Update on UN Dangerous Goods Hazard-Based Classification System for Lithium Batteries

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George A. Kerchner
PRBA – The Rechargeable Battery Association
Washington, DC 20036
gkerchner@wiley.law / 202.719.4109

PRBA – The Rechargeable Battery Association

- Established in 1991, based in Washington, DC
- Members include:
  - Primary and secondary cell/battery manufacturers
  - Manufacturers of electronic equipment, medical devices, power tools, automobiles
  - Retailers, testing labs, and battery recyclers
  - Airlines, dangerous goods consultants, packaging manufacturers
- Focus now on regulatory, legislative, and policy issues at state, national and international level:
  - Safety, recycling, transportation, fire code
- International transportation forums:
  - UN Sub-Committee of Experts (since 2005)
  - ICAO Dangerous Goods Panel
  - IMO Sub-Committee on Carriage of Cargoes and Containers

Purpose of New Lithium Battery Hazard-Based Classification System

- Address differences between new and existing lithium ion and lithium metal battery chemistries
- Examples:
  - ✓ Recent presentation from Battery Association of Japan on solid state lithium ion batteries
  - ✓ Previous UN proposals on regulating rechargeable lithium metal polymer batteries
  - ✓ Lithium ion chemistries today (e.g., lithium iron phosphate, mixed metal oxides – cobalt, nickel, aluminum, manganese)
  - ✓ Lithium metal chemistries today (e.g., manganese dioxide, thionyl chloride, iron disulfide)
- Provide more definitive classification of different lithium battery chemistries based on hazards

UN Lithium Battery Informal Working Group

- First meeting: November 2017
- Participants in working group from –
  - Korea, China, Japan, U.S., and Europe lithium cell, battery, equipment, and automobile manufacturers
  - Dangerous goods transport authorities
  - Test labs
  - Aircraft manufacturers
  - Airlines
  - Pilots
- Test labs from Germany (BAM), U.S. (Fulcrum, FAA, UL), Canada (Transport Canada), Korea (LG), France (Ineris)

UN38.3 Lithium Cell and Battery Tests, UN Manual of Tests and Criteria

- Test 1: Altitude Simulation
- Test 2: Thermal
- Test 3: Vibration
- Test 4: Shock
- Test 5: External Short Circuit
- Test 6: Impact
- Test 7: Overcharge
- Test 8: Forced Discharge

✓ Watt-hour rating of lithium ion cells and batteries impact packaging, shipping procedures

✓ Grams of lithium metal in cells and batteries impact packaging, shipping procedures

Hazards Related to Lithium Batteries

- Informal Working Group identified and agreed following hazards should be considered:
  - Capability for thermal runaway to propagate from cell to cell, and battery to battery
  - Capability to generate a flame
  - Capability to generate significant quantities of toxic and/or flammable gases
  - Capability to produce high temperature

Proposed Test Protocols Supporting Classification under Development

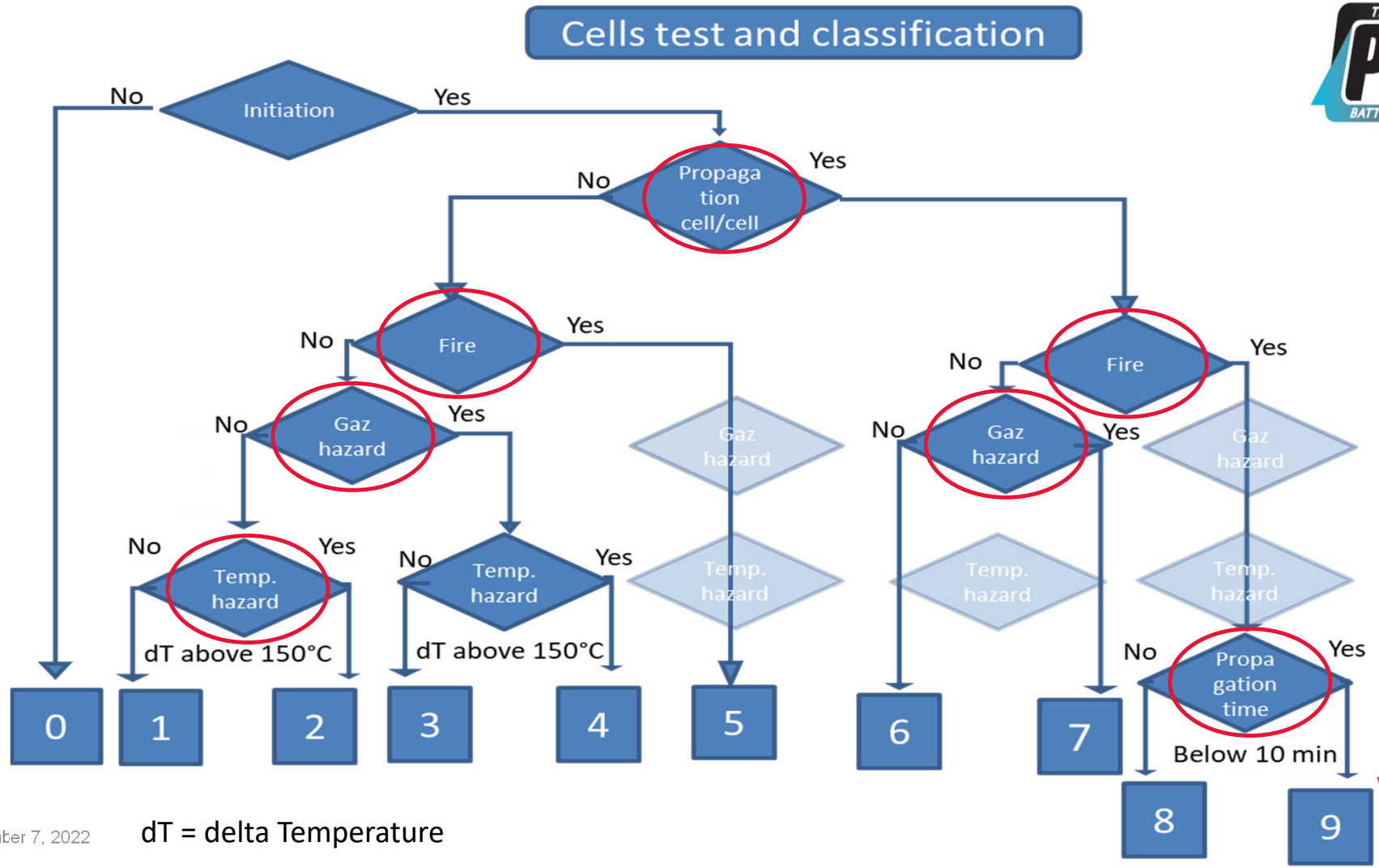
- **Test 1: Propagation of thermal run away**
  - Test under development. Based on specific set up demonstrating propagation risk in worst case scenario (e.g., 100% SOC for Li ion batteries)
- **Test 2: Quantity of gas**
  - Test under development. Collection and measure quantity presents significant technical challenges

Proposed Test Protocols Supporting Classification

- **Test 3**: **Flammability / toxicity of gases**
  - Test under development. Gases collected and shown in proper air/fuel mixture to be noncombustible, or complementary analysis for flammability and toxicity
- **Test 4**: **Battery testing**
  - Conceptually, test batteries as the cells, with battery casing considered as a package

Next Steps for Testing Labs

1. Each lab still in process of testing cells of various sizes and chemistries, determining number of cells for final test
2. Testing needs to include lithium ion and lithium metal cells
3. Verify and quantify:
   - Propagation
   - Flammability of gas in case of no spontaneous ignition (e.g., small lithium ion/lithium metal button cells, solid state lithium ion)
   - Capture gas - verify type and volume
   - Temperature
4. Verify test protocol on batteries: initiation method, and temperature verification (e.g., on battery case?)
5. Define and run a round robin test, on specific cases identified – verify reproducibility
6. **Significant work remains**



dT = delta Temperature

Recent Testing of Small, Solid State Lithium ion Cells

- Recent testing from Japan on 100% state of charge, solid state lithium ion cells
- Tests included external short circuit, projectile, gas analysis (by heating cell to 200º C)
- No disassembly, rupture, ignition
- No toxic gases generated
- New hazard-based classification exempt cells from dangerous goods regulations?

Next Steps, Round Robin Testing, Meetings

- Test plan proposal to verify feasibility of tests
- Prepare and conduct round robin testing to verify reproducibility
- Labs will continue testing, meet virtually to share test data, develop test plan
- Informal Working Group scheduled to meet December 7 – 9 in Geneva, Switzerland

Timetable for Implementation of Hazard-Based System in Dangerous Goods Regulations

- In 2023, 2024 significant work remains for Informal Working Group, UN Sub-Committee, and testing labs
- In 2024, 2025 ICAO Dangerous Goods Panel and IMO Sub-Committee on Carriage of Cargoes and Containers will need to address changes agreed to by UN Sub-Committee
- Resulting effective date of January 1, 2027 is earliest date new hazard-based classification system could become effective
- What of SAE G-27 committee's work on AS6413 standard?

Next Steps for Testing Labs

- **Overall Objective**:
  - Determine feasibility of tests in all cases
  - Propose and test solutions to the issues identified
  - Propose text protocol improvements
  - Check internal repeatability
- Propagation, gas, and flammability test demonstrations
  - Apply process and verify combination test propagation and flammability,
  - Test cells (and batteries) for multiple lithium battery chemistries first,
  - Goal is to demonstrate criteria to be measured:
    - Propagation yes/no
    - Gas yes/no
    - Flammability yes/no
    - Temperature hazard : T value (possibly multiple thresholds).
  - Verify number of cells in test (4 or 6 ?)
- Purpose: each lab test as many different size and chemistry cells to determine number of cells for final test. If possible tests should include LiFePO4 (lithium ion) and LiSO2 (lithium metal),
- O verify flammability of gaz in case of no spontaneous ignition (small LFP cells, button cells?),
- O Measure of Li metal cells, (with risk of bursting: possibility to determine gaz flammability, or only in a closed sphere?)
- 1-2: Question 3: verify gaz volume (also case of Li metal cells in a close sphere?): one criteria to be measured, the gaz volume. Also possible verification on a battery test.
- 1-3: Question 5: verify the test protocol on batteries: initiation method, and temperature verification on the outside. Gaz flammability possible combination.
- 2nd step: define and run a round robin test, on specific cases identified, to verify reproducibility