Certificate of Test

NCT CO., LTD.
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea
(Tel: +82-31-323-6070 / Fax: +82-31-323-6071)

Report No.: NS2112-B012

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1. **Client**
   - ○ Name : Sevenking energy Corporation
   - ○ Address : 686, Godeung-ri, Sojeong-myeon, Sejong-si, Korea
   - ○ Date of Receipt : 2021. 08. 31

2. **Use of Report :** Third party report

3. **Test Sample :** Hybrid Solid State Battery

4. **Place of Test :** ■ Fixed test □ Field test

(Address: 211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea)

5. **Date of Test :** 2021. 09. 06 ~ 2021. 12. 16

6. **Test method used :** Client's Test Specification

7. **Testing Environment :**
   - ○ Temperature: (25 ± 5) °C, Humidity: Less than 70 % R.H.

8. **Test Results : Refer to the test results**

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This Test Report cannot be reproduced, except in full.
This test report is not related to KOLAS recognition and RRA designation.

Affirmation	**Tested by** Jae Kwon, Kim (signature)	**Technical Manager** Jea Young, Jang (signature)

Dec 31, 2021

NCT CO., LTD.

010692

Contact us at report@nct.re.kr to confirm the authenticity of this report

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1. Summary of test results

<table>
<tr><th>No.</th><th>Test name</th><th>Result</th><th>Test dates</th><th>remark</th></tr>
<tr><td>1</td><td>Energy density test</td><td>- Energy density per volume [Wh/L]<table><tr><th>Sample No.</th><th>25 degree</th><th>60 degree</th></tr><tr><td>#1</td><td>293.65</td><td>300.37</td></tr><tr><td>#2</td><td>298.59</td><td>304.28</td></tr></table>- Energy density per weight [Wh/kg]<table><tr><th>Sample No.</th><th>25 degree</th><th>60 degree</th></tr><tr><td>#1</td><td>190.87</td><td>195.24</td></tr><tr><td>#2</td><td>191.61</td><td>195.27</td></tr></table></td><td>2021. 10. 25 ~
2021. 10. 29</td><td>-</td></tr>
<tr><td>2</td><td>Power density test</td><td>Refer to the test result table.</td><td>2021. 09. 15 ~
2021. 09. 18</td><td>-</td></tr>
<tr><td>3</td><td>Cycle life test</td><td>- Capacity retention after 1000 cycles at 25 degree
#5: 87.9 %
#6: 82.5 %
- Capacity retention 500 cycles after at 60 degree
#1: 78.2 %
#2: 77.4 %</td><td>2021. 09. 15 ~
2021. 12. 16</td><td>-</td></tr>
<tr><td>4</td><td>External short circuit test</td><td>#7: Sample remained intact
#8: Sample remained intact</td><td>2021. 09. 27 ~
2021. 09. 28</td><td>-</td></tr>
<tr><td>5</td><td>Crush test</td><td>#9: Sample remained intact
#10: Sample remained intact</td><td>2021. 09. 23</td><td>-</td></tr>
<tr><td>6</td><td>Forced discharge test</td><td>#11: Sample remained intact
#12: Sample bulged</td><td>2021. 09. 23</td><td>-</td></tr>
<tr><td>7</td><td>Overcharge test</td><td>#13: Sample bulged
#14: Sample bulged</td><td>2021. 10. 21</td><td>-</td></tr>
<tr><td>8</td><td>Heating Test</td><td>#15: Sample bulged
#16: Sample bulged</td><td>2021. 09. 16</td><td>-</td></tr>
</table>

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2. Laboratory details

Name	:	NCT Co., Ltd.
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Telephone	:	+82-31-323-6070
Facsimile	:	+82-31-323-6071
Homepage	:	www.nct.re.kr

3. Test sample information

Description	:	Hybrid Solid State Battery
Model name	:	SKEC-6216265
Test sample quantity	:	16 EA
Test sample No.	:	#1, #2, #3, #4, #5, #6, #7, #8, #9, #10, #11, #12, #13, #14, #15, #16

4. Test results

4.1 Energy density test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	BATTERY MODULE TESTER	PEBC05-30	PNE solution	2022. 02. 15
2	Vernier calipers	CD-15APX	MITUTOYO	2022. 07. 05
3	Vernier calipers	BD500-600	BLUETEC	2021. 12. 07
4	Electronic balance	FX-3000i	AND	2022. 04. 09
5	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 10. 25 ~ 2021. 10. 29

3) Test methods

1) Measure the weight and size of the cell.

2) Charge and discharge at (25 ± 5) °C before the test according to the procedure below.

- CC/CV charge: Voltage 4.2 V, Current 0.2 C, Cut-off current 0.05 C
- Rest: 1 h
- CC discharge: Votlage 3.0 V, Current 0.2 C

3) Stabilize at ambient temperature after charging according to the method below.

- CC/CV Charge: Voltage 4.2 V, Current 0.2 C, Cut-off current 0.05 C
- Rest: 1 h

4) Discharge to the end voltage indicated by the manufacturer with a current of 0.2 ItA.

- CC discharge: Votlage 3.0 V, Current 0.2 C
- Rest: 1 h

5) According to the procedure below, the discharge capacity of the second cycle is taken as the capacity to be measured twice.

- CC/CV charge: Voltage 4.2 V, Current 0.2 C, Cut-off current 0.05 C
- Rest: 1 h
- CC discharge: Voltage 3.0 V, Current 0.2 C
- Rest: 1 h

6) Energy density per volume and energy density per weight are calculated, and 1-5 processes are repeated at a temperature of 60 °C.

4) Test results

- Size and weight measurement

Sample no.	Size [mm]			Weight [g]
	Thickness	Width	Height	
#1	5.79	79.67	161.87	114.875
#2	5.76	78.28	162.92	114.470

- Measurement at 25 degree

Sample no.	Capacity [Ah]	Average voltage [V]	Energy [Wh]	Energy density per volume [Wh/L]	Energy density per weight [Wh/kg]
#1	5.935	3.69	21.93	293.65	190.87
#2	5.935	3.70	21.93	298.59	191.61

- Measurement at 60 degree

Sample no.	Capacity [Ah]	Average voltage [V]	Energy [Wh]	Energy density per volume [Wh/L]	Energy density per weight [Wh/kg]
#1	6.021	3.73	22.43	300.37	195.24
#2	6.000	3.73	22.35	304.28	195.27

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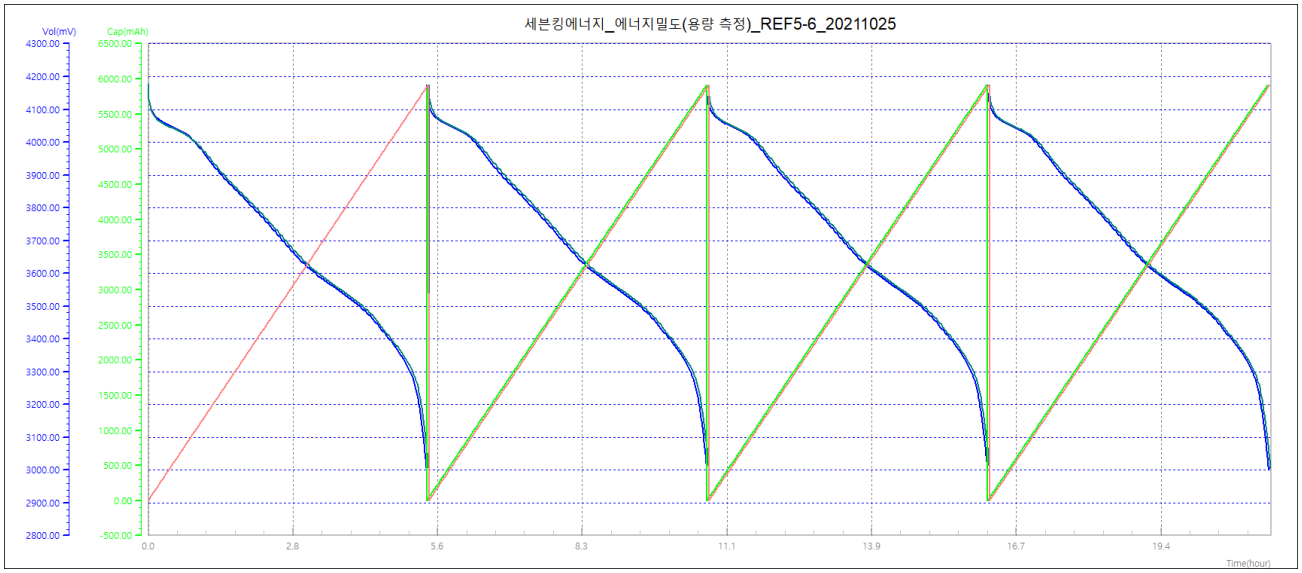
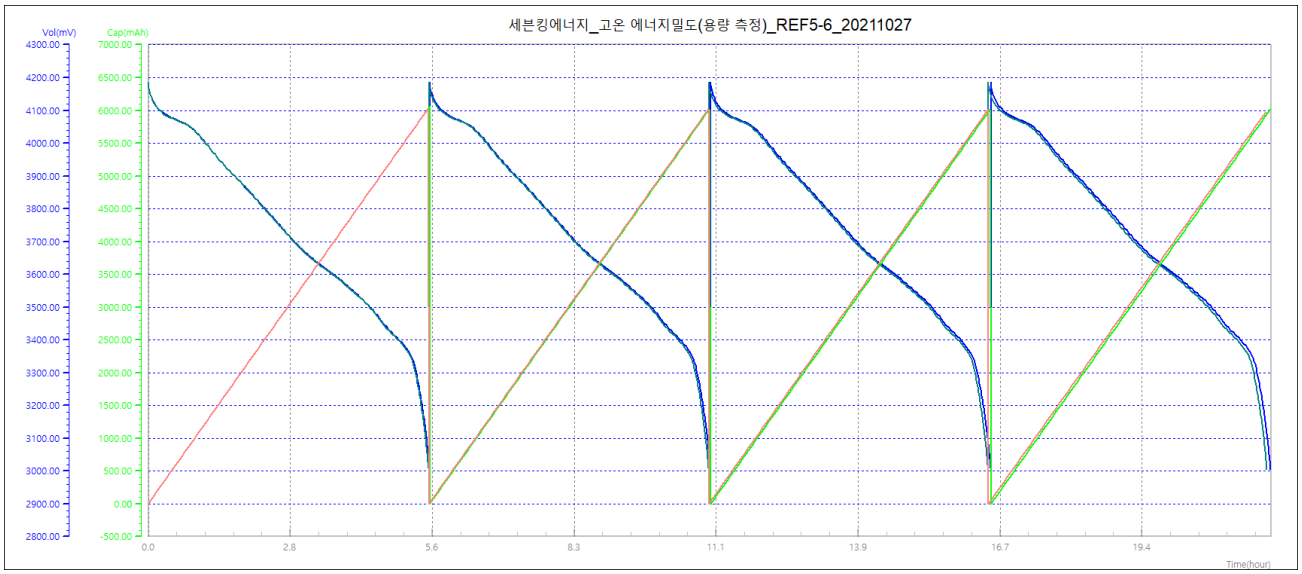
5) Profile



[Energy density test graph_25 degree_#1-2]



[Energy density test graph_60 degree_#1-2]

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4.2 Power density test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	Multi-cycling battery&capacitor	SERIES 4000	MACCOR	2022. 04. 09
2	OVEN	PLM-73S	FUTABA KAGAKU	2022. 04. 09
3	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11
4	Electronic balance	FX-3000i	AND	2022. 04. 09

2) Test dates

- 2021. 09. 15 ~ 2021. 09. 18

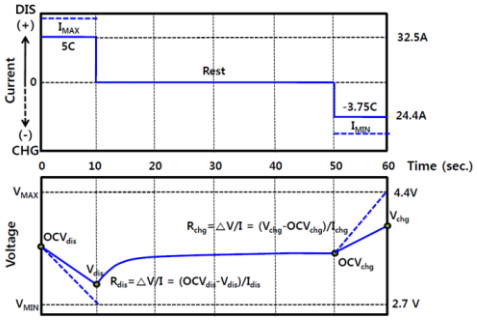
3) Test methods

1) After 3 cycles according to the conditions below, the third cycle capacity is recorded.
- CC/CV charge: Voltage 4.2 V, Current 2.75 A, Cut-off current 0.275A
- Rest : 10 min
- CC discharge: Voltage 3.0 V, Current 2.75 A
- Rest : 10 min

2) Calculate the C-rate current as a result of the third cycle and proceed with the procedure below.

a) CC discharge: Current 0.5 C-rate, Cut-off time: Each SOC time(For example, SOC 90 = 12 min)
b) Rest: 1 h
c) CC discharge: Current 5 C-rate, Cut-off time: 10 s
d) Rest: 40 s
e) CC charge: Current 3.75 C-rate, Cut-off time: 10 s
f) Rest: 10 min
g) CC/CV charge: Voltage 4.2 V, Current 2.75 A, Cut-off current 0.275 A
h) Rest: 10 min
i) Repeat a-h until SOC 90 to SOC 10.

Refer to the equation below for the Discharge/charge Pulse Power calculation equation.
HPPC is 1.15 times the calculated value of 25 degree pulse power



Discharge Pulse Power = $V_{MIN} \times I_{MAX} = V_{MIN} \times (OCV_{dis} - V_{MIN})/R_{dis}$
Charge Pulse Power = $V_{MAX} \times I_{MIN} = V_{MAX} \times (V_{MAX} - OCV_{chg})/R_{chg}$

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4) Test results

Sample no.	Weight [g]
#3	105.93
#4	107.71

- Discharge DCIR, Ω

Sample no.	SOC 90	SOC 80	SOC 70	SOC 60	SOC 50	SOC 40	SOC 30	SOC 20	SOC 10
#3	14.49	14.16	13.85	13.56	13.93	14.17	14.86	16.51	25.47
#4	16.60	16.29	15.82	15.57	15.85	16.15	16.87	18.66	27.78

- Discharge HPPC, W/kg

Sample no.	SOC 90	SOC 80	SOC 70	SOC 60	SOC 50	SOC 40	SOC 30	SOC 20	SOC 10
#3	2780.9	2700.0	2589.3	2436.0	2172.4	1981.1	1793.2	1486.4	845.2
#4	2399.4	2331.5	2232.0	2093.5	1877.5	1709.2	1551.9	1300.6	763.6

- Charge DCIR, Ω

Sample no.	SOC 90	SOC 80	SOC 70	SOC 60	SOC 50	SOC 40	SOC 30	SOC 20	SOC 10
#3	14.20	14.09	13.80	13.31	13.59	13.66	14.08	15.11	16.79
#4	11.79	11.78	11.52	11.23	11.32	11.37	11.66	12.37	13.42

- Charge HPPC, W/kg

Sample no.	SOC 90	SOC 80	SOC 70	SOC 60	SOC 50	SOC 40	SOC 30	SOC 20	SOC 10
#3	1227.8	1526.6	1834.8	2214.3	2508.5	2753.1	2841.0	2890.3	2909.2
#4	1071.1	1310.7	1622.7	1937.2	2225.8	2444.4	2539.0	2596.1	2677.6

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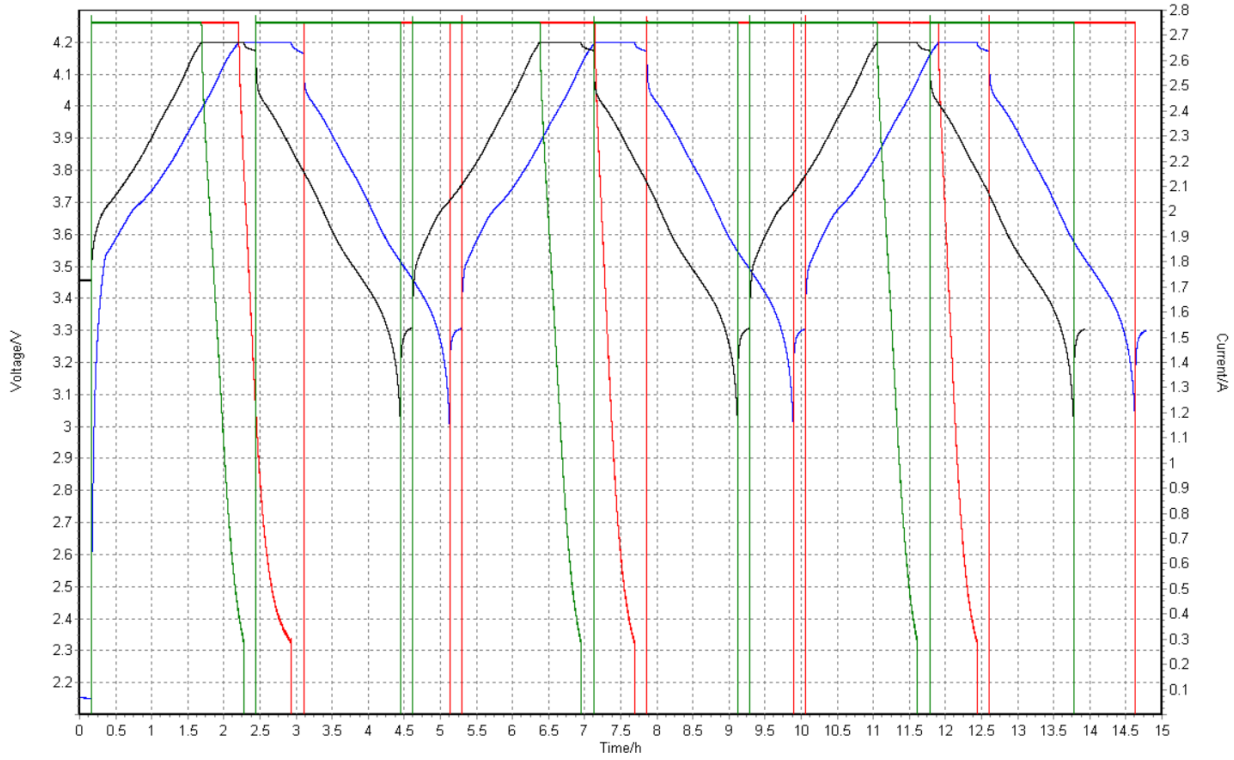
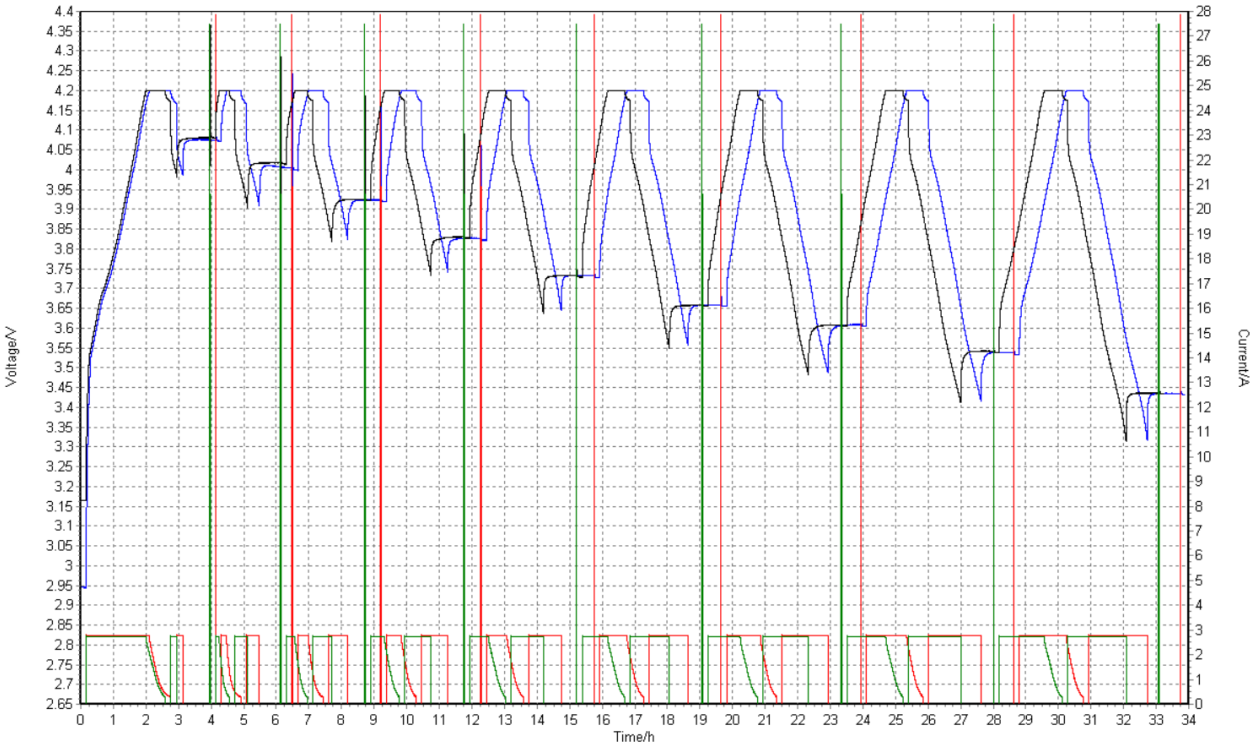


[3 cycle graph]



[Power density test graph]

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4.3 Cycle life test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	BATTERY MODULE TESTER	PEBC05-30	PNE solution	2022. 02. 15
2	Temperature & humidity cabinet	LHU-113	ESPEC	2022. 04. 09
3	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 09. 15 ~ 2021. 12. 16

3) Test methods

1) It is performed 1000 cycles at 25 degree and 500 cycles at 60 degree according to the procedure below.

- CC/CV charge: Voltage 4.2 V, Current 5.5 A, Cut-off current 0.05 C
- Rest: 10 min
- CC discharge: Voltage 3.0 V, Current 5.5 A
- Rest: 10 min

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4) Test results

- 25 degree

Cycles	Sample No.			
	#5		#6	
	Capacity [Ah]	Retention [%]	Capacity [Ah]	Retention [%]
2	4.214	100.0	3.874	100.0
100	4.045	96.0	3.813	98.4
200	4.024	95.5	3.805	98.2
300	3.931	93.3	3.700	95.5
400	3.915	92.9	3.663	94.6
500	3.789	89.9	3.716	95.9
600	3.809	90.4	3.531	91.1
700	3.725	88.4	3.459	89.3
800	3.778	89.7	3.163	81.6
900	3.769	89.4	3.423	88.4
1000	3.702	87.9	3.197	82.5

- 60 degree

Cycles	Sample No.			
	#1		#2	
	Capacity [Ah]	Retention [%]	Capacity [Ah]	Retention [%]
2	5.698	100.0	5.682	100.0
100	5.314	93.3	5.308	93.4
200	5.059	88.8	5.03	88.5
300	4.854	85.2	4.81	84.7
400	4.646	81.5	4.591	80.8
500	4.455	78.2	4.396	77.4

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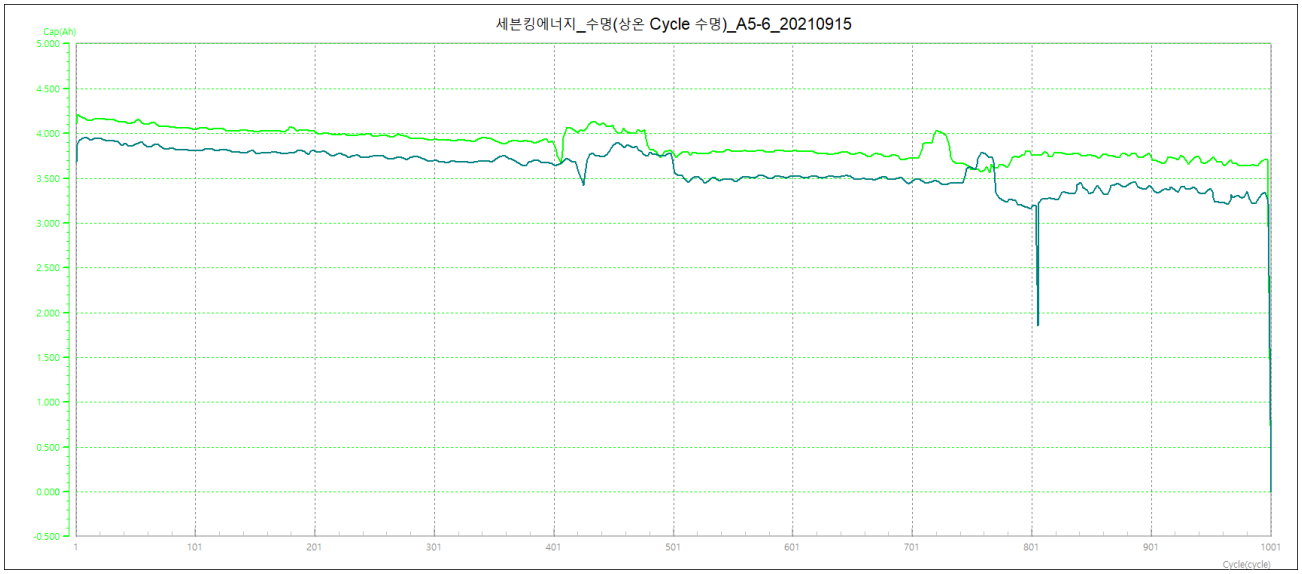
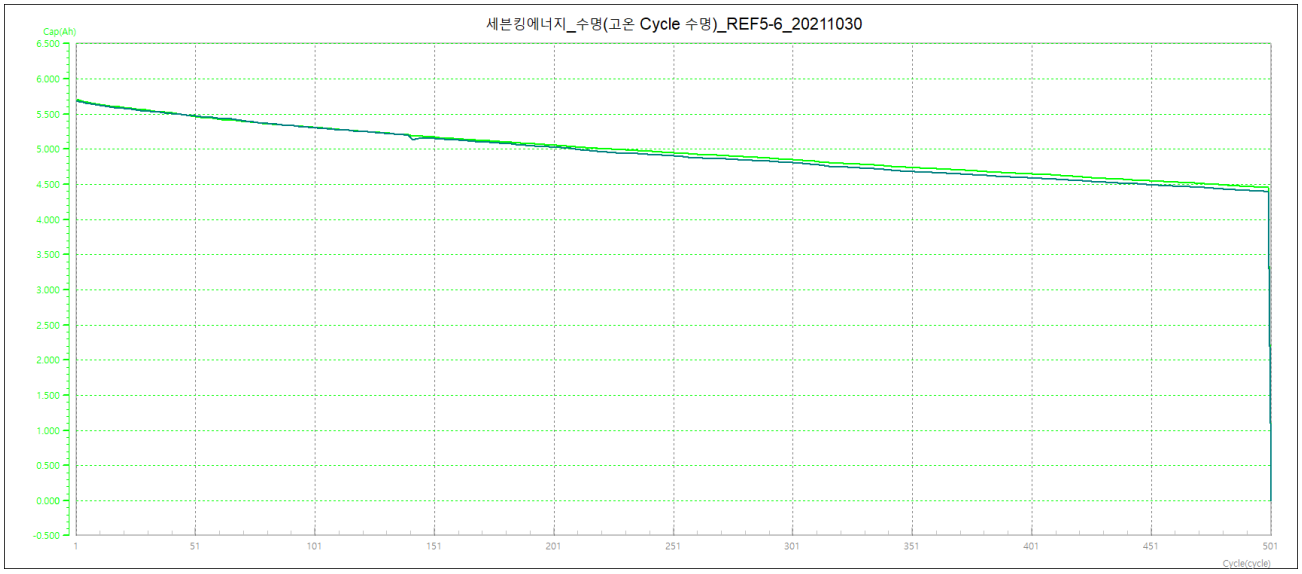
5) Profile



[Cycle life test graph_#5-6]



[Cycle life test graph_#1-2]

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4.4 External short circuit test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	Milliohm hi-tester	3540	HIOKI	2022. 07. 07
2	Memory hi-logger	LR8400-20	HIOKI	2022. 04. 20
3	AC/DC current sensor	CT 6865	HIOKI	2022. 07. 22
4	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 09. 27 ~ 2021. 09. 28

3) Test methods

- Fully charged cells are stored in an ambient temperature of 25 °C ± 5 °C. Each cell is then short-circuited by connecting the positive and negative terminals with a total external resistance of 30 mΩ ± 10 mΩ.

The cells are to remain on test for 6 h or until the case temperature declines by 80 % of the maximum temperature rise, whichever is the sooner

4) Test results

Sample no.	Initial open circuit voltage [V]	Resistance load [mΩ]	Maximum current [A]	Maximum temperature [°C]
#7	4.120	30.0	79.1	96.4
#8	4.106	30.0	90.2	86.7

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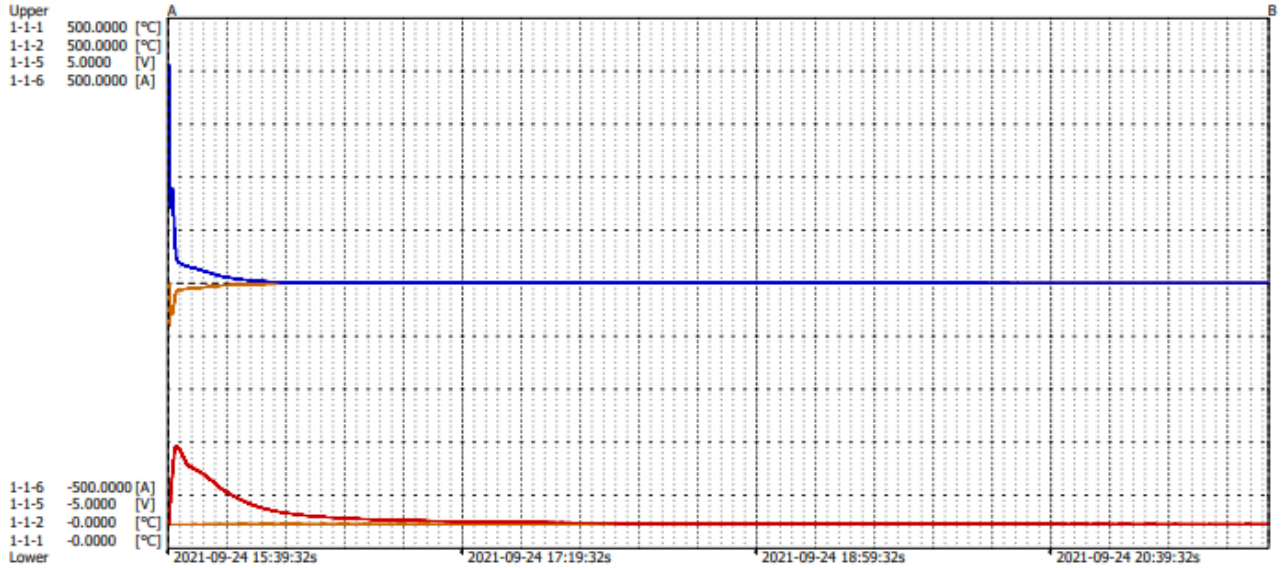
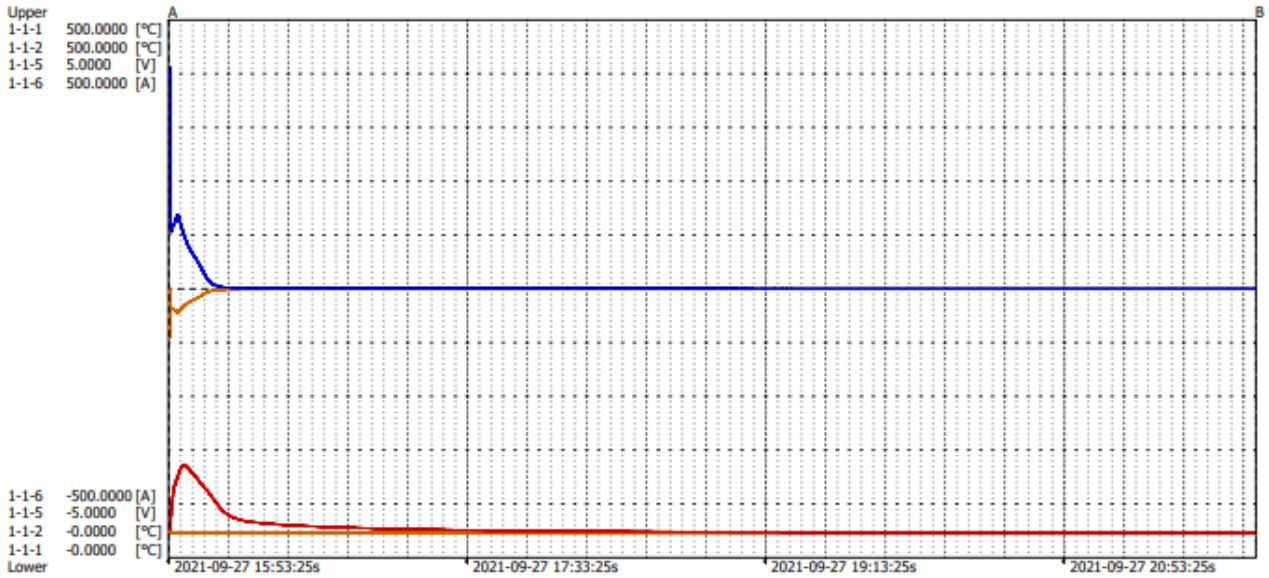
5) Profile



[External short circuit test graph_#7]



[External short circuit test graph_#8]

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6) Before and after test picture

Before	After
#7	#7
	
#8	#8
	

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4.5 Crush test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	Nail/Crush Tester	A06801	JANONE	2022. 04. 09
2	Midi logger	GL840	GRAPHTEC	2022. 04. 09
3	Electronic balance	FX-3000i	AND	2022. 04. 09
4	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 09. 23

3) Test methods

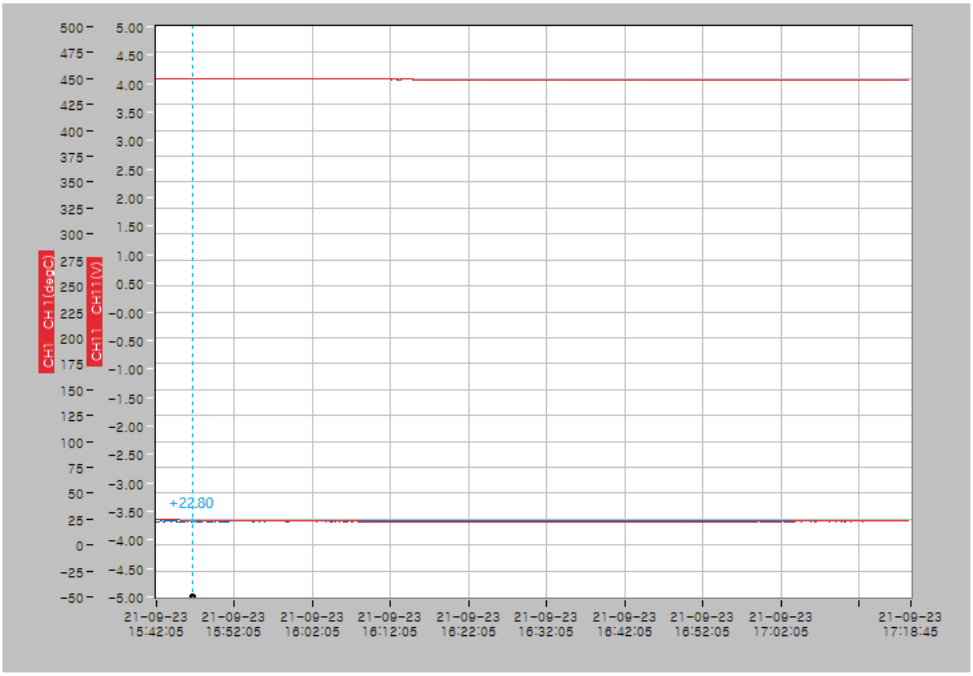
- Each fully charged cell is placed on the insulated flat surface, it is compressed using a compression tool such as a hemispherical shape with a diameter of 150 mm. A pressing force is applied in a direction perpendicular to the anode and cathode surfaces inside the cell.

When the voltage of the cell is dropped to 1/3 or less of the initial value or a force is applied 1000 times or more of the weight of the cell, the compression force is released.

4) Test results

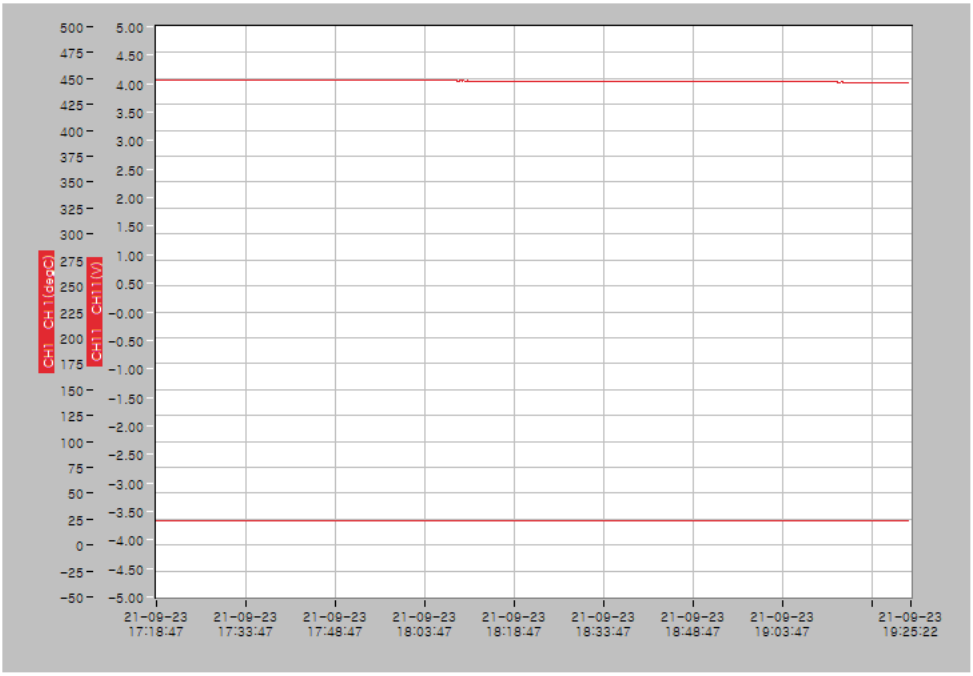
Sample no.	The weight of the cell [g]	OCV before test [V]	OCV at removal of crushing force [V]	Maximum force applied to the cell during crush [N]
#9	106.72	4.076	4.076	1122
#10	119.58	4.057	4.057	1167

5) Profile



[Crush test graph_#9]

[Crush test_#9]



[Crush test graph_#10]

[Crush test_#10]

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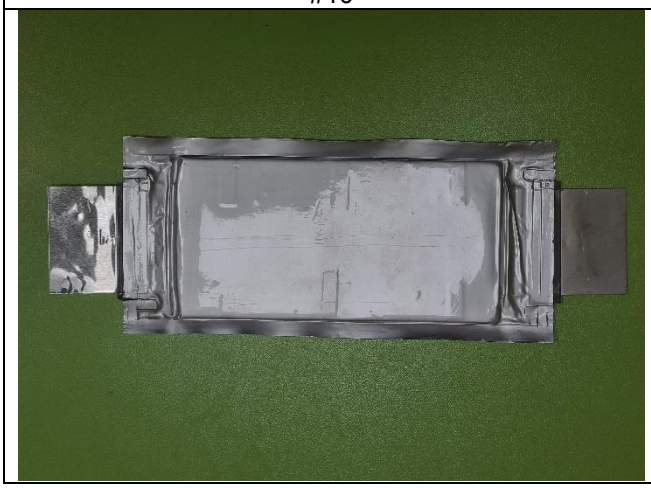
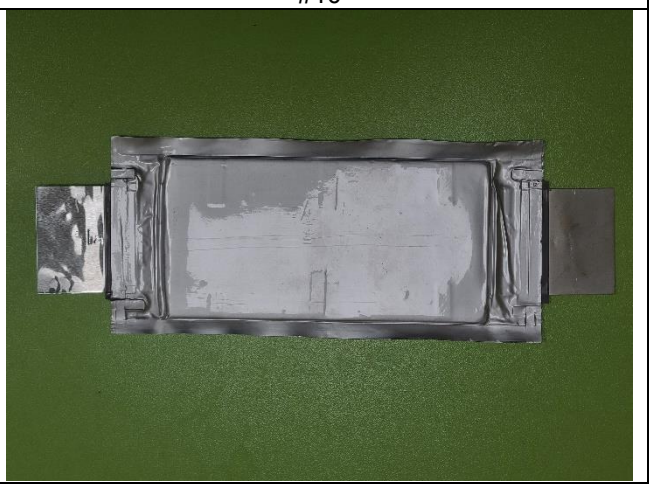
6) Before and after test picture

Before	After
#9	#9
	
#10	#10
	

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4.6 Forced discharge test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	BATTERY TEST SYSTEM	2300	MACCOR	2021. 12. 18
2	Midi logger	GL840	GRAPHTEC	2022. 04. 09
3	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 09. 23

3) Test methods

- A discharged cell is subjected to a forced discharge at a constant current of 0.5 It A for a test period of 90 min.

4) Test results

Sample no.	Initial open circuit voltage [V]	Forced discharge current [A]	Total time for forced discharge application [min]	Maximum temperature on cell casing [°C]
#11	3.164	2.75	90	44.7
#12	3.184	2.75	90	46.9

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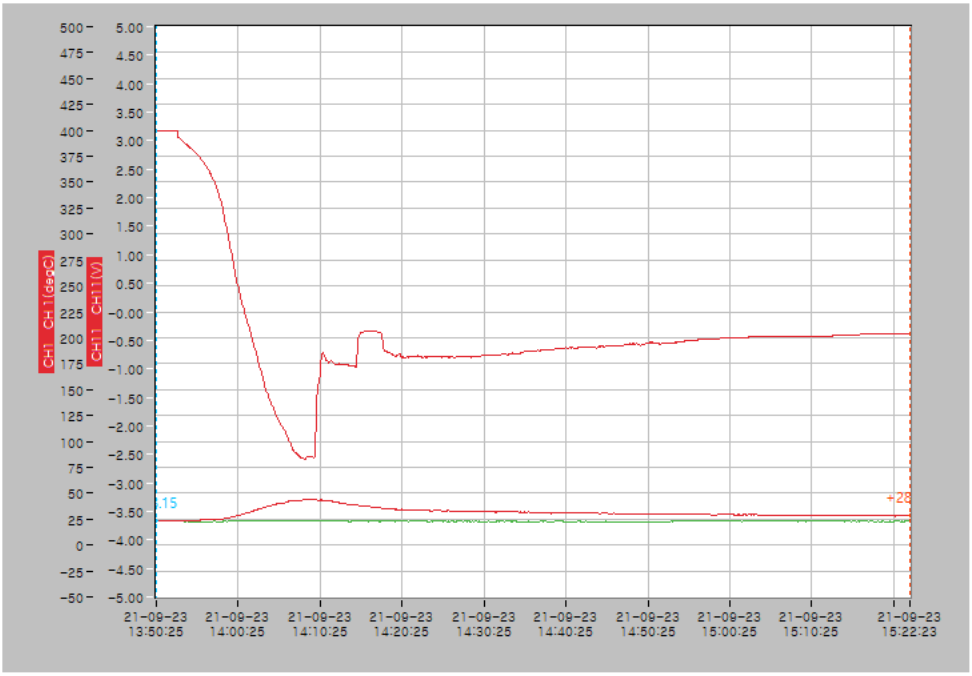
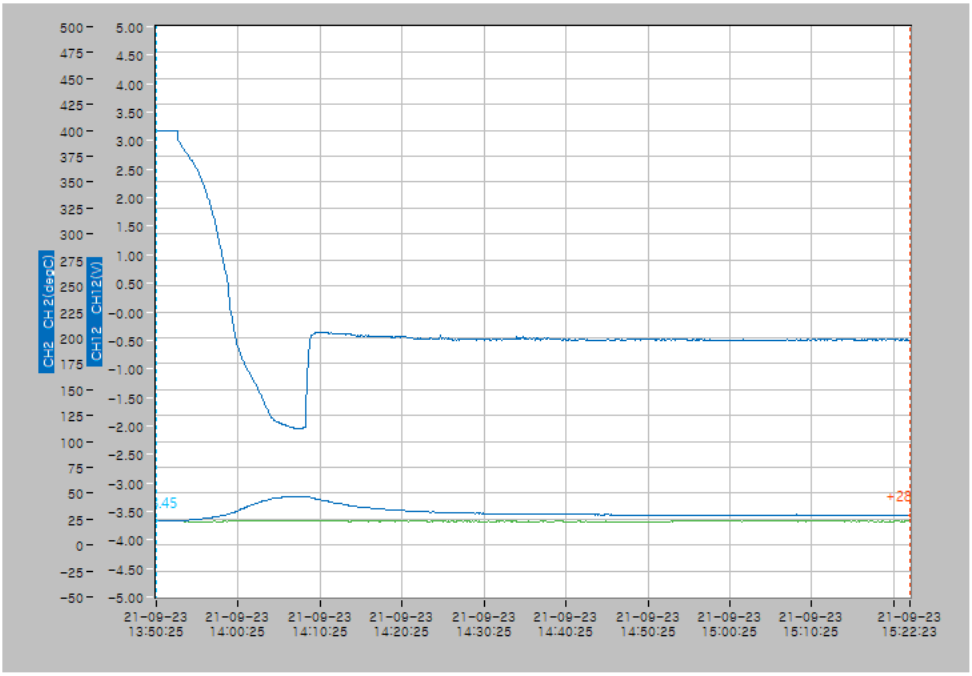
5) Profile



[Forced discharge test graph_#11]



[Forced discharge test graph_#12]

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6) Before and after test picture

Before	After
#11	#11
	
#12	#12
	

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4.7 Overcharge test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	BATTERY testing system	CT-4008-20V15A-NFA	FAMTECH	2022. 02. 15
2	Midi logger	GL840	GRAPHTEC	2022. 04. 09
3	Humi./Baro/Temp. data recorder	MHB-382SD	Lutron	2022. 03. 11

2) Test dates

- 2021. 10. 21

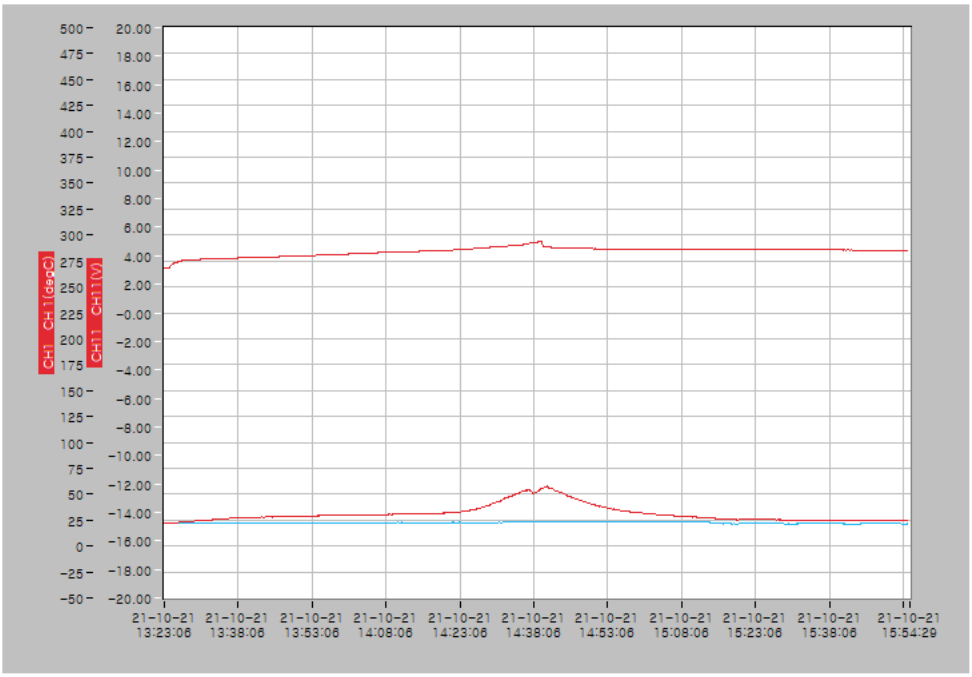
3) Test methods

- Sample cells shall then be charged with a constant current equal to the maximum specified charging current of the battery system until the voltage reaches 120 % of the maximum voltage value or 200 % of rate capacity. Then, the charging is terminated.

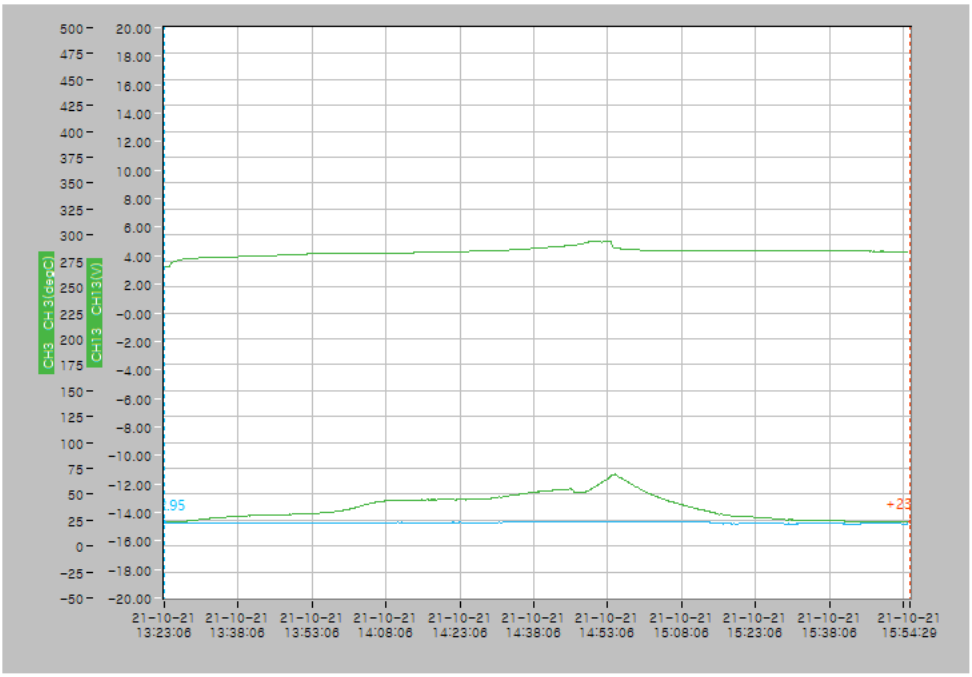
4) Test results

Sample no.	Initial open circuit voltage [V]	Charge current [A]	Total charging time [min]	Maximum temperature on cell casing [°C]
#13	3.127	5.5	90	57.7
#14	3.212	5.5	90	69.5

5) Profile



[Overcharge test graph_#13]



[Overcharge test graph_#14]

6) Before and after test picture

Before	After
#13	#13
	
#14	#14
	

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4.8 Heating Test

1) Test instrument lists

No.	Description	Model	Manufacturer	Cal. Due
1	Bench Top Temperature chamber	MTCB-120QZ	TERCHY	2021. 10. 16
2	Midi logger	GL840	GRAPHTEC	2022. 04. 09

2) Test dates

- 2021. 09. 16

3) Test methods

- A battery is to be heated in a gravity convection or circulating air oven with an initial temperature of (20 ± 5) °C. The temperature of the oven is to be raised at a rate of (5 ± 2)°C per minute to a temperature of (130 ± 2) °C and remain for 10 min. The sample shall return to room temperature (20 ± 5) °C and then be examined.

4) Test results

Sample no.	Initial open circuit voltage [V]	Measured maximum temperature [°C]
#15	4.049	126.9
#16	4.012	134.6

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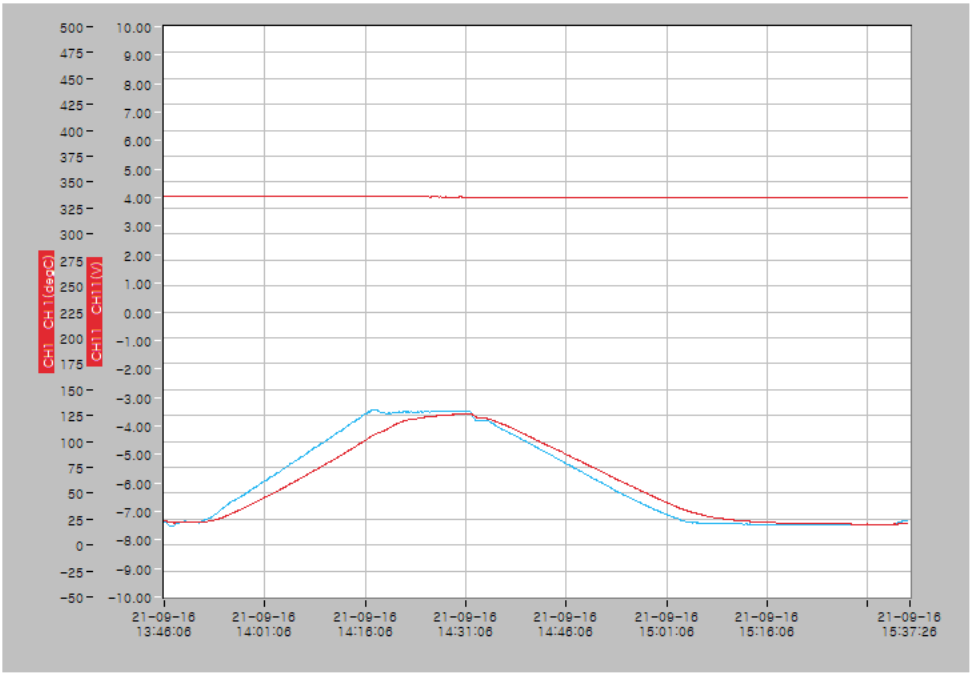
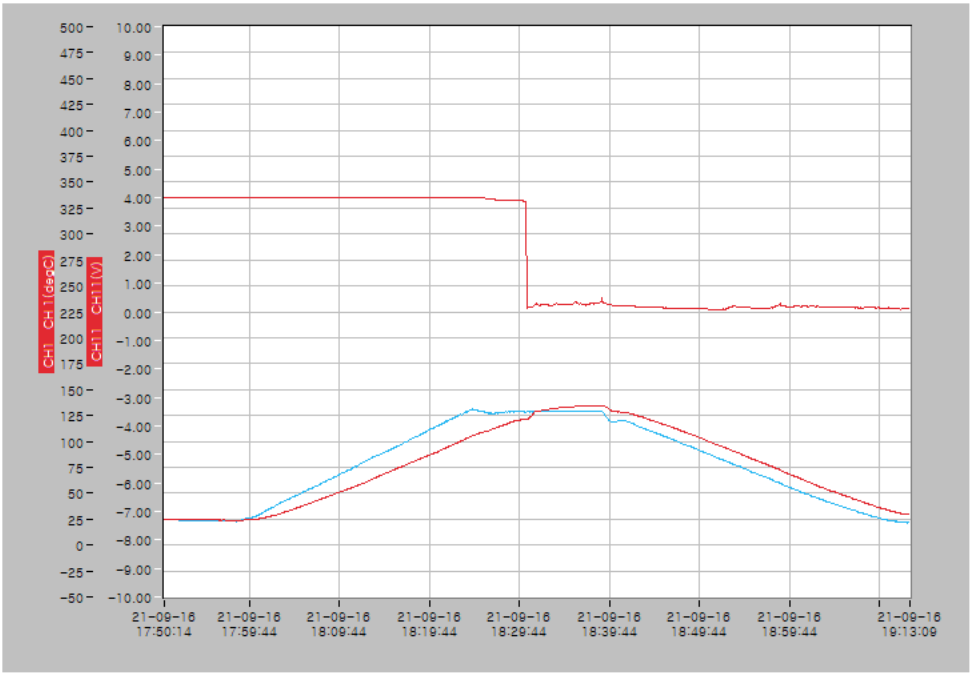
5) Profile



[Heating Test_#15]



[Heating Test_#16]

6) Before and after test picture

Before	After
#15	#15
	
#16	#16
	

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5. Photographs

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