Eclipse Energy LLC
1752 Fields Blvd.
Greenfield, IN 46140
317-318-9993
www.eclipseenergy.us

Test Report: RPT-21-635_Ivanhoe_Cell Characterization_Rev.1

Ivanhoe Capital Acquisition

For:
Mark Newman
Ivanhoe Capital Acquisition

By:
Eclipse Energy
1752 Fields Blvd.
Greenfield, IN 46140

Test Performed by:
Jeff Robbins, Senior Test Engineer

Test Report Author:
Angie Crane, Director of Test Operations

Dates Testing Performed:
April 8 – April 22, 2021

Date Report Submitted:
May 7, 2021

Eclipse Project Number:
BIN-21-635

Report Authorized By:
Chris Murphy, Quality Manager

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1. GENERAL INFORMATION

Test Requested by:
Mark Newman
Ivanhoe Capital Acquisition
mark@ivanacq.com

Testing Locations:
Eclipse Energy LLC
1752 Fields Blvd.
Greenfield, IN 46140

Eclipse Test Order #:
BIN-21-635 & BIN-21-639

Customer PO#:
N/A

Date Test Samples Received:
April 7, 2021

Test Sample Types & ID's:
All values in this table were measured by customer prior to shipping to Eclipse Energy.

Sample ID	Mass (g)	Thickness (mm)	Temp (C)	OCV @ SOC 0% (V)	ACR (mΩ)	Capacity (Ah)	Energy Density (Wh/kg)	Energy Density (Wh/L)
S06L45004	43.4	6.52	25	3.525	4.91	4.21	370	711
S06L45005	43.6	6.56	25	3.525	4.75	4.20	368	705
S06L45006	43.6	6.54	25	3.525	4.83	4.21	368	708

Post-test Sample Disposition:
Samples to be disposed of by Eclipse per customer instructions.

2. SAMPLING METHOD

Sampling was not conducted by Eclipse Energy. Samples were selected by SES and all results of testing contained in this report apply to the samples as-received.

3. TEST EQUIPMENT

Asset ID	Type	Mfr	Model #	Serial #	Cal Due
BIN-BITR-0036	CYCLER	Bitrode	MCV16-25-12	113050	11/30/2021
BIN-BLNC-0006	SCALE	Mettler	PM4000	N61844	10/31/2021
BIN-METR-012	METER	Hioki	BT3554	171042394	3/31/2022
BIN-CMBR-0023	CHAMBER	Whirlpool	WZC3115DW00	U51602631	Ref. Only
BIN-CMBR-0031	CHAMBER	Percival	I-37X	3683.04.94I	Ref. Only
BIN-CMBR-0025	CHAMBER	Custom	N/A	N/A	Ref. Only
BIN-TEMP-0010	TEMP GAUGE	Omega	CL23A	T-294458	10/31/2021
BIN-TMON-001	TEMP MONITOR	Omega	OM-CP-RFTCTEMP2000A	Q44650	10/31/2021
BIN-TMON-008	TEMP MONITOR	Omega	OM-CP-RFTCTEMP2000A	Q50969	10/31/2021
BIN-TMON-006	TEMP MONITOR	Omega	OM-CP-RFTCTEMP2000A	Q51627	7/31/2021
BIN-CLPR-0006	CALIPER	INSIZE	1108-150	041292630	4/30/2021

Table 1: Test Equipment Information

4. TEST STANDARDS AND METHODS

a. *Customer specification:*
   i. PDF document “Eclipse_Instruction for Testing SES Pouch Cells for testing for rated peformance_040621_rev1” provided by customer for rate tests.
      1. Change made to recharge capacity limit for cell testing at 40°C. Limit changed from 4.410 Ah to 4.500Ah by customer on April 12th, 2021.
      2. Change made to maximum temperature limit for all three cells. Limit changed from maximum 70°C to 80°C by customer on April 12th, 2021.
   ii. 4C Fast charge instructions as communicated by the customer via email.

5. TEST SEQUENCE AND RESULTS SUMMARY

Sequence of Measurements and Testing:

1. As-received weight, OCV/IR, and dimensional measurements.
2. Capacity and rate capability test.
3. 4C Fast charging test.

Results Summary

The required output of the rate test was gravimetric discharge energy density in Wh/kg (also referred to as specific energy) and volumetric discharge energy density in Wh/L (also referred to simply as energy density).

The tables and charts in this section show the calculated discharge energy densities by discharge rate.

Wh/kg	Temp (C)	0.1C/0.1C	0.33C/0.1C	0.33C/0.33C	0.33C/1C	0.33C/2C	0.33C/3C	0.33C/5C	0.33C/7C
Cell 004	**25**	375	375	357	339	329	325	321	322
Cell 005	**0**	324	324	311	298	290	286	282	282
Cell 006	**40**	387	385	376	363	354	350	346	344

Table 2: Specific Energy (Wh/kg) by Discharge Rate

Wh/L	Temp (C)	0.1C/0.1C	0.33C/0.1C	0.33C/0.33C	0.33C/1C	0.33C/2C	0.33C/3C	0.33C/5C	0.33C/7C
Cell 004	**25**	735	735	699	665	645	636	629	630
Cell 005	**0**	634	634	609	583	568	561	553	552
Cell 006	**40**	758	755	738	711	695	686	678	674

Table 3: Energy Density (Wh/L) by Discharge Rate

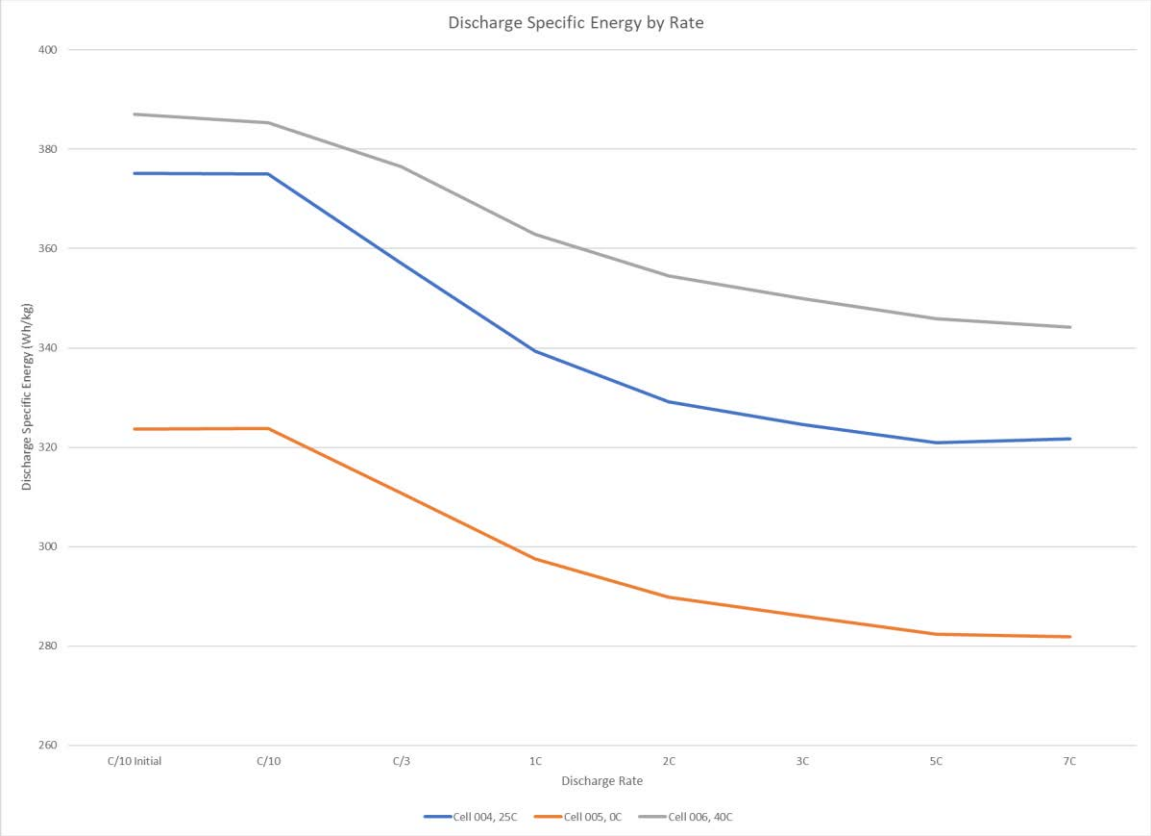

Figure 1: Specific Energy (Wh/kg) by Discharge Rate

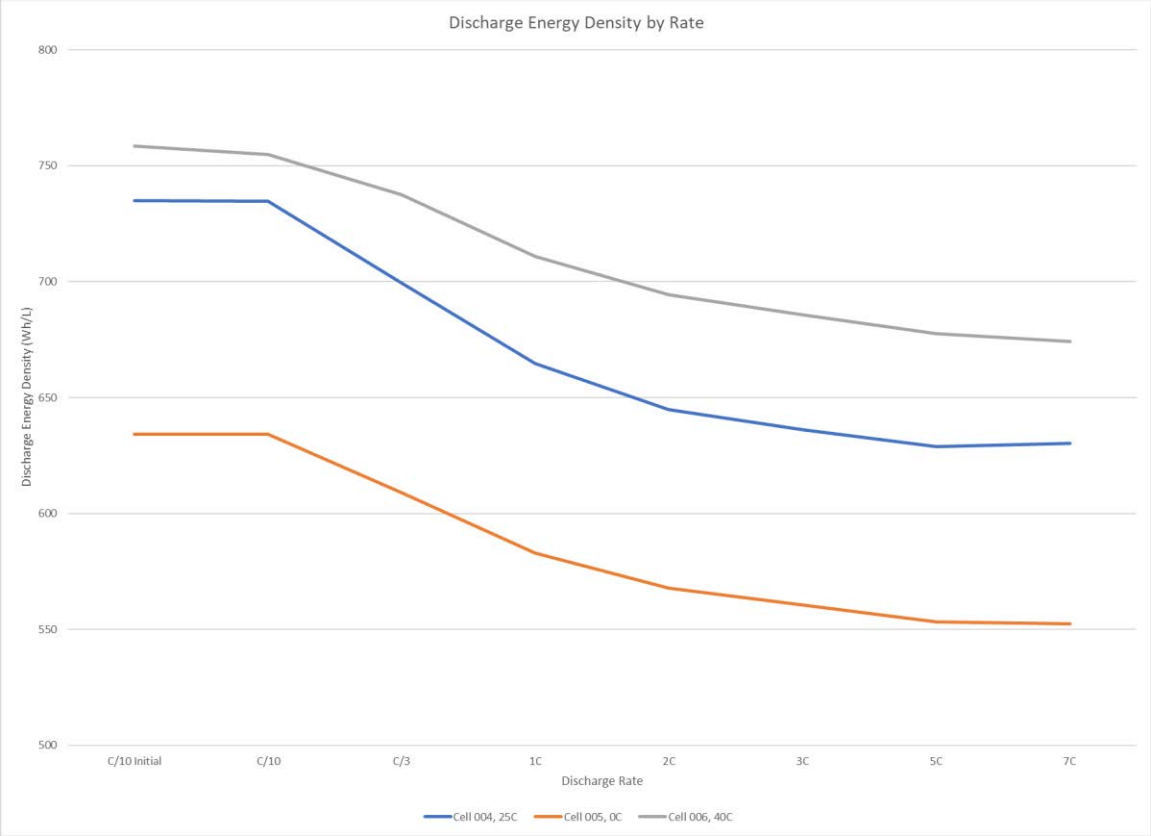

Figure 2: Energy Density (Wh/L) by Discharge Rate

No requirements for output of 4C fast charge test were given. The table below is the summary of charge time, capacity, and energy at 4C charge rate. The 4C charge started at 10% SOC and ended at 80% SOC.

Start SOC	End SOC	Temp (C)	Charge Rate	Time (min)	Capacity (Ah)	Energy (Wh)
10%	80%	25	4C	10.5	2.940	11.643

Table 4: 4C Fast Charge Time, Capacity, and Energy

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6. PROCEDURES, NOTES, AND RESULTS

a. *As-received measurements*

The cell samples were received in a metal drum, each cell contained inside a plastic compression jig and each jig placed in an individual plastic box. Cells were removed from the packaging and as-received measurements of weight, open circuit voltage (OCV), internal resistance (IR), thickness, height, and width were taken.

The procedure for measuring cell width involved folding and compressing the cell pouch edges. Additional instructions were provided by the customer after the first measurement to ensure a good compression was applied to the folded edges with the caliper. A second set of width measurements were taken and the compression of the caliper was held as tightly as possible without any deformation of the cell stack. The second measurement values for width are included in the measurements table below. All other measurements were captured with one iteration.

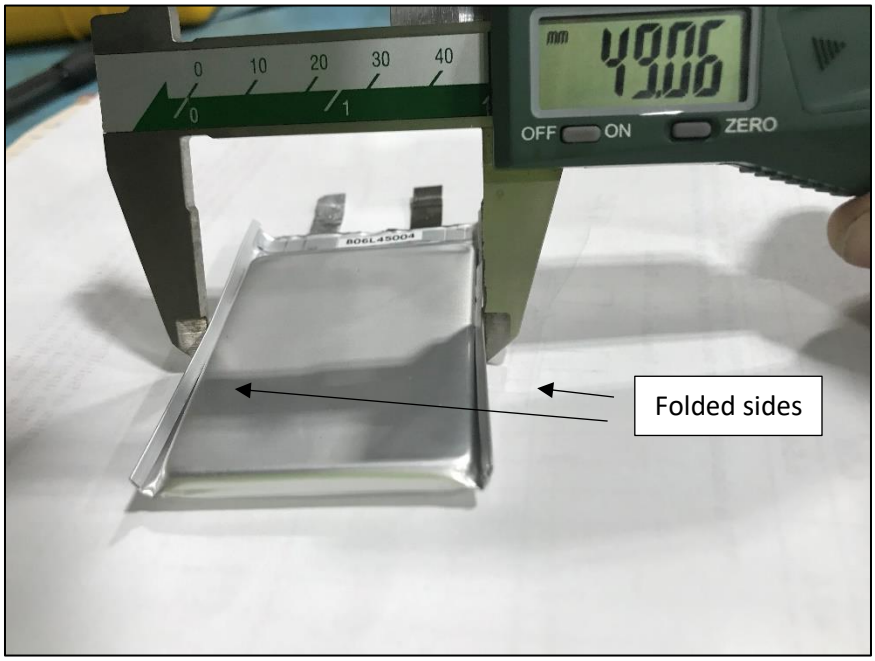

Figure 3: Cell Width Measurement Procedure

Measurement	Cell 004	Cell 005	Cell 006
As-rec Wt. (g)	43.42	43.60	43.63
As-rec OCV (V)	3.525	3.525	3.525
As-rec IR (mΩ)	4.25	4.42	4.39
Avg. Thickness (mm)	6.50	6.53	6.55
Avg. Width (mm)	47.81	48.43	47.72
Avg. Height (mm)	71.31	71.42	71.25

Table 5: As-received Cell Measurements

b. *Placement of cells in test fixture*

After as-received measurements, the cells were placed in the individual test fixtures according to the instructions in the customer test specification. The cells were positioned in the fixture with the cell bottom contained between the plates at the edge and the cell top with terminals extending past the plates. The plates were centered and the fasteners were torqued to 5 in-lbs force using the provided torque wrench. The fasteners were torqued in the sequence shown in the customer test specification.

Figure 4: Cell Placed in Test Fixture - Top Face View

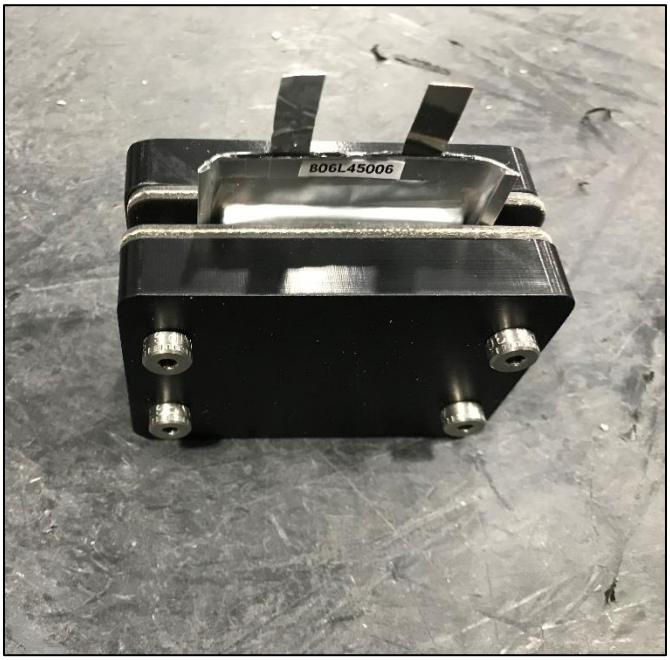

Figure 5: Cell Placed in Test Fixture - Top Terminal View

c. *Placement of test fixtures in chamber and connection to test channel*
After the cells were secured in the customer test fixtures, the cell tabs were clamped into the test channel fixture inside the temperature chambers. Voltage sense leads were attached to the cell terminals with alligator clips just above the top seal of the pouch. The thermocouple was placed on the cell in the center between the terminals and as close to the test fixture plate as possible without touching the plate.

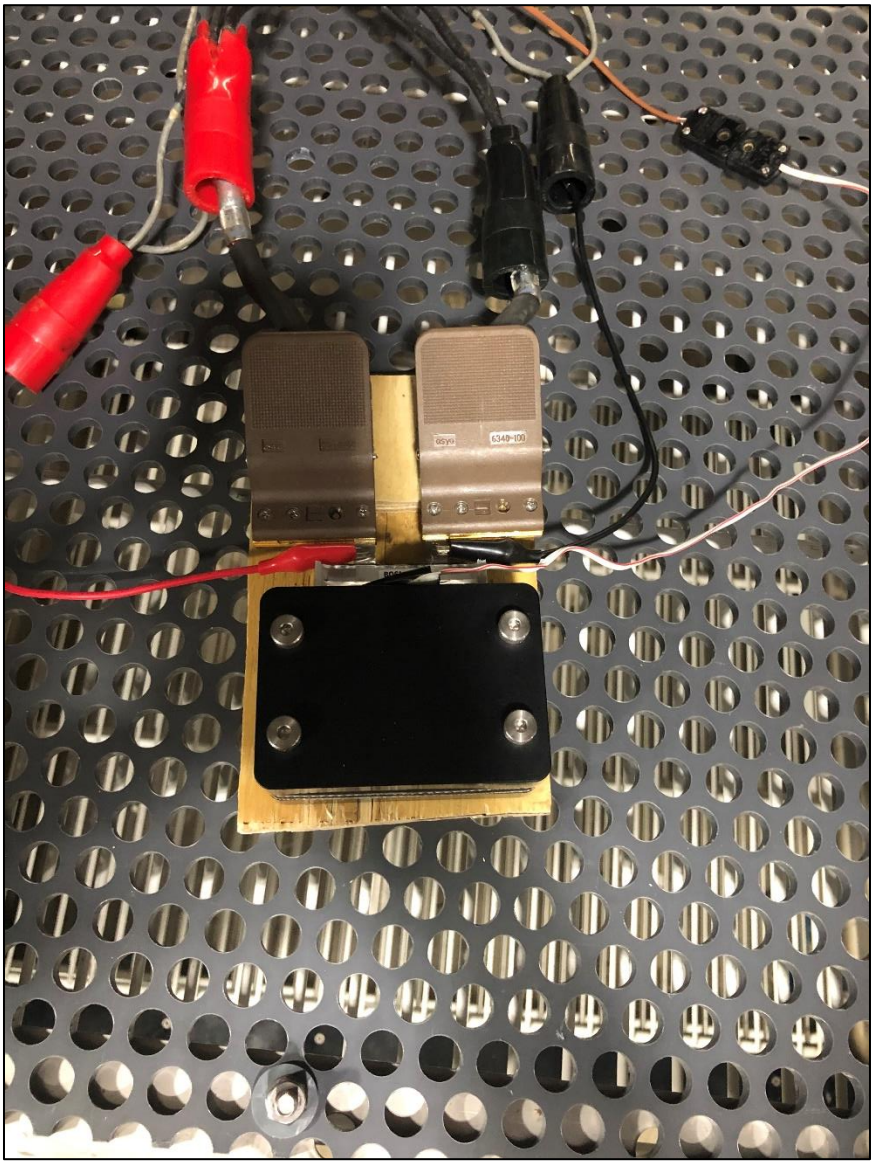

Figure 6: Cell Terminal Clamped in Test Channel Fixture in Temp Chamber

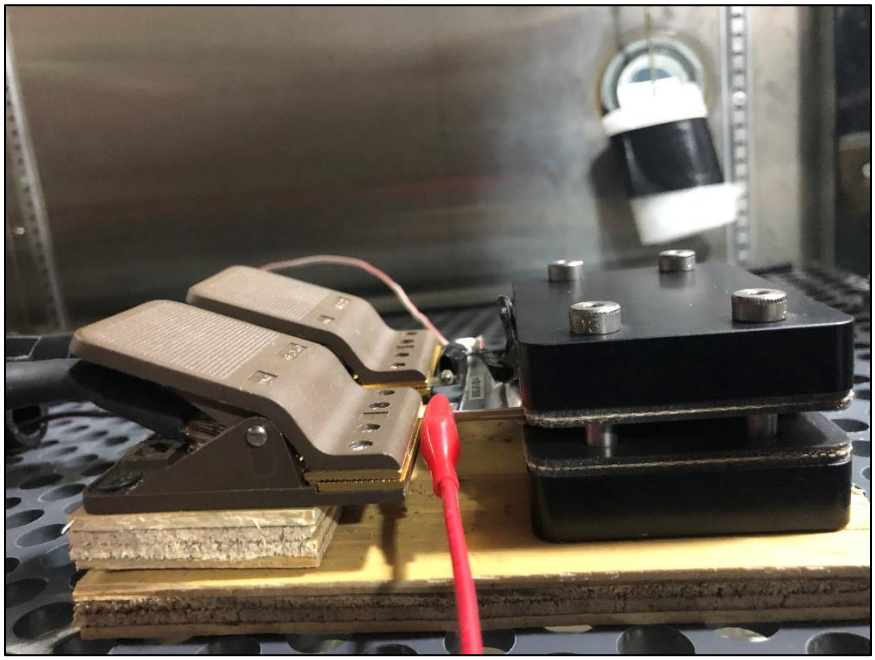

Figure 7: Voltage Sense Leads on Terminals

d. *Capacity and rate tests at 0°C, 25°C, and 40°C*
After each cell was connected to the test channel inside a temperature chamber at each of 0°C, 25°C, and 40°C temperatures, the test profile defined the customer test specification was started. Each cell stayed two hours at open circuit voltage in the temperature chamber. After the two-hour soak, the cells charged and discharged at a 10-hour rate for the initial capacity measurement. The cells were then charged at a 3-hour rate and discharged through seven increasing discharge rates of C/10, C/3, 1C, 2C, 3C, 5C, and 7C.

The following charts present the measured voltage and current data collected during the full test sequence and the discharge capacity vs. cell voltage curves at the different discharge rates.

Cell 004 (25°C) Data Charts:

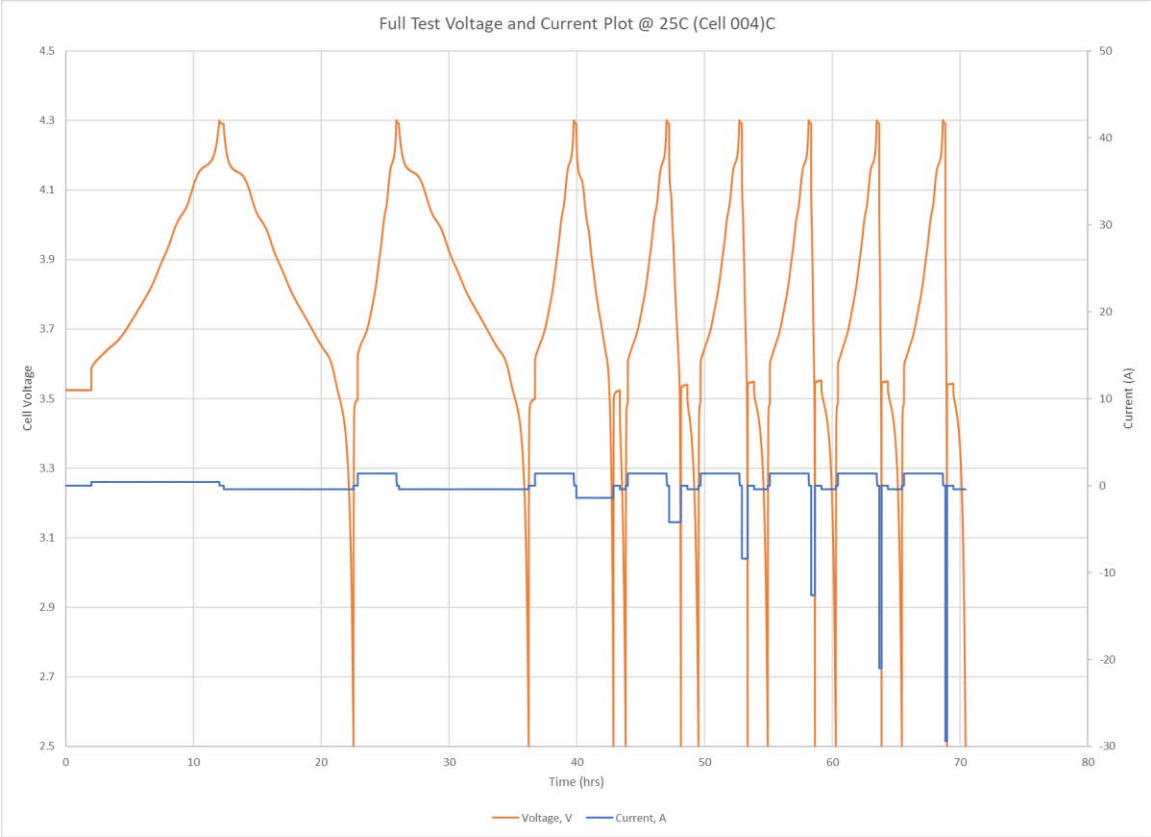

Figure 8: Cell 004, 25C - Full Test Voltage and Current

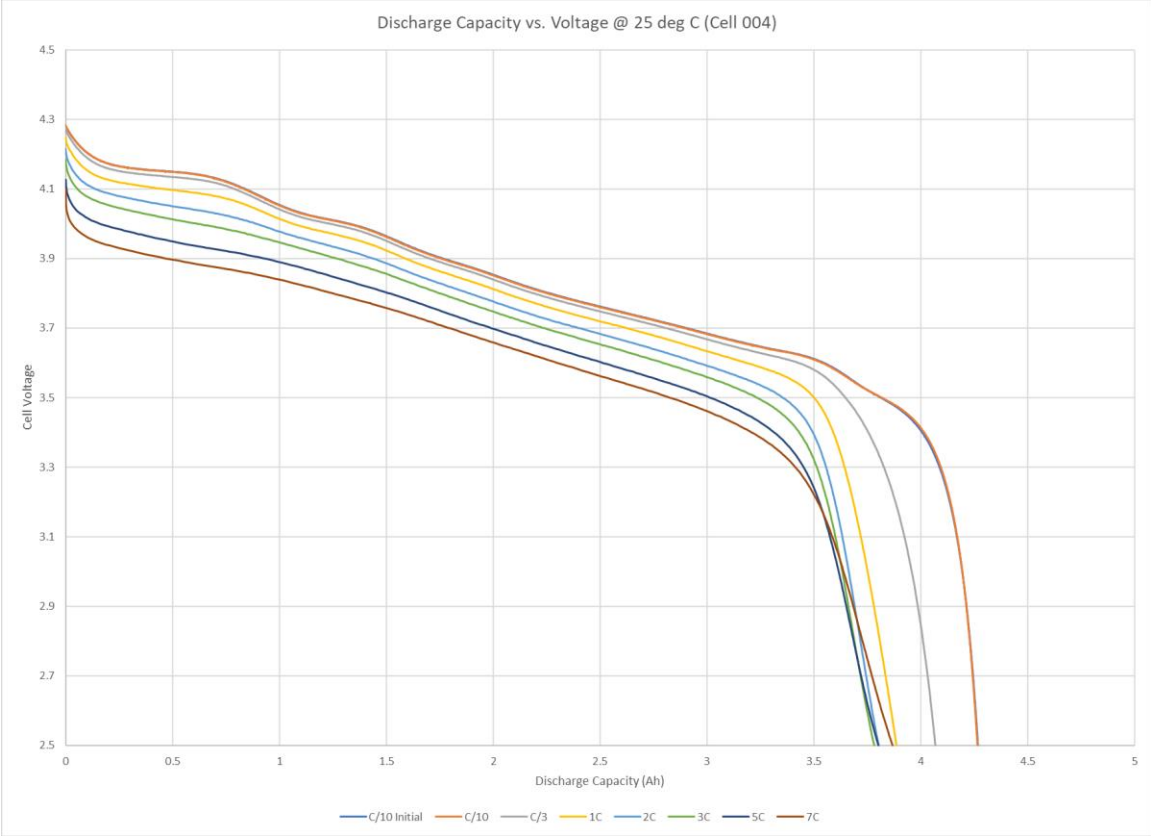

Figure 9: Cell 004, 25C - Discharge Capacity vs. Voltage

Cell 005 (0°C) Data Charts:

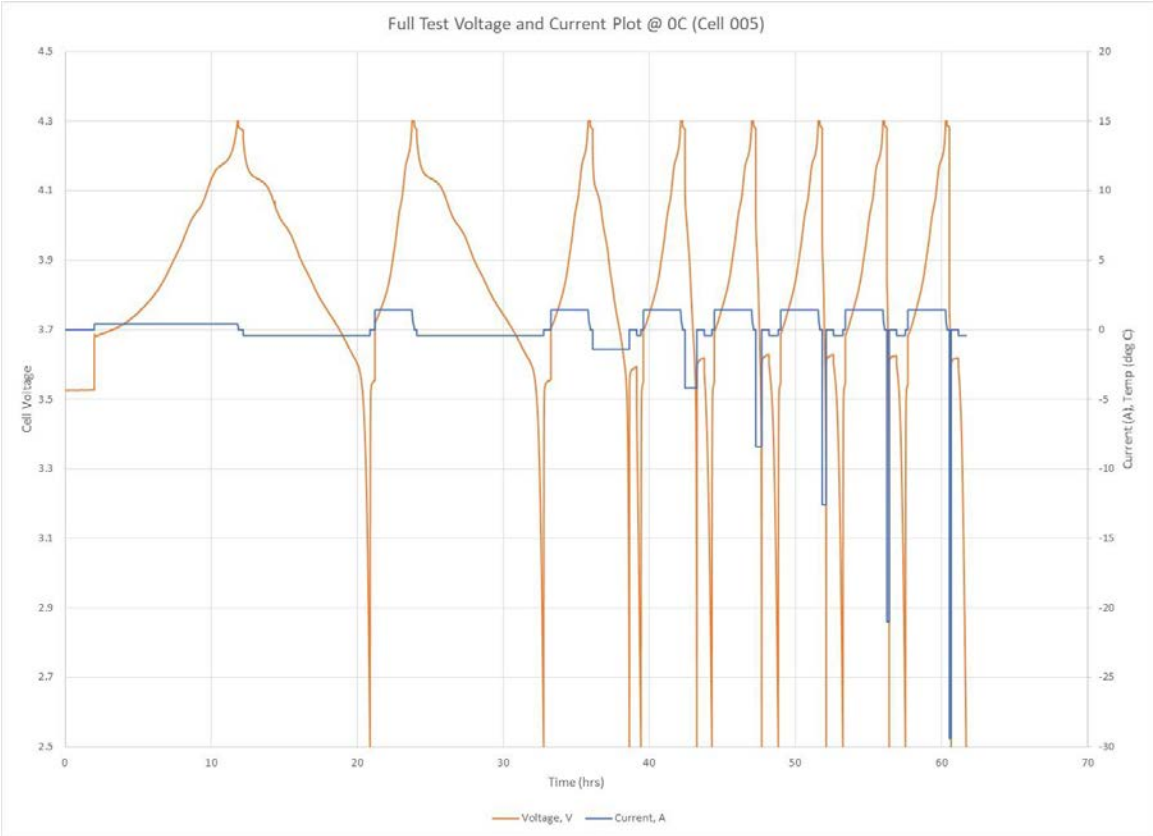

Figure 10: Cell 005, 0C - Full Test Voltage and Current

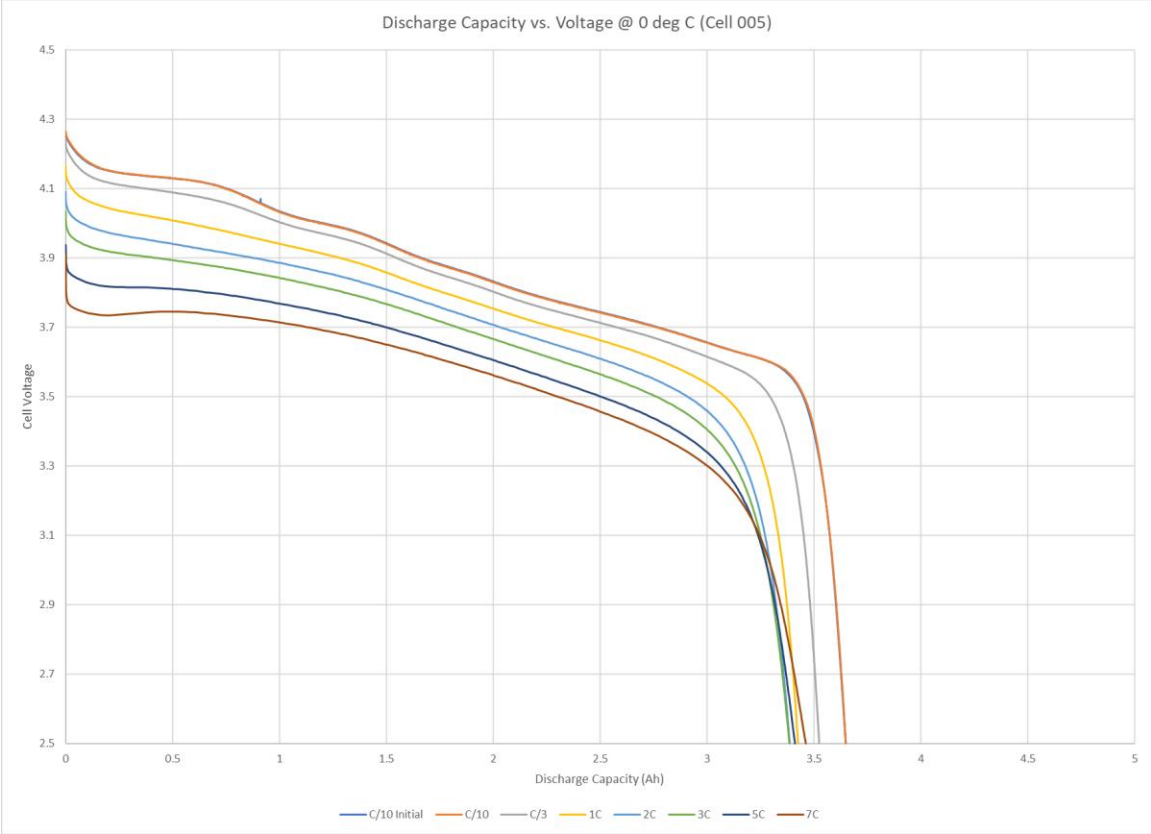

Figure 11: Cell 005, 0C - Discharge Capacity vs. Voltage

Cell 006 (40°C) Data Charts:

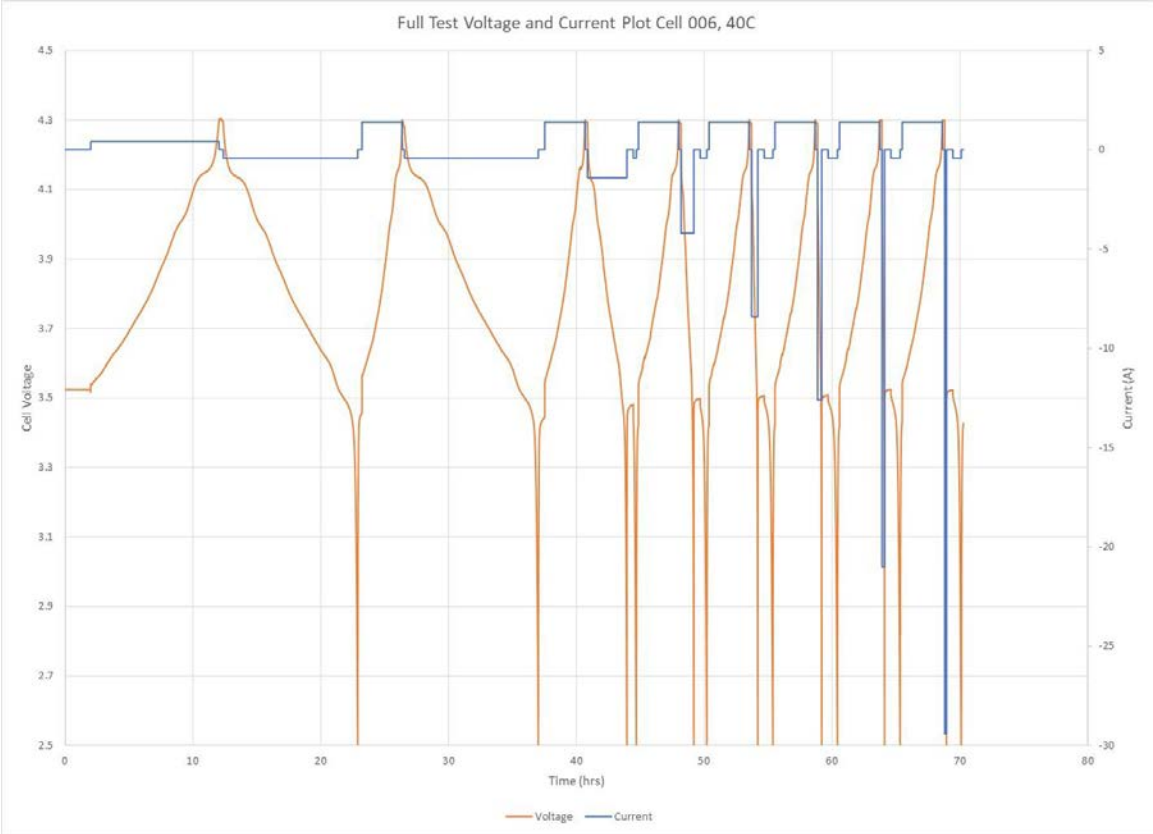

Figure 12: Cell 006, 40C - Full Test Voltage and Current

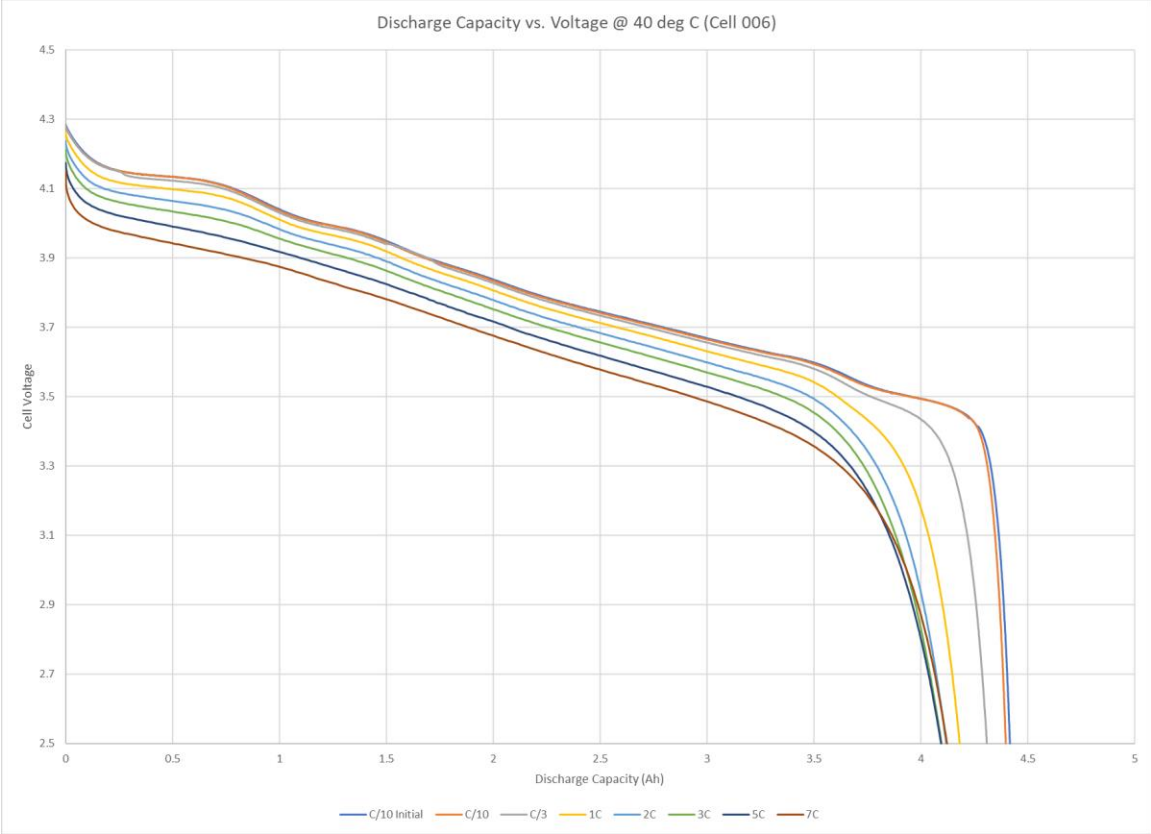

Figure 13: Cell 006, 40C - Discharge Capacity vs. Voltage

e. *4C Fast Charge Test at 25°C*

At the conclusion of the rate tests, Cell 004 was moved on to a 4C fast charge test at 25°C. The cell was fully discharged and then recharged at a C/3 rate until 0.42Ah was reached (10% SOC). The cell was then charged at 4C rate until 2.94Ah was reached, ending the fast charge at 80% SOC.

The following charts present the measured voltage and current data collected during the full test sequence and the 4C charge capacity vs. voltage.

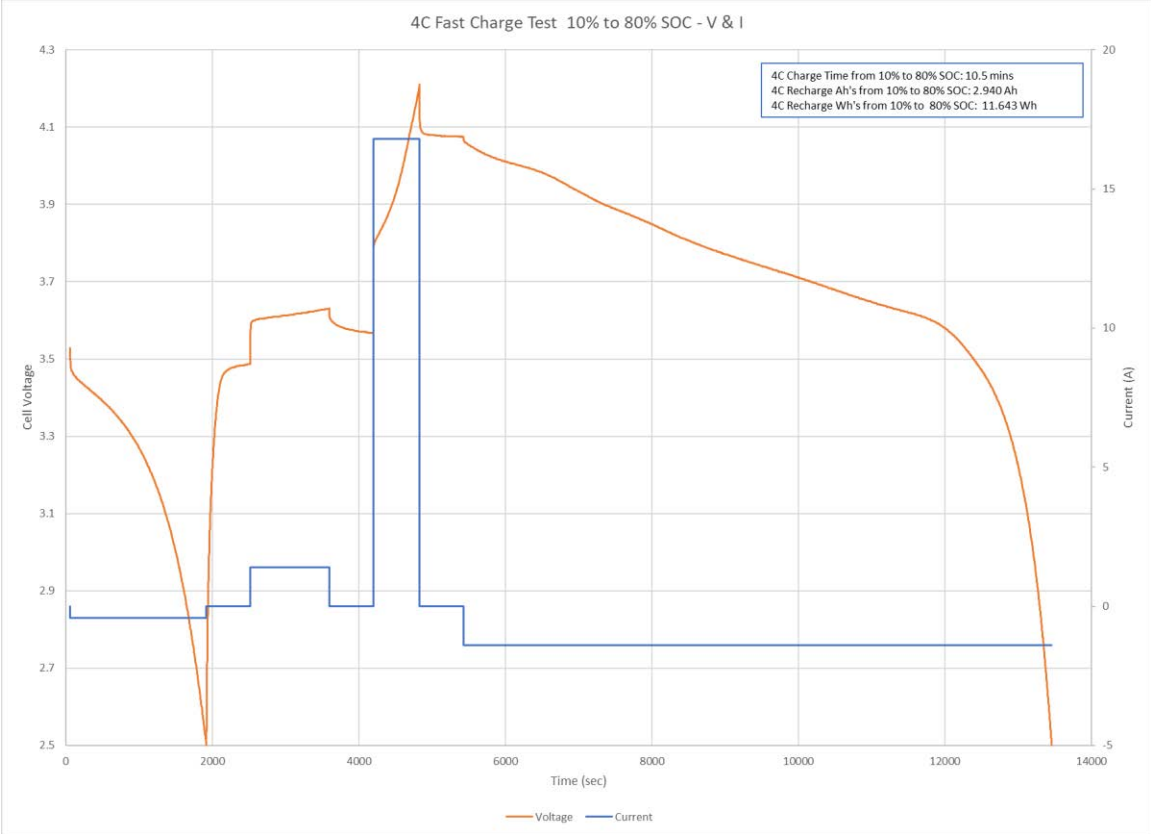

Figure 14: 4C Fast Charge 10% to 80% SOC - Full Test Voltage and Current

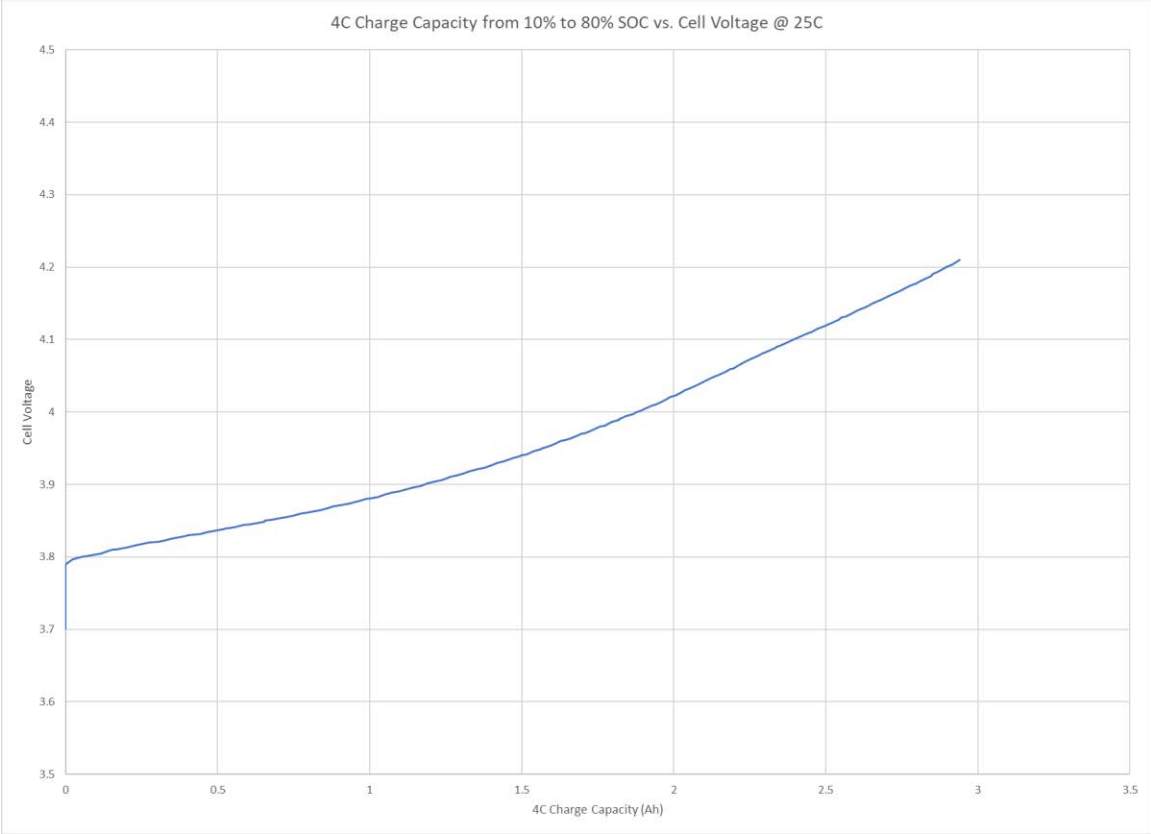

Figure 15: 4C Fast Charge - 4C Charge Capacity vs. Cell Voltage

7. TEST DEVIATIONS

All measurements and electrical tests were performed according to the provided customer test specification with adjustments made as noted in section 4.a.i. 1 and 2 of this test report.

8. TEST CONCLUSIONS

All measurements and testing requested was conducted as required by the provided customer test specification and all samples completed the measurement and test sequences.

a. Energy Density Comparisons

The energy density values obtained during the 25°C, 0.1C charge/0.1C discharge test at Eclipse Energy showed slightly higher values than the average values shown in the customer test specification.

0.1C/0.1C	Wh/kg		
	SES Avg.	Eclipse	% Diff
25C	369	375	⬆ 1.8%

Table 6: Wh/kg Comparison

0.1C/0.1C	Wh/L		
	SES Avg.	Eclipse	% Diff
25C	708	735	⬆ 3.8%

Table 7: Wh/L Comparison

The energy density values shown in the Eclipse column were calculated as follows:

Wh/kg

- Total watt-hours (Wh) are calculated by multiplying the measured current and voltage to get a power (W) value, then multiplying the average power value between data points by the time (hrs) elapsed between points and summing the watt-hours over the full discharge.
- The Energy Density in Wh/kg was obtained by dividing the total watt-hours for the discharge by the mass (kg) of each cell that was measured on receipt at the laboratory.

Wh/L

- The Energy Density in Wh/L was obtained by dividing the same total watt-hours for the discharge by the volume (L) of the cell.
- The cells were measured in three dimensions on receipt at the laboratory. The cubic millimeters were calculated and then converted to liters.

b. Additional data

Cell capacity (Ah) and energy (Wh) data is also included in the tables below for reference.

Ah	Temp (C)	0.1C/0.1C	0.33C/0.1C	0.33C/0.33C	0.33C/1C	0.33C/2C	0.33C/3C	0.33C/5C	0.33C/7C
Cell 004	**25**	4.267	4.265	4.068	3.886	3.803	3.782	3.802	3.868
Cell 005	**0**	3.649	3.649	3.542	3.426	3.387	3.385	3.411	3.462
Cell 006	**40**	4.417	4.397	4.309	4.182	4.119	4.097	4.095	4.123

Table 8: Capacity (Ah) by Discharge Rate

Wh	Temp (C)	0.1C/0.1C	0.33C/0.1C	0.33C/0.33C	0.33C/1C	0.33C/2C	0.33C/3C	0.33C/5C	0.33C/7C
Cell 004	**25**	16.29	16.281	15.5	14.733	14.292	14.096	13.936	13.968
Cell 005	**0**	14.056	14.057	13.493	12.92	12.583	12.422	12.262	12.241
Cell 006	**40**	16.806	16.73	16.344	15.757	15.391	15.193	15.017	14.942

Table 9: Energy (Wh) by Discharge Rate

9. TERMS AND ABBREVIATIONS

Term/Abbreviation	Definition
Ah	Amp-hours capacity unit
C	Rated capacity in amp-hours for 1 hour rate
C	Degrees Celsius
°C	Degrees Celsius
g	Grams
ID	Identification number or code
IR	Internal resistance
in-lb	Inch-pounds force unit
mm	millimeter
mΩ	milliohm
OCV	Open circuit voltage
Sec	Seconds time unit
Temp	Temperature
V	Voltage
Wh/kg	Watt-hours per kilogram
Wh/L	Watt-hours per liter

Table 10: Terms and Abbreviations

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10. AUTHORIZATION SIGNATURES

JEFF ROBBINS — **05/07/2021**
SENIOR TEST ENGINEER — Date

ANGIE CRANE — **05/07/2021**
DIRECTOR OF TEST OPERATIONS — Date

CHRIS MURPHY — **05/07/2021**
QUALITY MANAGER — Date

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END OF REPORT