TEST REPORT

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

The transport of dangerous good, manual of tests and criteria

Report

Reference No.....: 190718023GZU-001

Tested by (+ signature).....: Vin Zhou Vin .....

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

Date of issue .....: 23-Sep-2019

Contents .....: 16 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

Client

Name .....: Arapaho Technologies Inc

Address.....: 4756 McKinley Drive, Boulder, Colorado 80303, USA

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	Li-ion Polymer Battery	
Trademark:	N/A	
Model and/or type reference:	LABat-001	
Manufacturer:	Shenzhen Sun Ease Battery Company 8211 Room, YintaiBuilding, Dalang Street, Longhua, Shenzhen	
Rating(s):	Model	Rating
	LABat-001	11.1V, 500mAh, 5.55Wh

Particulars: test item vs. test requirements		
Type of battery	:	Lithium ion rechargeable battery
Nominal voltage of battery	:	11.1V
Weight of battery	:	Approx. 60.5g
Standard charge voltage/current of battery	:	12.6V, 250mA
Max. charge current of battery	:	500mA
End charge current of battery	:	5mA
Standard discharge current of battery	:	250mA
Maximum discharge current of battery	:	500mA
Cut-off voltage of battery	:	9.0V
Cell mode	:	503035
Cell number	:	3PCS
Nominal capacity of cell	:	3.7V, 500mAh
Weight of cell	:	Approx. 8.0g
Diameter of cell	:	35*30*5mm
Standard charge voltage/current of cell	:	4.2V, 250mA
Max. Charge current of cell	:	500mA
End charge current of cell	:	5mA
Standard discharge current of cell	:	250mA
Maximum discharge current of cell	:	1000mA
Cut-off voltage of cell	:	2.75V

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~ 06 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.

Determination of the test conclusion is based on IEC Guide 115 in consideration of measurement uncertainty. This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to permit copying or distribution of this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.

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)			
LABat-001	001	At first cycle, in fully charged states	61.056	12.571	61.051	12.562	0.008	99.928	No
	002		60.707	12.574	60.704	12.562	0.005	99.905	No
	003		61.132	12.570	61.127	12.561	0.008	99.928	No
	004		61.077	12.572	61.074	12.560	0.005	99.905	No
	005	After 25 cycles ending in fully charged states	61.618	12.571	61.613	12.562	0.008	99.928	No
	006		60.894	12.573	60.889	12.561	0.008	99.905	No
	007		60.936	12.571	60.933	12.559	0.005	99.905	No
	008		61.037	12.572	61.032	12.563	0.008	99.928	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)			
LABat-001	001	At first cycle, in fully charged states	61.051	12.562	61.045	12.442	0.010	99.045	No
	002		60.704	12.562	60.694	12.433	0.016	98.973	No
	003		61.127	12.561	61.121	12.441	0.010	99.045	No
	004		61.074	12.560	61.064	12.431	0.016	98.973	No
LABat-001	005	After 25 cycles ending in fully charged states	61.613	12.562	61.603	12.433	0.016	98.973	No
	006		60.889	12.561	60.883	12.441	0.010	99.045	No
	007		60.933	12.559	60.923	12.430	0.016	98.973	No
	008		61.032	12.563	61.026	12.434	0.010	98.973	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)			
LABat-001	001	At first cycle, in fully charged states	61.045	12.442	61.042	12.433	0.005	99.928	No
	002		60.694	12.433	60.689	12.421	0.008	99.903	No
	003		61.121	12.441	61.118	12.432	0.005	99.928	No
	004		61.064	12.431	61.059	12.419	0.008	99.903	No
LABat-001	005	After 25 cycles ending in fully charged states	61.603	12.433	61.598	12.421	0.008	99.903	No
	006		60.883	12.441	60.880	12.432	0.005	99.928	No
	007		60.923	12.430	60.918	12.418	0.008	99.903	No
	008		61.026	12.434	61.021	12.422	0.008	99.903	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>Test 4: Shock</td><td>P</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Purpose:</td><td colspan="2">This test simulates possible impacts during transport.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Test procedure:</td><td colspan="2">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="3"></td></tr>
<tr><td>Requirement:</td><td colspan="2">● 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)			
LABat-001	001	At first cycle, in fully charged states	61.042	12.433	61.037	12.424	0.008	99.928	No
	002		60.689	12.421	60.686	12.409	0.005	99.903	No
	003		61.118	12.432	61.113	12.423	0.008	99.928	No
	004		61.059	12.419	61.054	12.407	0.008	99.903	No
LABat-001	005	After 25 cycles ending in fully charged states	61.598	12.421	61.595	12.409	0.005	99.903	No
	006		60.880	12.432	60.875	12.423	0.008	99.928	No
	007		60.918	12.418	60.915	12.409	0.005	99.928	No
	008		61.021	12.422	61.016	12.410	0.008	99.903	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.	

Model	Sample No	Sample Status	External peak temperature(°C)	Other Event
LABat-001	001	At first cycle, in fully charged states	57.1	No
	002		57.3	No
	003		57.5	No
	004		57.6	No
LABat-001	005	After 25 cycles ending in fully charged states	57.4	No
	006		57.2	No
	007		57.3	No
	008		57.1	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: Crush	P
Purpose:	These tests simulate mechanical abuse from an impact or crush that may result in an internal short circuit.	
Crush		
Test procedure:	A cell or component cell is to be crushed between two flat surfaces. The crushing is to be gradual with a speed of approximately 1.5 cm/s at the first point of contact. The crushing is to be continued until the first of the three options below is reached. (a) The applied force reaches 13 kN ± 0.78 kN; Example: The force shall be applied by a hydraulic ram with a 32 mm diameter piston until a pressure of 17 MPa is reached on the hydraulic ram. (b) The voltage of the cell drops by at least 100 mV; or (c) The cell is deformed by 50% or more of its original thickness. Once the maximum pressure has been obtained, the voltage drops by 100 mV or more, or the cell is deformed by at least 50% of its original thickness, the pressure shall be released. A prismatic or pouch cell shall be crushed by applying the force to the widest side. A button/coin cell shall be crushed by applying the force on its flat surfaces. For cylindrical cells, the crush force shall be applied perpendicular to the longitudinal axis. Each test cell or component cell is to be subjected to one crush only. The test sample shall be observed for a further 6 h. The test shall be conducted using test cells or component cells that have not previously been subjected to other tests.	
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	24.9	No
010		24.6	No
011		24.5	No
012		24.8	No
013		25.0	No
014	After 25 cycles ending at 50% of the design rated capacity	24.8	No
015		24.7	No
016		24.9	No
017		24.6	No
018		24.7	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.	

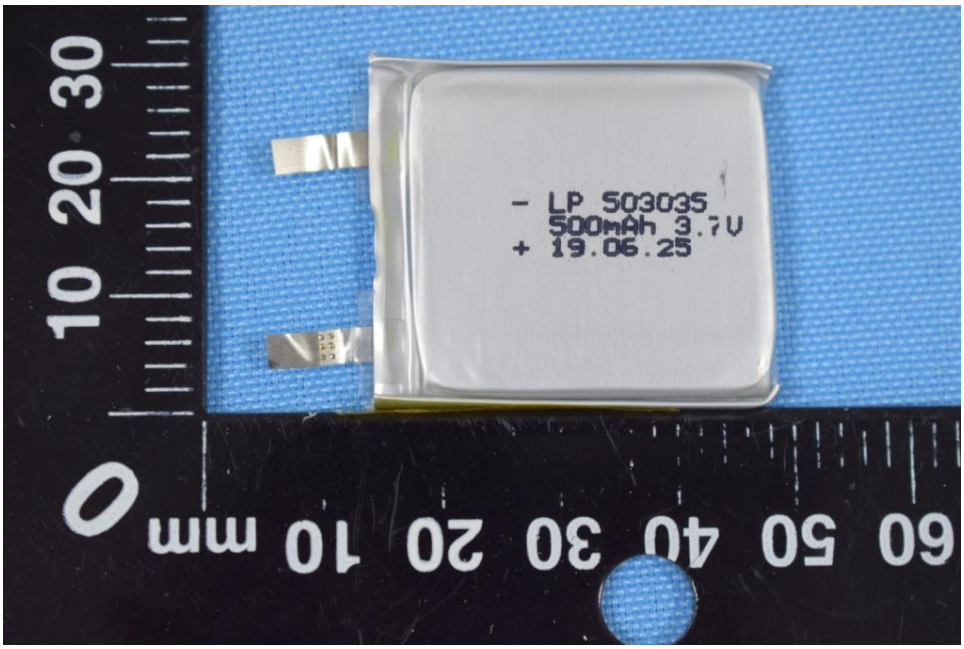
Data Record:			
Model	Sample No	Sample Status	Other Event
LABat-001	019	At first cycle, in fully charged states	No
	020		No
	021		No
	022		No
	023	After 25 cycles ending in fully charged states	No
	024		No
	025		No
	026		No
Note: D-Disassembly; F-Fire; No- No disassembly, No fire,			

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.	

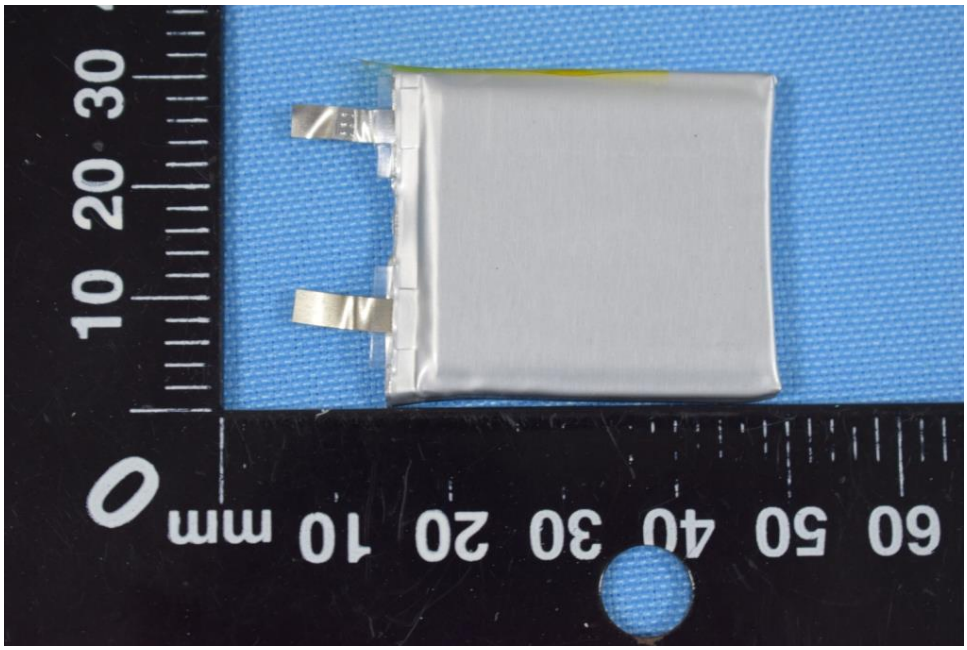
Data Record:		
Sample No	Sample Status	Other Event
027	At first cycle in fully discharged states	No
028		No
029		No
030		No
031		No
032		No
033		No
034		No
035		No
036		No
037	After 25 cycles ending in fully discharged states	No
038		No
039		No
040		No
041		No
042		No
043		No
044		No
045		No
046		No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

Overview of battery

Overview of battery

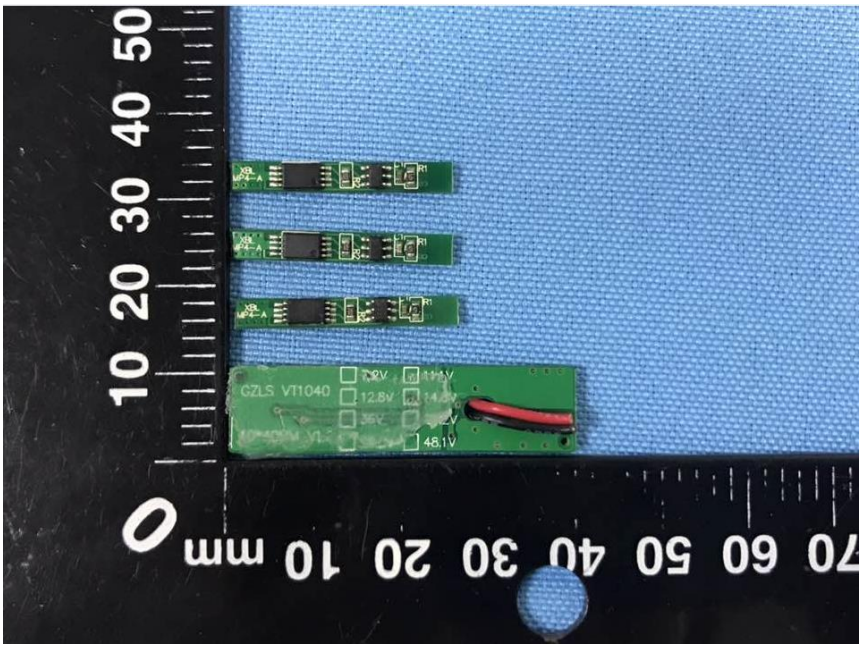


Overview of cell

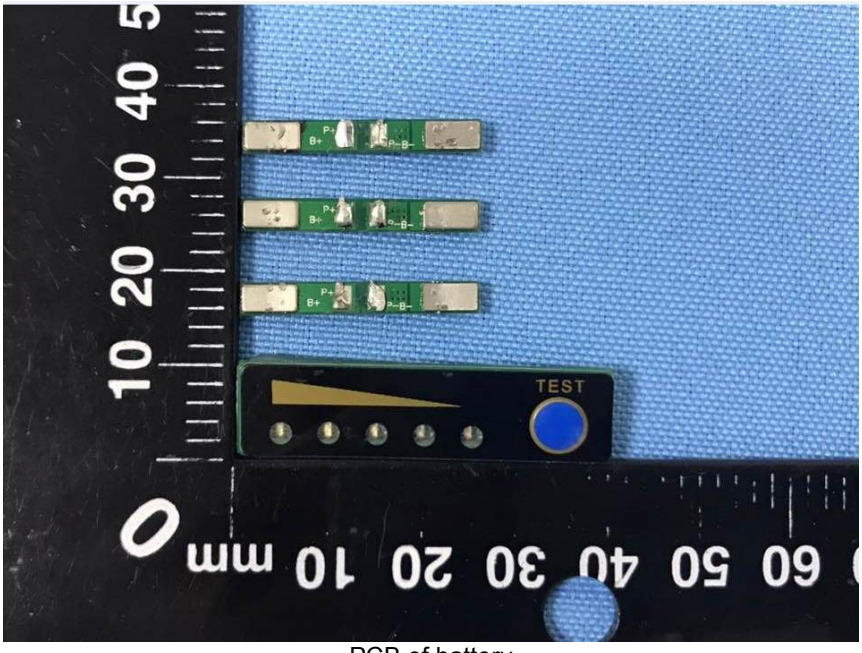


Overview of cell

Appendix: Photos



PCB of battery



PCB of battery

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