TEST REPORT

ST/SG/AC.10/11/Rev.6/Amend.1

The transport of dangerous good, manual of tests and criteria

Report

Reference No.....: 190724151GZU-001

Tested by (+ signature).....: Brown Li Project Engineer .....

Approved by (+ signature) .....: Peter Lu Senior Engineer .....

Date of issue .....: 19-Aug-2019

Contents .....: 19 pages

Testing laboratory

Name .....: Intertek Testing Services Shenzhen Ltd. Guangzhou Branch

Address.....: Block E, No.7-2 Guang Dong Software Science Park, Caipin Road, Guangzhou Science City, GETDD, Guangzhou, China

Testing location.....: same as above

e-mail .....: sunny.yan@gdutl.com Telephone .....: 0086-769-3893-3228

Client

Name .....: Square Scrub LLC

Address.....: 196 County Road 702-Jonesboro, AR 72405, the United States

Test specification

Standard .....: ST/SG/AC.10/11/Rev.6/Amend.1, Part III, Subsection 38.3 (UN 38.3)

Test procedure .....: Testing

Procedure deviation.....: N/A

Non-standard test method .....: N/A

Test Report Form/blank test report

Test Report Form No. .....: UN38.3C

Test Report Form(s) Originator. .....: Intertek Testing Services Shenzhen Ltd. Guangzhou Branch

Master TRF.....: -

Test item

Description	Lithium ion rechargeable battery
Trademark:	SQUARE SCRUB
Model and/or type reference:	Li-18650

Manufacturer:	Suzhou Lumos New Energy Technology Co., Ltd. Room 203, 31st Building, Xin'tai Garden, SND, Suzhou City Jiangsu Province, China, 215011

e-mail: kevin.zhang@cnlumos.com Telephone: 0086-512-6841-5280 Website: www.cnlumos.com

Rating(s):	Model	Rating
	Li-18650	36V, 3200mAh, 115.2Wh

Particulars: test item vs. test requirements

Type of battery	:	Lithium ion rechargeable battery
Nominal voltage of battery	:	36V
Weight of battery	:	Approx. 556.58g
Standard charge voltage/current of battery	:	42V, 0.64A
Max. charge current of battery	:	2A
End charge current of battery	:	0.16A
Standard discharge current of battery	:	0.64A
Maximum discharge current of battery	:	4A
Cut-off voltage of battery	:	28V
Cell mode	:	INR18650-320
Cell number	:	10pcs
Nominal capacity of cell	:	3.6V
Weight of cell	:	Approx. 43.79g
Diameter of cell	:	Type: 18650
Standard charge voltage/current of cell	:	4.2V, 1.6A
Max. Charge current of cell	:	3.2A
End charge current of cell	:	0.16A
Standard discharge current of cell	:	0.64A
Maximum discharge current of cell	:	6.4A
Cut-off voltage of cell	:	2.5V

Test case verdicts

Test case does not apply to the test object	:	N/A
Test item does meet the requirement	:	P(ass)
Test item does not meet the requirement	:	F(ail)

Testing

Date of receipt of test item	:	24 Jul., 2019
Date(s) of performance of test	:	24 Jul., 2019~ 05 Aug., 2019

General remarks:

This test report shall not be reproduced except in full without the written approval of the testing laboratory.

The test results presented in this report relate only to the item tested.

Determination of the test result includes consideration of measurement uncertainty from the test equipment and methods.

"(see remark #)" refers to a remark appended to the report.

"(see appended table)" refers to a table appended to the report.

Throughout this report a point is used as the decimal separator.

The samples are executed necessary charging and discharging procedures according the Chapter 38.3.3 of this standard in the test site.

When determining the test conclusion, the Measurement Uncertainty of test has been considered.

The test report only allows to be revised only within the report defined retention period unless standard or regulation was withdrawn or invalid

Summary of testing:	
Tests performed (name of test and test clause): Battery: Test 1: Altitude simulation 38.3.4.1 Test 2: Thermal Test 38.3.4.2 Test 3: Vibration 38.3.4.3 Test 4: Shock 38.3.4.4 Test 5: External short circuit 38.3.4.5 Test 6: Impact / Crush 38.3.4.6 Test 7: Overcharge 38.3.4.7 Test 8: Forced discharge 38.3.4.8	**Testing location:** **Intertek Testing Services Shenzhen Ltd. Guangzhou Branch** Block E, No.7-2 Guang Dong Software Science Park, Caipin Road, Guangzhou Science City, GETDD, Guangzhou, China

38.3.4.1	**Test 1: Altitude simulation**	**P**
Purpose:	This test simulates air transport under low-pressure condition	
Test pressure:	Test cells and batteries shall be stored at a pressure of 11.6kPa or less for at least six hours at Ambient temperature(20±5°C)	
Requirement:	● No mass loss: mass loss does not exceed 0.5%(Mass of cell or battery < 1g); mass loss does not exceed 0.2%(1g<=Mass of cell or battery <= 75g); mass loss does not exceed 0.1%(Mass of cell or battery > 75g). ● No leakage, no venting, no disassembly, no rupture and no fire. ● After testing, voltage of fully charged battery shall ≥90% voltage before test. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.	

Data Record:									
Model	Sample No	Sample Status	Before test		After test		Mass Loss (%)	Residual OCV(%)	Other Event
			Weight (g)	OCV(v)	Weight (g)	OCV(v)			
Li-18650	001	At first cycle, in fully charged states	556.580	41.885	556.570	41.883	0.002	99.995	No
	002		556.217	41.885	556.217	41.884	0.000	99.998	No
	003		556.685	41.881	556.675	41.880	0.002	99.998	No
	004		556.519	41.883	556.499	41.882	0.004	99.998	No
	005	After 25 cycles ending in fully charged states	556.918	41.884	556.898	41.882	0.004	99.995	No
	006		556.844	41.886	556.834	41.885	0.002	99.998	No
	007		556.702	41.881	556.682	41.879	0.004	99.995	No
	008		556.223	41.880	556.203	41.879	0.004	99.998	No
Note: L-Leakage; V-Venting; D-Disassembly; R-Rupture; F-Fire; No- No leakage, No venting, No disassembly, No rupture, No fire.									

38.3.4.2	Test 2: Thermal Test	P

Purpose:	This test assesses cell and battery seal integrity and internal electrical connections. The test is conducted using rapid and extreme temperature changes.
Test procedure:	Test cells and batteries are to be stored for at least six hours at a test temperature equal to72± 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 until 10 total cycles are complete, 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.
Requirement:	● No mass loss: mass loss does not exceed 0.5%(Mass of cell or battery < 1g); mass loss does not exceed 0.2%(1g<=Mass of cell or battery <= 75g); mass loss does not exceed 0.1%(Mass of cell or battery > 75g). ● No leakage, no venting, no disassembly, no rupture and no fire. ● After testing, voltage of fully charged battery shall ≥90% voltage before test. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Data Record:

Model	Sample No	Sample Status	Before test		After test		Mass Loss (%)	Residual OCV(%)	Other Event
			Weight (g)	OCV(v)	Weight (g)	OCV(v)			
Li-18650	001	At first cycle, in fully charged states	556.570	41.883	556.290	41.866	0.050	99.959	No
	002		556.217	41.884	555.897	41.870	0.058	99.967	No
	003		556.675	41.880	556.305	41.861	0.066	99.955	No
	004		556.499	41.882	556.169	41.868	0.059	99.967	No
	005	After 25 cycles ending in fully charged states	556.898	41.882	556.558	41.867	0.061	99.964	No
	006		556.834	41.885	556.574	41.867	0.047	99.957	No
	007		556.682	41.879	556.342	41.869	0.061	99.976	No
	008		556.203	41.879	555.873	41.866	0.059	99.969	No

Note: L-Leakage; V-Venting; D-Disassembly; R-Rupture; F-Fire; No- No leakage, No venting, No disassembly, No rupture, No fire.

38,3,4,3	Test 3: Vibration	P
Purpose:	This test simulates vibration during transport.	
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 shall differ for cells and batteries with a gross mass of not more than 12 kg (cells and small batteries), and for batteries with a gross mass of more than 12 kg (large batteries). For cells and small batteries: from 7 Hz a peak acceleration of 1 gn 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 gn occurs (approximately 50 Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200 Hz. For large batteries: from 7 Hz to a peak acceleration of 1 gn 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 2 gn occurs (approximately 25 Hz). A peak acceleration of 2 gn is then maintained until the frequency is increased to 200 Hz.	
Requirement:	● No mass loss: mass loss does not exceed 0.5%(Mass of cell or battery < 1g); mass loss does not exceed 0.2%(1g<=Mass of cell or battery <= 75g); mass loss does not exceed 0.1%(Mass of cell or battery > 75g). ● No leakage, no venting, no disassembly, no rupture and no fire, ● After testing, voltage of fully charged battery shall ≥90% voltage before test. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.	

Data Record:

Model	Sample No	Sample Status	Before test		After test		Mass Loss (%)	Residual OCV(%)	Other Event
			Weight (g)	OCV(v)	Weight (g)	OCV(v)			
Li-18650	001	At first cycle, in fully charged states	556.290	41.866	556.270	41.864	0.004	99.995	No
	002		555.897	41.870	555.887	41.869	0.002	99.998	No
	003		556.305	41.861	556.305	41.860	0.000	99.998	No
	004		556.169	41.868	556.159	41.866	0.002	99.995	No
	005	After 25 cycles ending in fully charged states	556.558	41.867	556.548	41.865	0.002	99.995	No
	006		556.574	41.867	556.574	41.865	0.000	99.995	No
	007		556.342	41.869	556.322	41.868	0.004	99.998	No
	008		555.873	41.866	555.853	41.864	0.004	99.995	No

Note: L-Leakage; V-Venting; D-Disassembly; R-Rupture; F-Fire; No- No leakage, No venting, No disassembly, No rupture, No fire.

<table>
<tr><td>38,3,4,4</td><td colspan="2">Test 4: Shock</td><td>P</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Purpose:</td><td colspan="3">This test simulates possible impacts during transport.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Test procedure:</td><td colspan="3">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 halfsine shock of peak acceleration of 150 gn and pulse duration of 6 milliseconds.
Alternatively, large cells may be subjected to a half-sine shock of peak acceleration of 50 gn and pulse duration of 11 milliseconds.

Each battery shall be subjected to a half-sine shock of peak acceleration depanding on the mass of the battery. The pulse duration shall be 11 milliseconds for large batteries.The formulas below are provided to calculate the appropriate minimm peak accelerations.
<table>
<tr><th>Battery</th><th>Minimum peak acceleration</th><th>Pulse duration</th></tr>
<tr><td>Small batteries</td><td>150 g_n or result of formula
$Acceleration(g_n) = \sqrt{\left(\frac{100850}{mass^a}\right)}$
whichever is smaller</td><td>6 ms</td></tr>
<tr><td>Large batteries</td><td>50 g_n or result of formula
$Acceleration(g_n) = \sqrt{\left(\frac{30000}{mass^a}\right)}$
whichever is smaller</td><td>11 ms</td></tr>
</table>
[a] Mass is expressed in kilograms.

Each cell or battery is subjected to three shocks in the positive direction followed by three shocks in the negative direction of each of three mutually perpendicular mounting positions of the cell for a total of 18 shocks.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Requirement:</td><td colspan="3">● No mass loss:
mass loss does not exceed 0.5%(Mass of cell or battery < 1g);
mass loss does not exceed 0.2%(1g<=Mass of cell or battery <= 75g);
mass loss does not exceed 0.1%(Mass of cell or battery > 75g).
● No leakage, no venting, no disassembly, no rupture and no fire,
● After testing, voltage of fully charged battery shall ≥90% voltage before test.
The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.</td></tr>
</table>

Data Record:									
Model	Sample No	Sample Status	Before test		After test		Mass Loss (%)	Residual OCV(%)	Other Event
			Weight (g)	OCV(v)	Weight (g)	OCV(v)			
Li-18650	001	At first cycle, in fully charged states	556.270	41.864	556.260	41.862	0.002	99.995	No
	002		555.887	41.869	555.887	41.868	0.000	99.998	No
	003		556.305	41.860	556.305	41.859	0.000	99.998	No
	004		556.159	41.866	556.139	41.864	0.004	99.995	No
	005	After 25 cycles ending in fully charged states	556.548	41.865	556.528	41.864	0.004	99.998	No
	006		556.574	41.865	556.564	41.864	0.002	99.998	No
	007		556.322	41.868	556.312	41.866	0.002	99.995	No
	008		555.853	41.864	555.843	41.863	0.002	99.998	No
Note: L-Leakage; V-Venting; D-Disassembly; R-Rupture; F-Fire; No- No leakage, No venting, No disassembly, No rupture, No fire.									

38,3,4,5	**Test 5: External short circuit**	**P**
Purpose:	This test simulates an external short circuit.	
Test procedure:	The cell or battery to be tested shall be temperature stabilized so that its external case temperature reaches **57 ± 4** °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 57 ± 4 °C. This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to 57 ± 4 °C. The short circuit and cooling down phases shall be conducted at least at ambient temperature.	
Requirement:	● External temperature does not exceed 170°C, ● No disassembly, no rupture and no fire during the test and within 6 hours after the test and within six hours after the test.	

Data Record:				
Model	Sample No	Sample Status	External peak temperature(°C)	Other Event
Li-18650	001	At first cycle, in fully charged states	57.7	No
	002		58.0	No
	003		57.9	No
	004		58.0	No
	005	After 25 cycles ending in fully charged states	57.4	No
	006		57.9	No
	007		57.3	No
	008		57.3	No
Note: L-Leakage; V-Venting; D-Disassembly; R-Rupture; F-Fire; No- No disassembly, no rupture and no fire during the test and within 6 hours after the test and within six hours after the test.				

38,3,4,6	Test 6: Impact	P
Purpose:	These tests simulate mechanical abuse from an impact or crush that may result in an internal short circuit.	
Impact		
Test procedure:	The sample cell or component cell is to be placed on a flat smooth surface. A 15.8 mm ± 0.1mm diameter, at least 6 cm long, or the longest dimension of the cell, whichever is greater, Type 316 stainless steel bar is to be placed across the centre of the sample. A 9.1kg ± 0.1kg mass is to be dropped from a height of 61 ± 2.5 cm at the intersection of the bar and sample in a controlled manner using a near frictionless, vertical sliding track or channel with minimal drag on the falling mass. The vertical track or channel used to guide the falling mass shall be oriented 90 degrees from the horizontal supporting surface. The test sample is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 15.8 mm ± 0.1mm diameter curved surface lying across the centre of the test sample. Each sample is to be subjected to only a single impact.	
Requirement:	● External case temperature does not exceed 170°C, ● No disassembly and no fire during the test and within 6 hours after test.	

Data Record:			
Sample No	Sample Status	Max, External Temperature (°C)	Other Event
009	At first cycle at 50% of the design rated capacity	73.1	No
010		78.2	No
011		76.5	No
012		70.8	No
013		71.3	No
014	After 25 cycles ending at 50% of the design rated capacity	73.3	No
015		81.2	No
016		79.3	No
017		81.5	No
018		73.2	No
Note: D-Disassembly; R-Rupture; F-Fire; No- No disassembly, No rupture, No fire, The test sample component cell of rechargeable batteries.			

38,3,4,7	Test 7: Overcharge	P
Purpose:	This test evaluates the ability of a rechargeable battery to withstand an overcharge condition.	
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.	
Requirement:	● No disassembly and no fire during the test and within seven days after the test.	

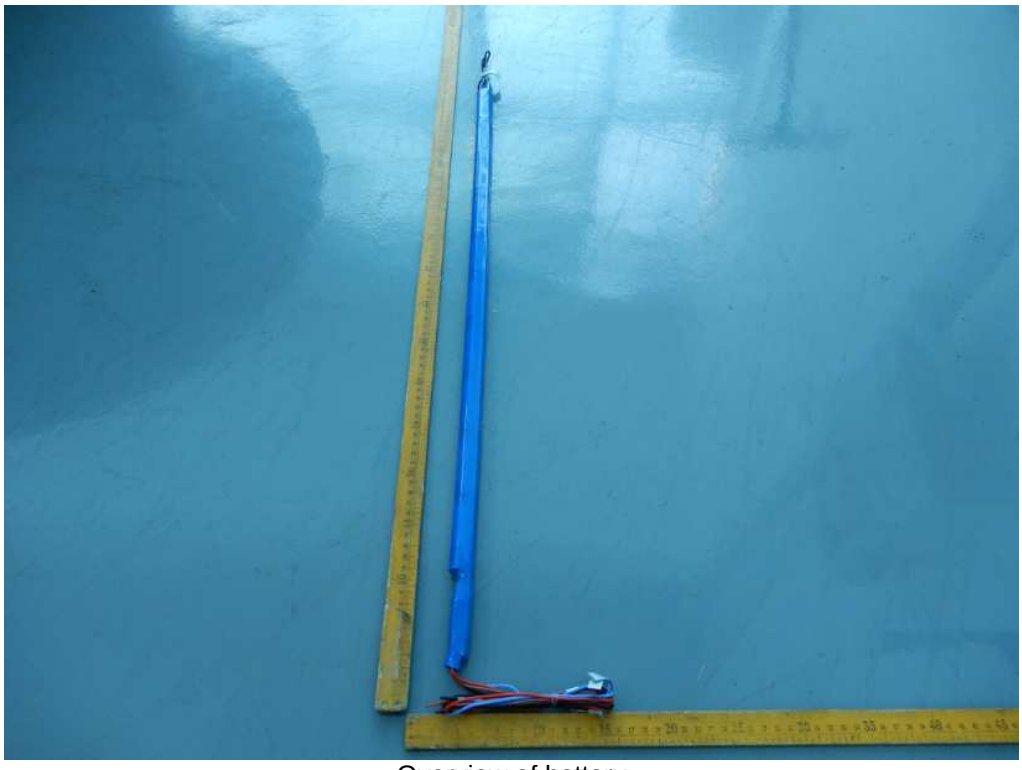
Data Record:			
Model	Sample No	Sample Status	Other Event
Li-18650	019	At first cycle, in fully charged states	No
	020		No
	021		No
	022		No
	023	After 25 cycles ending in fully charged states	No
	024		No
	025		No
	026		No
Note: D-Disassembly; F-Fire; No- No disassembly, No fire,			

38,3,4,8	Test 8: Forced discharge	P
Purpose:	This test evaluates the ability of a primary or a rechargeable cell to withstand a forced discharge condition.	
Test procedure:	Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12V 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).	
Requirement:	● No disassembly and no fire during the test and within seven days after the test.	

Data Record:		
Sample No	Sample Status	Other Event
027	At first cycle in fully discharged states	No
028		No
029		No
030		No
031		No
032		No
033		No
034		No
035		No
036		No
037	After 25 cycles ending in fully discharged states	No
038		No
039		No
040		No
041		No
042		No
043		No
044		No
045		No
046		No
Note: D-Disassembly; F-Fire; No- No disassembly, No fire,		

Appendix: Photos

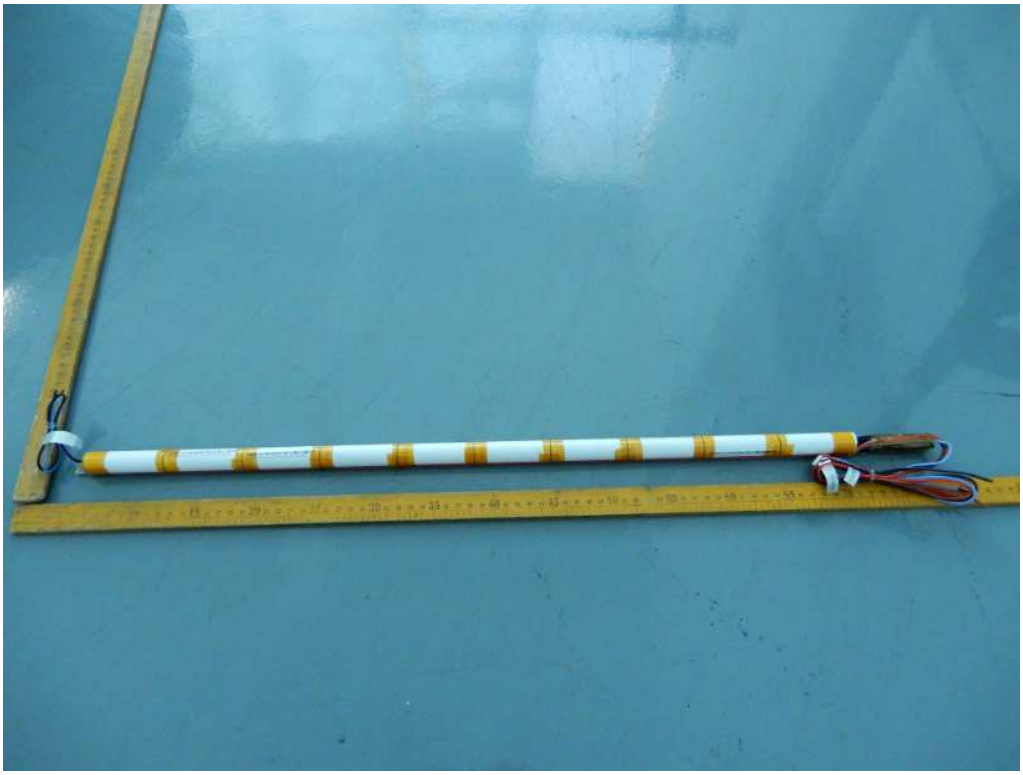
Overview of battery



Overview of battery

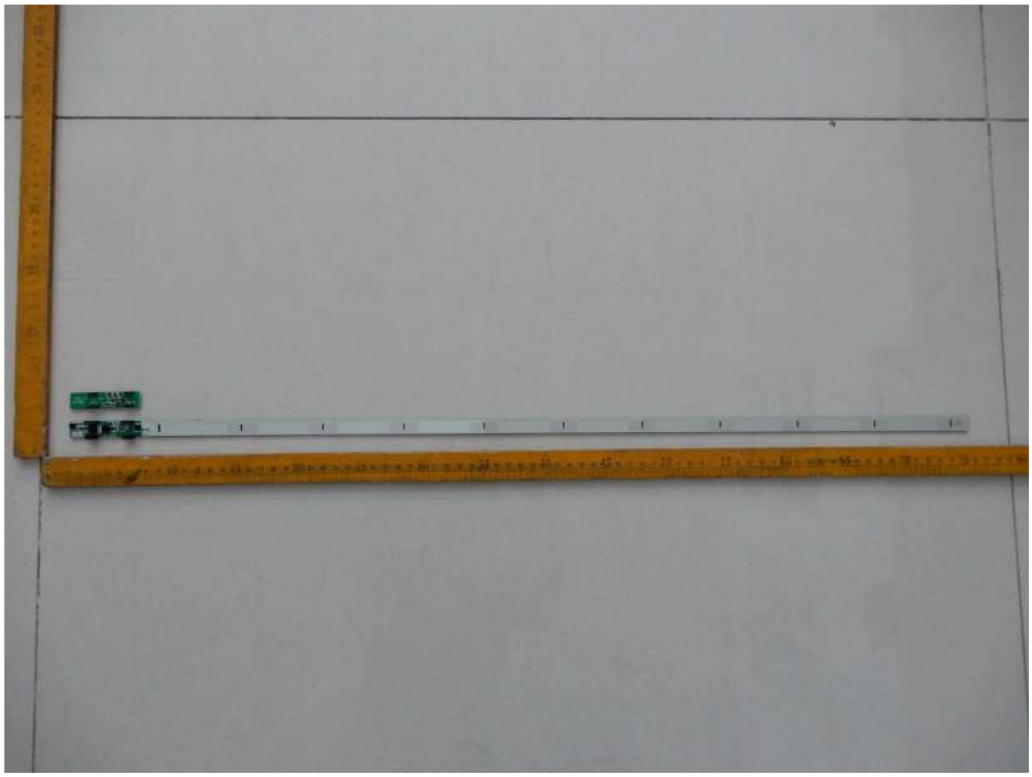
Appendix: Photos

Overview of battery

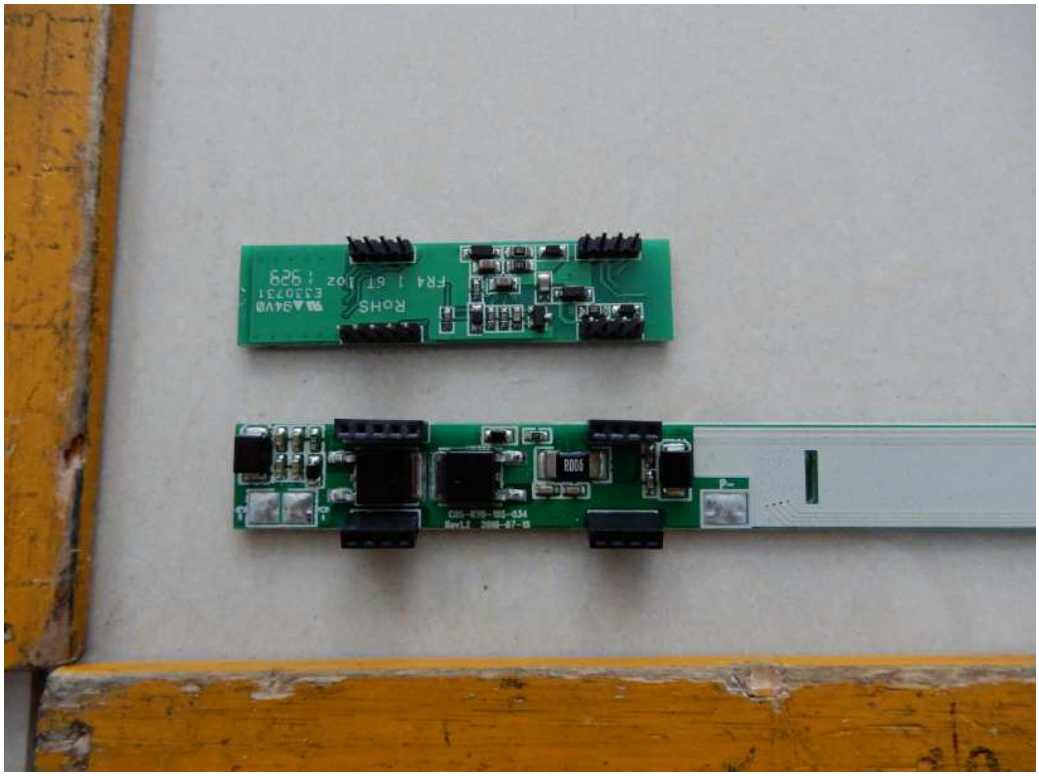


Internal view of battery

Appendix: Photos



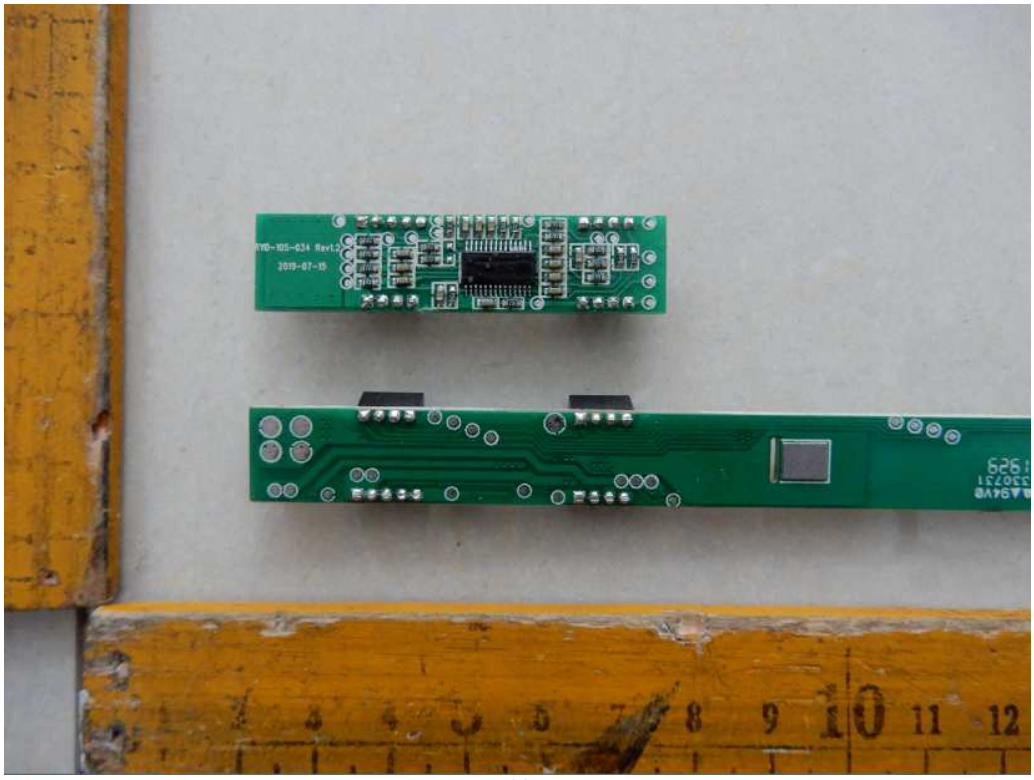
PCB of battery



PCB of battery

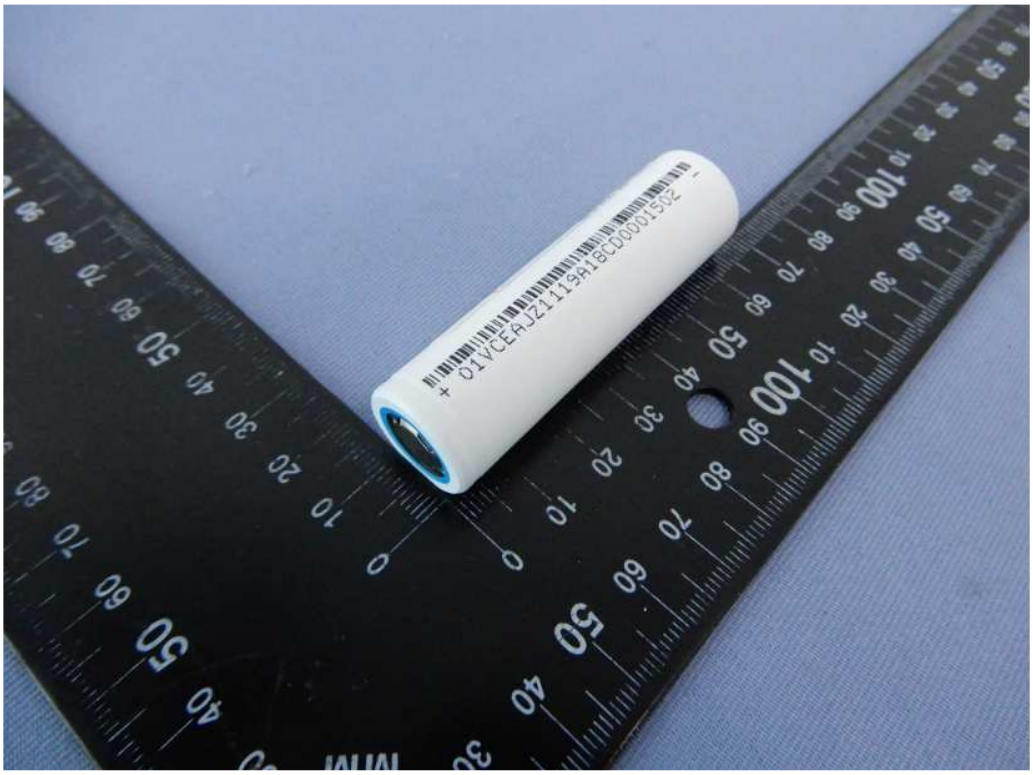
Appendix: Photos

PCB of battery

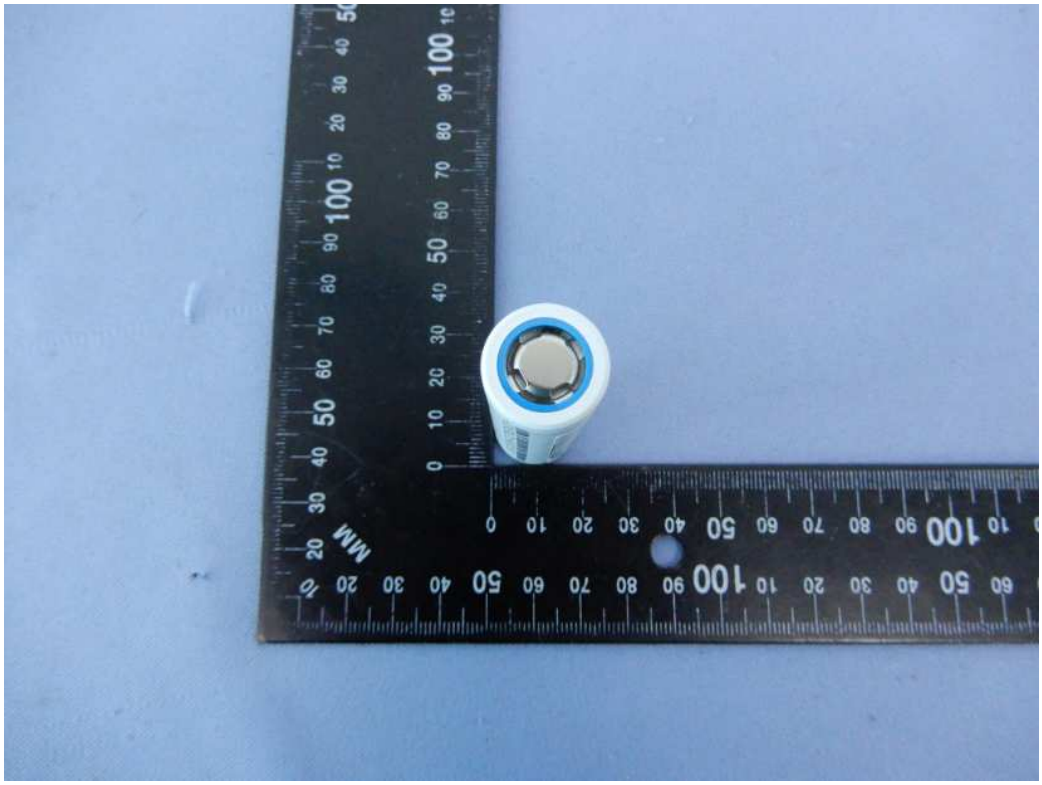


PCB of battery

Appendix: Photos



Cell view



Cell view

------End of Report-------