LITHIUM ION BATTERY SAFETY TESTING REPORT

Applicant:	Eurogreen International INC. No. 48, Lane 220, Sec 1, Fu-Zun Rd., Yuan-Lin City, Chang-Hua County 51055, Taiwan, R.O.C. Tel: +886-4-831-9633 ; E-mail: amy@supamobility.com Website: www.supamobility.com
Product:	Lithium-Ion Battery
Model:	9037905: SUP-001-25.2Vx11.6Ah
Rating:	25.2 Vdc, 274.4 Wh, 11.6 Ah
Test method & Criterion	UNITED NATIONS "Recommendations on the TRANSPORT OF DANGEROUS GOODS" Manual of Tests and Criteria ST/SG/AC.10/11/Rev.6/Amend.1
Appearance	Plastic shell
Verification Issuing Office Name	AnTek Certification Inc. 7F., No. 351, Yangguang St., Neihu District, Taipei City, Taiwan Tel: +886-2-8752-3779 ; Website, E-mail: atc@atclab.com.tw
Test Performed Date:	Jun. 27, 2019 – Jul. 18, 2019
Test Items:	See Page 2 for details.
Conclusion:	The sample has passed the test items of UN 38.3
Date of Issued:	Jul. 23, 2019
Comment:	Internal cell source: Panasonic / NCR18650PF

Prepared by:

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TEST ITEMS

No.	Name of Test Items	Conclusion	Remark
T1.	Altitude Simulation	Passed	--
T2.	Thermal Test	Passed	--
T3.	Vibration	Passed	--
T4.	Shock	Passed	--
T5.	External Short Circuit	Passed	--
T6.	Impact	Passed	--
	Crush	N/A	--
T7.	Overcharge	Passed	--
T8.	Forced Discharge	Passed	--
Test Environment Condition	Ambient Temperature: 24.0 °C ~ 24.5 °C Ambient Humidity: 52% ~ 58%		

SAMPLES FOR TYPE TESTS:

Test Number	Cell / Battery Type	Test Samples
T1 ~ T5	☐ Primary Cells	Ten cells in undischarged states Ten cells in fully discharged states
	☐ Primary Batteries (Small Type)	Four batteries in undischarged states Four batteries in fully discharged states
	☐ Primary Batteries (Large Type)	Four batteries in undischarged states Four batteries in fully discharged states
	☐ Rechargeable Cells	Five cells at first cycle, in fully charged states Five cells after 25 cycles ending in fully charged states
	☐ Single Cell type Battery	Five cells at first cycle, in fully charged states Five cells after 25 cycles ending in fully charged states
	☒ Rechargeable Batteries (Small Type)	Four batteries at first cycle, in fully charged states Four batteries after 25 cycles ending in fully charged states
	☐ Rechargeable Batteries (Large Type)	Two batteries at first cycle, in fully charged states Two batteries after 25 cycles ending in fully charged states
T6	☐ Primary cells	Five cells in undischarged states Five cells in fully discharged states
	☐ Component cells of primary batteries	Five cells in undischarged states Five cells in fully discharged states
	☐ Rechargeable cells	Five cells at first cycle at 50% of the design rated capacity Five cells after 25 cycles ending at 50% of the design rated capacity
	☒ Component cells of rechargeable batteries	Five cells at first cycle at 50% of the design rated capacity Five cells after 25 cycles ending at 50% of the design rated capacity
T7	☒ Rechargeable Batteries (Small Type)	Four batteries at first cycle, in fully charged states Four batteries after 25 cycles ending in fully charged states
	☐ Rechargeable Batteries (Large Type)	Two batteries at first cycle, in fully charged states Two batteries after 25 cycles ending in fully charged states
T8	☐ Primary cells	Ten cells in fully discharged states
	☐ Primary component cells	Ten cells in fully discharged states
	☐ Rechargeable cells	Ten cells, at first cycle in fully discharged states Ten cells after 25 cycles ending in fully discharged states
	☒ Rechargeable component cells	Ten cells, at first cycle in fully discharged states Ten cells after 25 cycles ending in fully discharged states

T1: Altitude Simulation

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 (20 ± 5 °C).

Requirement:

Cells and batteries meet this requirement if there is 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.

Results:

Sample No	Sample State	Before Test		After Test		Mass Loss (%)	Residual Voltage (%)	Phenomenon
		Mass (g)	Open-Circuit Voltage (V)	Mass (g)	Open-Circuit Voltage (V)			
01	A	1830.2	29.267	1830.1	29.265	0.01	99.99	O
02	A	1830.5	29.261	1830.3	29.259	0.01	99.99	O
03	A	1831.1	29.263	1831.0	29.261	0.01	99.99	O
04	A	1830.7	29.259	1830.6	29.258	0.01	100.00	O
05	B	1830.5	29.268	1830.5	29.267	0.00	100.00	O
06	B	1831.2	29.262	1831.1	29.261	0.01	100.00	O
07	B	1830.4	29.268	1830.3	29.267	0.01	100.00	O
08	B	1830.2	29.267	1830.1	29.265	0.01	99.99	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
L – Leakage; V – Venting; D – Disassembly; R – Rupture; F – Fire.
O - No leakage, no venting, no disassembly, no rupture and no fire.

T2: Thermal Test

Test procedure:

Test cells and batteries are to be stored for at least six hours at a test temperature equal to 72 ± 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:

Cells and batteries meet this requirement if there is 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.

Results:

Sample No	Sample State	Before Test		After Test		Mass Loss (%)	Residual Voltage (%)	Phenomenon
		Mass (g)	Open-Circuit Voltage (V)	Mass (g)	Open-Circuit Voltage (V)			
01	A	1830.1	29.265	1829.1	28.912	0.05	98.79	O
02	A	1830.3	29.259	1829.5	28.891	0.04	98.74	O
03	A	1831.0	29.261	1830.2	28.873	0.04	98.67	O
04	A	1830.6	29.258	1829.8	28.871	0.04	98.68	O
05	B	1830.5	29.267	1830.1	28.902	0.02	98.75	O
06	B	1831.1	29.261	1830.4	28.898	0.04	98.76	O
07	B	1830.3	29.267	1829.6	28.889	0.04	98.71	O
08	B	1830.1	29.265	1829.3	28.881	0.04	98.69	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
L – Leakage; V – Venting; D – Disassembly; R – Rupture; F – Fire.
O - No leakage, no venting, no disassembly, no rupture and no fire.

T3: Vibration

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:

Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire during the test and after the test and if the open circuit voltage of each test cell or battery directly after testing in its third perpendicular mounting position 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.

Results:

Sample No	Sample State	Before Test		After Test		Mass Loss (%)	Residual Voltage (%)	Phenomenon
		Mass (g)	Open-Circuit Voltage (V)	Mass (g)	Open-Circuit Voltage (V)			
01	A	1829.1	28.912	1829.0	28.907	0.01	99.98	O
02	A	1829.5	28.891	1829.3	28.888	0.01	99.99	O
03	A	1830.2	28.873	1830.1	28.869	0.01	99.99	O
04	A	1829.8	28.871	1829.6	28.867	0.01	99.99	O

Sample No	Sample State	Before Test		After Test		Mass Loss (%)	Residual Voltage (%)	Phenomenon
		Mass (g)	Open-Circuit Voltage (V)	Mass (g)	Open-Circuit Voltage (V)			
05	B	1830.1	28.902	1829.9	28.897	0.01	99.98	O
06	B	1830.4	28.898	1830.3	28.893	0.01	99.98	O
07	B	1829.6	28.889	1829.4	28.884	0.01	99.98	O
08	B	1829.3	28.881	1829.2	28.876	0.01	99.98	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
L – Leakage; V – Venting; D – Disassembly; R – Rupture; F – Fire.
O - No leakage, no venting, no disassembly, no rupture and no fire.

T4: Shock

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 shall be subjected to a half-sine 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 depending on the mass of the battery. The pulse duration shall be 6 milliseconds for small batteries and 11 milliseconds for large batteries. The formulas below are provided to calculate the appropriate minimum peak accelerations.

Battery	Minimum peak acceleration	Pulse duration
Small batteries	150 g_n or result of formula $Acceleration(g_n) = \sqrt{\left(\frac{100850}{mass^{a}}\right)}$ whichever is smaller	6 ms
Large batteries	50 g_n or result of formula $Acceleration(g_n) = \sqrt{\left(\frac{30000}{mass^{a}}\right)}$ whichever is smaller	11 ms

[a] Mass is expressed in kilograms.

Each cell or battery shall be subjected to three shocks in the positive direction and to three shocks in the negative direction in each of three mutually perpendicular mounting positions of the cell or battery for a total of 18 shocks.

Requirement:

Cells and batteries meet this requirement if there is 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.

Results:

Sample No	Sample State	Before Test		After Test		Mass Loss (%)	Residual Voltage (%)	Phenomenon
		Mass (g)	Open-Circuit Voltage (V)	Mass (g)	Open-Circuit Voltage (V)			
01	A	1829.0	28.907	1828.8	28.906	0.01	100.00	O
02	A	1829.3	28.888	1829.2	28.887	0.01	100.00	O
03	A	1830.1	28.869	1830.0	28.867	0.01	99.99	O
04	A	1829.6	28.867	1829.5	28.865	0.01	99.99	O
05	B	1829.9	28.897	1829.7	28.895	0.01	99.99	O
06	B	1830.3	28.893	1830.1	28.891	0.01	99.99	O
07	B	1829.4	28.884	1829.2	28.883	0.01	100.00	O
08	B	1829.2	28.876	1829.1	28.874	0.01	99.99	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
L – Leakage; V – Venting; D – Disassembly; R – Rupture; F – Fire.
O - No leakage, no venting, no disassembly, no rupture and no fire.

T5: External Short Circuit

Test procedure:

The cell or battery to be tested shall be shall be heated for a period of time necessary to reach a homogeneous stabilized temperature of 57 ± 4 °C, measured on the external case. This period of time depends on the size and design of the cell or battery and should be assessed and documented. If this assessment is not feasible, the exposure time shall be at least 6 hours for small cells and small batteries, and 12 hours for large cells and large batteries. Then the cell or battery at 57 ± 4 °C shall be subjected to one short circuit condition with a total external resistance of less than 0.1 ohm.

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, or in the case of the large batteries, has decreased by half of the maximum temperature increase observed during the test and remains below that value.

The short circuit and cooling down phases shall be conducted at least at ambient temperature.

Requirement:

Cells and batteries meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly, no rupture and no fire during the test and within six hours after the test.

Results:

Sample No	Sample State	External Highest Temperature (°C)	Initial Voltage(V)	External resistance(mΩ)	Phenomenon
01	A	56.9	28.906	75.74	O
02	A	56.8	28.887	80.81	O
03	A	56.5	28.867	80.39	O
04	A	56.9	28.865	75.35	O
05	B	56.8	28.895	81.64	O
06	B	56.9	28.891	81.21	O
07	B	56.9	28.883	77.25	O
08	B	56.8	28.874	79.28	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
L – Leakage; V – Venting; D – Disassembly; R – Rupture; F – Fire.
O - No leakage, no venting, no disassembly, no rupture and no fire.

T6: Impact/Crush

☒ Test procedure - Impact (applicable to cylindrical cells not less than 18.0 mm in diameter):

The test sample cell or component cell is to be placed on a flat smooth surface. A 15.8 mm ± 0.1 mm 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 9.1 kg ± 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 ± 0.1 mm diameter curved surface lying across the centre of the test sample. Each sample is to be subjected to only a single impact.

☐ Test procedure - Crush (applicable to prismatic, pouch, coin/button cells and cylindrical cells less than 18.0 mm in diameter):

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.

Note: Diameter here refers to the design parameter (for example the diameter of 18650 cells is 18.0 mm).

Requirement:

Cells and component cells meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly and no fire during the test and within six hours after this test.

Results:

Sample No	Sample State	External Highest Temperature (°C)	Phenomenon
17	A	29.1	O
18	A	28.5	O
19	A	30.2	O
20	A	27.4	O
21	A	29.6	O
22	B	29.3	O
23	B	28.5	O
24	B	27.5	O
25	B	30.0	O
26	B	30.6	O

Sample state:
A – Cell at first cycle at 50% of the design rated capacity.
B – Cell after 25 cycles ending at 50% of the design rated capacity.
Phenomenon:
D – Disassembly; F – Fire; O - No disassembly and no fire;

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T7: Overcharge

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

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

Results:

Sample No	Sample State	During Test		Phenomenon
		Charge Current	Charge Voltage	
09	A	10.00 A	35.28 V	O
10	A	10.00 A	35.28 V	O
11	A	10.00 A	35.28 V	O
12	A	10.00 A	35.28 V	O
13	B	10.00 A	35.28 V	O
14	B	10.00 A	35.28 V	O
15	B	10.00 A	35.28 V	O
16	B	10.00 A	35.28 V	O

Sample state:
A – Battery at first cycle, in fully charged states.
B – Battery after 25 cycles ending in fully charged states.
Phenomenon:
D – Disassembly; F – Fire; O - No disassembly and no fire.

T8: Forced Discharge

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

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

Results:

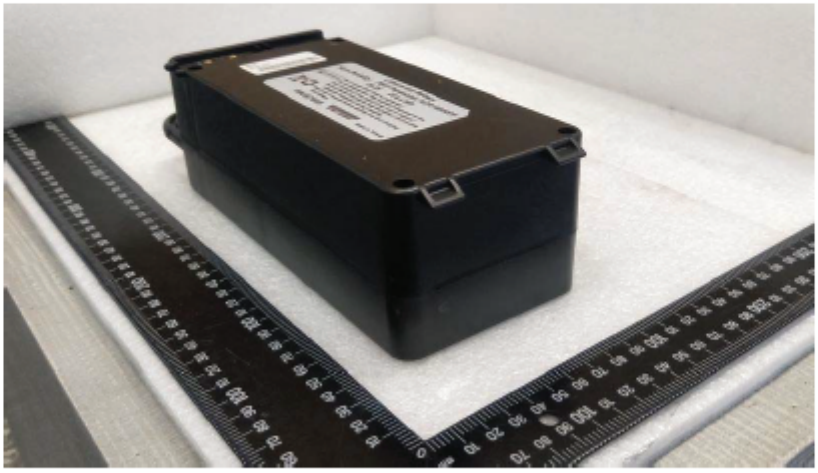
Sample No	Sample State	Discharge Current	Discharge Duration	Phenomenon
27	A	10 A	0.27 h	O
28	A	10 A	0.27 h	O
29	A	10 A	0.27 h	O
30	A	10 A	0.27 h	O
31	A	10 A	0.27 h	O
32	A	10 A	0.27 h	O
33	A	10 A	0.27 h	O
34	A	10 A	0.27 h	O
35	A	10 A	0.27 h	O
36	A	10 A	0.27 h	O
37	B	10 A	0.27 h	O
38	B	10 A	0.27 h	O
39	B	10 A	0.27 h	O
40	B	10 A	0.27 h	O
41	B	10 A	0.27 h	O
42	B	10 A	0.27 h	O
43	B	10 A	0.27 h	O
44	B	10 A	0.27 h	O

Sample No	Sample State	Discharge Current	Discharge Duration	Phenomenon
45	B	10 A	0.27 h	O
46	B	10 A	0.27 h	O

Sample state:
A – Cell at first cycle in fully discharged states.
B – Cell after 25 cycles ending in fully discharged states.
Phenomenon:
D – Disassembly; F – Fire; O - No disassembly and no fire.

Photographs

<Fig. #1>



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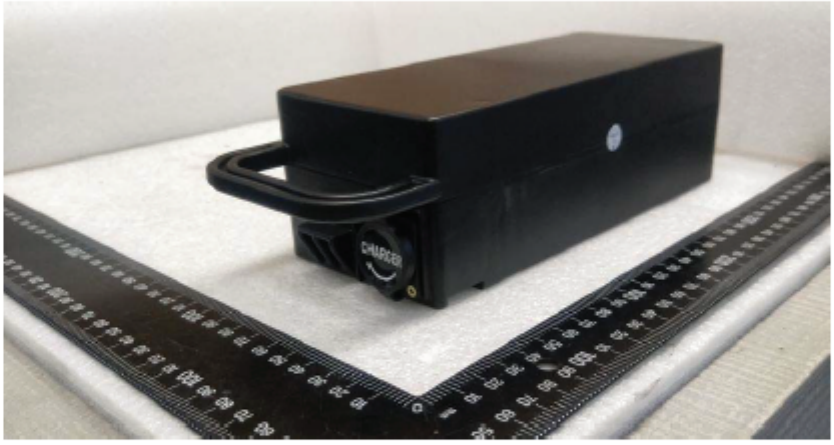
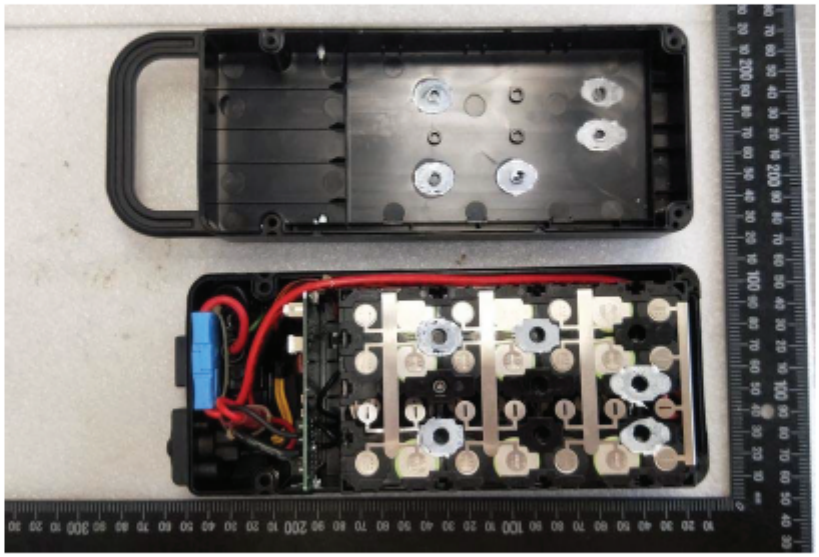


Photographs

<Fig. #3>



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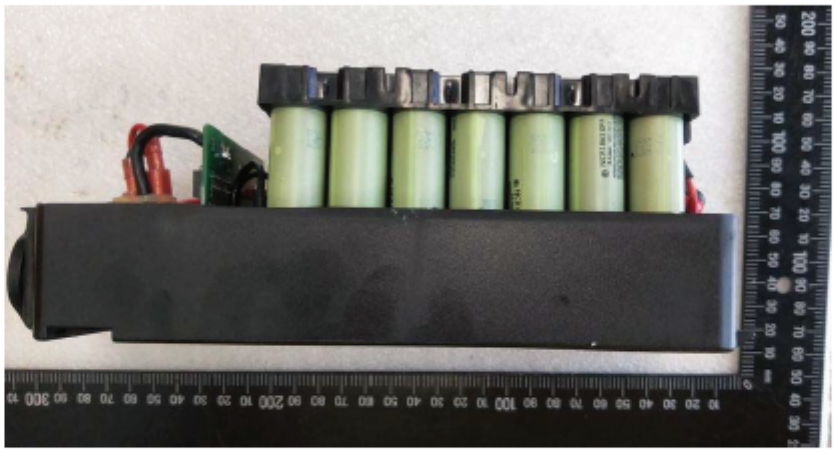
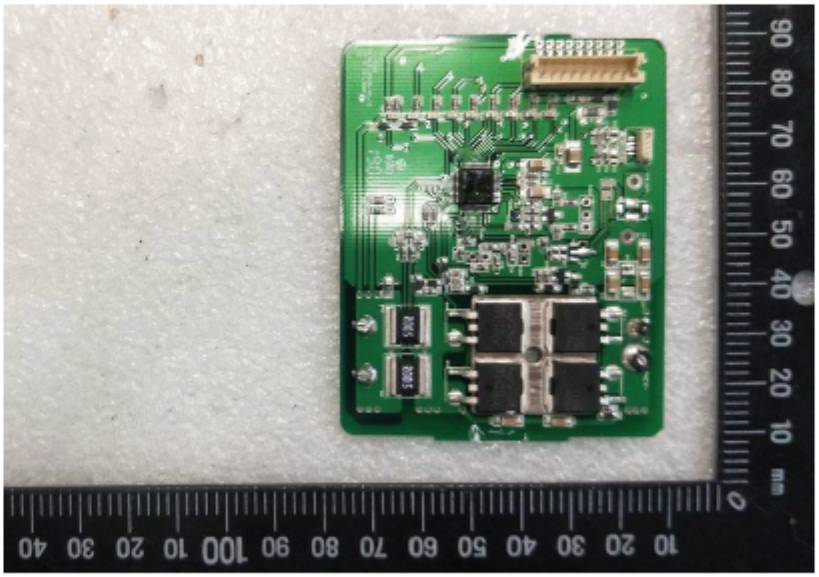


Photographs

<Fig. #5>



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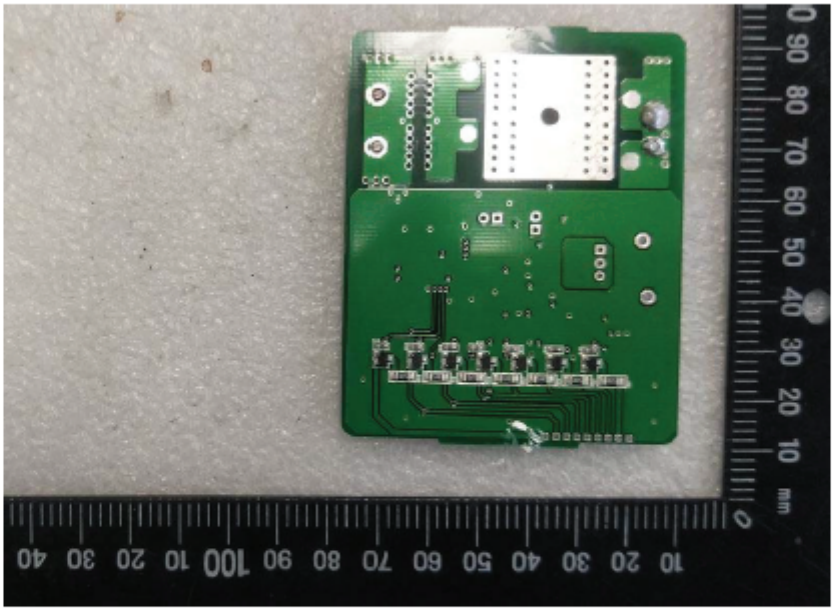
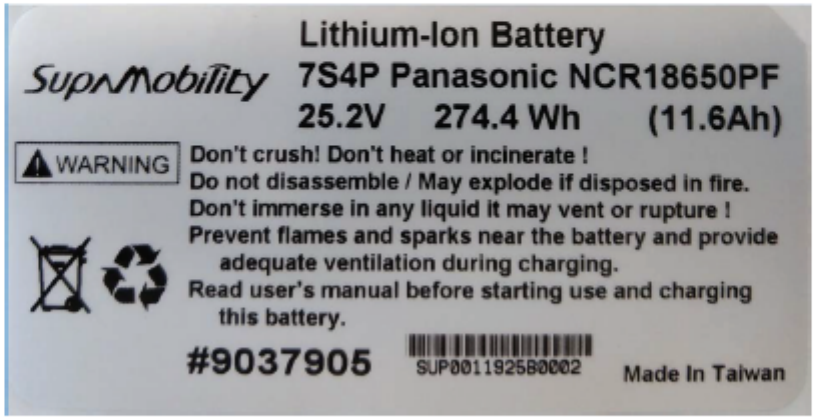


Photographs

<Fig. #7> Label Drawing