

# Donut Lab Solid-State Battery V1 Self-Discharge Performance Test

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<b>Report's title</b> Donut Lab Solid-State Battery V1 Self-Discharge Performance Test	
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<b>Project name</b> Solid-State Battery Performance Test	<b>Project number/Short name</b> 144511 / SSB Performance Test
<p><b>Summary</b></p> <p>The aim of the project was to conduct an independent self-discharge performance test on the energy storage device supplied by the customer, which the customer identified as a solid-state battery cell. Based on the results of the initial capacity test conducted within the recommended voltage range, the capacity of the tested cell was determined to be 26.5 Ah.</p> <p>The cell was first fully charged, and its capacity was measured using a charging current of 24 A with a 0.48 A constant-voltage cut-off current. After charging, the cell was discharged at a constant current of 24 A until the lower voltage limit of 2.7 V was reached.</p> <p>Following the capacity measurement, the self-discharge behaviour of the cell was evaluated at ambient temperature (22–28 °C). The cell was charged in two stages to approximately 50 % state of charge and then left to idle for 240 hours, during which the cell voltage was recorded at 10-second intervals. After the idle period, the cell was discharged at a 24 A current to measure the remaining discharge capacity. A total of 97.7 % of the charged capacity was able to be discharged from the cell.</p>	
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## Approval

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## 1. Description and objectives

The aim of the project was to conduct independent performance tests on the energy storage devices supplied by the customer, which the customer identified as solid-state battery cells. Three visually identical cells were provided for testing and labeled DL1, DL2, and DL3. Each cell was subjected to different tests conducted in parallel, all of which began with an initial capacity test. This report presents the results of the self-discharge tests performed on cell DL1.

The specification of the device under test is presented in Table 1. All tests described in this report were carried out on the same cell, following the customer's test plan. The tests were performed using a PEC ACT0550 battery tester, with the cell placed inside a fume hood. The specification of the test equipment is presented in Table 2.

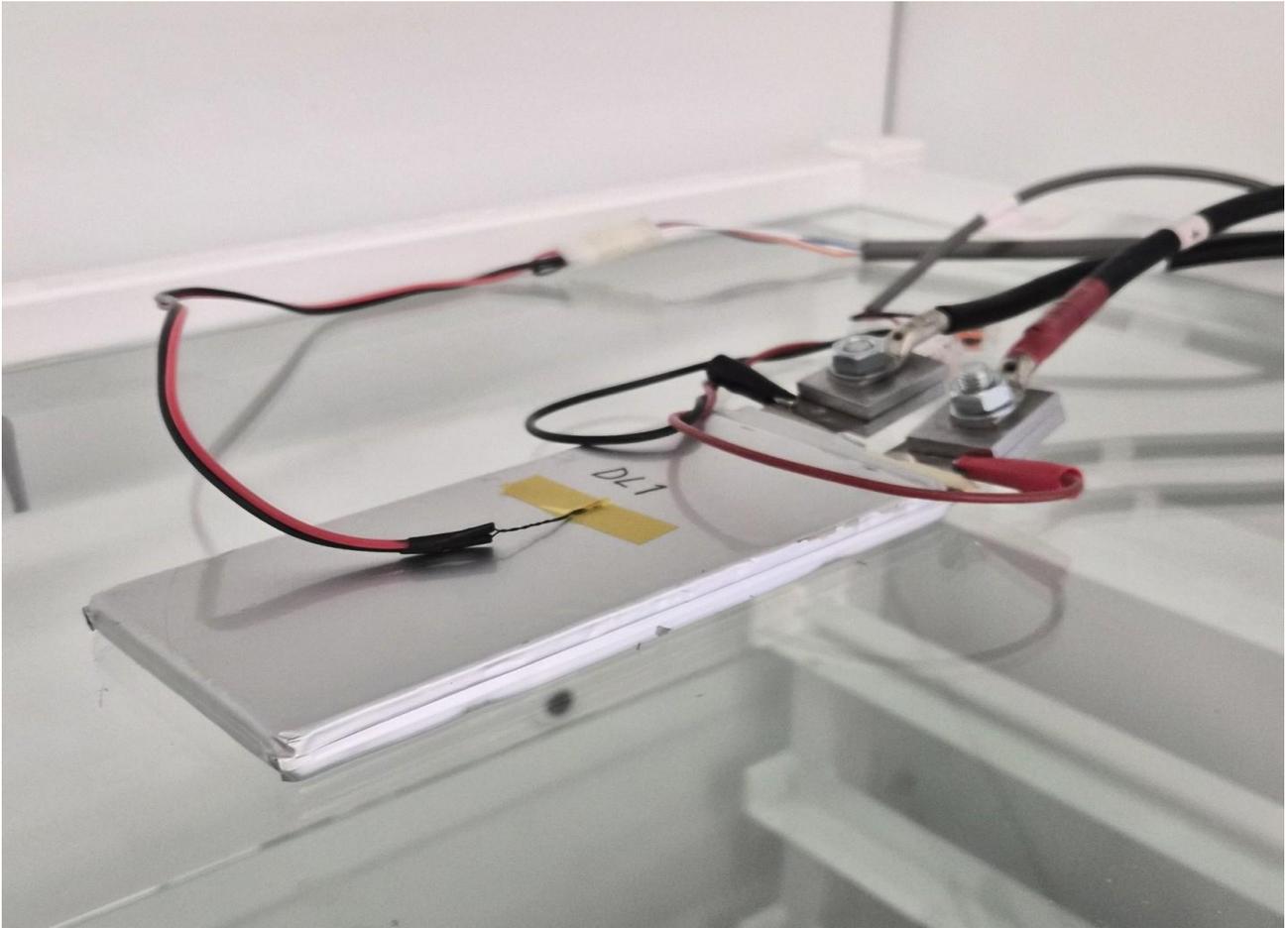
*Table 1. Preliminary specification of device under test, given by customer.*

Type of cell	Donut Solid State Battery V1
Nominal capacity	26 Ah at 1C (standard discharge)
Nominal voltage	3.6 V
Nominal energy	94 Wh
Recommended voltage	2.7–4.15 V
Standard charging method	CC–CV @ 1C, 4.15 V, CV cut-off 0.02C
Maximum charging voltage	4.3 V

*Table 2. Specification of the battery tester.*

Product	PEC ACT0550 cell tester, 80 channels
Output voltage	0–5 VDC
Voltage measurement accuracy	0.005 % fsd
Voltage measurement resolution	1.9 $\mu$ V
Automatically switched current ranges	0–50 mA, 50–500 mA, 0.5–5 A, 5–50 A
Current measurement accuracy	0.03 % fsd (each current range)
Current measurement resolution	8 $\mu$ A

Current cables were attached to the cell tabs using aluminium bars secured with bolts and nuts. Voltage sense wires were connected using insulated alligator clips. The cell surface temperature sensor was positioned on top of the cell. The test setup is shown in Figure 1.



*Figure 1. Cell positioned on a shelf inside a fume hood.*

**Tests conducted for the cell:**

1. Initial capacity test (#1)
2. Self-discharge test (#2)

## 2. Methods

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### 2.1 Initial capacity test (#1)

The free-standing cell was positioned on a shelf inside a fume hood at ambient temperature (24–27 °C).

Start: the cell was charged at a constant current of 24 A until the highest recommended voltage of 4.15 V was reached, followed by constant voltage charging at 4.15 V until the current decreased to 0.48 A (standard charge procedure).

Cycle 1: After a one-hour idle period, the cell was discharged at a constant current of 24 A until the voltage reached 2.7 V (standard discharge procedure), followed by another one-hour idle period. The cell was then recharged using the standard charge procedure. Subsequently, the cell was discharged again at 24 A until the voltage reached 2.7 V (standard discharge procedure), followed by a one-hour idle period.

### 2.2 Self-discharge test (#2)

The free-standing cell was positioned on a shelf inside a fume hood at ambient temperature (22–28 °C).

Cycle 1: The cell was charged at a constant current of 24 A until a charge throughput of 6.668 Ah was reached, followed by a one-hour idle period. The cell was then charged again at 24 A to an additional 6.667 Ah, corresponding to a total state of charge of approximately 50 %. Subsequently, a 240-hour idle period at ambient temperature was initiated. During the idle period, the cell voltage was recorded at a sampling interval of 10 s. After the idle period, the cell was discharged at 24 A current until the voltage reached 2.7 V. At the end of the tests, the cell was charged to approximately 25 % state of charge before it was disconnected.

The voltage, current, capacity, and temperature measured during the capacity and self-discharge tests are presented in Figure 2–Figure 4.

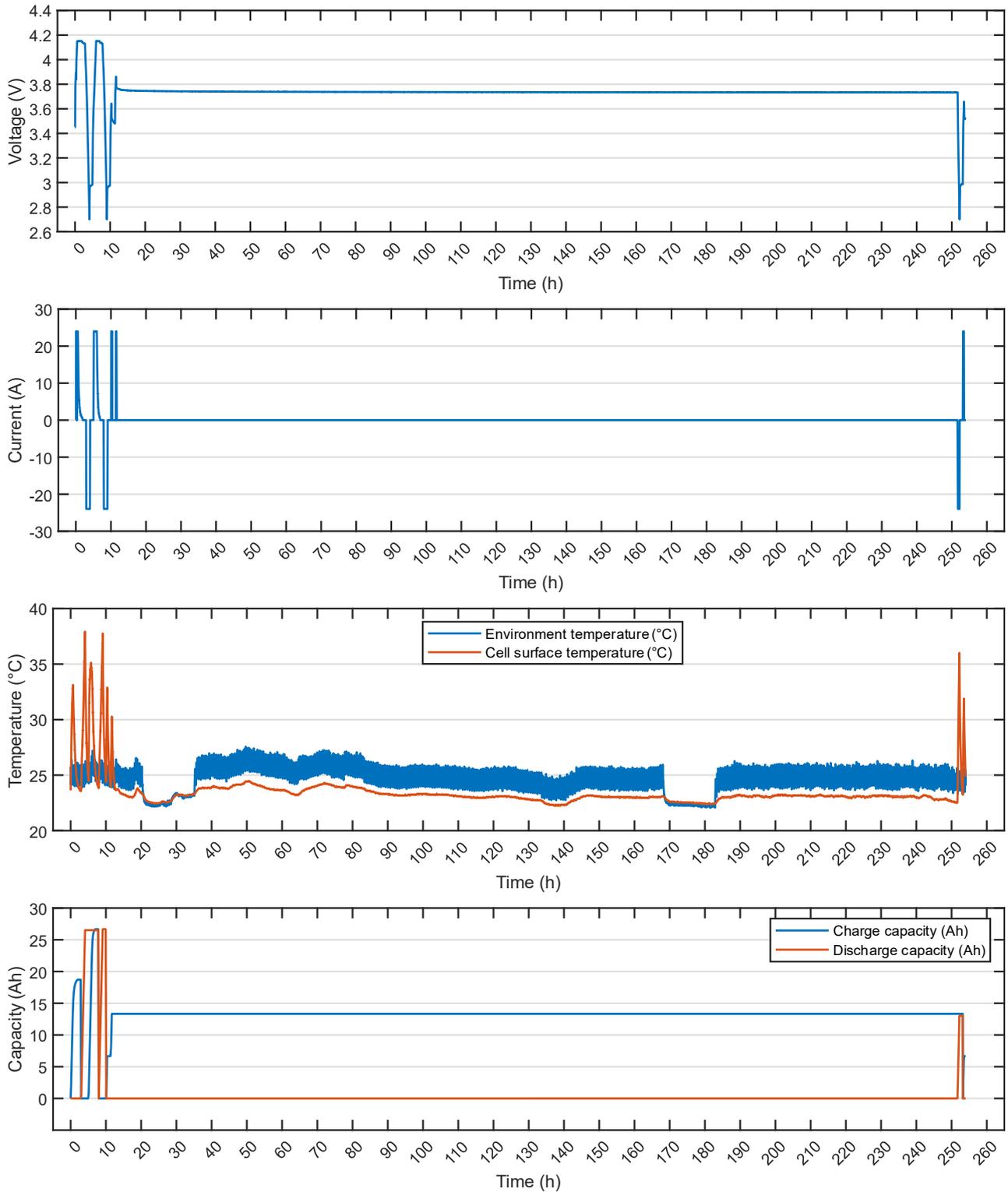


Figure 2. Voltage, current, temperature, and capacity during the capacity and self-discharge tests.

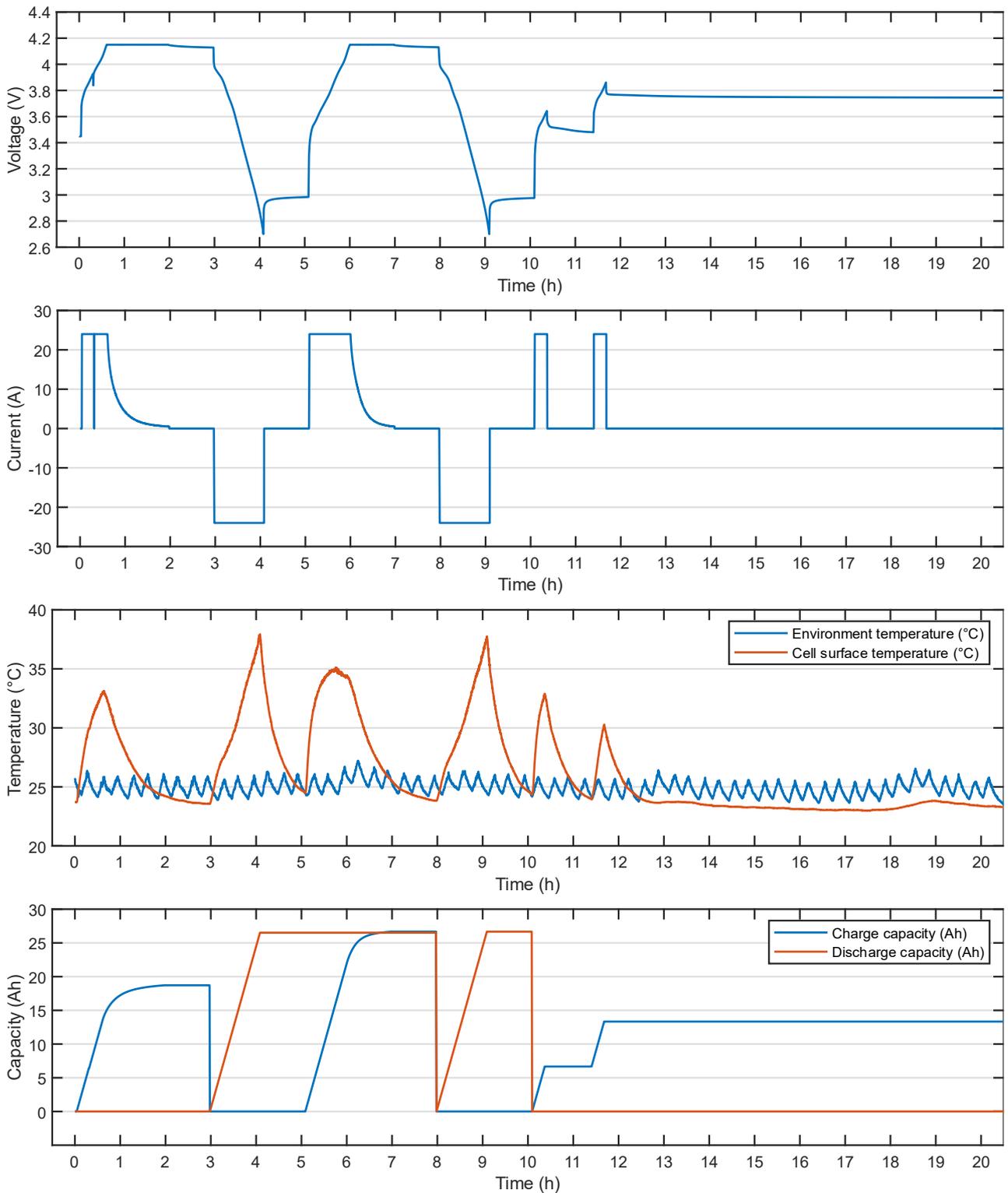


Figure 3. Voltage, current, temperature, and capacity during the capacity test and the initial phase of the self-discharge test.

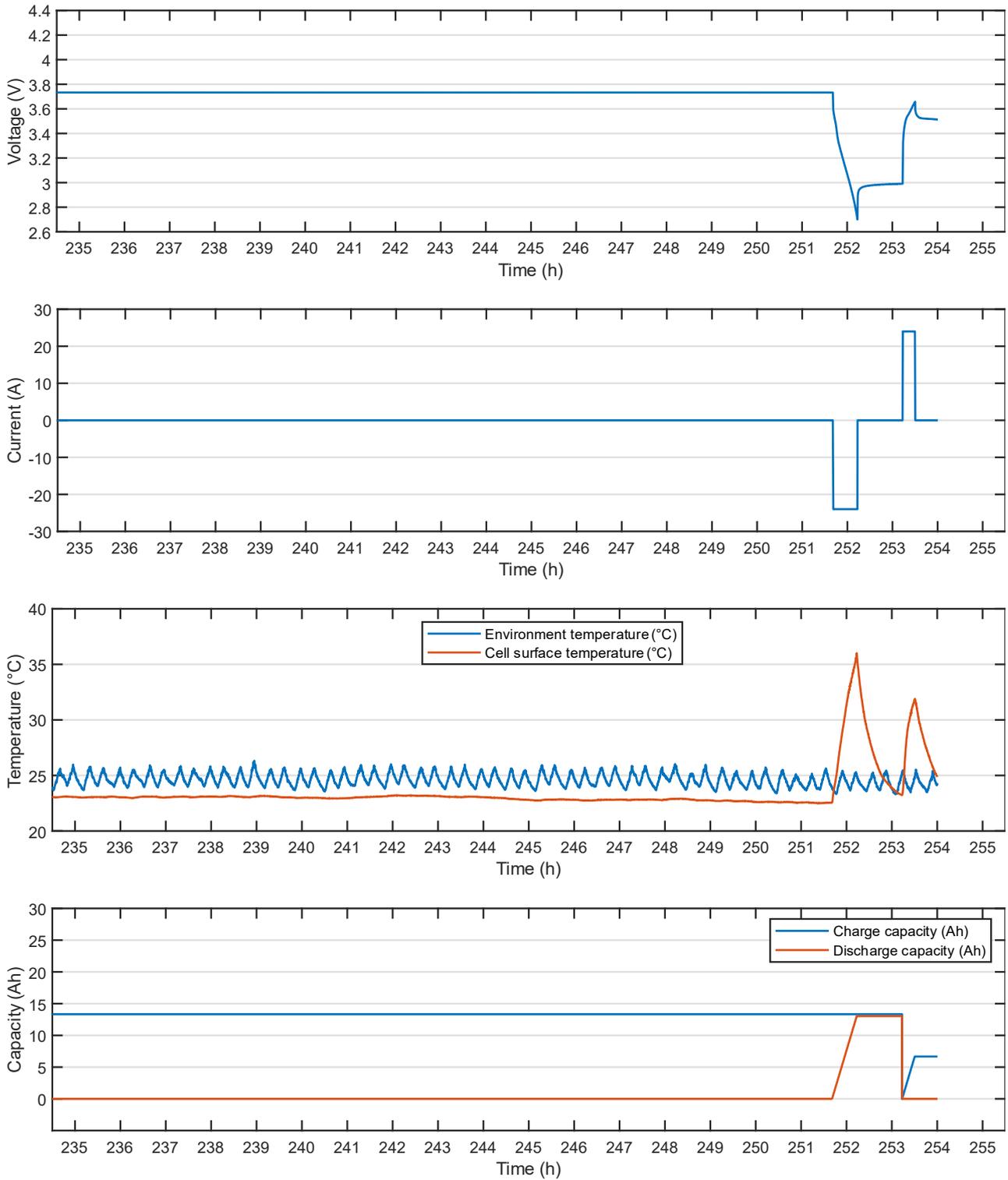


Figure 4. Voltage, current, temperature, and capacity at the end of self-discharge test.

### 3. Results

#### 3.1 Initial capacity test (#1)

The measured capacity during Test #1 for Cycle 1 is presented in Table 3. Cycle 1 was performed at ambient temperature (24–27 °C).

*Table 3. Measured capacity and energy during the capacity test at ambient temperature.*

	Discharge capacity	Charge capacity	Discharge energy	Charge energy
Cycle 1	26.514 Ah	26.667 Ah	91.805 Wh	102.522 Wh
Cycle 1 end discharge	26.668 Ah		92.565 Wh	

#### 3.2 Self-discharge test (#2)

The measured capacity during Test #2 for Cycle 1 is presented in Table 4. The voltage drop over time during the self-discharge period is presented in Table 5 and Figure 5. Cycle 1 and the subsequent self-discharge period of 240 h were performed at ambient temperature (22–28 °C). Variations in ambient temperature were caused by other cells being cycled in the same fume hood.

*Table 4. Measured capacity and energy during the self-discharge test at ambient temperature.*

	Discharge capacity	Charge capacity	Discharge energy	Charge energy
Cycle 1: 1 <sup>st</sup> charge		6.668 Ah		23.495 Wh
Cycle 1: 2 <sup>nd</sup> charge		6.667 Ah		25.042 Wh
Cycle 1: total	13.029 Ah	13.335 Ah	40.876 Wh	48.537 Wh

*Table 5. Voltage over time during the self-discharge period.*

	0 s	10 s	1 min	1 hour	10 hours	240 hours
Voltage	3861 mV	3801 mV	3778 mV	3758 mV	3745 mV	3733 mV
Voltage change	0 mV	-60 mV	-83 mV	-103 mV	-116 mV	-128 mV

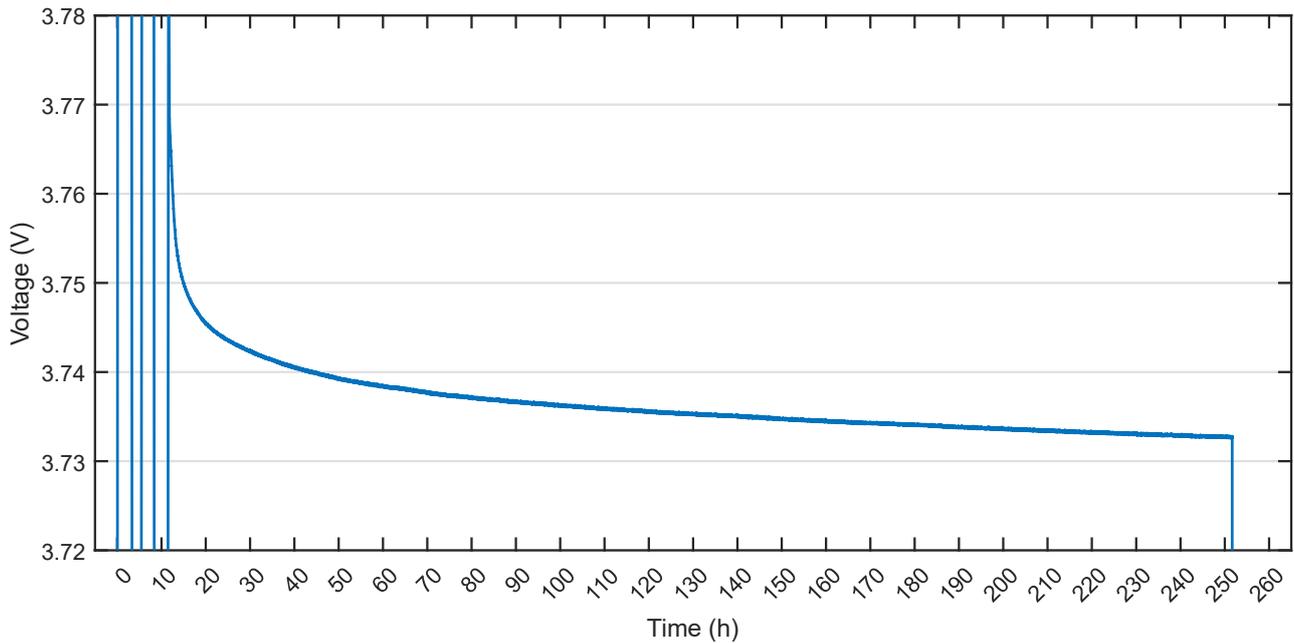


Figure 5: Voltage over time during the self-discharge period.

#### 4. Conclusions and summary

This project included an independent self-discharge performance test on the energy storage device supplied by the customer, which the customer identified as a solid-state battery cell. Based on the initial capacity test, the capacity was determined to be 26.5 Ah at a constant current of 24 A.

After a 240-hour idle period, 97.7 % of the charged capacity was able to be discharged from the cell. The testing caused no visible damage or changes to the cell.