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Annex 1

Working Group on Lithium Batteries  
~~ANNEX~~

**Special Provisions for Lithium Batteries**

It is proposed that the special provisions applicable to lithium batteries be amended as follows:

188 Lithium cells and batteries offered for transport are not subject to other provisions of these Regulations if they meet the following provisions:

(a) For a lithium metal or lithium alloy cell, ~~with a liquid cathode, the lithium content is not more than 0.5 g.~~  
~~For a lithium metal or lithium alloy cell with a solid cathode, the lithium content is not more than 1 g, and for a~~  
lithium-ion cell, the equivalent lithium content is not more than 1.5 g;

(b) For a lithium metal or lithium alloy battery with liquid cathodes, the aggregate lithium content is not more than 1 g, for a lithium metal or lithium alloy battery with solid cathodes, the aggregate lithium content is not more than 2 g, and for a lithium-ion battery, the aggregate equivalent lithium content is not more than 8 g;

~~(c) Each cell or battery containing a liquid cathode is hermetically sealed;~~

(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;

~~(e) Cells are separated so as to prevent short circuits;~~

(d) Cells and batteries are separated so as to prevent short circuits and are packed in strong packagings, except when installed in electronic devices; and

|| ~~(e) Each package containing more than 20 lithium cells or 10 lithium batteries shall in addition meet the following requirements:~~  
except when installed in electronic devices,  
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Each package shall be marked indicating that it contains lithium batteries and that special procedures should be followed in the event that the package is damaged;

Each shipment shall be accompanied with a document indicating that packages contain lithium batteries and that special procedures should be followed in the event a package is damaged;

Each package is capable of withstanding a 1.2 meter 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 contact and without release of contents; and

|| Except in the case of lithium batteries packed in or with equipment, packages may not exceed 30 kg gross mass.



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~~(f) If, when fully charged, the aggregate lithium content of the anodes in a liquid cathode battery is more than 0.5 g, or of the aggregate lithium content of the anodes in a solid cathode battery is more than 1 g, it does not contain a liquid or gas which is considered dangerous unless the liquid or gas, if free, would be completely absorbed or neutralized by other materials in the battery;~~

~~Lithium cells and lithium batteries are also not subject to these Regulations if they meet the following provisions:~~

~~(g) The lithium content of the anode of each cell, when fully charged, is not more than 5g;~~

~~(h) The aggregate lithium content of the anodes of each battery, when fully charged, is not more than 25 g;~~

~~(i) Each cell or battery is of the type proved to be non dangerous by testing in accordance with tests in the Manual of Tests and Criteria, Part III, sub-section 38.3; such testing shall be carried out on each type prior to the initial transport of that type; and~~

~~(j) Cells and batteries are designed or packed in such a way as to prevent short-circuits under conditions normally encountered in transport.~~

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 "equivalent lithium content" in grams is calculated to be 0.3 times the rated capacity in ampere-hours.

230 This entry applies to cells and batteries containing lithium in any form, including lithium polymer and lithium ion cells and batteries. Lithium cells and batteries may be transported under this entry if they meet the following provisions:

~~(a) Each cell or battery type has been~~ is of the type proved to meet the requirements of each test ~~determined to meet the criteria for assignment to Class 9 on the basis of tests carried out in accordance with the Manual of Tests and Criteria, Part III, sub-section 38.3;~~

(b) Each cell and battery incorporates a safety venting device or is designed to preclude a violent rupture under conditions normally incident to transport;

(c) Each cell and battery is equipped with an effective means of preventing external short circuits;

(d) Each battery containing cells or series of cells connected in parallel is equipped with effective means as necessary to prevent dangerous reverse current flow (e.g., diodes, fuses, etc.).

~~287~~ *Delete SP 287 - Add new SP XXX as follows:*  
New, uncycled and uncharged lithium ion cells and batteries are not subject to these Regulations if:

*XXX* The testing requirements in Chapter 38.3 of the Manual of Tests and Criteria do not apply to production runs consisting of not more than 100 lithium cells and batteries or lithium ion cells and batteries or to pre-production prototypes of lithium cells and batteries or lithium ion cells and batteries when they are transported for testing, if

(a) the cells and batteries are transported in an outer packaging that is a metal, plastic or plywood drum or a metal, plastic or wooden box and that meets the criteria for Packing Group I packaging; and

(b) each cell and battery is individually packed in an inner packaging inside an outer packaging and is surrounded by material that is ~~non-flammable~~ or non-combustible, ~~cushioning~~ and non-conductive.

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## Annex

## Testing Requirements for Inclusion in the Manual of Tests and Criteria

*(Note: The changes to the introductory portions of the tests and criteria for lithium batteries show additions in bold type and deletions are indicated by ~~strikeout~~. Beginning with paragraph 38.3.4, the existing text should be deleted in its entirety and replaced with the text below beginning with 38.3.3.)*

## 38.3 Lithium batteries

## 38.3.1 Purpose

This section presents the procedures to be followed for the classification of lithium cells and batteries (see UN 3090 and UN 3091, and **the applicable** special provisions ~~188 and 230~~ of Chapter 3.3 of the Model Regulations).

## 38.3.2 Scope

~~38.3.2.1 Lithium cells and batteries offered for transport are not subject to the Model Regulations if they meet the requirements of Special Provision 188 of Chapter 3.3 of the Model Regulations.~~

~~38.3.2.2 Lithium cells and batteries may be assigned to Class 9 if they meet the requirements of Special Provision 230 of Chapter 3.3 of the Model Regulations.~~

38.3.2.3 **1** Lithium cells and batteries should be subjected to ~~the series T tests, where applicable,~~ 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. Lithium cells or batteries which differ from a tested type by:

- or
- (a) A change of more than  $\left. \begin{array}{l} 20\% \text{ by mass} \\ 10.1 \text{ g or} \end{array} \right\} \text{ , whichever is greater,}$  to the cathode, to the anode, or to the electrolyte;
  - (b) A change that would materially affect the test results

should be considered a new type and should be subjected to the required tests. In the event that a lithium cell or battery type does not meet **one** of the test requirements criteria in 38.3.4.7, steps should be taken to correct the deficiency or deficiencies that caused the failure before such cell or battery type is retested.

38.3.3 ~~Classification procedure~~ *or more*

~~38.3.3.1 Lithium cells and batteries which are required to be tested should be subjected to each test of series T in section 38.3.4 and should be classified according to the criteria given in 38.3.4.7.~~

38.3.3.2.2 For the purposes of classification, the following definitions apply:

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

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NOTE:

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**Battery** means ~~two~~ <sup>one</sup> or more cells which are electrically connected together by a permanent means, including case, terminals, and marking. Units that are commonly referred to as "battery packs" having the primary function of providing a source of power to another piece of equipment are for purposes of these Regulations treated as batteries.

**Button cell or battery** means a round small cell or battery when the overall height is less than the diameter.

**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.

**Equivalent lithium content** is defined in the definition of lithium content.

**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 designed ~~starting condition~~ rated capacity.

**Fully discharged** means either:

a primary cell or battery which has been electrically discharged to remove 100% of its rated capacity; or

a rechargeable cell or battery which has been electrically discharged to a ~~load voltage or less than 2/3 of its starting open circuit voltage~~ its endpoint 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 anode of a lithium metal or lithium alloy cell, which for a primary cell is measured when the cell is in an undischarged state and for a rechargeable cell is measured when the cell is fully charged, ~~except that in the case of a lithium ion cell the lithium content is measured in terms of equivalent lithium content, which in grams is calculated to be 0.3 times the rated capacity in~~

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ampere-hours. 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-equivalent 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 with 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.  
**Prismatic [cell or battery]** means a cell or battery whose ends are similar, equal and parallel rectilinear figures, and whose sides are parallel polygons.

**Protective devices** means devices such as fuses, diodes and current limiters which step 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 of the anode, when fully charged, is not more than 12 g.

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

**Undischarged** means a primary cell or battery that which has not been wholly or partly discharged. ~~such a discharge does not include normal self-discharge resulting from reactions during storage.~~

**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 =  $(M_1 - M_2) / M_1 \times 100\%$  where  $M_1$  is the mass before the test and  $M_2$  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".

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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%

Delete 38.3.4 in its entirety 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:

- (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 ~~test~~ cycles ending in fully charged states, and
- (vi) four batteries after fifty ~~test~~ cycles ending in fully discharged states.

x  
x

(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 ~~test~~ 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 ~~test~~ cycles ending in fully discharged states.

x

x

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:

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- X (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:

- X (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 ~~deep~~ cycles ending in fully discharged states.

~~When large batteries having passed all applicable tests are offered for transport electrically connected to form a battery assembly, the battery assembly must be capable of passing Tests 1 to 5.~~

### 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. Test 7 may be conducted using undamaged batteries previously used in Tests 1 to 5 for purposes of testing on ~~deep~~ cycled batteries.

#### 38.3.4.1 Test 1: Altitude simulation

##### 38.3.4.1.1 Purpose

This test simulates air transport under low pressure conditions.

##### 38.3.4.1.2 Test Procedure

X Test cells and batteries shall be stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature  $(20^{\circ}\text{C} \pm 5^{\circ}\text{C})$ .

##### 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.

#### 38.3.4.2 Test 2: Thermal Test

##### 38.3.4.2.1 Purpose

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

##### 38.3.4.2.2 Test Procedure

Test cells and batteries are to be stored for at least six hours at a test temperature equal to  $75 (\pm 2)^{\circ}\text{C}$ , followed by storage for at least six hours at a test temperature equal to  $-40 (\pm 2)^{\circ}\text{C}$ . The maximum

large  
 « When <sup>large</sup> batteries that have passed all applicable tests are electrically connected to form a large battery assembly, that large battery assembly does not need to be tested if it is equipped with a system capable of monitoring the large battery assembly and preventing short circuits, ~~or~~ ~~prevention of~~ over discharge between the batteries in the assembly and any overcharge of the large battery assembly. »

overheat or overtest

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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 ( $20 (\pm 5) ^\circ\text{C}$ ). For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

### 38.3.4.2.3 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.

### 38.3.4.3 Test 3: Vibration

#### 38.3.4.3.1 Purpose

This test simulates vibration during transport.

#### 38.3.4.3.2 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.

#### 38.3.4.3.3 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.

### 38.3.4.4 Test 4: Shock

#### 38.3.4.4.1 Purpose

This test simulates possible impacts during transport.

#### 38.3.4.4.2 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

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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<sub>n</sub> and pulse duration of 11 milliseconds. 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.

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.

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 with 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 ~~60°C~~ <sup>170°C</sup> 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~~ <sup>impact.</sup>

38.3.4.6.2 Test Procedure

~~The~~ <sup>The</sup> test sample cell or component cell is to be placed on a flat surface. A ~~15.8~~ <sup>15.8</sup> mm diameter bar is to be placed across the centre of the sample. A 9.1 kg weight is to be dropped from a height of 61 cm onto the sample.

A cylindrical or prismatic cell is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the ~~7.5~~ <sup>15.8</sup> mm diameter curved surface lying across the centre of the test sample. A prismatic cell is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the impact. Each sample is to be subjected to only a single impact. Separate samples are to be used for each impact.

A coin or button cell is to be impacted with the flat surface of the sample parallel to the flat surface and the ~~7.5~~ <sup>15.8</sup> mm diameter curved surface lying across its centre.

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~~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

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Cells and component cells meet this requirement if their external temperature does not exceed ~~160~~ °C and there is no disassembly and no fire within six hours of this test.

### 38.3.4.7 Test 7: Overcharge

#### 38.3.4.7.1 Purpose

This test 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 minimum voltage of the test shall be as follows:

- (a) when the manufacturer's recommended charge voltage is not more than 18V, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage of the battery or 22V.
- (b) when the manufacturer's recommended charge voltage is more than 18V, the minimum voltage of the test shall be 1.2 times the maximum charge voltage.

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

This 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.



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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.

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