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**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****Fifty-third session**

Geneva, 25 June-4 July 2018

Item 4 (e) of the provisional agenda

**Electric storage systems: miscellaneous****Testing of discharged primary lithium cells and batteries****Transmitted by the Rechargeable Battery Association (PRBA) and the  
Advanced Rechargeable & Lithium Batteries Association  
(RECHARGE)\*****Introduction**

1. Primary lithium cells and batteries are subject to a series of abuse tests found at Sub-section 38.3 of the Manual of Tests and Criteria. The tests require cells and batteries be tested at a discharged and undischarged state. In this paper, we are proposing to eliminate the testing of discharged primary lithium cells and batteries.
2. A similar issue was addressed by the Sub-Committee in 2008 based on a paper submitted by PRBA (See ST/SG/AC.10/C.3/2008/57). The Sub-Committee agreed at that time to eliminate the testing of discharged rechargeable (lithium ion) cells and batteries. It should be noted that the T.8 Forced discharge test still requires testing of discharged lithium ion cells because the intent of the test is to evaluate the ability of a primary and rechargeable cell to withstand a forced discharge condition. Therefore, we are not proposing to eliminate the testing requirements in T.8 for primary cells.
3. PRBA and RECHARGE members have acquired considerable experience over the past 35 years testing primary lithium cells and batteries. Through this experience it has become apparent that subjecting primary lithium cells and batteries to the Tests T.1 to T.6 (*i.e.*, altitude, simulation, thermal, vibration, shock, external short circuit, and impact tests) “in fully discharged state” provides no useful information regarding the classification and

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\* In accordance with the programme of work of the Sub-Committee for 2017–2018 approved by the Committee at its eighth session (see ST/SG/AC.10/C.3/100, paragraph 98 and ST/SG/AC.10/44, para. 14).

safety of the cells and batteries when these tests already require testing at an undischarged state.

4. When testing a new, undischarged primary lithium cell, lithium metal is present in the anode and voltage will be at its highest (*e.g.*, 3.1 V for a LiMnO<sub>2</sub> cell). In a discharged state, the voltage when most of the capacity has been expended will be approximately 2.0 V (for a LiMnO<sub>2</sub> cell) and most, if not all, of the lithium metal in the anode is consumed. This lower voltage and the absence of, or very small amount of lithium metal in the anode, results in a far less reactive cell compared to an undischarged cell.

5. Consistent with Sub-Committee's decision in 2008 regarding the testing of discharged lithium ion cells, we are *not* proposing to eliminate the testing requirements in the T.8 Forced discharge test for primary lithium cells. That is, cells will still be subject to a forced discharge at an initial current equal to the maximum discharge current specified by the cell manufacturer. The test requires that there be no disassembly and no fire during the test and within seven days after the test. This will help to identify any potential safety issues associated with a primary lithium cell at a discharged state.

6. Included with this paper are excerpts from test data section 38.3 from the most common primary lithium cell form factors and chemistries on the market today: CR2032 button cells (LiMnO<sub>2</sub>), CR123A cylindrical cells (LiMnO<sub>2</sub>), and AA cylindrical lithium iron disulfide (LiFeS<sub>2</sub>). The data show virtually no difference in results between cells tested in the undischarged state and cells tested in the discharged state. In most cases, the discharged cell is less reactive (*e.g.*, lower temperatures after testing in T.5 and T.6 tests). All of the test data associated with the excerpts will be provided in a separate informal document.

## T.2 Thermal test on LiMnO<sub>2</sub>, CR123A cell

Sample No.	Sample condition	Weight before test in grams	Weight after test in grams	Percentage of weight loss	Voltage before test (V)	Voltage after test (V)	Percent of residual voltage	Results
S9788	(A)	16.498	16.487	0.067	--	--	--	(6), (7)
S9789	(A)	16.428	16.417	0.067	--	--	--	(6), (7)
S9790	(A)	16.582	16.576	0.036	--	--	--	(6), (7)
S9791	(A)	16.587	16.582	0.030	--	--	--	(6), (7)
S9792	(B)	16.482	16.473	0.055	3.187	3.246	100.000	(6), (7)
S9793	(B)	16.565	16.562	0.018	3.184	3.246	100.000	(6), (7)
S9794	(B)	16.374	16.368	0.037	3.193	3.249	100.000	(6), (7)
S9795	(B)	16.554	16.549	0.030	3.195	3.250	100.000	(6), (7)
S9796	(B)	16.646	16.639	0.042	3.167	3.241	100.000	(6), (7)

(A) Discharged

(B) Undischarged

(6) No leakage, no venting, no disassembly, no rupture, no fire

(7) Open circuit voltage after testing was greater than 90%

**T.5 External test on LiMnO<sub>2</sub>, CR123A cell**

Sample No.	Sample condition	Voltage before test (V)	Maximum temperature °C	Results
S9788	(A)	2.587	56.5	(4), (5)
S9789	(A)	2.517	56.1	(4), (5)
S9790	(A)	2.675	55.7	(4), (5)
S9791	(A)	2.654	54.3	(4), (5)
S9792	(B)	3.246	78.5	(4), (5)
S9793	(B)	3.245	80.1	(4), (5)
S9794	(B)	3.248	88.0	(4), (5)
S9795	(B)	3.251	84.3	(4), (5)

(A) Discharged

(B) Undischarged

(4) No disassembly, no rupture, no fire

(5) The maximum temperature did not exceed 170 °C

**T.6 Crush test on LiMnO<sub>2</sub>, CR123A cell**

Sample No.	Sample condition	Voltage before test (V)	Maximum temperature °C	Results
S9802	(A)	3.181	23.7	(3), (4)
S9803	(A)	3.185	26.2	(3), (4)
S9804	(A)	3.192	21.3	(3), (4)
S9805	(A)	3.184	25.1	(3), (4)
S9806	(A)	3.180	29.3	(3), (4)
S9807	(B)	2.701	22.8	(3), (4)
S9808	(B)	2.693	23.6	(3), (4)
S9809	(B)	2.592	25.4	(3), (4)
S9810	(B)	2.576	26.4	(3), (4)
S9811	(B)	2.588	23.8	(3), (4)

(A) Undischarged

(B) Discharged

(3) No disassembly, no fire

(4) The maximum temperature did not exceed 170 °C

## Proposal

7. The proposed changes to the primary lithium cell and battery testing requirements in 38.3.3 (a) and (c) (Manual of Tests and Criteria, Rev.6, Amendment 1) are provided below.

“38.3.3 When a cell or battery type is to be tested under this sub-section, the number and condition of cells and batteries of each type to be tested are as follows:

- (a) When testing primary cells and batteries under tests T.1 to T.5 the following shall be tested in the quantity indicated:
  - (i) ten cells in undischarged states;
  - ~~(ii) ten cells in fully discharged states;~~
  - (iii) four small batteries in undischarged states;
  - ~~(iv) four small batteries in fully discharged states;~~
  - (iii) ~~(v)~~ four large batteries in undischarged states; ~~and~~
  - ~~(vi) four large batteries in fully discharged states.~~
- (b) *[Unchanged]*
- (c) When testing primary and rechargeable cells under test T.6, the following shall be tested in the quantity 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 at 50% of the design rated capacity; 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 at 50% of the design rated capacity.”.