



**Committee of Experts on the Transport of Dangerous Goods
and on the Globally Harmonized System of Classification
and Labelling of Chemicals****Sub-Committee of Experts on the Transport of Dangerous Goods****Forty-ninth session**

Geneva, 27 June – 6 July 2016

Item 4 (a) of the provisional agenda

Electric storage systems: testing of lithium batteries**Report on the third meeting of the informal working group
on lithium batteries****Transmitted by the expert from France (in his capacity as Chairman of
the informal working group), RECHARGE, the Rechargeable Battery
Association (PRBA) and the Council of Safe Transportation of
Hazardous Articles (COSTHA)¹**

1. The third meeting of the informal working group on lithium batteries was held in Bordeaux, France from 30 March – 1 April 2016. It was co-organized by PRBA, RECHARGE and COSTHA. A total of 43 participants from the Sub-Committee and the industry attended the meeting. The expert from France, Mr. Claude Pfauvadel, Vice-Chair of the Sub-Committee, chaired the meeting.

2. This document contains a number of proposals based on consensus reached within the working group. It summarizes also the main points where some guidance is needed from the Sub-Committee. Information supporting this summary such as a detailed report of the discussions, proposals and the list of participants are available on the RECHARGE's website:

<http://www.rechargebatteries.org/3rd-informal-working-group-2015-2016-un-manual-of-tests-and-criteria/>

3. A review of definition related issues identified during the first meeting of the group was made. As several discussions were concluded with the need to receive some guidance from the Sub-Committee, these issues are listed in Section C below. In addition, the group

¹ In accordance with the programme of work of the Sub-Committee for 2015–2016 approved by the Committee at its seventh session (see ST/SG/AC.10/C.3/92, paragraph 95 and ST/SG/AC.10/42, para. 15).

came to a consensus on several items tabled in the agenda and is proposing that its conclusions be reviewed by the Sub-Committee (sections A and B below).

A. Issues where a consensus was reached

1. Definition of hybrid batteries (combined Li-metal and Li-ion cells and batteries)

4. Regarding the language in SP387, the group supported using existing limits as justification of the size limits. Options offered included a varying limit between 2 g and 40 Wh or simply using the current limits for lithium ion cells and primary batteries (20 Wh and 2 g). The 10Wh limit is justified by current battery designs and technology. The 20 Wh limit is recognized limit already found in SP188. A pure technical justification could not be determined. The group noted proportionality was difficult to use as the relationship as it is not supported in practice (smaller primary / larger secondary). Some participants felt without technical justification, they preferred a more conservative approach. Therefore, the group concluded the primary battery limit would be the less than the current limit in SP188 (1.5 g) and the secondary limit would be based on current practical applications (10 Wh). Proposed text is included in Proposal 1.

2. Definition of “Disassembly”

5. The group discussed the performance requirement for disassembly and the possibility to remove the wire mesh penetration as many laboratories have faced difficulties with conducting the test. The group also concluded that the wire mesh requirement may not be appropriate for batteries. A note was prepared that addresses the use of a wire mesh test or equivalent for cells. The definition was reconciled with the definitions of rupture, venting and leakage and language was revised as appropriate. Revised text is provided in Proposal 2.

3. Summary table of cell and battery testing requirements

6. The informal working group reviewed proposed summary tables of cell and battery testing requirements to be added to 38.3.3. The tables are proposed to be provided as 38.3.3.1 in addition to the text in 38.3.2.1. Two options were given as examples. The group agreed to provide both options to the Sub-Committee for review and adoption. Suggested tables are included as Proposal 3, Options 1 and 2.

4. Cell cycling before battery testing.

7. The group discussed the benefit of testing cycled cells vs. fresh cells. Some participants were not convinced cycling would improve cell testing or that reducing the cycling from 50 to 25 would be beneficial. Others supported including cell cycling in T.6. The anomaly often manifests as a drop in capacity during cycling but then is clearly identified as a failure in the T.1-T.5 tests. After further discussion, the group supported including the cycling process for cells, dropping the number of cycles from 50 to 25, testing 5 cells in each cycle, and including cell cycling in T.6 for rechargeable cells and component cells. Revised text is included as Proposal 4.

5. Batteries integral to equipment

8. The group reviewed proposed language to address the testing of batteries integral to equipment. Consensus language is included in Proposal 5.

B. Proposals

Proposal 1

9. Revise SP387 to read:

“387 Lithium batteries in conformity with 2.9.4(f) containing both primary lithium metal cells and rechargeable lithium ion cells shall be assigned to UN Nos. 3090 or 3091 as appropriate. When such batteries are transported in accordance with special provision 188, the total lithium content of all lithium metal cells contained in the battery shall not exceed 1.5 g and the total capacity of all lithium ion cells contained in the battery shall not exceed 10 Wh.”.

Proposal 2

10. Revise the definition of Disassembly in 38.3.2.3 to read:

“Disassembly means a rupture of the cell or battery case where solid components are ejected. A vent or rupture where solid matter from any part of a cell or battery penetrates a wire mesh screen (annealed aluminium wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell or battery is forcibly expelled.

NOTE: During cell or component cell testing, ejection of internal components is acceptable. Energy of ejected components shall be limited and can be measured as follows:

(a) It will not penetrate a wire mesh screen (annealed aluminium wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell; or

(b) It can be measured by method demonstrated to be equivalent to the one described in paragraph (a) above.

Proposal 3

Option 1

11. Introduce the following new paragraph at the end of 38.3.3

“38.3.3.1 The provisions of 38.3.2.1 and 38.3.3 are summarized in the following tables:

Table 38.3.2: Summary table of [required/applicable] tests for primary cells and batteries

Primary cells and batteries										
		T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8	Total
Cells not transported separately	undischarged state						5			20
	fully discharged state						5		10	
Cells	undischarged state	10					5			40
	fully discharged state	10					5		10	
Single cell batteries ^a	undischarged state	10					5			40
	fully discharged state	10					5		10	
Batteries	undischarged state	4								8
	fully discharged state	4								
Batteries assembled with tested batteries ≤ 500 g	undischarged state			1						1
Batteries assembled with tested batteries > 500 g ^b										0

^a Except for the T.7 Overcharge test, a single cell battery containing one tested cell does not require testing unless a change in cell design could result in the failure of any test.

^b If it is equipped with a system capable of monitoring the assembled battery and preventing short circuits, or over discharge between the batteries in the assembled battery and any overheat or overcharge of the assembled battery.

Table 38.3.3: Summary table of [required/applicable] tests for rechargeable cells and batteries

Rechargeable cells and batteries										
		T.1	T.2	T.3	T.4	T.5	T.6	T.7 ^a	T.8	Total
Cells not transported separately from a battery	first cycle, 50% charged state						5			25
	first cycle, fully discharged state								10	
	50th cycle, fully discharged state								10	
Cells	first cycle, fully charged state	10								35
	first cycle, 50% charged state						5			
	first cycle, fully discharged state								10	
	50th cycle, fully discharged state								10	
Single cell batteries ^b	first cycle, fully charged state	10						4		43
	first cycle, 50% charged state						5			
	50th cycle, fully charged state							4		
	first cycle, fully discharged state								10	
	50th cycle, fully discharged state								10	
Small batteries	first cycle, fully charged state	4						4		16
	50th cycle, fully charged state	4						4		
Large batteries	first cycle, fully charged state	2						2		8
	25th cycle, fully charged state	2						2		
Batteries assembled with tested batteries ≤ 6,200 Wh or ≤ 500g Li	fully charged state			1						1
Batteries assembled with tested batteries > 6,200 Wh or > 500g Li ^c										0

^a Batteries or single cell batteries not equipped with battery overcharge protection that are designed for use only as a component in another battery or in equipment, which affords such protection, are not subject to the requirements of this test;

^b Except for the T.7 Overcharge test, a single cell battery containing one tested cell does not require testing unless a change in cell design could result in the failure of any test;

^c If it is equipped with a system capable of monitoring the assembled battery and preventing short circuits, or over discharge between the batteries in the assembled battery and any overheat or overcharge of the assembled battery.”.

Option 2

Introduce the following new paragraph at the end of 38.3.3

38.3.3.1 The provisions of 38.3.2.1 and 38.3.3 are summarized in the following tables:

Table 38.3.2: Summary table of [required/applicable] tests for primary cells and batteries

Primary cells and batteries

Tests	Discharge state	Cells ^a	Batteries and Their Component Cells			Assembled Batteries ^b
			Component Cells	Batteries		
				Small	Large	
Tests T-1 to T-5	Undischarged	10	X	4	2	1
	Fully discharged	10	X	4	2	X
Test T-6	Undischarged	5	5	X	X	X
	Fully discharged	5	5	X	X	X
Test T-8	Fully discharged	10	10	X	X	X
TOTALS		40	20	8	4	1

^a A single cell battery containing one tested cell does not require testing unless a change in cell design could result in a failure of any tests.

^b Only T3, T4 and T5 are required for one assembled battery with not more than 500 g lithium content or 6,200 Watt-hours, as applicable, that is assembled from batteries that have passed all applicable tests. See 38.3.3(f).

When batteries that have passed all applicable tests are electrically connected to form a battery with more than 500 g lithium content or 6,200 Watt-hours, as applicable, it does not need to be tested if the assembled battery is of a type that has been verified as preventing (i) Overcharge; (ii) Short circuits; and (iii) Over discharge between the batteries. See 38.3.3(g).

Table 38.3.3: Summary table of [required/applicable] tests for rechargeable cells and batteries

Rechargeable cells and batteries

Tests	Cycles and Discharge State	Cells ^a	Batteries and Their Component Cells			Assembled Batteries ^b
			Component Cells	Batteries		
				Small	Large	
Tests T-1 to T-5	At first cycle, fully charged	10	X	4	2	1
	After 25 cycles, fully charged	X	X	X	2	X
	After 50 cycles, fully charged	X	X	4	X	X
Test T-6	At first cycle, at 50 % DOD	5	5	X	X	X
Test T-7 ^c	At first cycle, fully charged	X	X	4	2	1
	After 25 cycles, fully charged	X	X	X	2	X
	After 50 cycles, fully charged	X	X	4	X	X
Test T-8	At first cycle, fully discharged	10	10	X	X	X
	After 50 cycles, fully discharged	10	10	X	X	X
TOTALS		35	25	16	8	1

^a Except for the T7 Overcharge test, a single cell battery containing one tested cell does not require testing unless a change in cell design could result in a failure of any tests. When conducting T7 test on single cell battery, follow testing requirements for batteries.

^b Only T3, T4, T5 and T7 required for one assembled battery with not more than 500 g lithium content or 6,200 Watt-hours, as applicable, that is assembled from batteries that have passed all applicable tests. See 38.3.3(f).

When batteries that have passed all applicable tests are electrically connected to form a battery with more than 500 g lithium content or 6,200 Watt-hours, as applicable, it does not need to be tested if the assembled battery is of a type that has been verified as preventing (i) Overcharge; (ii) Short circuits; and (iii) Over discharge between the batteries. See 38.3.3(g).

^c Batteries or single cell batteries not equipped with battery overcharge protection that are designed for use only as a component in another battery or in equipment, which affords such protection, are not subject to the requirements of this test. See 38.3.3(d), last paragraph.

Proposal 4

13. Revise 38.3.3, paragraphs (b), (c), (d) and (e) to read as follows:

“(b) When testing rechargeable cells and batteries under tests T.1 to T.5 the following shall be tested in the quantity indicated:

- (i) Five ~~ten~~ cells at first cycle, in fully charged states;
- (ii) Five cells after 25 cycles ending in fully charged states;
- (iii) Four small batteries at first cycle, in fully charged states;
- (iv) Four small batteries after ~~50~~25 cycles ending in fully charged states;
- (v) Two large batteries at first cycle, in fully charged states; and
- (vi) Two large batteries after 25 cycles ending in fully charged states

(c) When testing primary and rechargeable cells under test T.6, the following shall be tested in the quality indicated:

- (i) For primary cells, five cells in undischarged states and five cells in fully discharged states;
- (ii) For component cells of primary batteries, five cells in undischarged states and five cells in fully discharged states;
- (iii) For rechargeable cells, five cells at first cycle at 50% of the design rated capacity and five cells after 25 cycles ending in fully charged states; and
- (iv) For component cells of rechargeable batteries, five cells at first cycle at 50% of the design rated capacity and five cells after 25 cycles ending in fully charged states.

(d) When testing rechargeable batteries or rechargeable single cell batteries under test T.7, the following shall be tested in the quantity indicated:

- (i) Four small batteries at first cycle, in fully charged states;
- (ii) Four small batteries after ~~50~~25 cycles ending in fully charged states;
- (iii) Two large batteries at first cycle, in fully charged states; and
- (iv) Two large batteries after 25 cycles ending in fully charged states.

[(e) When testing primary rechargeable cells and component cells under test T.8, the following shall be tested in the quantity indicated:

- (i) Ten primary cells in fully discharged states;
- (ii) Ten primary component cells in fully discharged states;
- (iii) Ten rechargeable cells, at first cycle in fully discharged states;
- (iv) Ten rechargeable component cells, at first cycle in fully discharged states;
- (v) Ten rechargeable cells after ~~50~~25 cycles ending in fully discharged states; and
- (vi) Ten rechargeable component cells after ~~50~~25 cycles ending in fully discharged states.]

Proposal 5

Add the following new sentence at the end of 38.3.2.1

“A cell or battery that is an integral part of the equipment it is intended to power that is transported only when installed in the equipment, may be tested in accordance with the applicable tests when installed in the equipment.”.

C. List of items where guidance is requested from the Sub-Committee for follow-up to the 3rd meeting of the informal working group on lithium batteries

	Discussion items	Comments requested from the Sub-Committee
1.	Definition of equipment in SP188	The group considered proposals to amend the definition of equipment in SP188. It was noted ambiguity exists however, no consensus was reached on revised language.
2.	Change in cell definition to address cells with zero voltage.	The group addressed the issue of cells where the voltage is reduced to zero. It noted that in this case it was not clear whether they would fall under the current definition of a cell. The group looked at options to clarify the point including a note to the current definition, but was not able to agree on precise language.
3.	Harmonization of the energy rating under SP188 for rechargeable lithium metal polymer batteries (RLMP)	The group discussed the reasoning for treating such batteries as lithium ion batteries for transport and how the lithium metal content changes with SOC. Others voiced concern about using SOC as a condition for transport as it is impractical to measure the SOC in all battery cases notwithstanding recent decisions by ICAO. Some participants indicated a new definition is required as currently there is overlap for lithium metal and lithium ion batteries. After discussion, the Chairman summarized the discussion with the following points: <ul style="list-style-type: none"> - A definition is needed for rechargeable lithium metal batteries including reference to electrolyte; - Creation of two new entries may be required; - Additional safety data is needed to prove if the technology is similar to lithium ion batteries. If provided, the batteries may be then described as lithium ion batteries.
4.	Cells exceeding 20 Wh limit in small batteries not exceeding 100 Wh limit with regards to SP188	The group discussed justification for the interpretation that cell and battery limits specified in SP 188 must be applied independently (e.g., small lithium ion batteries <100 Wh may contain large lithium ion cells >20 Wh). The Chairman pointed out the current provisions do not explicitly prohibit large cells in small batteries and if the Sub-Committee decided the cell and battery limits apply together, changes must be made to SP188. Given the discussion, the group concluded the limits should be applied independently, and any participants who felt the limits should be applied together should bring additional data to the discussion.

	Discussion items	Comments requested from the Sub-Committee
5.	Flow chart describing cell and battery testing requirements	In addition, the group reviewed a flow chart that describes the testing criteria. The Chairman noted the text would need to be changed to reflect the language used in the UN Manual. Participants commented additional flow charts would need to be developed all testing options (primary, rechargeable, cells, batteries, etc.). The group agreed to share the flow chart example with the Sub-Committee and clarify the chart is only a draft document. Provided the Sub-Committee indicated support for the effort, further discussion may be based on informal papers to be prepared by interested parties.
6.	Fail safe conditions	The group discussed the challenges with replacing cells/batteries which have activated a fail-safe mechanism with new cells/batteries. The Chairman explained the purpose of conducting the T.5 after T.1-T.4 was to determine if an external short circuit can result from the events recreated in T.1-T.4. Therefore it may not be appropriate to replace cells completely. Given all participants were not able to agree to all aspects of the discussion, developed text would be presented to the Sub-Committee in an information paper.
7.	Revisions to SP376	The group reviewed the hazards resulting from damage and defective batteries and existing mitigation methods. After reviewing the efficiency criteria of those methods and possible packaging solutions, the group agreed to the following positions: <ul style="list-style-type: none"> • Because of the large number of cases (battery size or technology, etc.), there may be unavoidable ejection of particles, heat generation, flame production. However, levels of protection (packaging) can be developed which will limit or eliminate the associated risks. • The values for packaging performance can be determined and defined under the premise that conditions that could result outside the package would not damage an adjacent package. • The group can look at criteria where certain battery chemistries will not require the heightened packaging performance. Proposals for revisions of SP376 as well as examples of packaging options were reviewed and may be submitted to the Sub-Committee separately from this report.

	Discussion items	Comments requested from the Sub-Committee
8.	Lithium battery test report	The group discussed the recommended elements to be included in a lithium battery test report and made suggested changes. The revised list is included in the annex to this report.

Annex

Elements of a lithium battery testing report

- Name of the battery manufacturer
 - Name of third party test laboratory (if applicable)
 - A unique test report identification
 - Date of test report
 - Description of cell or battery (e.g., Li ion or Li metal cell or battery, voltage, net mass, Watt-hour rating, grammes of lithium metal content, cell/battery geometry, model numbers and design types)
 - List of tests conducted and results (i.e., pass/fail)
 - Reference to assembled battery testing requirements, if applicable (i.e., 38.3.3(f) and 38.3.3(g))
 - Reference to the edition of the Manual of Tests and Criteria used (identification of the published edition or amendment, e.g. “Revision 3” or “Revision 3, amendment 1).
 - Test report to be signed with name and status of signatory
 - Contact information to include phone number, email address or website for more information.
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