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**COMMITTEE OF EXPERTS ON THE TRANSPORT OF
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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 Lithium Batteries and Lithium Battery Assemblies

Transmitted by the Portable Rechargeable Battery Association (PRBA)¹

Introduction

1. At the thirty-third session of the Sub-Committee, PRBA submitted proposal ST/SG/AC.10/C.3/2008/46 that contained modifications to the testing requirements for large lithium ion batteries and lithium metal batteries, lithium battery assemblies, several new definitions, and new limits for what constitutes a new “design type” for rechargeable lithium cells and batteries. There was general recognition that changes to the testing requirements for large lithium batteries in Section 38.3 of the UN Manual of Tests and Criteria are needed, but that PRBA’s proposal should be reconsidered. On the basis of those comments and recent meetings between automotive and lithium battery manufacturers, PRBA has developed the following proposal.

¹ 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.10/34, para. 14).

2. Global concerns regarding greenhouse gas emissions and energy security have accelerated the commercialization of hybrid electric vehicles (HEV), Plug-in Hybrid Electric vehicles (PHEV), and electric vehicles (EV). As a result, this has led to an increase in demand for high-power and high-energy density batteries. Lithium ion batteries are one of the most promising secondary batteries for the propulsion of these vehicles. Several automotive companies are expected to introduce lithium ion batteries into EV and HEV applications in 2010; and PHEV applications by 2012. Therefore, it is critical that this Sub-Committee address the necessary changes to the large lithium battery testing requirements in the UN Manual rather than waiting until the next biennium.

3. Large lithium ion batteries and lithium metal batteries are used in many military and aerospace applications. These sophisticated batteries often meet military and aerospace testing standards that far exceed the testing requirements contained in the UN Manual.

4. The UN Manual previously distinguished between testing large and small lithium batteries and provided relief from certain testing requirements for large lithium batteries. The distinction between testing large and small batteries was contained most recently in the Third Revised Edition of the UN Manual, which was in effect until 31 December 2002. Therefore, PRBA's proposal to separate the testing requirements for large and small batteries as outlined below is not inconsistent with previous UN lithium battery tests.

Discussion of Large Battery and Battery Assembly Designs and Testing Implications

5. As explained in ST/SG/AC.10/C.3/2008/46, large lithium batteries are constructed from many cells. These cells are typically electrically connected together to form a battery, which is sometimes referred to as a battery "module." Batteries also are connected together to form a "battery assembly," which is the most common design for EV and HEV applications. PRBA proposes to clarify these terms in the current "NOTE" under the definition for "Battery" in the UN Manual.

6. Since the UN test now uses Watt hours as the basis for assessing the size of rechargeable batteries, PRBA proposes changes in the provision specifying what design changes to a rechargeable cell or battery necessitate testing in Section 38.3.2.1 of the UN Manual.

7. A "Large battery" is defined in the UN Manual as a battery in which the aggregate lithium content of all anodes, when fully charged, is more than 500 g, or in the case of lithium ion batteries, with a Watt-hour rating of more than 6200 Watt-hours. It is not clear why this limit was chosen. In any case, this limit no longer seems relevant. Lithium metal batteries and lithium ion batteries used in many "industrial" applications (e.g., PHEV, EV, HEV, stationary, military and aerospace) are below the large battery limit. Yet it seems unrealistic to think that a sophisticated 300 g military lithium metal battery or a 1000 Watt-hour HEV lithium ion battery is a small battery. Over the past six months, PRBA has worked closely with the world's leading automobile manufacturers and lithium battery manufacturers and carefully evaluated the size of batteries that can reasonably be expected in PHEV, EV, HEV, military, aerospace, and stationary applications. Based on this evaluation, PRBA proposes a more realistic definition for "Large battery" and "Small Battery" with a threshold of 80 g (for lithium metal batteries) and 600 Watt-hours (for lithium ion batteries) to distinguish between Large and Small batteries. Batteries of this size (over 80 g and 600 Wh) would never be found in small, portable consumer applications.

8. Large lithium batteries are very sophisticated and expensive batteries to manufacture and assemble. The cost to manufacture and test sixteen large, expensive rechargeable batteries pursuant to the UN Manual creates a significant financial burden for battery manufacturers. PRBA proposes that eight Large rechargeable batteries be subject to UN testing, which is the same number currently required for lithium primary (non-rechargeable) batteries, and a requirement of 25 charge/discharge cycles prior to initiation of testing instead of the current 50 cycles.

9. Cells, batteries and battery assemblies are subject to UN testing requirements to allow these materials to be classified as Class 9 dangerous goods. The current UN Manual requirements in 38.3.3 provide testing relief for large battery assemblies (i.e., more than 500 g of lithium or more than 6200 Watt-hours). However, no relief is provided for smaller battery assemblies in size ranges that are common in most EV, PHEV, HEV, military and aerospace applications. To require the complete range of UN testing of battery assemblies comprised of UN tested cells and UN tested batteries is of questionable benefit. For example, the Altitude simulation test (Test 1) simulates air transport under low-pressure conditions. If the cells and batteries used to construct a battery assembly have already passed this test, there is no reason to believe the battery assembly will not pass the same test. Therefore, altitude testing of battery assemblies serves no useful purpose and is a waste of valuable resources. On this basis, PRBA proposes a simplified testing scheme for smaller battery assemblies.

10. Batteries used to construct battery assemblies generally do not have the hardware to easily charge them independent of the final assembly, and so are frequently designed without overcharge protection. These batteries are transferred items which, in order to be used, must be assembled into a larger, more complex battery assembly. In addition, they are not designed to be or expected to be charged independently by anyone other than the manufacturer. Therefore, it is not possible to conduct the Overcharge test on these batteries because the electronic overcharge protection is designed into the battery assembly. On this basis, PRBA proposes that the Overcharge test not be required for batteries without installed overcharge protection that are designed for use in a battery assembly.

Summary of PRBA Proposed Changes

11. PRBA therefore proposes:

- (a) To clarify certain battery terminology by introducing the terms “module” and “battery assembly” in the “NOTE” provision under the “Battery” definition;
- (b) 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 determine what constitutes a new rechargeable cell or battery design based on a change in Watt-hour capacity or voltage;

- (c) 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 Watt-hours (lithium ion) should be used to distinguish between large and small batteries. A large lithium ion battery would then be on the order of ten times the size of the largest notebook computer batteries commonly in use, and a lithium metal battery would be forty times the size of typical consumer-type battery;
- (d) To require fewer test samples and cycles for large batteries, in recognition that these are frequently subject to more stringent industry, military and government testing standards and generally more sophisticated and costly to manufacture and test;
- (e) To require simplified testing for battery assemblies that comprise tested component (*i.e.*, cells and batteries), while maintaining the testing relief already afforded battery assemblies of more than 500 g lithium or 6200 Watt-hours; and
- (f) To eliminate Overcharge testing for certain batteries designed for use in battery assemblies, in recognition that such batteries do not have overcharge protection until installed in a battery assembly.

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, a change 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 NOTE under “Battery” definition and add new definitions for “Large battery” and “Small battery” in 38.3.2.2 as follows:

“NOTE: Units that are commonly referred to as “battery packs”, “modules” or “battery assemblies” having the primary function of providing a source of power to another piece of equipment are for purposes of these Regulations treated as batteries.”

“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 Watt-hours.”

....

“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 Watt-hours.”

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 under tests 1 to 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,
 - (v) Four large batteries in undischarged states, and
 - (vi) Four large batteries in fully discharged states.

- (b) When testing rechargeable cells, batteries under tests 1 to 5 the following shall be tested in the 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 large batteries at first cycle, in fully charged states, and
 - (v) Two large batteries after twenty-five cycles ending in fully charged states.

Note: 38.3.3(b) includes changes adopted at the thirty-third session of the UN Sub-Committee.

- (c) When testing primary and rechargeable cells under test 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
 - (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.

Note: 38.3.3(c) includes changes adopted at the thirty-third session of the UN Sub-Committee.

- (d) When testing rechargeable batteries under test 7, the following shall be tested in the 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 large batteries at first cycle, in fully charged states, and
 - (iv) Two large batteries after twenty five cycles ending in fully charged states.

Batteries not equipped with overcharge protection that are designed for use only in a battery assembly, which affords such protection, are not subject to the requirements of this test.

- (e) When testing primary and rechargeable cells under test 8, the following shall be tested in the quantity indicated:
 - (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 assembly 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 or batteries 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 a rechargeable battery assembly. For a rechargeable battery assembly, the assembly shall have been cycled at least 25 cycles.

When batteries that have passed all applicable tests are electrically connected to form a battery assembly in which the aggregate lithium content of all anodes, when fully charged, is more than 500 g, 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.
