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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS

Sub-Committee of Experts on the Transport of Dangerous Goods
(Eighteenth session,
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Agenda item 5(b)

REQUIREMENTS FOR LITHIUM BATTERIES

Transmitted by the Chairman of the Lithium Battery Working Group
(Mr. F. Wybenga, United States of America)

Report of the intersessional meeting of the Lithium Battery Working Group

Ottawa (Canada) 13-15 March 2000

Document: ST/SG/AC.10/C.3/1999/73 (Canada/Japan)

Informal documents: UN/SCETDG/17/INF.7 (Canada/Japan)
UN/SCETDG/17/INF.20 and INF.21 (France)

Introductory Note: At the 17th session of the Sub-Committee of Experts on the Transport of Dangerous Goods, which was held in Geneva, 6-15 December 1999, a joint Canada/Japan Informal document (UNSCETDG/17/INF.7) was presented, which was an update of Document: ST/SG/AC.10/C.3/1999/73 (Canada/Japan).

Two other Informal documents were also presented: UN/SCETDG/17/INF.20 and INF.21 (France).

The Expert from Canada indicated that the various Experts who had demonstrated an interest in the matter were not prepared to proceed. The Expert from Japan asked the Sub-Committee to grant the Working Group authority to hold an inter-sessional meeting at which the remaining questions regarding adequate testing and regulation for lithium batteries could be advanced.

The Chairman said that it was for the correspondence group to organize its work as it thought fit, provided that if it submitted a document for the next session it did so in accordance with the mandate it had been given at the last session.

Accordingly, the Experts from Canada, France, Germany, Japan, the United Kingdom and the United States of America agreed to meet in Ottawa, Canada, 13-15 March 2000.

The Experts invited participation from various industry representatives as well as from other interested parties.

The report of the meeting in this Informal paper includes the minutes of the meeting, the list of participants and the amended **Recommendation 2** from INF.7.

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Annexes

REPORT

1. The lithium batteries Working Group met in Ottawa, Canada, from 13 to 15 March 2000 with Mr. F. Wybenga (United States of America) as Chairman.

2. Experts from the following countries took part in the meeting: Canada, France, Germany, Japan, United Kingdom and United States of America. *See Appendix 2.*

3. Other participants are also listed in Appendix 2.

4. The meeting was opened by Dr. John Read, Transport Canada, who welcomed the participants to Ottawa. Dr. Read advised the group that Mr. Frits Wybenga, United States, had agreed to Chair the meeting.

5. Dr. Read gave a brief history of the lithium battery issues before the Working Group including the issue of normal conditions of transport vs. accident conditions.

6. Mr. Wybenga (United States of America) assumed the Chairmanship and asked the participants to introduce themselves.

7. Mr. Wybenga indicated that the Working Group would consider documents UNSCETDG/17/INF.7, UNSCETDG/17/INF.20 and UNSCETDG/17/INF.21.

8. Additional documents were presented by some participants and circulated for consideration as required.

9. The Working Group agreed to first discuss testing requirements for lithium cells and batteries and then to discuss the content of the special provisions. It was recognized that the two were interrelated and that it may be necessary to return to points previously agreed. A summary of comments made during the discussion on the testing requirements begins with paragraph 50 of this report. The amendments to the testing requirements as agreed to by the Working Group, are reflected in Annex 1.

10. After completing a reading of the test requirements, the working group proceeded into a discussion on the contents of the special provisions to be applied to lithium cells and batteries.

11. The representative from the United States provided a proposal to amend the current special provisions (188, 230 and 287). The major points in the US proposal were as follows:

a) require that all lithium batteries independent of size be subjected to the lithium battery testing requirements in order to qualify for classification in Class 9;

b) allow up to 5 cells or batteries with a lithium content limited in accordance with the current special provision 188 paragraphs (a) and (b) to be transported as not being subject to the regulations provided the batteries are protected against short circuits;

c) require that more than 5 small cells or batteries (as per special provision 188 paragraph (a) and (b)) in packagings up to 30 kg gross mass and cells and batteries with up to 5 grams and 25 grams respectively be treated as limited quantities of dangerous goods provided the packaging is capable of withstanding in any drop orientation a 1.2 metre drop test without releasing batteries from the packaging and retaining the batteries in their original orientation;

d) require that packagings containing more than 5 small cells or batteries and more than 30 kg gross mass be subject to the regulations as class 9 dangerous goods and subject to the packing group II performance criteria;

e) require that batteries larger than described in (c) above be subject to the regulations as class 9 dangerous goods and subject to package testing at the packing group II performance level; and

f) delete special provision 287.

12. Some participants favoured the approach put forward in the US document but felt that the text proposed required revision. Others expressed disagreement. Due to time constraints, the working group could not discuss the contents of the special provisions to a conclusion. The working group identified outstanding issues that still needed to be resolved. These included:

a) draft a definition of "equipment",

b) take a decision whether to retain the current three categories,

c) whether to base the various tests and other requirements on "normal conditions of transport",

d) whether battery-packs are to be treated as batteries,

e) whether to maintain the 20 volts value used in the overcharge test,

f) whether to institute a "propagation test",

g) whether the requirements for large and small batteries should be different,

h) how to address the requirements for small batteries of 12 g lithium content or less since individual cells under 2 g Li content are not regulated and do not "fit" anywhere,

i) how many units (if any) should be subject to a small quantity exemption,

j) whether testing of all sizes of cells and/or batteries should be required,

k) whether requirements applicable to lithium cells and/or batteries should differ from requirements applied to lithium ion cells and/or batteries.

DISCUSSION ON TESTING REQUIREMENTS

13. A new definition was added for *aggregate lithium content*.

14. The definition of *Battery* in INF.7 was considered.

15. The Chairman recalled that batteries include more than one cell and that that the words "electrically connected together by permanent means" should be reinstated into the definition of *Battery*.

16. The amended definition of *Battery* was placed in square brackets.

17. The Chairman moved to the definition of *Cell*. No change was offered to the revised definition.

18. There was no change proposed for *Component cell*.

19. There was no change proposed for *Cycle*.

20. The definition of *Disassembly* was removed by INF.7. Discussion was invited on this subject.

21. A member gave a short explanation and it was noted that *explosion*, contained within the definition of *disassembly*, has clear criteria but *disassembly* does not. The Chairman expressed concerns that the term *explosion*, already defined in the UN, should not have a different meaning for the purpose of lithium batteries.

22. The amended definition of *Disassembly* was reinstated.

23. There was no change proposed for *effluent*.

24. The definition for the term *Fire* was placed between square brackets.

25. There was no change proposed for *first cycle*.

26. The definition of *Fully charged* was examined.

27. After a lengthy discussion the Chairman, suggested that the proposed words "... designed rated capacity", to be added to the end of the sentence, be placed between square brackets.

28. The amended definition of *Fully discharged* was agreed to.

29. The definition of *leakage* was placed between square brackets.

30. The Working Group next considered the definition of *Lithium content*, which is currently in the Manual of Test and Criteria. As a result of the discussion, the definitions for *large battery* and *large cell* were retained pending completion of the work on the Special Provisions

31. The definitions of *lithium content* and *lithium equivalent content* were considered and a member wondered about placing the definitions in one place or separating them, but the system must be coherent.

The Chairman indicated that UN policy is to have the definitions in one place and, therefore, the definitions should be retained in the Manual of Test and Criteria. The two definitions were agreed to.

32. The definition of *primary* was agreed to without comment.

33. The definition of *protective devices* was agreed to without comment.

34. The definition of *rated capacity* was agreed to without comment.

35. The definition of *rechargeable* was agreed to without comment.

36. Following a discussion, the new definition for *rupture* was placed between square brackets.

37. The definition of *short circuit* was agreed to without comment.

38. The definition of *type* was agreed to without comment.

39. The amended definition of *undischarged* was agreed to after modification to clearly indicate that the definition would only apply to primary batteries and cells that had not been discharged to any extent.

40. The amended definition of *venting* was agreed to.

41. The definition of *weight loss* was reviewed. A member stated that the word "weight" should be changed to "mass" to conform to the international units of measurement. This was agreed and the definition of *mass loss*, together with Table 1, "Mass loss limit", duly corrected, were agreed to.

42. The definition of *ST Series Tests* was then considered.

43. A member mentioned that the IAEA Safety documents were now called "ST" and that efforts should be made not to confuse the two issues. He suggested that the designation "T" appeared viable. However, another member reminded the Working Group that tests for tanks in the UN Recommendations are prefixed "T" and, for the same reason, this should not be used. Another member suggested that the definition be deleted as it serves no real purpose.

44. The definition of *Series ST Tests* was deleted.

45. The "condition of cells and batteries to be tested" (38.3.3) was discussed as each test was being considered.

46. The “Procedure and General Pass Conditions” (38.3.4) was amended and the title was changed to “Procedure”.

47. The preamble of 38.3.3(a) and (b) were amended to read “... tests 1 to 5, ...”

48. The preamble of 38.3.3(c) was amended to read “... under test “[6]”, ...”, while the words “... at ... of the design rated capacity ...” were added to 38.3.3(c)(iii) and (iv) and minor amendments were also introduced.

49. The preamble to 38.3.3(d) was amended to read “... under test “7”.

50. The preamble to 38.3.3(e) was amended to read “... and rechargeable ... under test 8 ...”; 38.3.3(e)(ii) was deleted and the word “cells” was substituted for “batteries in 38.3.3(e)(iii) and (iv) (now renumbered (ii) and (iii)).

51. **Test 1: Vibration** (38.3.4.1) was considered and the “Purpose” (38.3.4.1.1) agreed to.

52. The “Test Procedure” (38.3.4.1.2) and the proposed test conditions were revised to simulate those that could be encountered in air transport, as indicated in the ICAO Technical Instructions.

53. The “Test Procedure” as set out in ST/SG.AC.10/1998/30 (Canada) was adopted.

54. The “Requirement” (38.3.4.1.3) was considered and a discussion took place as to the temperature which a cell or battery may reach during the test. A temperature of 150 ºC was agreed to and, with other minor amendments, the “Requirement” was agreed to.

55. **Test 2: Shock** (38.3.4.2) was considered.

56. The “Purpose” (38.3.4.2.1) was agreed with the addition of the words “...[simulates] possible impacts [during transport.]” to clarify that the test could not possibly simulate all impacts that could occur during transport.

57. On the subject of the “Test Procedure” (38.3.4.2.2), a number of observations were made, calling for adoption of wording from document INF.7, from document ST/SG.AC.10/1998/30 (Canada) and from the Farrington Lockwood Company Limited document.

58. The amended “Test Procedure” (38.3.4.2.2) was accepted.

59. The “Requirement” (38.3.4.2.3) was accepted with the text identical to that of the previous test.

60. **Test 3: Expansion and Contraction** (38.3.4.3) was considered. Numerous suggestions were made that the name or title of the test did not represent fairly the “Purpose” (38.3.4.3.1).

61. The title of the test was changed to “**Thermal Test**” and the “Purpose” (38.3.4.3.1) was agreed to without amendment.

62. The “Test Procedure” (38.3.4.3.2) was considered and extensive discussions took place, particularly on the subject of the length of time the test units were to be subjected to each extreme as well as to ambient temperatures.

63. It was agreed that conditions for small cells and batteries should be different from those for large cells and batteries; also that extreme temperatures should be allowed a certain range of compliance, i.e., ± 2 ºC and that ambient temperature should be defined as 20 ± 5 ºC.

64. The amended “Test Procedure” (38.3.4.3.2) was agreed to.

65. The “Requirement” (38.3.4.3.3) was accepted with the text identical to that of the previous test.

66. **Test 4: Pressure Differential** (38.3.4.4) was considered and discussion took place as to the appropriateness of the title since the test, unlike the test required for packaging under the ICAO Technical Instructions, does not require a sudden drop of ambient pressure but, rather, storage at a very low ambient pressure.

67. The title of the test was changed to “**Altitude Simulation**” and the “Purpose” (38.3.4.4.1) was agreed to.

68. The “Test Procedure” (38.3.4.4.2) was agreed to with an amendment.

69. The “Requirement” (38.3.4.4.3) was accepted with the text identical to that of the previous test.

70. **Test 5: External Short Circuit** (38.3.4.5) was next considered and the “Purpose” (38.3.4.5.1) was agreed to without amnedment.

71. The “Test Procedure” (38.3.4.5.2) gave rise to an extended discussion where the validity of the test was questioned, since a part of the packaging requirements is that the batteries cannot suffer an external short in transport and that there is no record of any lithium battery being involved in such an incident. The Expert from the United States stated that there are, in the US, 28 cases on record while admitting that not all batteries affected were of lithium technology.

72. The “Requirement” (38.3.4.5.3) was agreed with amendments to simplify the sentence and replace “... no explosion ...” with “ ... no disassembly, no rupture ...”.

73. **Test 6: Internal Short Circuit** (38.3.4.6) was considered. There was disagreement on whether this test was relevant to transport. There was also disagreement on whether this test should replace the existing test. Following an animated discussion, this test was placed in square brackets, with a note added in Recommendation 2.

74. **Test 7: Overcharge** (38.3.4.7) was then considered.

75. There was disagreement on whether this test was relevant to transport.

76. The test was retained and the”Purpose” (38.3.4.7.1) agreed to without modification.

77. The “Test Procedure” (38.3.4.7.2) was amended to include “the manufacturer’s recommended

maximumcontinuous charge current.", to change the maximum voltage to be used during the test and to amend the "Requirement" to use the word "disassembly" instead of "explosion".

78. **Test 8: Forced Discharge** (38.3.4.8) was considered and, after it was stated and agreed that this test should only be performed on primary or rechargeable cells, rather than batteries, the "purpose" (38.3.4.8.1) was agreed to.

79. A very long technical discussion took place following which an amended "Test Procedure" (38.3.4.8.2), as per Recommendation 2 (Annex 1).

80. The "Requirement" (38.3.4.8.2) was agreed to, amended to apply only to primary and rechargeable cells instead of batteries, and where the word "disassembly" replaced the word "explosion".

Annex 1

RECOMMENDATION 2

Recommendation 2:

Amend sub-section 38.3 of the Manual of Tests and Criteria to read:

"38.3.1 This section presents the tests required under special provision 188 of the Model Regulations.

38.3.2 This section presents definitions for special provision 188.

Aggregate lithium content **means the sum of the grams of lithium content or lithium-equivalent content contained by the cells comprising a battery.**

[*Battery* means two or more cells **which are electrically connected together by permanent means**, including case, terminals, and marking.**]**

Cell means a single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals. Under these Regulations, to the extent the encased electrochemical unit meets the definition of "cell" herein, it is a "cell," not a "battery," regardless of whether the unit is termed a "battery" or a "single cell battery" outside of these Regulations.

Component cell means a cell contained in a battery.

Cycle means one sequence of fully charging and fully discharging a rechargeable cell or battery,

Disassembly **means 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.**

Effluent means a liquid or gas released when a cell or battery vents or leaks.

[*Fire* means combustion of cell or battery components with emission of flame.**]**

First cycle means the initial cycle following completion of all manufacturing processes.

Fully charged means a rechargeable cell or battery, which has been electrically charged to its **[desing rated capacity].**

Fully discharged means either: (a) a primary cell or battery which has been electricalIv discharged to remove 100% of its rated capacity: or (b) a rechargeable cell or battery which has been electrically discharged to **its end point voltage as specified by the manufacturer**.

Large battery **means a battery in which the aggregate lithium content of all anodes, when fully charged, is more than 500 g.**

Large cell **means a cell in which the lithium content or lithium-equivalent content of the anode, when fully charged, is more than 12 g.**

[*Leakage* **means the escape of material from a cell or battery]**

Lithium content is applied to lithium metal and lithium alloy cells and batteries, and for a cell means the mass of lithium in the negative electrode of a lithium metal or lithium alloy cell when undischarged or fully charged. The lithium content of a battery equals the sum of the grams of lithium content contained in the component cells of the battery.

Lithium-equivalent content is applied to lithium-ion cells and batteries, and for a cell is measured as 0.3 times the rated capacity of the cell in ampere-hours, with the result expressed in grams. The lithium-quivalent content of a battery equals the sum of the grams of lithium-equivalent content contained in the component cells of the battery.

Lithium-ion cell or battery means a rechargeable electrochemical cell or battery in which the positive and negative electrodes are both intercalation compounds (intercalated lithium exists in an ionic or quasi-atomic form within the lattice of the electrode material) constructed with no metallic lithium in either electrode. A lithium polymer cell or battery that uses lithium-ion chemistries, as described herein, is regulated as a lithium-ion cell or battery.

Primary means a cell or battery which is not designed to be electrically charged or recharged.

Protective devices means devices such as fuses, diodes and current limiters which interrupt the current flow, block the current flow in one direction or limit the current flow in an electrical circuit.

Rated capacity means the capacity, in ampere-hours, of a cell or battery as measured by subjecting it to a load, temperature and voltage cutoff point specified by the manufacturer.

Rechargeable means a cell or battery which is designed to be electrically recharged.

[*Rupture* **means the mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage but not ejection of solid materials.]**

Short circuit means a direct connection between positive and negative terminals of a cell or battery that provides a virtual zero resistance path for current flow**.**

[*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.]**

[*Small cell* **means a cell in which the lithium content or lithium-equivalent content of the anode, when fully charged, is not more then 12 g.]**

Type means a particular electrochemical system and physical design of cells or batteries.

Undischarged means **a primary** cell or battery **that has not been wholly or partly discharged.**

Venting means the release of excessive internal pressure from a cell or battery in a manner intended by design to preclude **rupture or disassembly**.

***Mass** loss* means a loss of **mass** that exceed the values in Table 1 below. In order to quantify the **mass** loss, the following procedure is provided. **Mass** loss = ($\mathbf{M}_1$ - $\mathbf{M}_2$)/ $\mathbf{M}_1$ x 100% where $\mathbf{M}_1$ is the **mass** before the test and $\mathbf{M}_2$ is the **mass** after the test. When **mass** loss does not exceed the values in Table 1, it shall be considered as "no **mass** loss".

Table 1 - **Mass** loss limits

Mass ***M*** of cell or battery	**Mass** loss limit
M # 1 g	0.5%
1 g < **M** # 5 g	0.2%
M > 5 g	0.1%

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:

(i) ten cells in undischarged states,

(ii) ten cells in fully discharged states,

(iii) four batteries in undischarged states, and

(iv) four batteries in fully discharged states.

(b) When testing rechargeable cells and batteries under **tests 1 to 5** the following shall be tested:

(i) ten cells, at first cycle, in fully charged states,

(ii) ten cells, at first cycle, in fully discharged states,

(iii) four batteries, at first cycle, in fully charged states,

(iv) four batteries, at first cycle, in fully discharged states,

(v) four batteries after fifty deep cycles ending in fully charged states, and

(vi) four batteries after fifty deep cycles ending in fully discharged states.

(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 five cells after 50 deep cycles ending in fully discharged 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 50 deep cycles ending in fully discharged states.

For prismatic cells, ten test cells are required for each of the states of charge being tested, 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 crush.

(d) When testing rechargeable batteries under test **7**, the following shall be tested:

(i) four rechargeable batteries, at first cycle, in fully charged states, and

(ii) four rechargeable batteries after fifty deep 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

(iv) **ten** rechargeable **cells** after 50 deep cycles ending in fully discharged states.

38.3.4 Procedure

Each cell and battery type must be subjected to tests 1 to 8. Tests 1 to 5 must be conducted in sequence on the same cell or battery. Tests 6, 7 and 8 should be conducted using not otherwise tested cells or batteries.

38.3.4.1 Test 1: Vibration

38.3.4.1.1 Purpose

This test simulates vibration during transport.

38.3.4.1.2 Test Procedure

Cells and batteries are firmly secured to the platform of the vibration machine without distorting the cells in such a manner as to faithfully transmit the vibration. The vibration shall be a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell. One of the directions of vibration must be perpendicular to the terminal face.

The logarithmic frequency sweep is as follows: from 7 Hz a peak acceleration of 1 g_n is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8 g_n occurs (approximately 50 Hz). A peak acceleration of 8 g_n is then maintained until the frequency is increased to 200 Hz.

38.3.4.1.3 Requirement

Cells and batteries meet this requirement if there is no **mass** loss, no leakage, no venting**,** no **disassembly, no rupture** and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states. **At the conclusion of the test, the external temperature of the cell or battery shall not exceed 150 °C.**

38.3.4.2 Test 2: Shock

38.3.4.2.1 Purpose

This test simulates **possible impacts** during transport.

38.4.2.2 Test Procedure

Test cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. **Each cell or battery shall be subjected to a half-sine shock of peak acceleration of 150 g_n and pulse duration of 6 milliseconds. Each cell or battery shall be subjected to three** shocks **in the positive direction followed by three shocks in the negative direction** of three mutually perpendicular **mounting positions of the cell or battery for a total of 18 shocks**.

However, large cells and large batteries shall be subjected to a half-sine shock of peak acceleration of 50 g_n and pulse duration of 11 miliseconds. Each cell or battery is subjected to three shocks in the positive direction followed by three shocks in the negative direction each of three mutually perpendicular mounting positions of the cell for a total of 18 shocks.

3 8.3.4.2.3 Requirement

Cells and batteries meet this requirement if there is no **mass** loss, no leakage, no venting**,** no **disassembly, no rupture** and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells

and batteries at fully discharged states. **At the conclusion of the test, the external temperature of the cell or battery shall not exceed 150 °C.**

38.3.4.3 Test 3: Thermal Test

38.3.4.3.1 Purpose

This test assesses cell and battery seal integrity and internal electrical connections. The test is conducted using rapid and extreme temperature changes.

38.3.4.3.2 Test Procedure

Test cells and batteries are to be stored for at least six hours at a test temperature equal to 75 (± 2) °C , followed by storage for at least six hours at a test temperature equal to -40 (± 2) °C . The maximum time interval between test temperature extremes is 30 minutes. This procedure is to be repeated [10] times, after which all test cells and batteries are to be stored for 24 hours at ambient temperature (20 (± 5) °C). For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

38.4.3.3 Requirement

Cells and batteries meet this requirement if there is no **mass** loss, no leakage, no venting**,** no **disassembly, no rupture** and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states. **At the conclusion of the test, the external temperature of the cell or battery shall not exceed 150 °C .**

38.3.4.4 Test 4: Altitude simulation

38.3.4.4.1 Purpose

This test simulates air transport under low pressure conditions.

38.3.4.4.2 Test Procedure

Test cells and batteries shall be stored at a pressure of 11. 6 kPa or less for at least six hours **at ambient temperature.**

38.3.4.4.3 Requirement

Cells and batteries meet this requirement if there is no **mass** loss, no leakage, no venting**,** no **disassembly, no rupture** and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states. **At the conclusion of the test, the external temperature of the cell or battery shall not exceed 150 °C**

38.3.4.5 Test 5: External Short Circuit

38.3.4.5.1 Purpose

This test simulates an external short circuit.

38.3.4.5.2 Test Procedure

The cell or battery to be tested shall be **temperature** stabilized **so that its external case temperature reaches** 55 (±2) °C and then **the cell or battery shall be** subjected to a short circuit condition wth a total external resistance of less than 0.1 ohm at 55 (± 2) °C. This short circuit condition is continued for at least one hour after the cell or battery **external** case temperature has returned to 55 (± 2) °C. The cell or battery must be observed for a further six hours for the test to be concluded.

38.3.4.5.3 Requirement

Cells and batteries meet this requirement if their external temperature does not exceed 150°C and there is no **disassembly, no rupture** and no fire within six hours of this test.

[38.3.4.6 Test 6: Internal Short Circuit

38.3.4.6.1 Purpose

This test simulates an internal short circuit.

38.3.4.6.2 Test Procedure

The cell or component cell to be tested shall be crushed between two flat surfaces. The force shall be applied by a vice or by a hydraulic ram with a 32 mm diameter piston. The crushing shall be continued until

(1) the cell or component cell voltage drops abruptly or is reduced to at least one third, or

(2) a pressure reading of either 17 Mpa (an applied force of approximately 13kN) or a maximum force of 1 000 times the weight of the cell is attained, whichever is greater.

Once the voltage drops abruptly or is reduced to at least one third, or the maximum pressure has been attained, the pressure shall be released.

A cylindrical cell or component cell shall be crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. A prismatic cell or component cell shall be crushed by applying the force in the direction of one of the two axes perpendicular to its longitudinal axis and, separately, with another test cell or component cell, by applying the force in the direction of the other one of these two axes. A button/coin cell or component cell shall be crushed by applying force on its flat surfaces.

Each cell or component cell used in the test shall only be crushed once.

38.3.4 6.3 Requirement

The type of cell or component cell under test fails the test if any cell or component cell ignites or explodes. Cells and batteries meet this requirement if their external temperature does not exceed 150 °C and there is no explosion and no fire within six hours of this test.**]**

Note: A number of participants supported retention of the existing T4 internal short circuit test. Both tests remain under consideration. In addition, contrary to 38.3.3(c)(iii) and (iv), if the existing T4 test were retained rechargeable cells and component cells of rechargeable batteries would be tested at 100% of the design rated capacity.

38.3.4.7 Test 7: Overcharge

38.3.4.7.1 Purpose

This evaluates the ability of a rechargeable battery to withstand an overcharge condition.

38.3.4.7.2 Test Procedure

The charge current shall be twice the manufacturer's recommended **maximum** continuous charge current. The maximum voltage of the test shall be **the lesser of** two times the maximum charge voltage of the battery **or the maximum voltage of the battery plus** 20 V.

Tests are to be conducted at ambient temperature. The duration of the test shall be 24 hours.

38.3.4.7.3 Requirement

Rechargeable batteries meet this requirement if there is no **disassembly** and no fire within seven days of the test.

38.3.4.8 Test 8: Forced Discharge

38.3.4.8.1 Purpose

The test evaluates the ability of a primary or a rechargeable cell to withstand a forced discharge condition.

38.3.4.8.2 Test Procedure

Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12 V D.C. power supply at an initial current equal to the maximum discharge current specified by the manufacturer.

The specified discharge current is to be obtained by connecting a resistive load of the appropriate size and rating in series with the test cell.

Each cell shall be forced discharged for a time interval (in hours) equal to its rated capacity divided by the initial test current (in Ampere).

38.3.4.8.3 Requirement

Primary or rechargeable cells meet this requirement if there is no **disassembly** and no fire within seven days of the test.

Appendix 2

Li BATTERIES WORKING GROUP
INTER-SESSIONAL MEETING
OTTAWA, CANADA, MARCH 13 - 15, 2000

LIST OF PARTICIPANTS

CANADA

Dr. John Read, Director General, Transport Dangerous Goods Directorate, Transport Canada

Ms Linda Hume,	Chief, Legislation and Regulations, Transport Dangerous Goods Directorate, Transport Canada
Mr. Jacques Savard,	Director Regulatory Affairs, Transport Dangerous Goods Directorate, Transport Canada
Mr. Greg Lawson,	Senior Chemical Specialist, Transport Dangerous Goods Directorate, Transport Canada

FRANCE

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Advisors

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M Hosni Othman	(SAFT)

GERMANY

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Advisor

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Advisors

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UNITED KINGDOM

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Advisor	
Mr. Ian Bryer,	PIRA International

UNITED STATES OF AMERICA

Mr. Frits Wybenga,	RSPA, US DOT
Advisor	
Dr. Charles Ke,	RSPA, US DOT

INDUSTRY REPRESENTATIVES

Mr. Charles Monahan	(Panasonic)
Dr. R. Furumi	(Panasonic)
Mr. P. Krehl	(Wilson-Greatbatch)
Mr. Kanji Murano	(Sony)
Mr. D. Weinberg	(Howrey & Simon) PRBA

OTHER INTERESTED PARTIES

Ms Judith Code,	Chief, Dangerous Goods Standards, Civil Aviation Directorate.
Mr. Naim Nazha,	Senior Surveyor, Compliance, Ships and Operations Standards, Transport Canada (Marine)
M Benoit Chassé,	ArgoTech Productions inc,
Dr. George Donaldson,	Consultant (Li Batteries Expert)
Mr. Neil McCulloch,	International Air Transport Association

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