The Advanced Rechargeable & Lithium Batteries Association

Li-batteries hazards classification proposal

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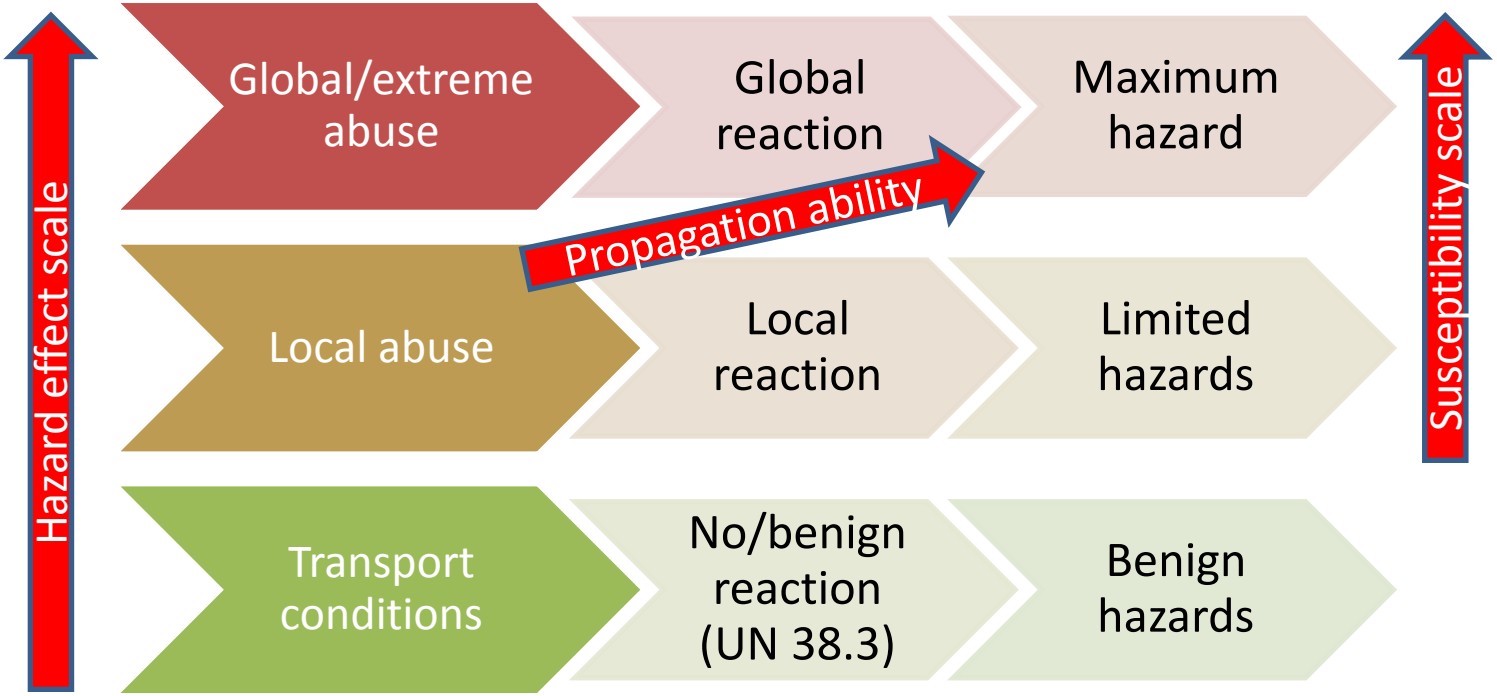
1.1 Factors for categorization of the hazards

The following factors of the lithium batteries could be considered, in order to define the hazards categories per product type.

- ✓ **The maximum hazard**
  - It corresponds to the maximum potential severity of the effect that can be intrinsically achieved (worst case)
  - It may be obtained when the battery is exposed to conditions leading to complete combustion
- ✓ **The susceptibility**
  - ✓ It characterize how easy or difficult it is for the battery to enter in the maximum hazard
  - ✓ It is linked to the threshold of the abusive conditions leading to a reaction
  - ✓ **The propagation ability** may be considered as one of parameters contributing to the susceptibility (the observed capacity of propagation of the hazards when exposed to local abuse or default)

1.2 Factors for categorization of the hazards

Safety control requirements: hazards proportional to abuse (controlled propagation) with known maximum hazard scale and acceptable susceptibility.



2 Categorization of the hazards: general approach

For each hazard category (see draft list in presentation hazard analysis)

1- Determination of the maximum potential hazard effect level (by test or analysis)

2- Characterization of the susceptibility (by test or analysis)

3- Determination of mitigation measures or safety controls appropriate to the reduction of the risk combination of 1 & 2

3.1 Categorization of the maximum hazard effect

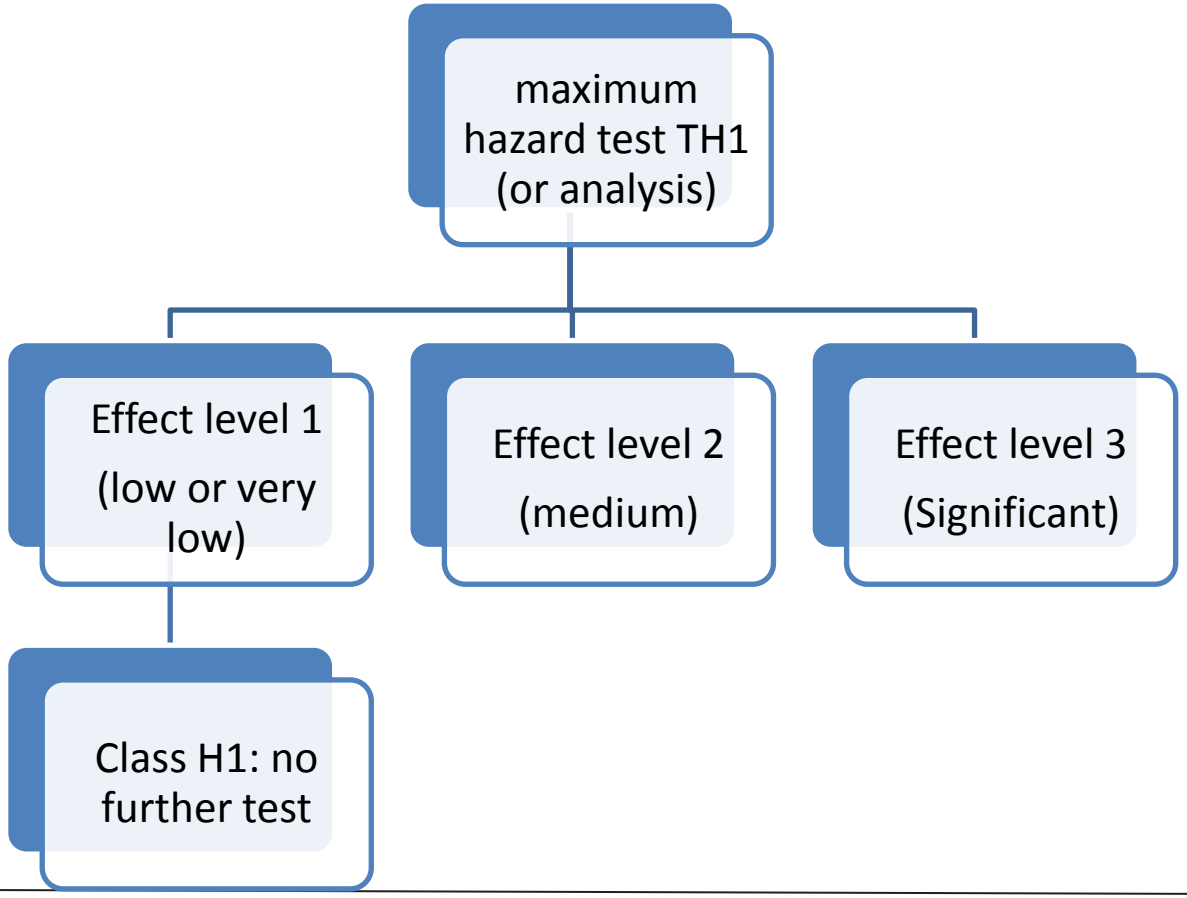
- ✓ **Maximum hazard test TH1**:
  - Purpose would be to measure such parameters as the temperature reached when under or after reaction, the maximum possible energy (ER) and the heat release rate (HRR) for the total cell/battery.
  - There are existing methodologies and equipment allowing for the measurement of energy release when a battery/cell is submitted to extreme temperatures leading to complete combustion reactions: see scientific literature (INERIS or other).

- ✓ **Evaluation of test results for parameters**:
  - Results on parameters may be compared to existing scales of properties for non-dangerous goods. (self-ignition of wood/paper at 200-246°C, of leather at 212°C,of polyethylene at 349°C, but melting at 110°C. Saw dust self-ignition at 120-140°C).

http://www.tcforensic.com.au/docs/article10.html, https://doctorfire.com/wood_ign.pdf; http://www.iafss.org/publications/fss/1/463/view

3.2 Categorization of the maximum hazard effect

Example of maximum hazard classification

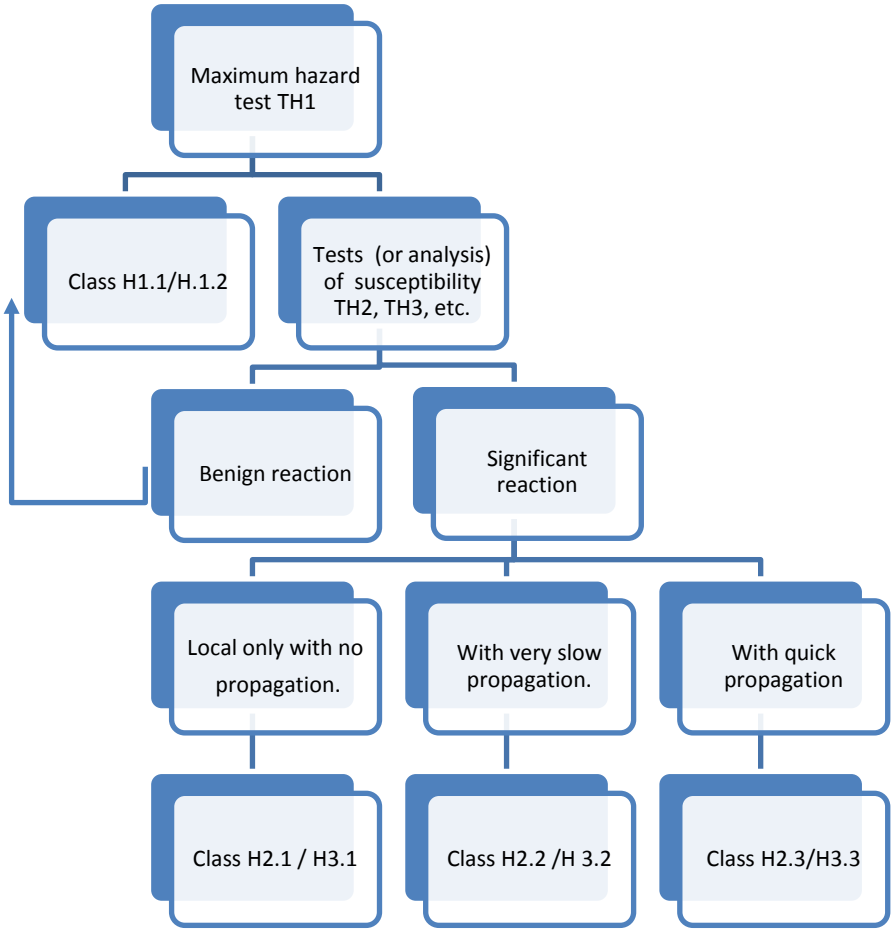


4.1 Categorization of the hazard susceptibility

- ✓ **Tests of susceptibility:**
  - Purpose would be determine the susceptibility of the product in case of local abuse and the local effect generated (such as consequences of thermal run-away)
  - The local abuse should be limited to a single cell or battery, and should be representative of a possible abuse.
  - As the cells/batteries are already tested according to UN 38.3 versus shocks, vibration and thermal exposure, such abuses should not be considered
  - Among the remaining possible significant abuse there are internal short circuit (see SAE std testing condition) or external temperature aggression
  - The propagation of the reaction could be assessed during the same test, on several cells/batteries packed with a high density inside the same enclosure, surrounding the abused cell/battery.
- ✓ **Evaluation of test results**:
  - The total hazard produced could be compared to threshold of acceptable hazards for each transport mode (presence/absence of propagation, quantities of gas, heat, flame, lead time before entering into reaction…).

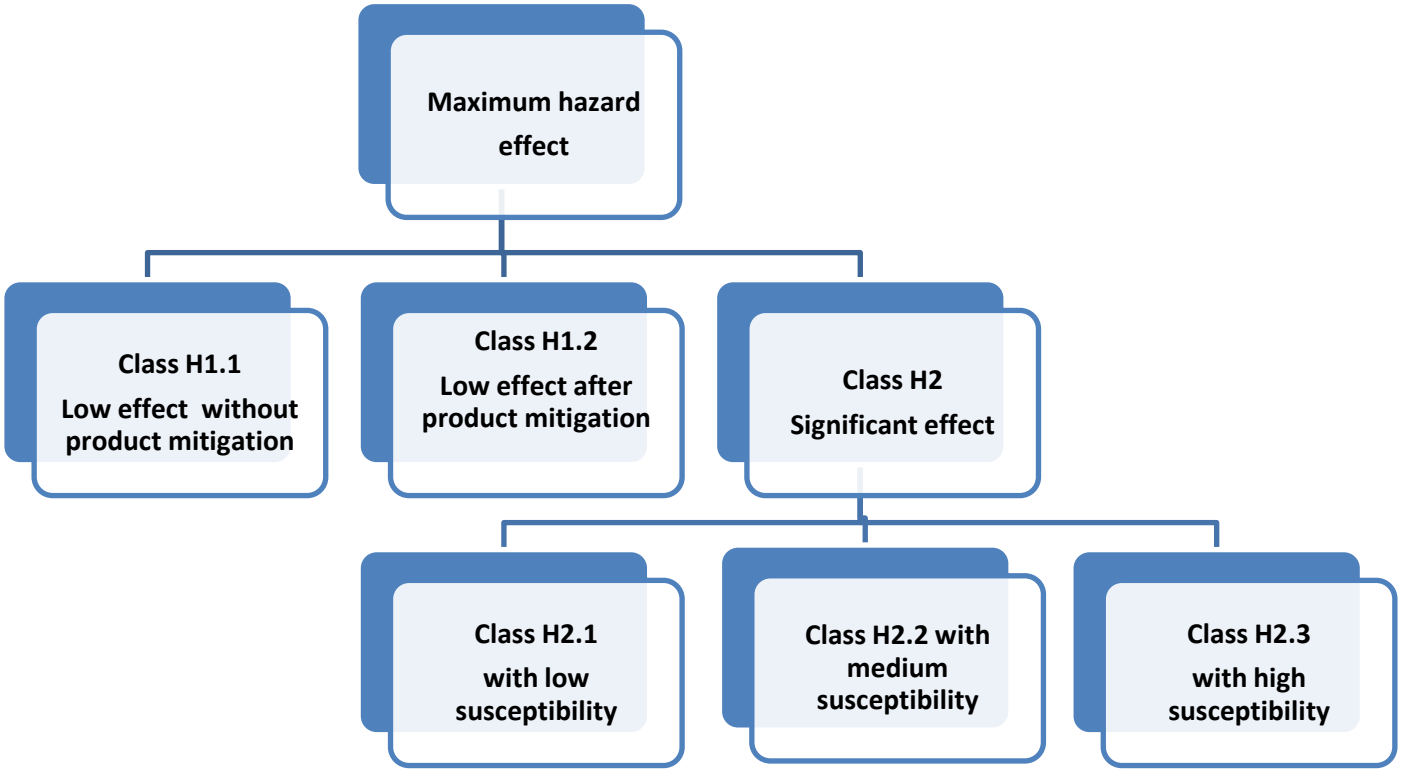
4.2 Categorization of the hazard susceptibility

Example of classification considering susceptibility



5. Products classification

Example on how the product may be finally classified in several classes or sub-classes depending on the maximum hazard level and the susceptibility



6.1 Determination of mitigation measures or safety controls

- Mitigation measures would be increasing as a function of the class from H1.1 to H.2.3; for H1 type class the measures could be less restrictive than the current ones and for H2.3 the measures could be more

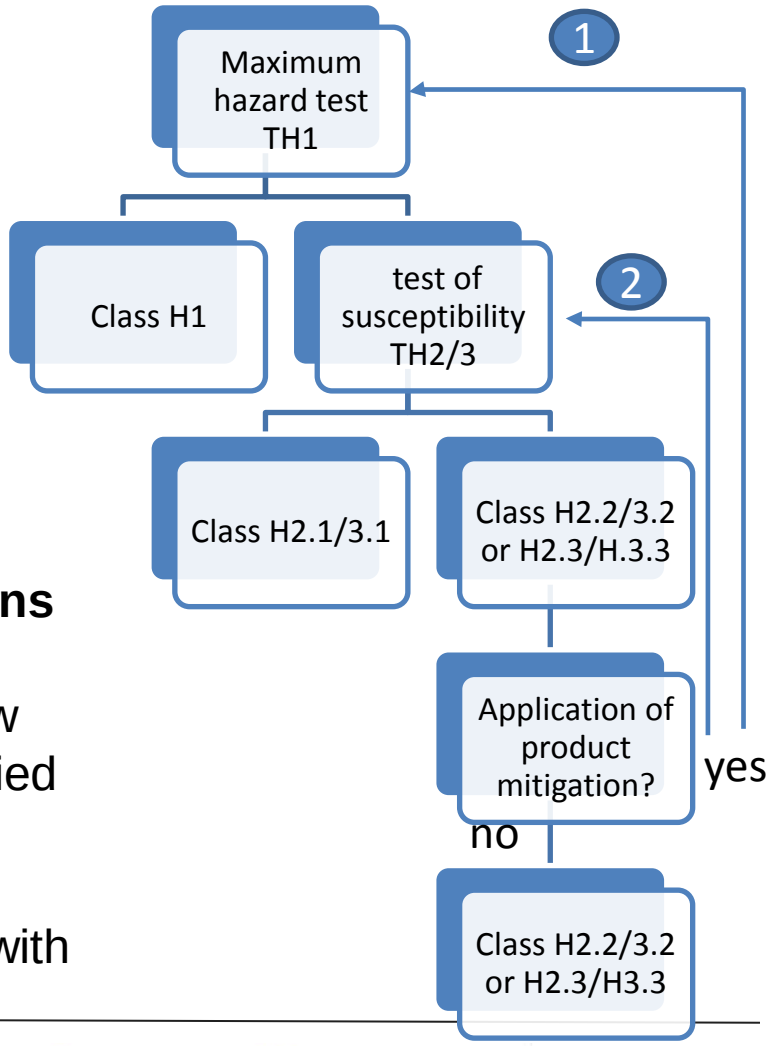
- Type of measures could encompass the following topics:
  - Product level mitigation (example: low state of change)
  - Packaging characteristics or performances
  - Limited quantity of products per outer packaging
  - Weight or energy thresholds per outer packaging
  - Transport conditions: segregation, temperature control, etc.
  - Transport equipment characteristics: pallets thermal insulations, etc., installation of dividers between consignments, etc.

6.2 Impact of mitigation implemented at product level on the classification status of the product

If risk is too high, mitigation means may be applied at the product level (independently of the packaging, etc.)

Mitigation measures could be used according to 2 different principles:

- Before classification evaluation: test with mitigation => impact on classification
- As a mitigation of risk after classification => consequence of classification



For implementation before classification, 2 options may be considered:

1- the product is made less reactive (i.e. low State of Charge,…): test from test TH1 with the applied mean of mitigation.

2- the product is made less susceptible (product associated protections): retest from TH2/3 with the applied mean of protection.

6.3 Determination of the packaging per hazards

Example of packaging requirements as a function of the class:

- Class H1: packaging according UN regulation 2016 (including the specific product mitigation mean when required) or less stringent packaging

- Class H2.1: packaging according to UN regulation 2016 (including the specific product mitigation mean when required) + **protection required for the local hazard exceeding the acceptable hazard effect level : case of gas and flame for example**

- Class H2.2/2.3: packaging according to UN regulation + protection required for the local hazard exceeding the acceptable hazard for the transport mode + **additional protection and/or mitigation required to reduce susceptibility (for example avoiding propagation) adapted to the level of susceptibility**

7. Scope of work

- Determination of the scope of the classification
  - Role of the classification versus role of the tests of the UN Manual §38.3
  - Position of the classification versus topics like damaged & defective, special provisions
- Determination of definition of terms that are useful for the classification such as hazard, maximum hazard, susceptibility, risk, etc.
- Determination of the hazard categories (chemical, mechanical, thermal, etc.)
- Determination of the tests that are the base for the classification
- For each test, determination of appropriate thresholds and criteria associated to the various hazard categories
- Determination of appropriate mitigation and safety control measures depending on the thresholds and criteria for the tests
- Determination of possible similarity principles for type family, sub-assembly test rules dispositions
- Determination whether there is any impact on other dispositions of the current regulation (special provisions)

Thank you for your kind attention !

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