



Secretariat

Distr.
GENERAL

ST/SG/AC.10/C.3/2005/46
13 September 2005

Original: ENGLISH

**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

Twenty-eighth session, 28 November-7 December 2005
Item 5 of the provisional agenda

LISTING, CLASSIFICATION AND PACKING

Use of Watt-Hours in place of equivalent lithium content for lithium ion batteries

Transmitted by the Portable Rechargeable Battery Association (PRBA)

1. At its twenty-seventh session, the Sub-Committee considered three proposals from PRBA in document ST/SG/AC.10/C.3/2005/13. To facilitate discussion, PRBA has chosen to resubmit revised versions of the proposals in three separate documents. This document restates the proposal that Watt-hours be used in place of “equivalent lithium content” (also expressed as “lithium-equivalent content”) as a measure of size in the case of lithium ion cells and batteries, provides the supporting justifications for this proposed change, and responds to related questions from the twenty-seventh session. In addition, a separate PRBA document (ST/SG/AC.10/C.3/2005/43) provides detailed information describing lithium ion cells and batteries and information relevant to their transport.

Background

2. In the mid 1990s, when the Sub-Committee adapted its existing requirements for lithium batteries to account for lithium ion cells and batteries (hereafter referred to as lithium ion batteries), it was necessary to devise an expression that gave an indication of cell and battery size analogous to the existing metallic lithium content measure for lithium batteries. The term “equivalent lithium content” (ELC) was developed to characterize the size of lithium ion batteries even though it was known that lithium ion batteries did not actually contain metallic lithium. ELC “in grams is calculated to be 0.3 times the rated capacity in ampere-hours.” It is important to note that ELC is only defined for cells. For batteries the ELC is the aggregate ELC of the cells present in the battery. This rather subtle point may not be widely understood and can lead to misapplication of the dangerous goods transport regulations.

Justification for replacing ELC with Watt-hours

3. There are three problems associated with using ELC:
- .1 ELC is a term unique to the UN Model Regulations. This causes confusion and delay when questions arise about a battery's size while it is in transport;
 - .2 ELC is difficult to determine, making regulations difficult to comply with and enforce, potentially frustrating some shipments needlessly while other shipments in violation of the regulations move without detection; and
 - .3 For a battery, the use of the ampere-hour rating on the outside case can lead to an erroneous ELC value.
4. To elaborate on the third point – cells in batteries may be connected in parallel, in series, or in a combination of the two. When cells are connected in series the voltage of the battery increases but the ampere-hours (Ah) do not change. By contrast, when cells are connected in parallel the ampere-hours of the battery (Ah) increase but the voltage stays the same. The figures in the diagrams below illustrate this point.

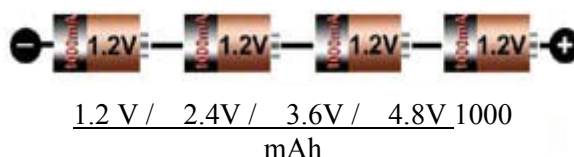
Diagram 1

Diagram 1 shows 1000 milliampere-hour (mAh) cells connected in series where the voltage increases but the milliampere-hours (mAh) stay the same. If ELC is calculated based on the ampere-hour rating of the battery, the result is $\frac{1}{4}$ the actual ELC.

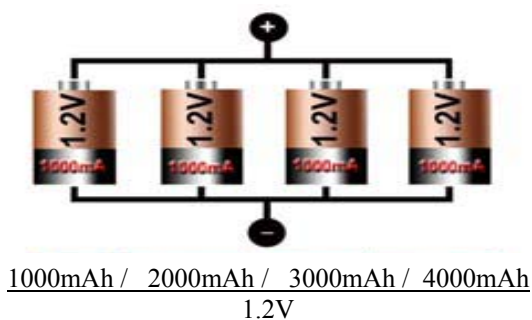
Diagram 2

Diagram 2 shows 1000 milliampere-hour (mAh) cells connected in parallel where the voltage stays the same but the milliampere-hours (mAh) increase. If ELC is calculated based on the ampere-hour rating on the battery, the result is the actual ELC.

5. The ampere-hour rating normally printed on a battery case is the ampere-hour rating of the battery. Information on individual cells and how they are connected is not normally provided. When cells

in a battery are connected in series, use of the ampere-hour rating printed on the battery will lead to an erroneous ELC value. This is further illustrated for selected example batteries in the chart below:

Battery Pack Equivalent Lithium Content (ELC) and Watt Hours

Cell Capacity, Ah	2.2	2.2	2.4	2.4	2.4	2.4	3.0	3.0
Cell Voltage, V	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
ELC per cell, grams	0.66	0.66	0.72	0.72	0.72	0.72	0.9	0.9
Cells in series	4	3	3	4	6	1	3	4
Cells in parallel	3	4	4	3	2	12	4	2
Number of cells	12	12	12	12	12	12	12	8
Total ELC, grams	7.92	7.92	8.64	8.64	8.64	8.64	10.8	7.2
Battery capacity, Ah	6.6	8.8	9.6	7.2	4.8	28.8	12	6
Battery voltage, V	14.8	11.1	11.1	14.8	22.2	3.7	11.1	14.8
Battery Watt-hours	97.68	97.68	106.56	106.56	106.56	106.56	133.2	88.8
Erroneous Battery ELC	1.98	2.64	2.88	2.16	1.44	8.64	3.6	1.8

Comparing the “Total ELC” with the “Erroneous Battery ELC” reveals that battery size can be significantly underestimated in the case of some battery configurations if the ampere-hour rating of the battery is used.

6. The use of Watt-hours overcomes the problems associated with ELC. Watt-hours is a widely understood technical term. It is independent of how cells are arranged within a battery and is directly proportional to the correct ELC of a battery. An ELC of 1.5 grams is equivalent to 18.5 Watt-hours and an ELC of 8 grams is equivalent to 98.7 Watt-hours. PRBA proposes that the Watt-hour rating of each lithium ion battery be printed on the outside of each battery for easy identification.

Relevant comments or questions from the 27th session

7. One suggestion at the twenty-seventh session was to consistently use Watt-hours as a measure of battery size for both lithium and lithium ion batteries. PRBA does not represent the interests of lithium primary battery manufacturers, but did contact an industry organization with interest in lithium primary batteries. That organization was reluctant to change the existing measure of size for lithium primary batteries in that the “lithium content” measure is well established and easily understood. Therefore, PRBA is not proposing to amend the size limits for lithium primary cells and batteries.

Proposal

8. On the basis of the above discussion, PRBA proposes to replace the terms “lithium equivalent content” and “equivalent lithium content” with “Watt-hours,” preceded by the appropriate value throughout the Model Regulations and the Manual of Test and Criteria, and to make consequential changes as necessary. PRBA also proposes to include a new requirement in SP 188 saying:

“Lithium ion batteries subject to this provision shall be marked with the Watt-hour rating on its outside case.”

9. On the basis of the above discussion, it is proposed that the following amendments be made:
- .1 amend SP 188 as follows (note that changes proposed in ST/SG/AC.10/2005/45 are shown in italics and new changes introduced by this document are shown in bold italics; Wh ratings are represented as xx and yy pending a decision on document ST/SG/AC.10/2005/44):
- 188 ~~Lithium~~ Cells and batteries offered for transport are not subject to other provisions of these Regulations if they meet the following:
- (a) For a lithium metal or lithium alloy cell, the lithium content is not more than 1 g, and for a lithium ion cell, the ~~lithium equivalent content~~ ***Watt-hour rating*** is not more than ~~1.5 g~~ ***xx Wh***;
 - (b) For a lithium metal or lithium alloy battery the aggregate lithium content is not more than 2 g, and for a lithium ion battery, the ~~aggregate lithium equivalent content~~ ***Watt-hour rating*** is not more than ~~8 g~~ ***yy Wh. Lithium ion batteries subject to this provision shall be marked with the Watt-hour rating on the outside case***;
 - (c) Each cell or battery is of the type proved to meet the requirements of each test in the Manual of Tests and Criteria, Part III, sub section 38.3;
 - (d) Cells and batteries are separated so as to prevent short circuits and are packed in strong packagings, except when installed in equipment; and
 - (e) Except when installed in equipment, each package containing more than 24 ~~lithium~~ cells or 12 ~~lithium~~ batteries shall in addition meet the following requirements:
 - (i) Each package shall be marked indicating that it contains lithium batteries *or lithium ion batteries, as appropriate*, and that special procedures should be followed in the event that the package is damaged;
 - (ii) Each shipment shall be accompanied with a document indicating that packages contain lithium batteries *or lithium ion batteries, as appropriate*, and that special procedures should be followed in the event a package is damaged;
 - (iii) Each package is capable of withstanding a 1.2 m drop test in any orientation without damage to cells or batteries contained therein, without shifting of the contents so as to allow battery to battery (or cell to cell) contact and without release of contents; and
 - (iv) Except in the case of lithium batteries *or lithium ion batteries* packed with equipment, packages may not exceed 30 kg gross mass.
- As used above and elsewhere in these Regulations, "lithium content" means the mass of lithium in the anode of a lithium metal or lithium alloy cell, ~~except in the case of a lithium ion cell the "lithium equivalent content" in grams is calculated to be 0.3 times the rated capacity in ampere hours.~~
- .2 amend the purpose in 38.3.1 of the Manual of Tests and Criteria by inserting:

- .1 “and lithium ion cells and batteries” immediately after “lithium cells and batteries”; and
- .2 “XXXX and YYYY” after “3091” and deleting the “and” preceding “3091”.
- .3 amend definitions in 38.3.3.2 of the Manual of Tests and Criteria as follows:
- .1 amend the definition of *Aggregate lithium content* to read as follows:
- “*Aggregate lithium content* means the sum of the grams of lithium content ~~or equivalent lithium content~~ contained by the cells comprising a battery.”
- .2 delete the definition of *Equivalent lithium content*.
- .3 amend the definition of *large battery* as follows:
- “*Large battery* means a battery in which the aggregate lithium content of all anodes, ~~when fully charged,~~ is more than 500 g, **or in the case of a lithium ion battery, means a battery with a Watt-hour rating of more than 6200 Wh.**”
- .4 amend the definition of *large cell* as follows:
- “*Large cell* means a cell in which the lithium content of the anode, ~~when fully charged,~~ is more than 12 g, **or in the case of a lithium ion cell, means a cell with a Watt-hour rating of more than 150 Wh.**”
- .5 amend the definition of *small battery* as follows:
- “*Small battery* means a battery composed of small cells and in which the aggregate lithium content of all cell anodes, when fully charged, is not more than 500 g **or in the case of a lithium ion battery, means a battery with a Watt-hour rating of not more than 6200 Wh.**”
- .6 amend the definition *small cell* as follows:
- “*Small cell* means a cell in which the lithium content of the anode, when fully charged, is not more than 12 g, **or in the case of a lithium ion cell, means a cell with a Watt-hour rating of not more than 150 Wh.**”
- .7 add a new definition of Watt-hour rating as follows:
- “***Watt-hour rating, expressed in Watt-hours, is calculated by multiplying a cell or battery’s rated capacity, in ampere-hours, by its nominal voltage.***”
- .4 amend the last sentence of paragraph 38.3.3 of the Manual of Tests and Criteria as follows:
- “When batteries that have passed all applicable tests are electrically connected to form a battery assembly **of a size comparable to a large battery** ~~in which the aggregate lithium content of all anodes, when fully charged, is more than 500g,~~ that battery assembly.....”
-