# Technical Comments :
# On Thermal Runaway Criteria and Packaging Requirements for Hazard-Based Battery Classification

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*Informal Working Group on Hazard-Based Classification of Lithium and Sodium Ion Batteries*
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SUMMARY

# Korea's three comments at a glance

## 01 Thermal-runaway criteria

Harmonize the determination criteria with UN GTR 20 so that one consistent thermal-runaway definition applies across UN instruments.

## 02 Packaging requirements

Define packaging by thermal-propagation-prevention performance — not by mandated materials. Move to technology- and performance-based requirements.

## 03 "Probability of event" concept

UN dangerous-goods classification is hazard-based. Korea does not support adding probability of occurrence to the scheme.

# 01. Thermal-runaway criteria

# Background: Thermal Runaway Definition

## ☐ Thermal Runaway definition in the current draft

> "*Thermal run-away (TR)* means the reaction of a cell or battery initiated by an uncontrolled and irreversible exothermic chemical reaction within the cell, causing further reactions that generate more heat and resulting in a rapid and accelerating rise of temperature.

> cut off when a thermal runaway is detected (detection of a continuous increase of the temperature of the initiation cell without increase of the heater power for more than *3 minutes)*, or in case the Thermal Runaway is not achieved when:

→ Key elements of the definition & Criteria

- Uncontrolled and irreversible exothermic chemical reaction
- Self-heating leading to further reactions
- Rapid and accelerating temperature rise
- A continuous rise in cell temperature is sustained for ≥ 3 minutes even without any increase in heater power.

## ☐ A result is recorded as "No thermal runaway" only when BOTH conditions are met:

> (a) the initiation cell temperature has reached 375 °C for at least 1 minute;
>
> (b) and the total energy delivered by the heater during the test is larger than two times the electrical energy content of the cell at the tested SOC.

**a** Cell surface temperature is held at ≥ 375 °C for 1 minute, and

**b** No temperature rise occurs even after heater energy ≥ 2× the cell's energy (at the test SOC) has been applied.

→ These are heater-termination conditions — the focus of Korea's two concerns that follow.

# Comment: The issue

## ☐ A fixed 375 °C threshold does not reflect real TR behavior

**Anchoring the decision to a fixed 375 °C surface-temperature threshold under thermal-propagation test conditions does not reliably reflect actual thermal-runaway behavior.**

### WHY THE THRESHOLD IS UNRELIABLE

- The 375 °C condition is a heater termination condition, not a direct indication of thermal runaway.
- A fixed surface-temperature threshold does not represent the onset of an uncontrolled internal exothermic reaction.
- The measured temperature may still be influenced by the heater, cell type, design and heat-transfer characteristics etc.,
- Different cell chemistries, types, capacities and SOCs may enter TR at different temperatures and heating conditions.

### WHAT REAL THERMAL RUNAWAY IS

- Initiation of exothermic reactions inside the cell;
- internal heat generation exceeding the heat dissipated to the surroundings;
- an increasing self-heating rate, rapid and uncontrolled temperature rise etc.,

→ TR is a dynamic reaction, not a fixed-temperature event.

Its onset temperature is not universal. It varies with the cell's characteristics.

# Comment: The issue

## ☐ The draft's own criteria are not fully aligned

**Within the draft itself, the definition and the detection criteria use different language for the same phenomenon:**

| Item | Current wording |
|---|---|
| **Thermal runaway definition** | Rapid and accelerating rise of temperature |
| **T.9 detection criterion** | Continuous increase of temperature |
| **T.11 detection criterion** | Increase of temperature slope |

The definition targets a rapid and accelerating rise driven by an exothermic reaction, **while T.9 uses a broader expression — "continuous increase of temperature."**

The detection criteria should be brought back to the same physical principle, so a single test does not classify the same event differently.

# Comment: Comparison of TR definition

## □ IWG draft vs UN GTR No. 20

| Criterion | UN IWG draft | UN GTR No. 20 |
|---|---|---|
| Thermal runaway | A continuous rise in cell temperature is sustained for ≥ 3 minutes without any increase in heater power. | Thermal runaway is determined when (a) & (c), OR (b) & (c) occur simultaneously. |
| "No TR" conditions | "No TR" requires BOTH:<br>a) cell surface ≥ 375 °C held for 1 min, and<br>b) no temperature rise after applying heater energy ≥ 2× the cell energy at the test SOC. | a) ≥ 25 % voltage drop vs. the initiation cell's initial voltage<br>b) cell surface temp exceeds the manufacturer's maximum operating temperature<br>c) dT/dt ≥ 1 °C/s sustained for ≥ 3 s |

**Why GTR No. 20 provides the more fundamental criterion**

- It identifies the source of the temperature increase as internal exothermic reactions.
- It focuses on whether the cell temperature increase has become uncontrolled.
- It does not depend on a universal temperature threshold.
- It can be applied across different cell chemistries, formats, capacities and states of charge.
- It clearly distinguishes internally driven self-heating from externally driven heating.

**The IWG draft provides a more detailed description of the reaction mechanism,**
**but its test criteria should remain consistent with the fundamental principle already established in UN GTR No. 20.**

# Comment: Proposal

## ☐ Harmonize TR definition/criterion with UN GTR 20

Align the thermal runaway definition and determination criteria with UN GTR 20, so that one consistent criterion applies across UN instruments.

Thermal Runaway should be identified when:

1. the increase in cell temperature becomes uncontrolled; and
2. the temperature increase is caused by exothermic reactions inside the cell.

The criteria should distinguish this condition from temperature increase caused mainly by continued external heating.

✔ The 375 °C and heater-energy conditions may be retained as test-termination or fallback conditions — but they should not be regarded as the definition of, or direct evidence for, Thermal Runaway.

# 02. Packaging requirements

# Comment: The issue

## ☐ A material-based requirement (non-combustible material)

**The draft mandates non-combustible material in several packaging conditions:**

(b) Batteries without a verified tested type or state of charge

In addition to all applicable provisions of paragraph (a), the material in contact with the batteries shall be verified as being non-combustible.

(b) Protection level 2 of special provision 310X

In addition to all applicable provisions of paragraph a), the material in contact with the batteries shall be verified as being non-combustible.

- P941(b): for batteries without a verified tested type or state of charge, the material in contact with the batteries shall be verified as non-combustible.
- P942(b): for protection level 2, the material in contact with the batteries shall be verified as non-combustible.
- SP 310X / Level 2: packaging is expected to prevent TRP and, in some cases, use non-combustible material.

**Why a non-combustible-material rule may not be the right criterion**

- non-combustibility does not directly demonstrate prevention of Thermal Runaway Propagation;
- material flammability alone does not represent the overall packaging performance;
- packaging safety depends on the complete design, including separation, insulation, heat absorption, venting path etc.;
- a prescriptive material requirement may exclude technically valid packaging solutions that can prevent propagation;
- it may create unnecessary design restrictions without clear evidence of additional safety benefit.

→ The regulatory requirement should focus on the actual safety function of the packaging, not on a specific material property alone.

# Comment: Proposal

## ☐ Make the requirement performance-based

**DEMONSTRATE PREVENTION / MITIGATION OF:**

- Thermal Runaway Propagation from article to article inside the package;
- propagation from package to package, where applicable;
- excessive heat transfer to neighboring batteries or packages;
- release of flame, debris or other hazardous effects, where containment is required.

**ALLOW COMPLIANCE THROUGH:**

- a representative packaging performance test;
- validated calculation or engineering assessment, where appropriate;
- demonstration of equivalent safety performance;
- clear pass/fail criteria linked to the intended safety function.

✖ NOT
*"The packaging shall use non-combustible material."*

✔ INSTEAD
*"The packaging shall demonstrate the required TRP-prevention performance under representative transport conditions."*

***Principle.*** *Non-combustible material may be accepted as one means of risk reduction — but not as a mandatory proxy for TRP prevention.*

# % 03.“Probability of event” concept

# Concern: Risk levels(Probability of Event)

## ☐ Transport risk levels from the probability of a TR event

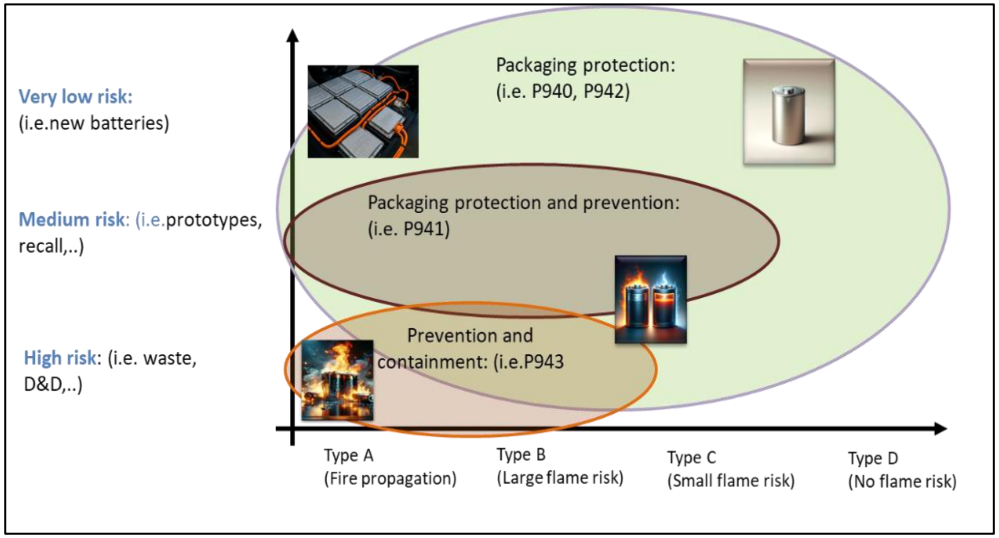
**The draft introduces transport risk levels based on the expected probability of a TR event during transport:**

- Very low risk: cells or batteries compliant with the tested type and SOC requirement;
- Medium risk: new products not tested, prototypes, damaged and defective batteries not liable to react, recall etc.;
- High risk: damaged and defective batteries liable to react during transport, and certain waste batteries.

**Very low risk in transport**. The cells and batteries may be new or used, at reduced or full SOC, or in equipment, but still compliant with the tested type and SOC requirement. In this case the risk of TR during transport is very limited as long as the batteries are correctly protected and the package is compliant to the TR prevention requirement as applicable.

**Medium risk.** This case includes new product not tested (assigned to type A by default), damaged and defective (D&D) product not liable to react during transport, products recalls and others. The level of confidence on the product robustness is reduced, but no direct safety risk during transport is identifiable. Similarly to the existing regulation (special provision 376), the assessment of the risk during transport will be under the responsibility of the shipper, for each individual case of transport. In this case the package is expected to contribute in the prevention of the TR propagation risk.

**High risk**. This case includes D&D product liable to react during transport, and also waste batteries, because the transport conditions are not expected to correctly protect the batteries from damage. In this case, the packaging requirement include the containment properties.




Korea understands the intent to reflect the different conditions of products in transport. **But qualitative levels — “very low”, “medium”, “high” — introduce ambiguity if they are used as a regulatory basis without objective and verifiable criteria.**

# Concern: Risk levels(Probability of Event)

## ☐ Qualitative probability is hard to apply consistently

**The hazard-based classification tests evaluate the hazard behavior of cells and batteries. They do not measure the probability that a TR event will occur during transport — so qualitative probability levels create several issues:**

- The boundary between “very low”, “medium” and “high” risk may not be clear.
- The same product could be assigned to different transport conditions depending on the shipper’s assessment.
- Product status categories, such as prototype, product recall, damaged and defective, or waste, do not always represent the same probability of Thermal Runaway
- A product recall may be unrelated to battery safety.
- Waste batteries may have different risk levels depending on sorting, diagnosis, SOC control and physical condition.
- Probability-based wording may make the regulation less reproducible and more difficult to enforce.

→ <u>This concept may introduce subjective judgement into the selection of packaging requirements.</u>

# Comment: Proposal

## ☐ Keep three things distinct — do not merge them

**1. Hazard Type**

The intrinsic hazard behavior of the cell or battery, determined by test results such as propagation, gas volume, flammability and temperature behavior.

**2. Product or Article Status**

The condition of the product offered for transport, such as tested type, prototype, damaged and defective, recall, waste, or unknown condition.

**3. Transport Mitigation Measures**

Measures applied for transport — SOC control, packaging performance, TRP prevention, containment, documentation and marking.

# Comment: Proposal

## ☐ Use objective, verifiable criteria

Packaging requirements should not be determined by qualitative probability levels alone. Instead, use objective and verifiable criteria, such as:

1. Hazard Type determined by test results
2. Conformity with the tested type
3. Verified maximum SOC for transport
4. Clear product-status category
5. Objective criteria for damaged & defective batteries
6. Demonstrated packaging performance
7. Competent-authority approval, where necessary

*Principle. Terms like “very low”, “medium” and “high” may serve as explanatory rationale — not as the primary regulatory trigger for assigning packaging instructions, unless backed by clear and verifiable criteria.*

# Thank you

Questions and discussion welcome.

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