battery if component cells propagate? Some participants suggested that if component cells propagate, then the cells installed within the module or battery would also propagate. Is it necessary to retest a battery if component cells do not propagate? It was suggested that if cells are included in a small battery, then it is not likely to lead to a larger reaction as the battery design is likely very similar to the test conducted to determine cell propagation and no additional test may be necessary. **However, if the battery is large, then an additional test to a module or battery may be required.**

Referred from UN-SCETDG-55-INF05e

- Battery design can be different from the cell configuration in the test conducted for the cell classification.
- The classification of large batteries, for instance used for electrical propelled vehicles, should be considered.

Example of Battery Design for Electrically Propelled Vehicle

Cell

Prismatic/25Ah

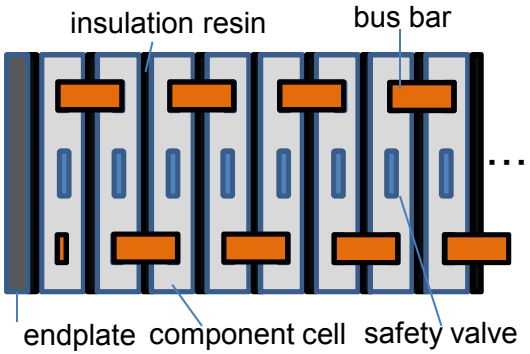
105(L),148(W),26.5(T)

Unit:mm

Battery (module)

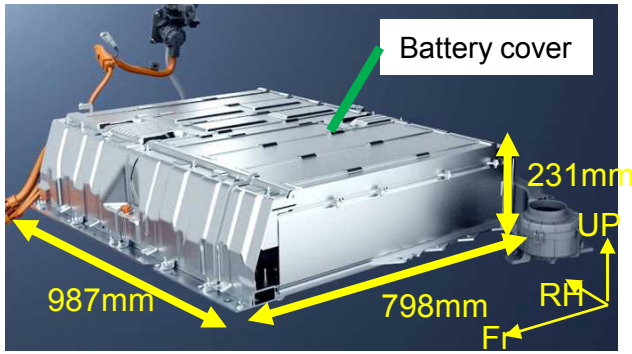
606(L),173(W),115(T)

19cells in a module.
The battery assembly consists of the same structure modules .



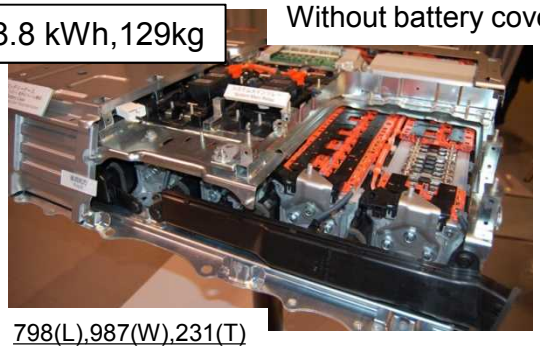
Schematic description of module above

Battery Assembly(pack)



8.8 kWh,129kg

Without battery cover



798(L),987(W),231(T)

Battery design of module and pack can be different from cell design.

2. Hazard Classification of Battery

＜Event of thermal propagation for the battery＞

It is necessary to understand the thermal propagation in the battery.

What happens if thermal runaway of a single cell occurs in the battery?

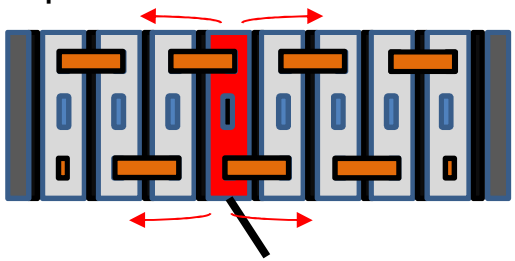
＜Hazard Classification of Battery＞

The hazard-based classification for the battery should be determined from both the test result of the cell and the battery, because the configuration of the cell test can be different from that of the battery design.

Event of Thermal Propagation for Battery

What happens in the batteries due to the thermal runaway of a cell?

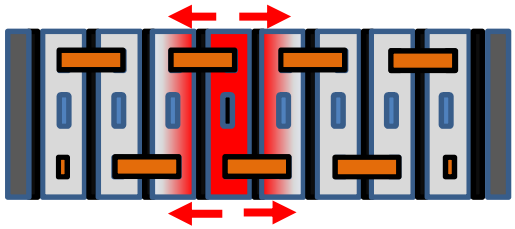
①Thermal runaway of a component cell, example



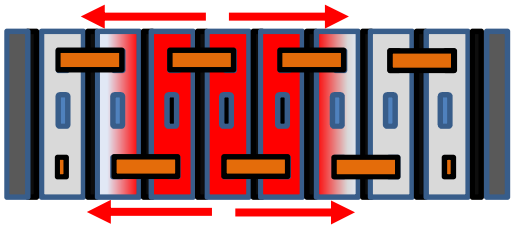
View from the top

Thermal runaway cell

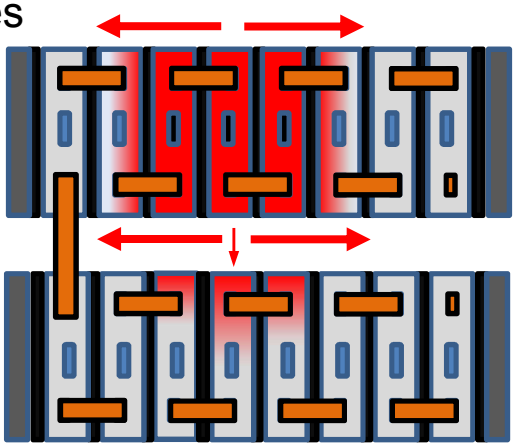
②Heat transfers to adjacent cells



③Thermal events spread in the battery



④Thermal events spread to the adjacent batteries



At the beginning of thermal events, heat transfers to adjacent cells.
Thermal events, i.e. thermal propagation, spread in the battery.

Current Definition of Propagation

Propagation – Transfer of heat energy from a cell experiencing thermal runaway that results in thermal runaway in one or more adjacent cells or batteries.

Referred from Annex1, classification criteria definitions Of UN/SCETDG/54/INF.42

Improvement of Definition for Propagation

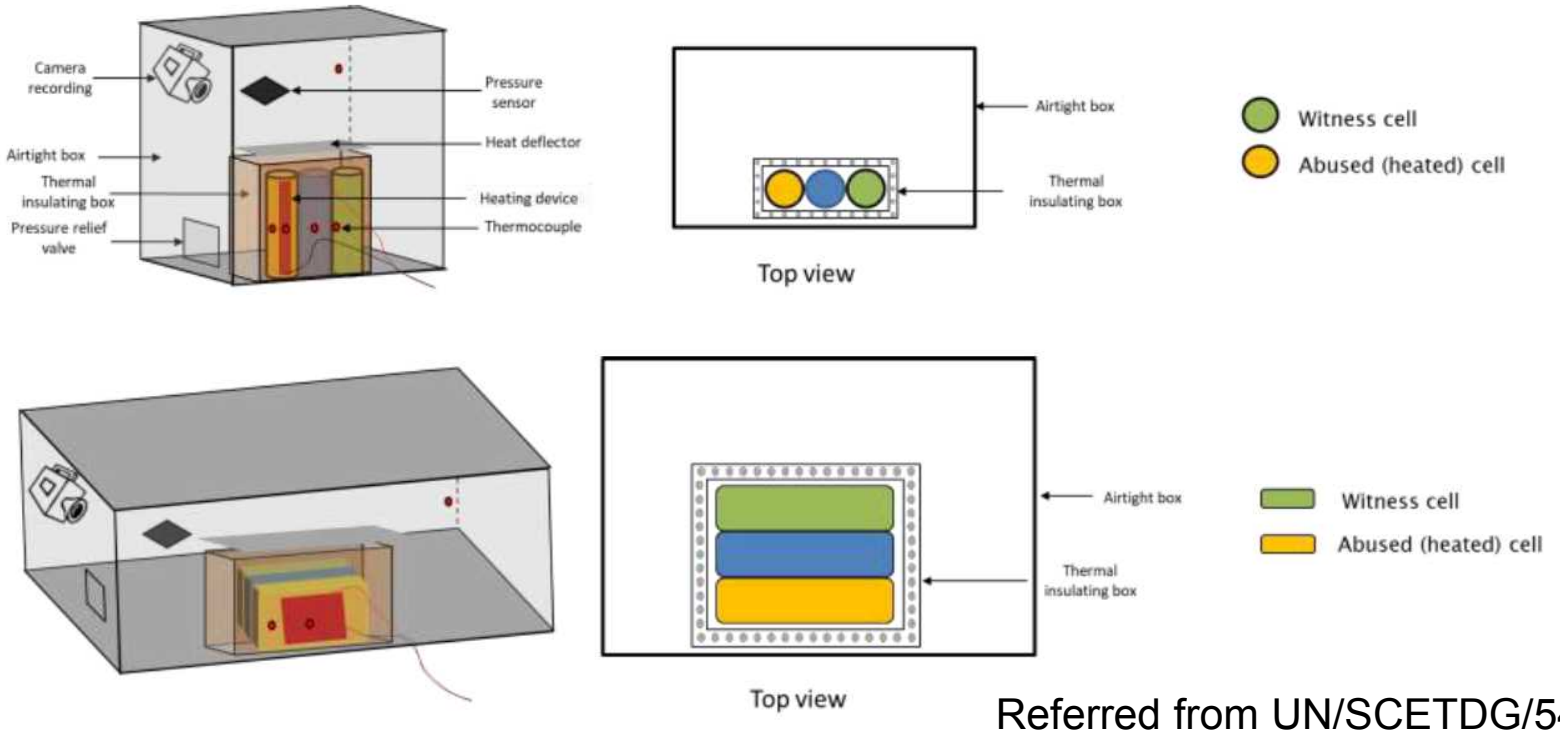
- Propagation of a cell– Transfer of heat energy from a cell experiencing thermal runaway that results in thermal runaway in one or more adjacent cells, batteries
- Propagation in a battery– Transfer of heat energy from a cell experiencing thermal runaway that results in thermal runaway in one or more adjacent cells, inside the battery
- Propagation of a battery– Transfer of heat energy from a cell experiencing thermal runaway that results in thermal runaway in one or more adjacent batteries

Classification for the Battery

Proposed Test Protocol for Lithium Cells

23. Some participants questioned the need in the test to place the cells side-by-side. It was explained that this scenario is designed to be a worst-case test to measure the inherent hazards of the cell.
(Referred from UN/SCETDG/55/INF.5)

Tests are performed by using three cells, which closely contact each other.



Referred from UN/SCETDG/54/INF.42

Hazard-based Classification of Battery(1)

- The hazard-based classification of the battery is determined from both the test result of the cell and the battery, because the configuration of the cell test can be different from that of the battery design.
- Propagation in a battery should be considered for the large type battery rather than propagation of a battery.
- Since the cell configuration at the test is designed to be a worst-case scenario, the followings are common understanding.

1. It is a natural consequence that a battery using cells that do not go into thermal runaway does not go into thermal runaway.
2. It is a natural consequence that a battery using cells that do not go into thermal propagation does not go into thermal propagation.

Hazard-based Classification of Battery(2)

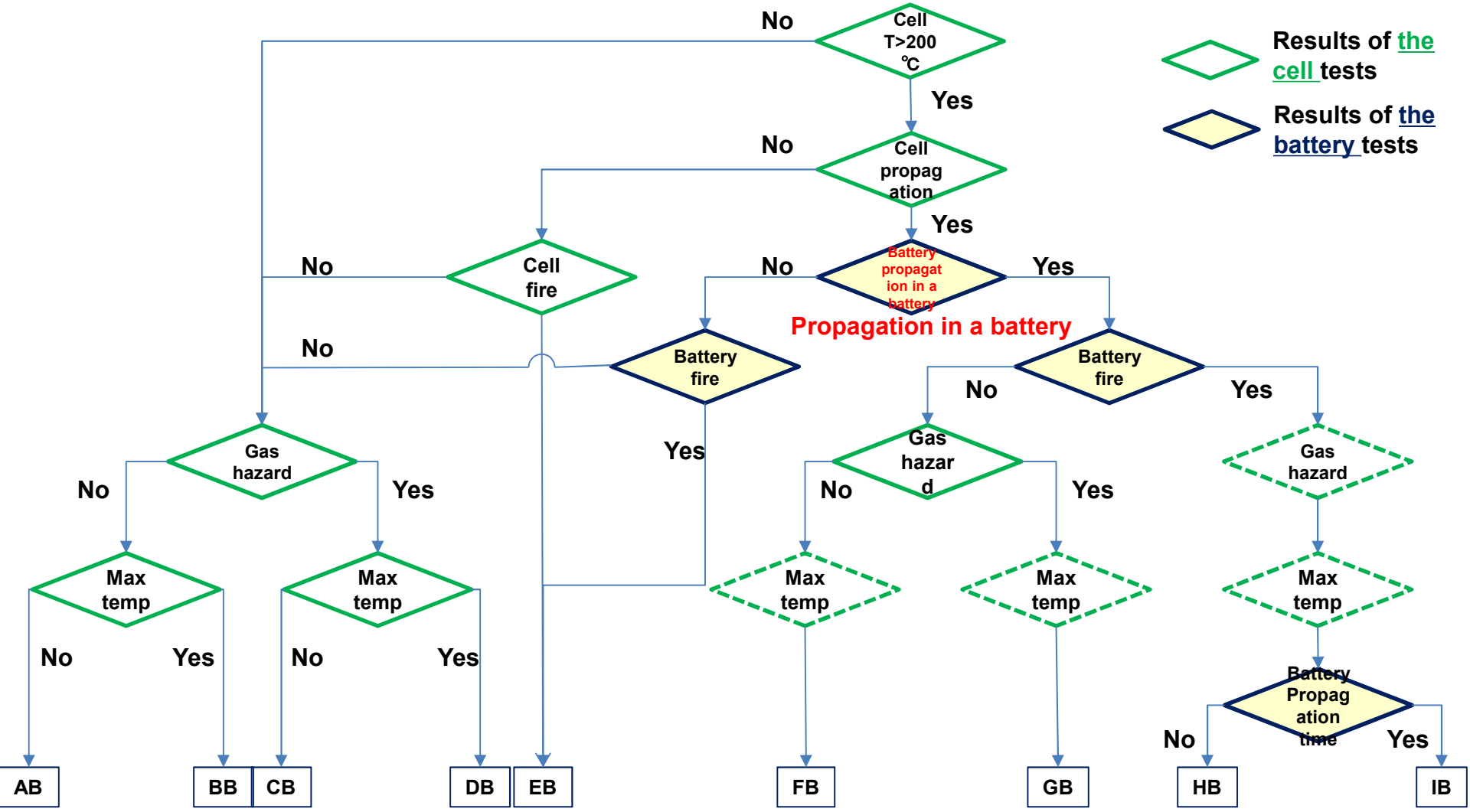
- The classification of the battery using the cells that go into thermal propagation can be determined by the test result of the battery.

- The battery assembly consisting of the batteries that do not go into thermal runaway/propagation can be classified as non-thermal runaway/propagation respectively.

  NOTE The test of the battery assembly can be performed with the battery assembly itself or the battery consisting of the battery assembly.

- Flow chart of battery classification is proposed on the next slide.

Flow Chart of Hazard-based Classification for Battery



RECHARGE
The Advanced Rechargeable & Lithium Batteries Association

TOYOTA

3. Test Procedures

- The initiation methods of the thermal runaway for the battery test should be basically the same for the cell test.
- Detail procedures such as test conditions will be discussed when test procedures for the cell are developed.
- Discussion is necessary how to test and classify the very large format batteries, because tests of such batteries cannot be performed due to limitation of test equipment.

4. Classification of Similar Batteries

- Similar batteries are ones using the same cells, parts and the same method of connection such as series and/or parallel, and using the different number of the cell and parts.

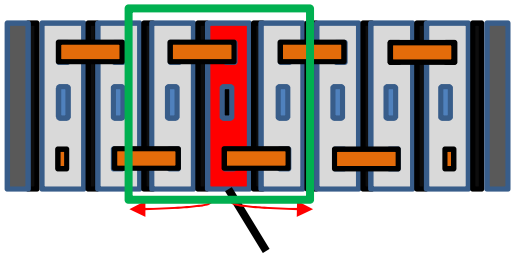
- Some batteries are designed to be similar structure using the same cells, parts, and the same connection of the series and/or parallel. They are “similar battery”.

- The test result of a battery can be referred to that of a similar battery, which means it is classified as the same hazard-based classification.

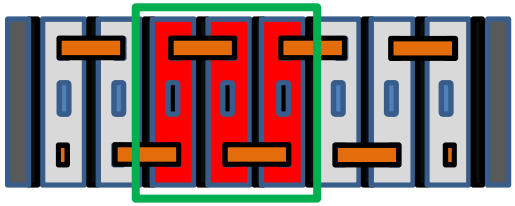
Note : Different from the mechanical behavior, the thermal behavior at the adjacent cells will depend on the thermal runaway cell and relevant parts. It means that thermal behavior of adjacent cells leads to the same consequence, if the battery is designed to be similar structure.

Thermal Behavior on Similar Battery

thermal runaway occurrence

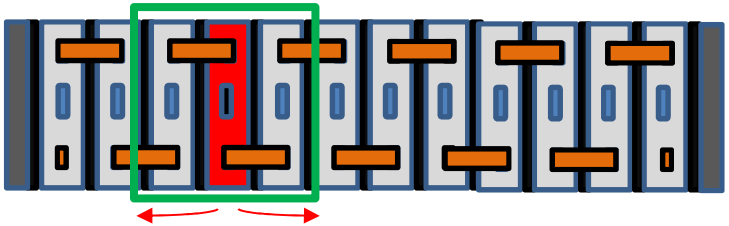


final heat transfer to adjacent cells



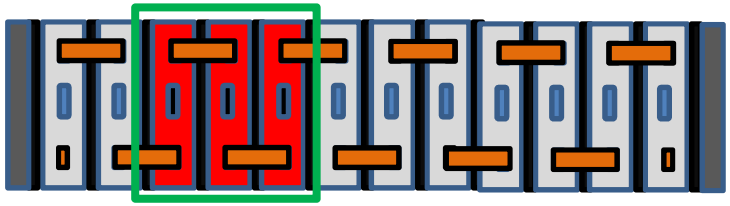
Heat transfer depends on the specification of the cell, parts and connection.

thermal runaway occurrence of **similar battery**



The number of cells is different, but the configuration is the same as a battery above.

final heat transfer to adjacent cells



The same consequence is assumed as above.

Similar batteries using the same cells, parts and the same connection such as series and/or parallel **can be classified as the same.**

5. Summary and Task

＜Summary＞

- Flow chart of hazard-based classification for the battery is proposed.
- Definition of propagation is proposed specifically for a cell and a battery.
- An idea of classification of similar battery is proposed.

<Task of battery classification>

- Hazard-based classification for the battery will be improved according to the progress of hazard-based classification for the cell.

IWG could bring more data and demonstration to the meeting on the classification of battery.