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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

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LISTING, CLASSIFICATION AND PACKING

Testing of large batteries, modules and battery assemblies

Transmitted by the Portable Rechargeable Battery Association (PRBA)*

Introduction

1. While lithium metal batteries and lithium ion batteries are well known for their use in portable electronic equipment (e.g., cellular phones, notebook computers, DVD players, MP3 players, flashlights, defibrillators), over the past five years their use has increasingly expanded into “large format” applications for telecommunications, hybrid-electric vehicles, electric vehicles, and for the military and aerospace purposes.

2. When the UN Subcommittee in December 2000 last substantially updated the lithium battery requirements in Section 38.3 of the UN Manual of Tests and Criteria, the significant changes in lithium battery technology that have occurred over the past eight years were not anticipated, particularly the widespread use of large format batteries. At that time small batteries typically used in portable electronic equipment were the primary focus.

* In accordance with the programme of work of the Sub-Committee for 2007-2008 approved by the Committee at its third session (refer to ST/SG/AC.10/C.3/60 para. 100 and ST/SG/AC.10/C.3/34, para. 14).

3. While the current UN Manual requirements in 38.3.3 provide testing relief for large batteries (i.e., more than 500 g of lithium or more than 6200 Wh) no relief is provided for smaller batteries in size ranges that are common in many “large format” battery applications. When the tests are applied to these large format batteries, testing costs increase substantially and technical difficulties are encountered. The high testing costs have a tendency to stifle battery innovation which in turn is detrimental to new product development, including providing solutions to issues of international importance such as global warming and dependency on petroleum.

4. As with standards of other organizations (e.g., International Electrotechnical Commission (IEC), International Standardization Organization (ISO), Underwriters Laboratories (UL), and Institute of Electrical and Electronics Engineers (IEEE)) it is necessary to keep the standards for lithium metal and lithium ion batteries in the UN Manual of Tests and Criteria under continuing review to ensure they appropriately reflect technological advances and a better understanding of lithium technologies.

5. PRBA members manufacture large format lithium batteries and have considerable experience with their testing according to requirements in the UN Manual for Tests and Criteria. Based on this experience, PRBA proposes modifications to the tests to take account of design features unique to large format batteries while maintaining an equivalent level of safety.

Discussion of “Large Format” Battery Designs and Testing Implications

6. Large format lithium batteries are constructed from many lithium cells. These cells are typically electrically connected together to form what is commonly referred to as a “battery module.” Modules are then electrically connected together to form a “battery assembly.” Annex 1 contains pictures showing examples of cells, modules, and battery assemblies.

7. Cells used to construct modules are subject to UN testing requirements. Modules, because they meet the definition of a “battery” also are subject to UN testing requirements. Finally, large format lithium metal battery assemblies with 500 g or less of lithium and large format lithium ion battery assemblies of 6200 Wh or less also must be tested. With increasing size, manufacturers face dramatically increasing costs and testing complexities and considering assemblies comprise UN tested cells and modules, the benefits of such extensive testing of assemblies is of questionable benefit.

8. In addition to battery assemblies, there is a second type of large format lithium battery being used in telecommunication and uninterruptible power supply (UPS) systems that is constructed from many UN tested cells without first being incorporated into modules. They are essential for “continuity of operations” in the event of power outages caused by natural disasters or other events. The use of these stand-alone lithium batteries in telecommunications and UPS systems is expected to increase substantially over the next 5-10 years. When lithium ion batteries are used in these applications they provide higher energy density and longer backup service than some battery technologies currently used in these applications.

9. For both types of large format batteries, manufacturers face technical and financial challenges when testing their products pursuant to the current UN Manual of Tests and Criteria

in addition to other testing protocols relevant to their intended application. In particular, the large number of rechargeable lithium batteries that must be used in testing contributes significantly to the testing costs. The table below identifies the number of cells and batteries required for testing.

	Cells		Batteries
	Cylindrical	Prismatic	
Primary lithium	40	50	8
Rechargeable lithium	50	60	24

10. As can be seen, for a typical rechargeable lithium battery assembly design, 24 battery assemblies are required for testing. The size of the batteries, the large number of batteries, the need to cycle test some rechargeable lithium batteries for 50 cycles and the wide array of tests (i.e., altitude simulation, thermal, vibration, shock, external short circuit, impact, overcharge and forced discharge) are all factors contributing to the substantial testing costs for large format batteries. Experience has shown the costs of such testing for large format batteries can be as high as \$500,000 (USD) per battery design.

Discussion of PRBA Proposed Changes

11. PRBA believes that in the same way large battery assemblies (i.e., more than 500 g lithium or 6200 Wh) presently are provided relief from certain testing when the component batteries have already been tested (see the last paragraph of 38.3.3), some relief from testing should also be provided for large format battery modules and assemblies when their components (i.e., cells and modules) have successfully passed the UN tests. PRBA proposes:

- (a) To introduce a more realistic distinction between small and large batteries so that large batteries are ones that would not reasonably be expected to be used in portable equipment and not likely to be transported by consumers. PRBA believes a threshold of 80 g (lithium metal) or 600 Wh (lithium ion) should be used to distinguish between large and small batteries. A large lithium ion battery would then be on the order of eight times the size of the largest notebook computer batteries commonly in use and for a lithium metal battery it would forty times the size of typical consumer-type battery;
- (b) To provide new definitions for battery assemblies and modules;
- (c) To require fewer test samples of newly defined large batteries while maintaining the testing relief already afforded battery assemblies of more than 500 g lithium or 6200 Wh;
- (d) To require simplified testing for battery assemblies, considering they comprise tested component cells and modules;
- (e) To provide new limits in 38.3.2.1 on what constitutes a new design type rechargeable cell or battery subject to testing as a new design. Consistent with the

Sub-Committee's previous decision (reflected in the 15th revised edition of the Model Regulations) to use Watt-hours as a measure of rechargeable cell or battery size, it is more appropriate to base what constitutes a new rechargeable cell or battery design on a change in Watt-hour capacity or voltage.

Proposal

12. Based on the above discussion, PRBA proposes the changes to subsection 38.3 of the 4th revised edition of Manual of Tests and Criteria as provided in the following paragraphs.

13. Delete the existing 38.3.2.1 and replace with the following:

“38.3.2.1 Lithium metal and lithium ion cells and batteries shall be subjected to the tests, as required by special provisions 188 and 230 of Chapter 3.3 of the Model Regulations prior to the transport of a particular cell or battery type. Cells or batteries which differ from a tested type by:

- (a) For primary cells and batteries, a change of more than 0.1 g or 20% by mass, whichever is greater, to the cathode, to the anode, or to the electrolyte;
- (b) For rechargeable cells and batteries, an increase in Watt-hours of more than 20% or an increase in voltage of more than 20%; or
- (c) A change that would materially affect the test results,

shall be considered a new type and shall be subjected to the required tests.

In the event that a cell or battery type does not meet one or more of the test requirements, steps shall be taken to correct the deficiency or deficiencies that caused the failure before such cell or battery type is retested.”

14. Insert new definitions for “battery assembly” and “module” and amend definitions for “large battery” and “small battery” as follows:

“*Battery assembly* means a battery made of interconnected modules or batteries and includes all ancillary subsystems for mechanical support, thermal management, and electronic control.”

....

“*Large battery* means a lithium metal battery in which the aggregate lithium content of all anodes, when fully charged, is more than 80 g, or in the case of a lithium ion battery, means a battery with a Watt-hour rating of more than 600 Wh.”

....

“*Module* means a battery designed only for use in a battery assembly.”

....

“*Small battery* means a lithium metal battery composed of small cells, and in which the aggregate lithium content of all cell anodes, when fully charged, is not more than 80 g, or in the case of a lithium ion battery, means a battery with a Watt-hour rating of not more than 600 Wh.”

15. Delete the current 38.3.3 and replace with the following:

“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, (other than a large battery assemblies composed of tested modules), and modules under tests 1 to 5, the following shall be tested in 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,
 - (v) two modules in undischarged states,
 - (vi) two modules in fully discharged states,
 - (vii) two large batteries in undischarged states, and
 - (viii) two large batteries in fully discharged states.

- (b) When testing rechargeable cells, batteries (other than a battery assembly) and modules under tests 1 to 5 the following shall be tested in quantity indicated:
 - (i) ten cells, at first cycle, in fully charged states,
 - (ii) four small batteries, at first cycle, in fully charged states,
 - (iii) four small batteries after fifty cycles ending in fully charged states,
 - (iv) two modules, at first cycle, in fully charged states,
 - (v) two modules after twenty-five cycles ending in fully charged states,
 - (vi) two large batteries at first cycle, in fully charged states, and
 - (vii) two large batteries after twenty-five cycles ending in fully charged states.

Note: 38.3.3(b) includes changes proposed in a separate document.

- (c) When testing primary and rechargeable cells under test 6, the following shall be tested:
 - (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
 - (iv) for component cells of rechargeable batteries, five cells at first cycle at 50% of the design rated capacity.

For prismatic cells, ten test cells are required instead of the five described above, so that the procedure can be carried out on five cells along the longitudinal axes and, separately, five cells along the other axes. In every case, the test cell is only subjected to one impact.

- (d) When testing rechargeable batteries and modules under test 7, the following shall be tested in quantity indicated:
 - (i) four small rechargeable batteries, at first cycle, in fully charged states,
 - (ii) four small rechargeable batteries after fifty cycles ending in fully charged states,
 - (iii) two modules, except as provided in 38.3.4.7.1, at first cycle, in fully charged states, and
 - (iv) two modules, except as provided in 38.3.4.7. after twenty five cycles ending in fully charged states,
 - (v) two large batteries at first cycle, in fully charged states, and
 - (vi) two large batteries after twenty five cycles ending in fully charged states.
- (e) When testing primary and rechargeable cells under test 8, the following shall be tested:
 - (i) ten primary cells in fully discharged states,
 - (ii) ten rechargeable cells, at first cycle in fully discharged states, and
 - (iii) ten rechargeable cells after fifty cycles ending in fully discharged states.

- (f) When testing a battery assemblies in which the aggregate lithium content of all anodes, when fully charged, is not more than 500 g, or in the case of a lithium ion battery, with a Watt-hour rating of not more than 6200 Watt-hours, that is assembled from cells, batteries or modules that have passed all applicable tests, one battery assembly in a fully charged state shall be tested under Tests 3, 4, and 5, and, in addition, Test 7 in the case of rechargeable battery assemblies. For rechargeable battery assemblies, the assemblies shall have been cycled at least 25 cycles.

When batteries or battery modules that have passed all applicable tests are electrically connected to form a battery assembly with an aggregate lithium content of all anodes, when fully charged, of more than 500 g, or in the case of a lithium ion battery, with a Watt-hour rating of more than 6200 Watt-hours, that battery assembly does not need to be tested if it is equipped with a system capable of monitoring the battery assembly and preventing short circuits, or over discharge between the batteries in the assembly and any overheat or overcharge of the battery assembly.”

16. In 38.3.4 insert the following note directly under the word “Procedure”:
- “Note: Unless indicated otherwise, the term ‘battery’ as used throughout these procedures may be taken to include a module or battery assembly (see definitions in 38.3.2.2).”
17. In 38.3.4, amend the first sentence of introductory text by adding the words “as required” so that it reads:
- “Each cell and battery type must be subjected to tests 1 to 8, as required.”
18. In 38.3.4.7.1 amend the purpose by adding the following at the end of the existing text:
- “This test is not required for modules without installed overcharge protection.”
19. For the convenience of the Sub-Committee portions of Section 38.3 as proposed to be revised in this paper will be provided in “Track Changes” format in an information paper.
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Annex



UN tested lithium ion cells



UN tested lithium ion battery modules containing multiple cells



Lithium ion battery assemblies containing multiple UN tested modules