

## **Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals**

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### **Sub-Committee of Experts on the Transport of Dangerous Goods**

#### **Fifty-first session**

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Item 4 (b) of the provisional agenda

**Electric storage systems:**

**Hazard-based system for classification of lithium batteries**

### **Hazard based classification of lithium batteries - Investigative testing to assess their reactivity**

**Transmitted by the expert from France**

#### **Introduction**

1. The informal working group on lithium batteries met in Montreal in March 2017 and discussed about the inherent hazards associated to lithium batteries (see ST/SG/AC.10/C.3/2017/16) with the goal of reaching a hazard-based system to classify lithium batteries and cells for transport.
2. Following this meeting, it was agreed that, to compare these hazards caused by lithium cells and batteries, destructive testing should be considered to assess their hazardous effects within accident scenarios. It was also agreed that, to achieve this goal, these tests should ensure that a thermal runaway occurs on the tested samples.
3. The hazardous effects to be considered within the classification process were discussed during the session and the tests should permit to measure the different parameters which are necessary to assess these hazards. Expected hazardous effects were classified in five categories: Thermal effects, Smoke/Vapor, Mechanical, Chemical and Electrical effects.
4. The expert from France was invited to present a document recommending an investigative testing plan to answer these questions. (see paragraph 41 to 44 of ST/SG/AC.10/C3/2017/16)
5. This document proposes some concepts to help developing such investigative plan. Several general principles for the testing plan that might be performed to determine the relevant parameters and the threshold values to be used to classify the lithium cells and batteries according to their hazards and effects when reacting are listed.
6. This document is produced as a thought starter. The subcommittee is invited to consider the different options and check how such plan may be implemented. A lunchtime working group might be held to discuss technical issues as proposed in document ST/SG/AC.10/C.3/2017/16.

## Background

7. To achieve the goal of comprehensively cover reaction hazards of lithium batteries the performed investigative testing should cover different influence parameters listed below:

- choice of a relevant initiation method to ignite the thermal runaway,
- Definition of a relevant state of charge of the sample,
- Investigation of a relevant sampling of the devices on the market,
- Definition of the nature of the device to be tested, (cells/batteries/modules).

8. Trying to achieve an exhaustive testing campaign, covering the entire lithium cells and batteries market (maybe 100 to 200 types) and several initiation methods (4 to 6), at several states of charges (around 3 values) , would result in performing several thousands of tests.

9. For each case, the parameters that must be measured are (see Annex of ST/SG/AC.10/C.3/2017/16):

- Thermal: heat flow, flame duration and height, temperature,
- Smoke/Vapor: opacity,
- Mechanical: energy of the ejected parts, pressure pulse,
- Chemical: toxicity, flammability,
- Electrical: total energy in system, possibility of ignition by high voltage,

Depending on the number of parameters to be measured and on the total number of tests, the cost of one test would be, based on an average cost on these types of tests observed in testing facilities in Europe, between 5 000 and 10 000 €. This would result in a cost exceeding several millions.

## Proposal

10. Therefore, in order to reduce the cost and the duration of the campaign, we propose to perform it in steps:

11. Step 1: First screening tests should be performed on several cells or batteries of different types (geometry, chemistry, ...) in order to study if the final reaction of each type varies greatly depending on the initiation method. This initiation method has to be meaningful and practical in reality. The initiation method that are proposed are:

- Fire,
- Radiant heat
- High temperature storage
- Heating cartridge
- Electrical stress (ex: over-charge)

12. During these screening tests, several sample scales (cell, modules, and batteries) would be tested to determine:

- if, by increasing the sample scale (cell → module → pack), the hazards effects observed during the tests are systematically lower,

- what is the maximum sample size that can be reasonably tested in a laboratory.
13. Step 2: A second screening tests campaign might be performed on several cells or batteries of different types using the selected initiation method in order to determine whether the state of charge has an impact on the parameters observed. The goal will be to determine which state of charge may be required to observed the highest hazardous effects that could be expected in transport.
14. Using these two screening tests, the informal working group will decide the initiation method and the state of charge (or the range of state of charge) that will then be used to conduct the Step 3 of the testing campaign.
15. During these screening tests, every parameter listed in the §8 of the present document will be measured. Therefore, there will be no need to perform then again during the complete testing campaign.
16. Step 3: Finally, in order to achieve the objective of campaign (see §1), a complete testing campaign will be performed. It will consist in performing, after having chosen the initiation method, the state of charge and the sample scale, one (or several) test(s) on a satisfactory representative sampling in order to be representative of the lithium battery market in terms of geometry (cylindrical, pouch, ...), chemistry (lithium-iron-phosphate, lithium-metal-polymer, lithium thionyle chloride, ...) and manufacturers.
17. This complete testing campaign could be performed in steps:
- Tests on a first selection of cells and batteries samples,
  - Analysis of the results and discussion about the possibility of optimizing the number of samples to be tested and the parameters to be measured,
  - Tests on a second selection of cells and batteries samples,
  - Etc.
  - results will be shared between the different parties within the framework of the informal working group on... in order to verify if the total number of tests can be lowered.
18. It has to be kept in mind that the number of tests to perform on each sample could be higher than one, if in fact, one test is not enough to get every parameter listed in §8. Some measurement might be incompatible one to each other.
19. The number and choice of cells and batteries that would be tested during the two screening tests (Step 1 and Step 2) and the satisfactory representative sampling (Step 3) should be defined with the help of battery manufacturers associations according to their knowledge of the product they are marketing.
20. Procedures to ensure confidentiality of the manufacturers should be defined an agreed upon. No company names should be displayed.
21. The expert of France, through INERIS is ready to take his part of the work however to shorten the duration of the testing campaign, the tests may be performed in several laboratories in a shared effort after having ensured that, using the same testing conditions, the results coming from every laboratory is equivalent.
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