2013 Nissan Leaf– VINs 0656, 5045, 7885 & 9270

Advanced Vehicle Testing –DC Fast Charging at Temperature Test Results




VEHICLE, ENERGY STORAGE SYSTEM, AND DCFC DETAILS[1]

Vehicle Details

Base Vehicle: 2013 Nissan Leaf
Vehicle Type: BEV
VINs: 1N4AZ0CP0DC405045; 1N4AZ0CP2DC420646; 1N4AZ0CP5DC417885; KNDJX3AE7F7001920

DCFC Details[2]

Manufacturer: BTC Power
Model/Type: EVFC-5-1-B-1-1-480/SAE CCS + CHAdeMO
Rated DC Charge Power: 50 kW
Rated DC Current[2]: 100 A

Energy Storage System Specifications

Manufacturer: Automotive Energy Supply Corp.
Type: Lithium-ion
Rated Pack Energy/Capacity: 24 kWh/66.2 Ah
Thermal Management: Passive – Air cooled

Test Dates by VIN

	0646	5045	7885	9270
0 °C	3/24/17	9/7/16	2/24/16	8/23/16
25 °C	3/28/17	9/13/16	2/26/16	8/25/16
50 °C	4/11/17	9/15/16	3/1/16	9/14/16

TEST RESULTS SUMMARY

Test Temp. (°C)	Total Charge Duration (hh:mm:ss)	End of Charge Range (mi)	Total DC Charge Energy (kWh)	Initial Charge Start/End SOC[3] (%)	Top-Off Charge Start/End SOC[3] (%)	Initial/Top-Off Charge Avg. Power (kW)	ESS ΔT[4] (°C)	ESS Thermal Regulation Energy[5] (kWh)
VIN 0646 - Beginning-of-Test (at 4,610 miles)[6]								
0 °C	01:58:04	Not Recorded	17.9	14.3 / 79.0	79.0 / 91.1	15.2 / 1.1	N/A	N/A
25 °C	01:03:57		19.2	14.1 / 86.4	86.3 / 93.9	32.7 / 3.4	N/A	N/A
50 °C	01:25:27		19.5	14.2 / 90.7	90.6 / 93.3	23.5 / 0.6	N/A	N/A
Middle-of-Test (at 24,065 miles)[6]								
0 °C	01:59:56	78	14.30	14.1 / 89.8	89.6 / 91.0	7.5 / 2.0	N/A	N/A
25 °C	00:55:33	75	15.47	14.7 / 91.3	91.0 / 91.3	17.1 / 1.5	N/A	N/A
50 °C	00:50:28	78	14.90	14.1 / 91.5	90.9 / 91.3	18.5 / 1.5	N/A	N/A
End-of-Test								
0 °C								
25 °C								
50 °C								
VIN 5045 - Beginning-of-Test (at 10,712 miles)[6]								
0 °C	01:59:57	82	17.4	14.4 / 73.4	73.4 / 91.0	15.3 / 1.2	N/A	N/A
25 °C	01:05:40	77	18.2	14.4 / 81.0	80.9 / 90.7	29.4 / 2.9	N/A	N/A
50 °C	01:00:38	65	17.9	14.1 / 84.7	84.7 / 87.1	24.3 / 1.5	N/A	N/A
Middle-of-Test (at 24,103 miles)[6]								
0 °C	02:00:19	59	9.54	14.5 / 89.1	89.0 / 89.5	4.8 / 1.4	N/A	N/A
25 °C	01:03:46	64	11.82	14.0 / 95.0	94.9 / 94.8	11.4 / 1.4	N/A	N/A
50 °C	00:58:22	65	12.15	14.5 / 96.9	96.8 / 96.8	12.6 / 1.5	N/A	N/A
End-of-Test								
0 °C								
25 °C								
50 °C								

Test Temp. (°C)	Total Charge Duration (hh:mm:ss)	End of Charge Range (mi)	Total DC Charge Energy (kWh)	Initial Charge Start/End SOC[3] (%)	Top-Off Charge Start/End SOC[3] (%)	Initial/Top-Off Charge Avg. Power (kW)	ESS ΔT[4] (°C)	ESS Thermal Regulation Energy[5] (kWh)
VIN 7885 - Beginning-of-Test (at 4,606 miles)[6]								
0 °C	01:57:14	Not Recorded	19.0	14.4 / 79.4	79.4 / 92.9	16.6 / 2.5	N/A	N/A
25 °C	01:03:57		19.1	14.3 / 83.2	83.1 / 93.4	32.5 / 3.4	N/A	N/A
50 °C	01:01:19		19.7	14.1 / 89.0	88.9 / 91.3	26.9 / 1.4	N/A	N/A
Middle-of-Test (at 24,023 miles)[6]								
0 °C	01:44:21	76	16.37	14.7 / 79.9	79.8 / 93.3	13.9 / 3.1	N/A	N/A
25 °C	00:54:34	77	16.23	14.1 / 92.7	92.6 / 92.8	18.5 / 1.4	N/A	N/A
50 °C	00:48:29	78	16.22	14.4 / 92.0	91.9 / 92.0	20.5 / 1.0	N/A	N/A
End-of-Test								
0 °C								
25 °C								
50 °C								
VIN 9270 - Beginning-of-Test (at 4,945 miles)[6]								
0 °C	01:51:02	Not Recorded	18.6	15.6 / 80.8	80.7 / 94.4	15.8 / 3.3	N/A	N/A
25 °C	01:01:16		19.3	15.0 / 89.4	89.3 / 95.9	31.0 / 3.6	N/A	N/A
50 °C	01:13:47		19.3	14.4 / 91.7	91.6 / 94.1	24.1 / 1.0	N/A	N/A
Middle-of-Test (at 24,123 miles)[6]								
0 °C	01:45:14	73	14.52	13.7 / 94.3	94.3 / 94.6	8.4 / 1.6	N/A	N/A
25 °C	01:11:52	75	15.54	14.4 / 94.2	94.1 / 94.2	13.3 / 1.3	N/A	N/A
50 °C	00:46:09	75	14.97	14.0 / 97.0	96.9 / 97.0	20.0 / 1.1	N/A	N/A
End-of-Test								
0 °C								
25 °C								
50 °C								

Test Results Analysis

DC fast charging at temperature testing includes tests that measure the charge duration, energy transfer, and energy used to thermally regulate the energy storage system (ESS) for charge events at 0, 25 and 50 °C.[7] The objective of this testing is to provide analysis about the effects of ambient temperature on DC fast charge-capable vehicles. These tests were performed as part of the US Department of Energy Advanced Vehicle Testing Activity, which is conducted by Idaho National Laboratory and Intertek Center for Evaluation of Clean Energy Technology (CECET).

Test Results: Energy and SOC

Figures 1a through 1f show the energy transferred to each vehicle and the change in state of charge (SOC) over the duration of each charge event for each of the specified temperatures. Each DC fast charge event consists of an initial charge event and a top-off charge event.[8,9] The end of the initial charge is denoted by a dashed oval. Many vehicle manufacturers report the time required for a charge of the ESS to 80% SOC as being 30 minutes; for VIN 0646, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 55.7%, 80.7%, and 83.2%, respectively. For VIN 5045, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 52.2%, 84.0%, and 79.4%, respectively. For VIN 7885, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 57.3%, 83.6%, and 84.1%, respectively. For VIN 9270, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 62.3%, 63.2%, and 90.1%, respectively.

Each MOT graph is followed by a graph for a typical vehicle (VIN 0646) showing a comparison between the charge profiles for BOT and MOT testing.

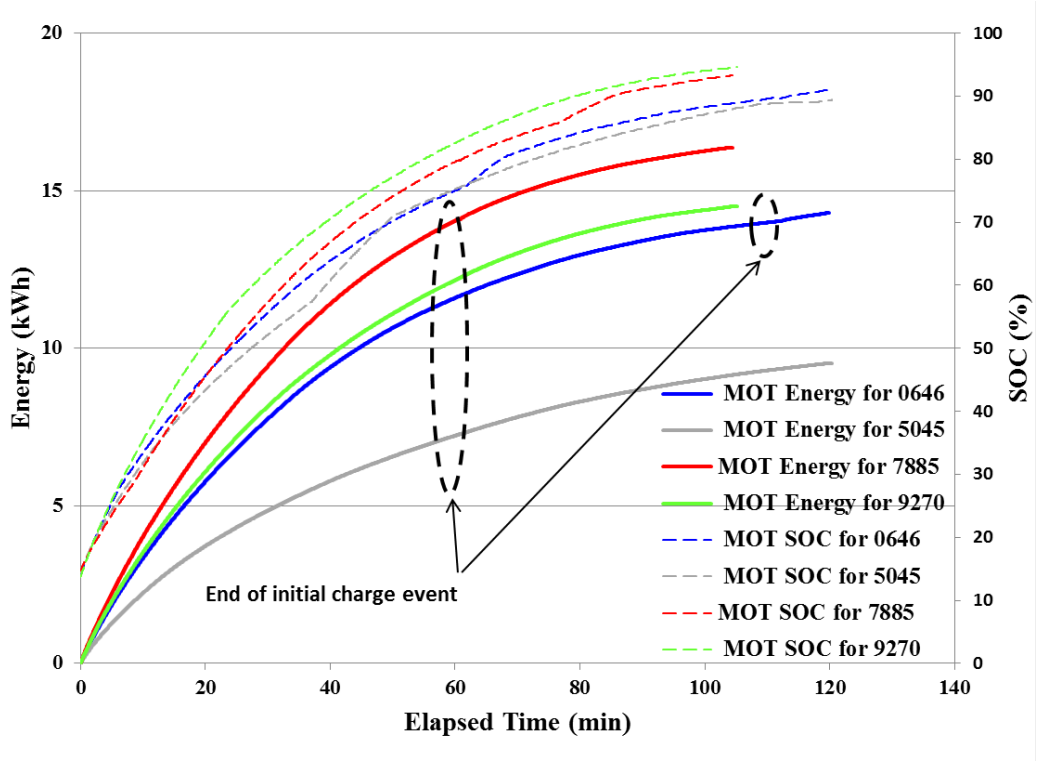

Figure 1a. 0 °C charge energy and SOC versus time

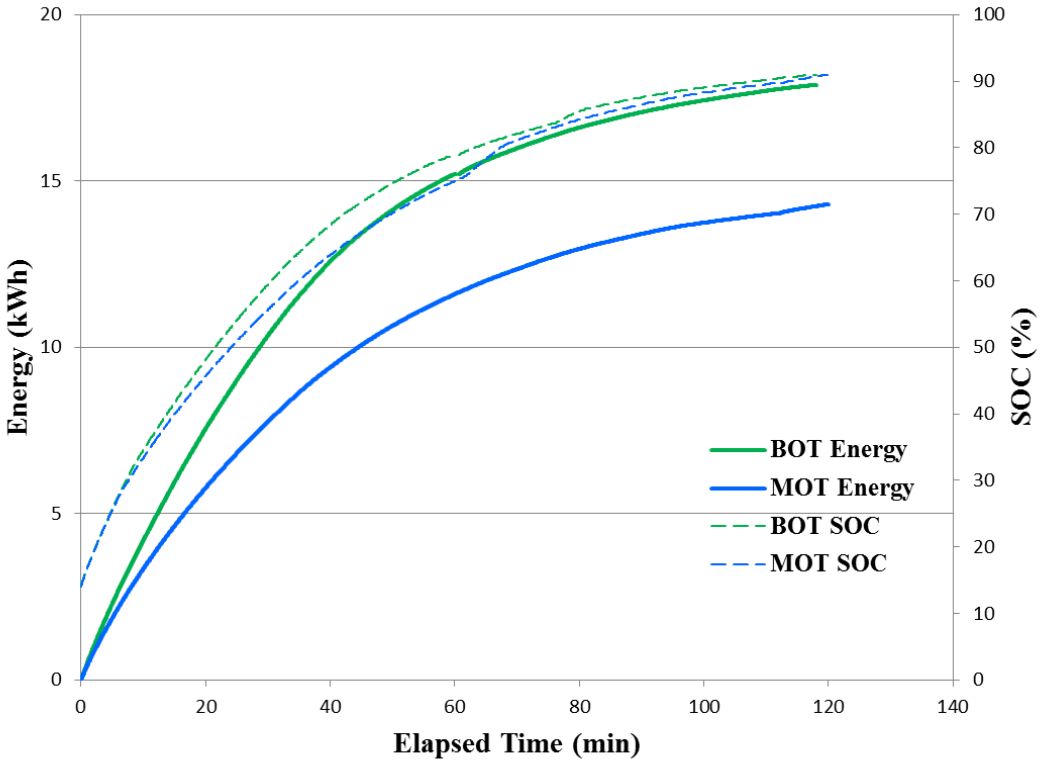

Figure 1b. 0 °C VIN 0646 BOT & MOT charge energy versus time

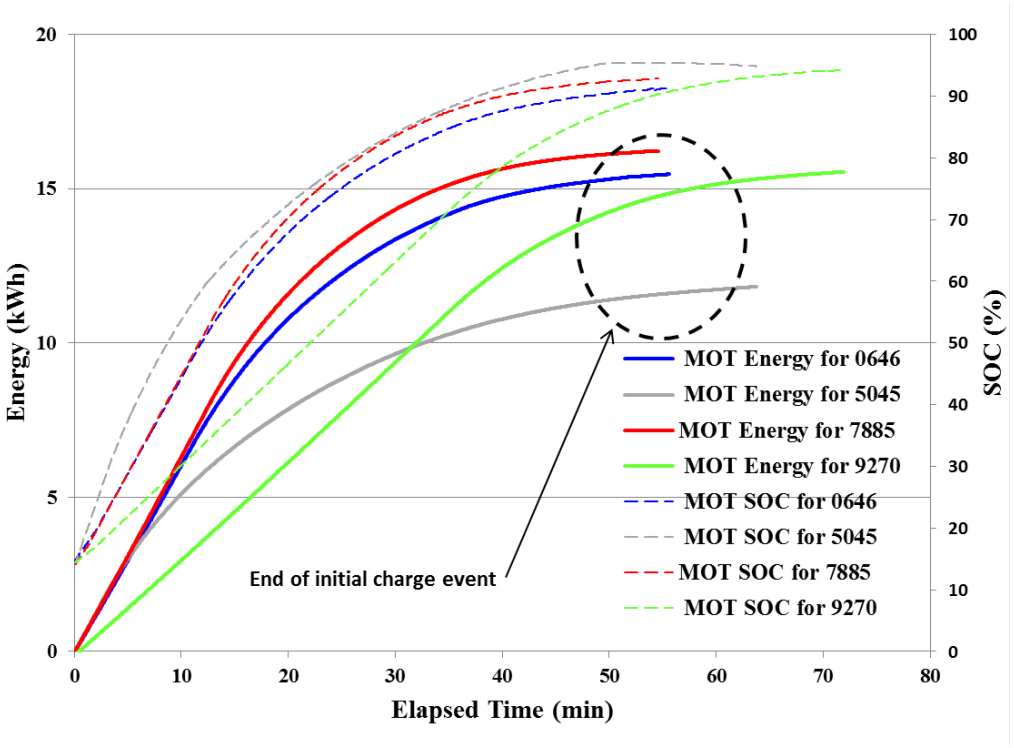

Figure 1c. 25 °C charge energy and SOC versus time

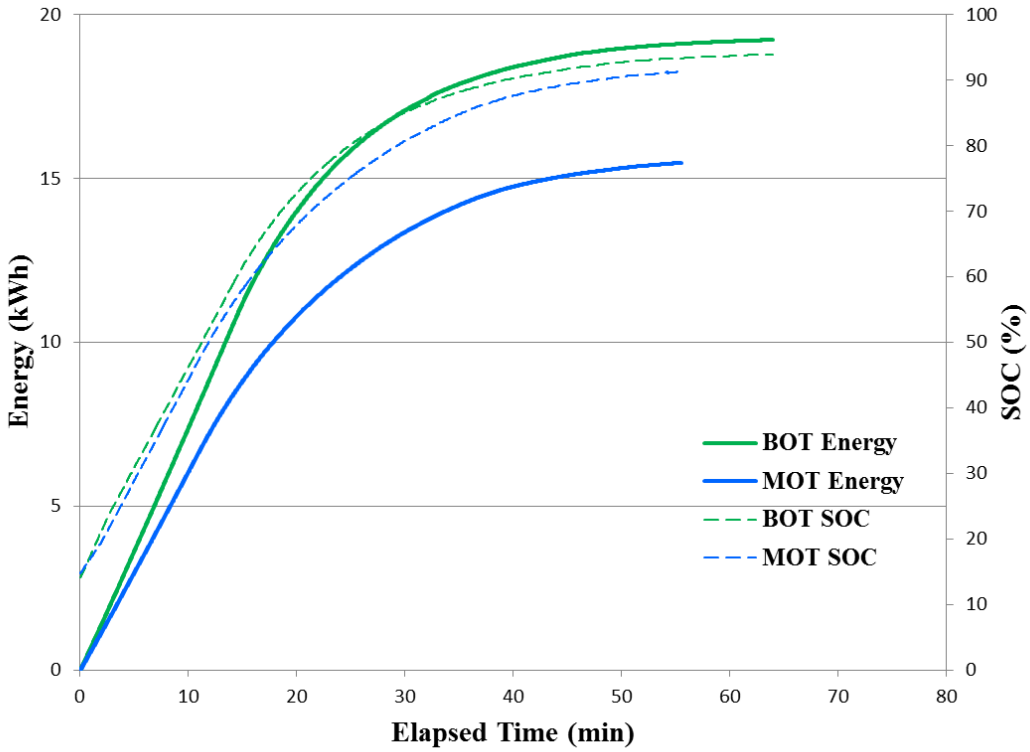

Figure 1d. 25 °C VIN 0646 BOT & MOT charge energy versus time

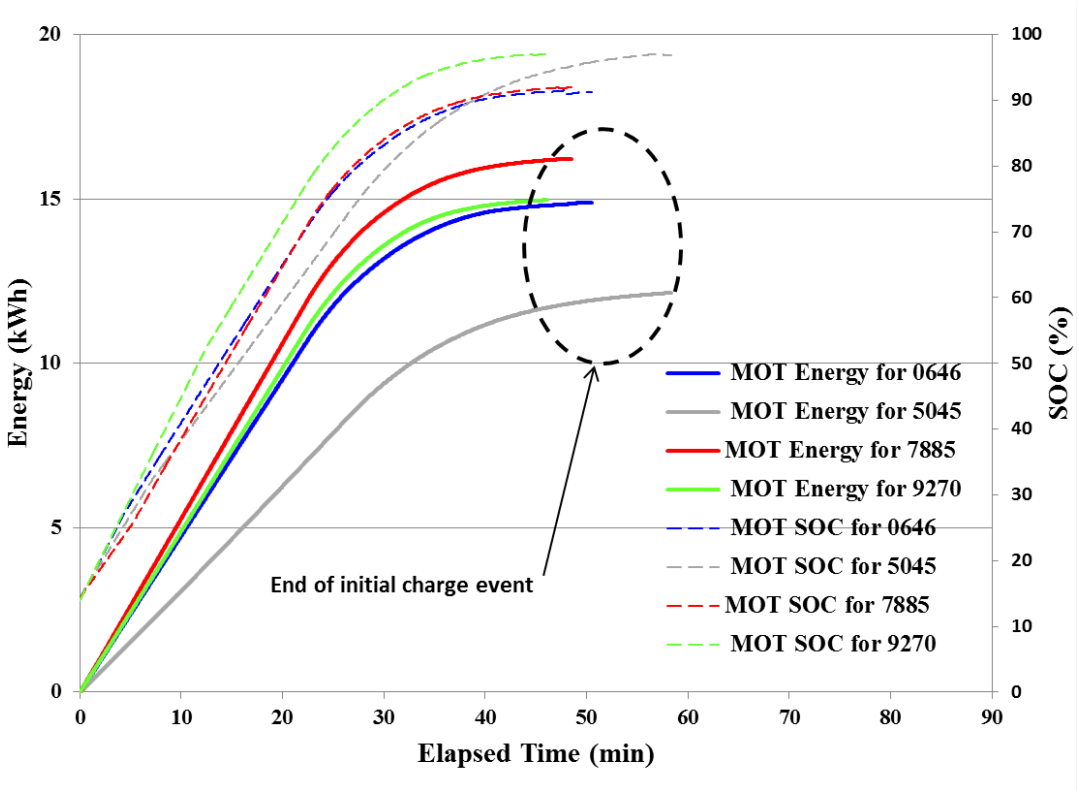

Figure 1e. 50 °C charge energy and SOC versus time

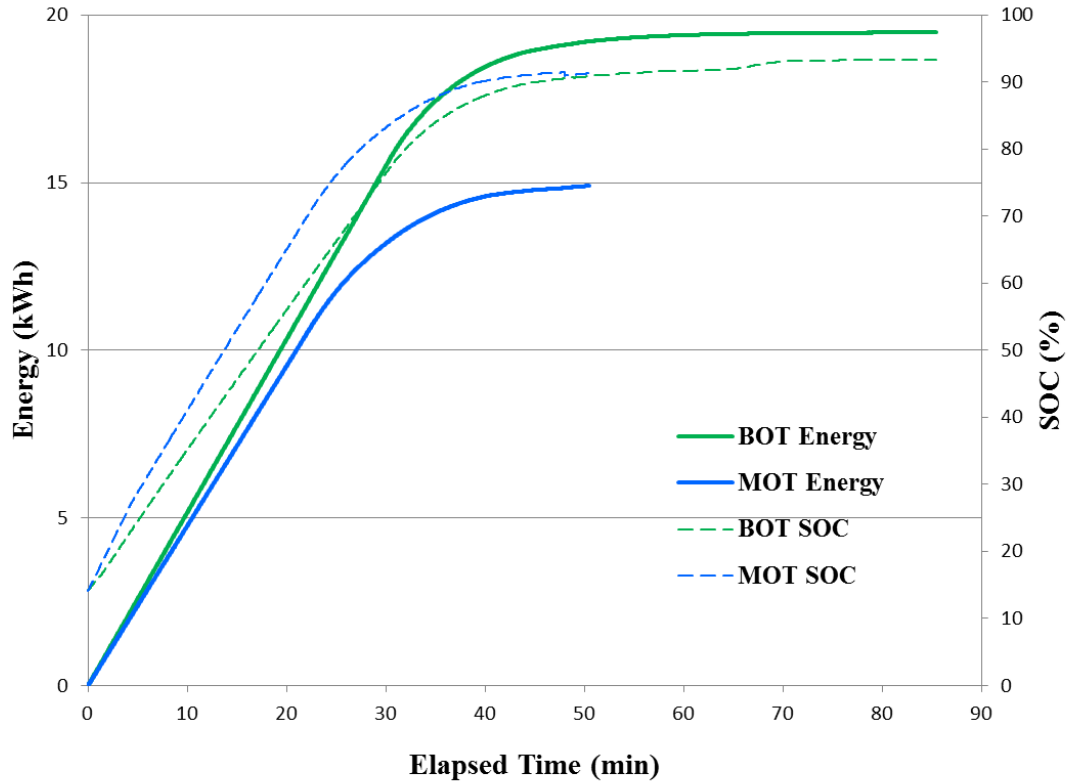

Figure 1f. 50 °C VIN 0646 BOT & MOT charge energy versus time

Test Results: Temperatures

Tables 1,2,3 and 4 show the initial and final ESS enclosure temperatures of each vehicle's ESS during charging events.

Table 1. VIN 0646 ESS enclosure temperature during test

Test Temperature (°C)	BOT ESS Enclosure Initial Temp. (°C)	BOT ESS Enclosure Maximum Temp. (°C)	MOT ESS Enclosure Initial Temp. (°C)	MOT ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured	-1.4	5.4
25 °C	Not Measured	Not Measured	24.6	29.3
50 °C	Not Measured	Not Measured	49.5	53.0

Table 2. VIN 5045 ESS enclosure temperature during test

Test Temperature (°C)	BOT ESS Enclosure Initial Temp. (°C)	BOT ESS Enclosure Maximum Temp. (°C)	MOT ESS Enclosure Initial Temp. (°C)	MOT ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured	0.4	2.6
25 °C	Not Measured	Not Measured	23.9	27.8
50 °C	Not Measured	Not Measured	48.6	50.6

Table 3. VIN 7885 ESS enclosure temperature during test

Test Temperature (°C)	BOT ESS Enclosure Initial Temp. (°C)	BOT ESS Enclosure Maximum Temp. (°C)	MOT ESS Enclosure Initial Temp. (°C)	MOT ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured	-0.7	6.4
25 °C	Not Measured	Not Measured	26.3	30.4
50 °C	Not Measured	Not Measured	48.2	52.4

Table 4. VIN 9270 ESS enclosure temperature during test

Test Temperature (°C)	BOT ESS Enclosure Initial Temp. (°C)	BOT ESS Enclosure Maximum Temp. (°C)	MOT ESS Enclosure Initial Temp. (°C)	MOT ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured	-1.5	4.7
25 °C	Not Measured	Not Measured	24.1	27.9
50 °C	Not Measured	Not Measured	48.7	52.8

Test Results: Charge Power[10,11]

Figures 2a through 2f show the power at which the ESS for each vehicle was charged for each of the specified temperatures. As before, the end of the initial charge event is denoted by a dashed oval. Each MOT graph is followed by a graph for a typical vehicle (VIN 0646) showing the power comparison between BOT and MOT testing.

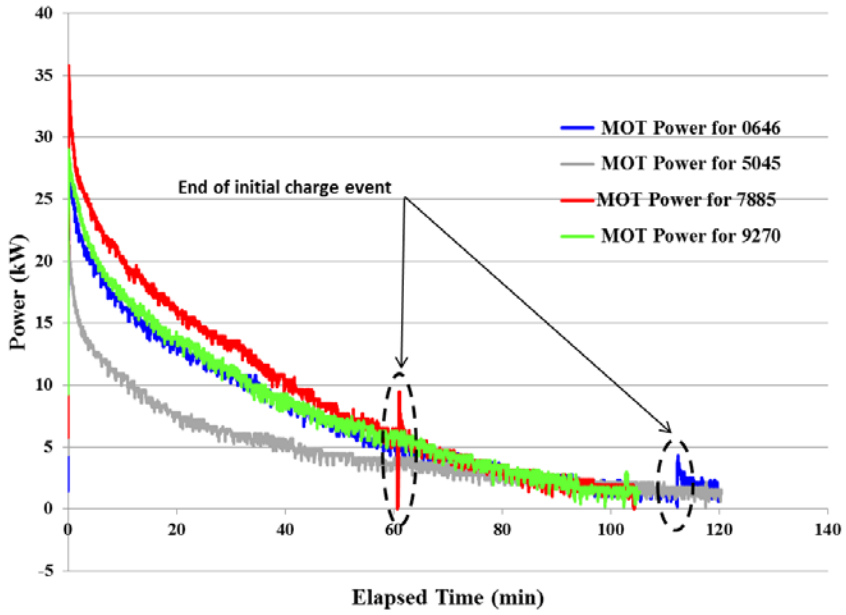

Figure 2a. 0 °C charge power profiles

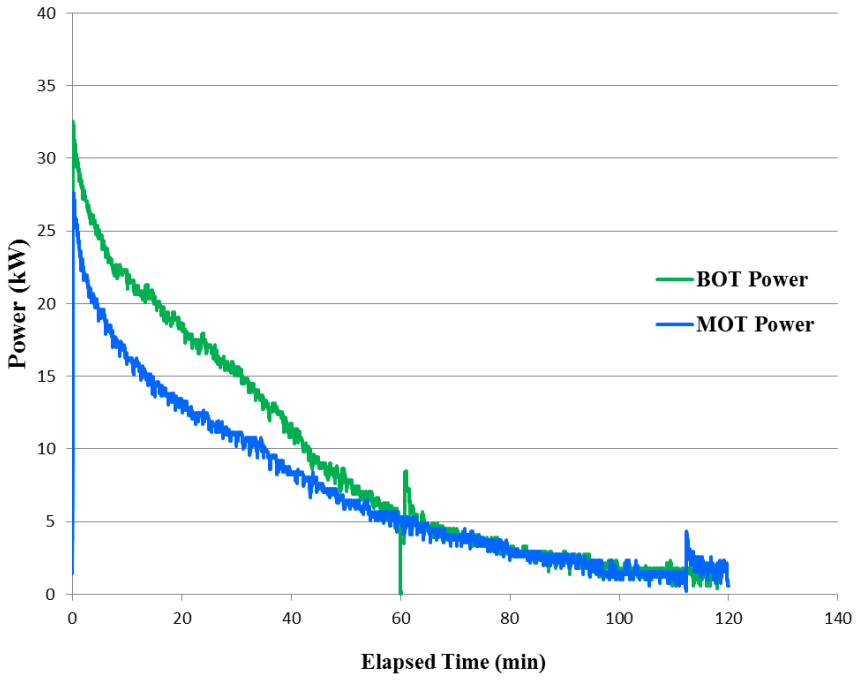

Figure 2b. 0 °C VIN 0646 BOT & MOT charge power profiles

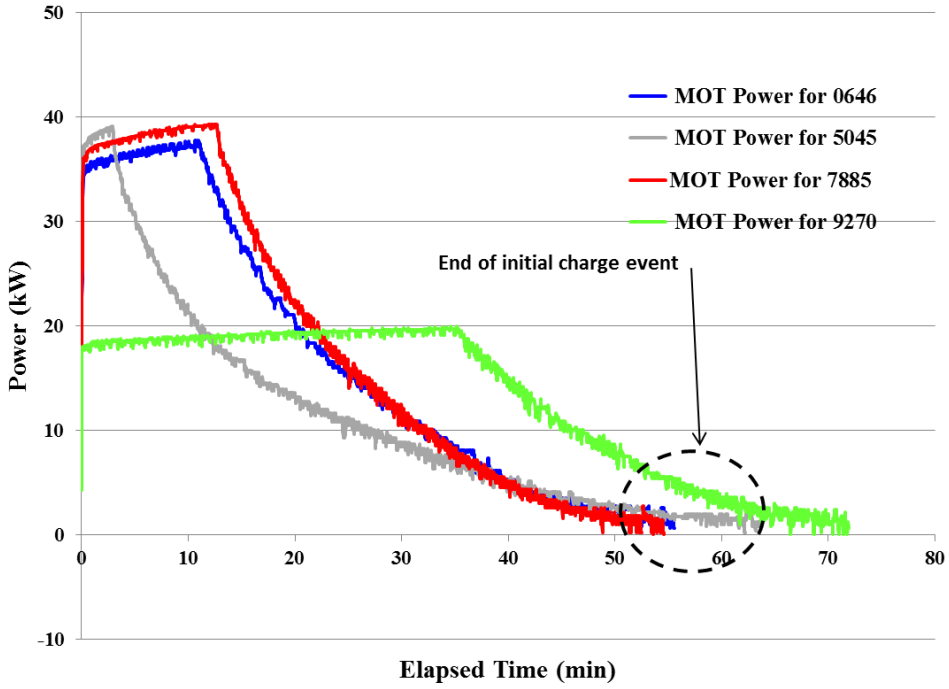

Figure 2c. 25 °C charge power profiles

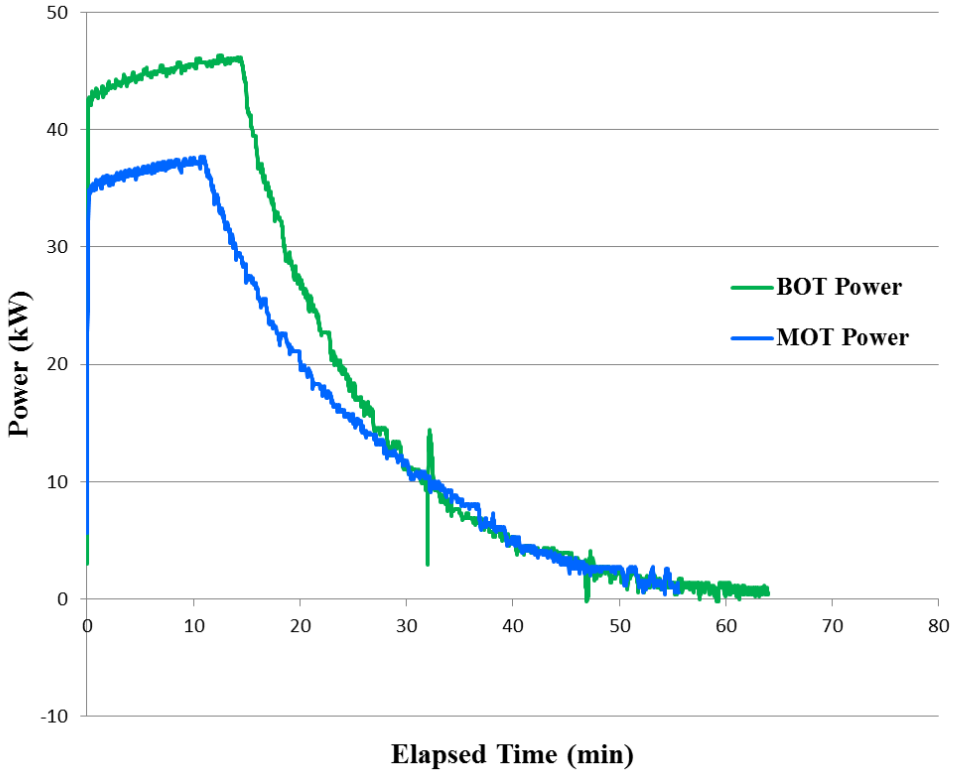

Figure 2d. 25 °C VIN 0646 BOT & MOT charge power profiles

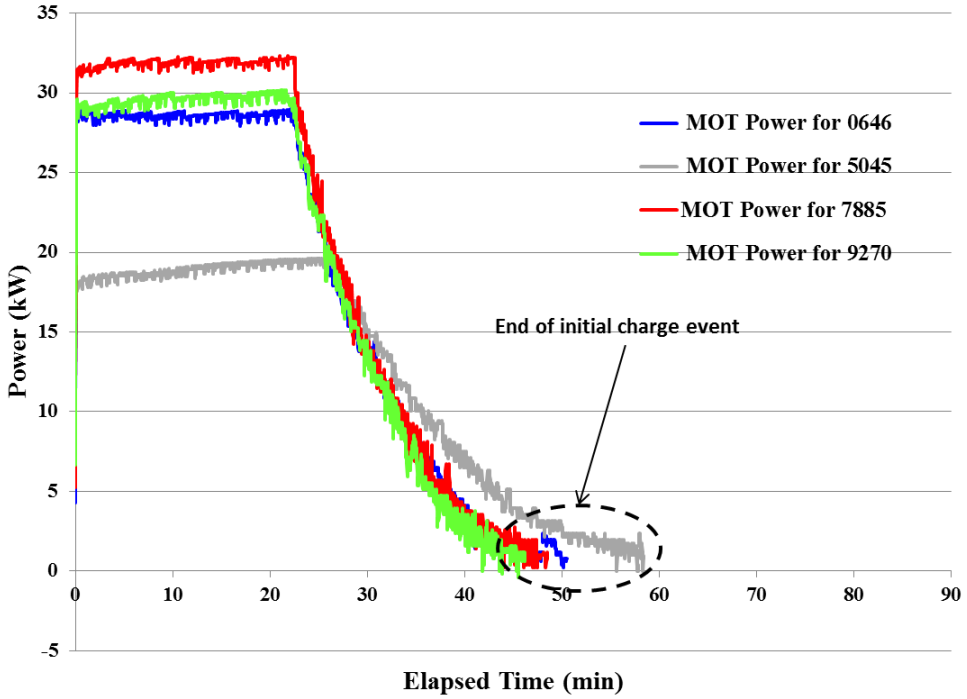

Figure 2e. 50 °C charge power profiles

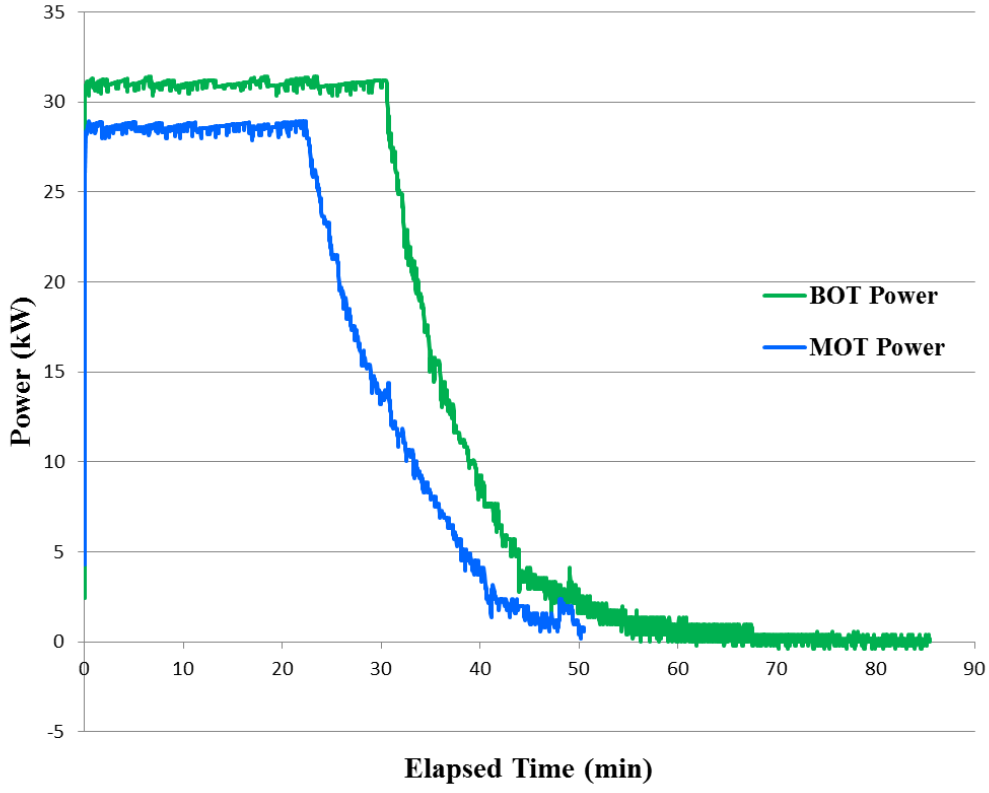

Figure 2f. 50 °C VIN 0646 BOT & MOT charge power profiles

Test Results: Charge Voltage and Current

Figures 3a through 3f show the voltage and current during the ESS charge for each of the specified temperatures. As before, the end of the initial charge event is denoted by a dashed oval. Each MOT graph is followed by a graph for a typical vehicle (VIN 0646) showing the voltage and current comparison between BOT and MOT testing.

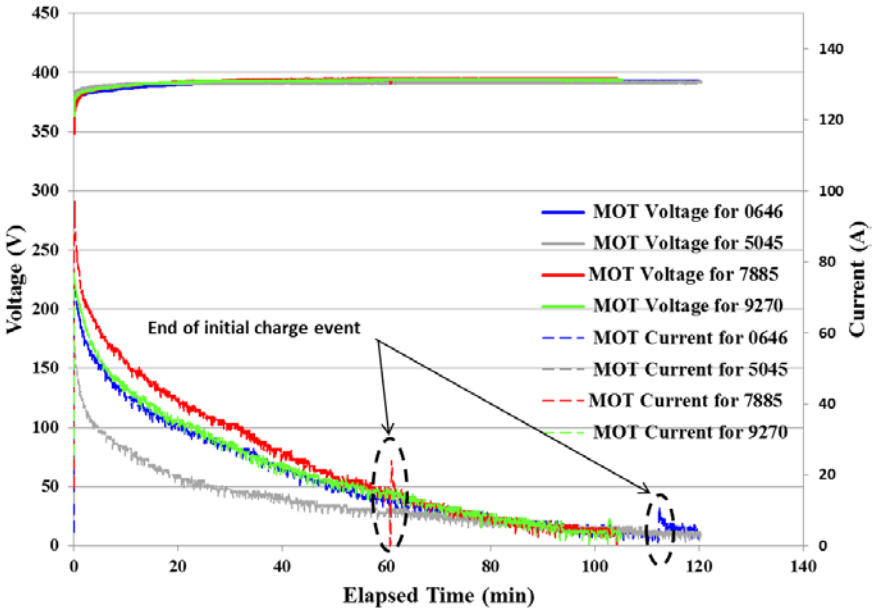

Figure 3a. 0 °C charge voltage and current profiles

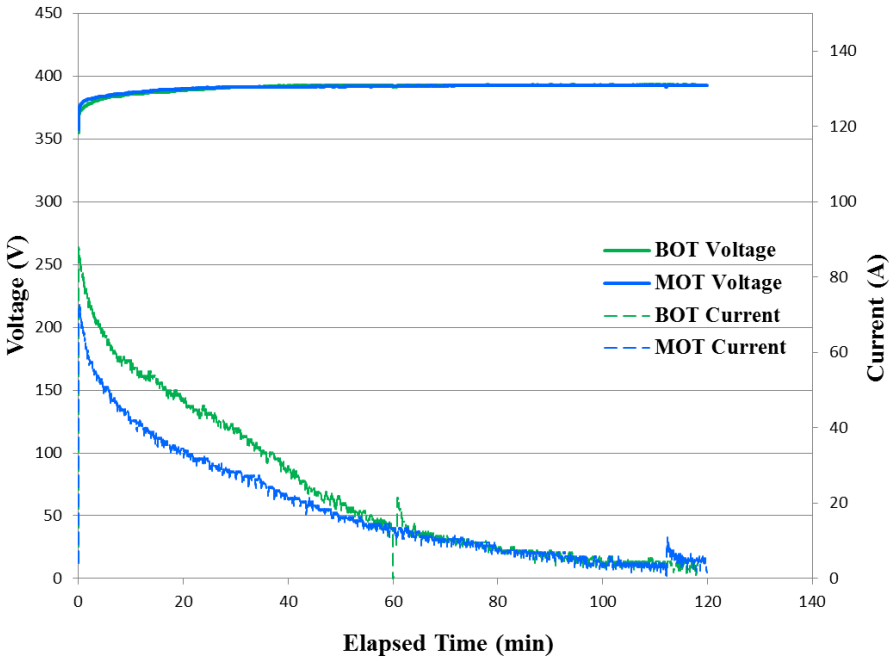

Figure 3b. 0 °C VIN 0646 BOT & MOT charge voltage and current profiles

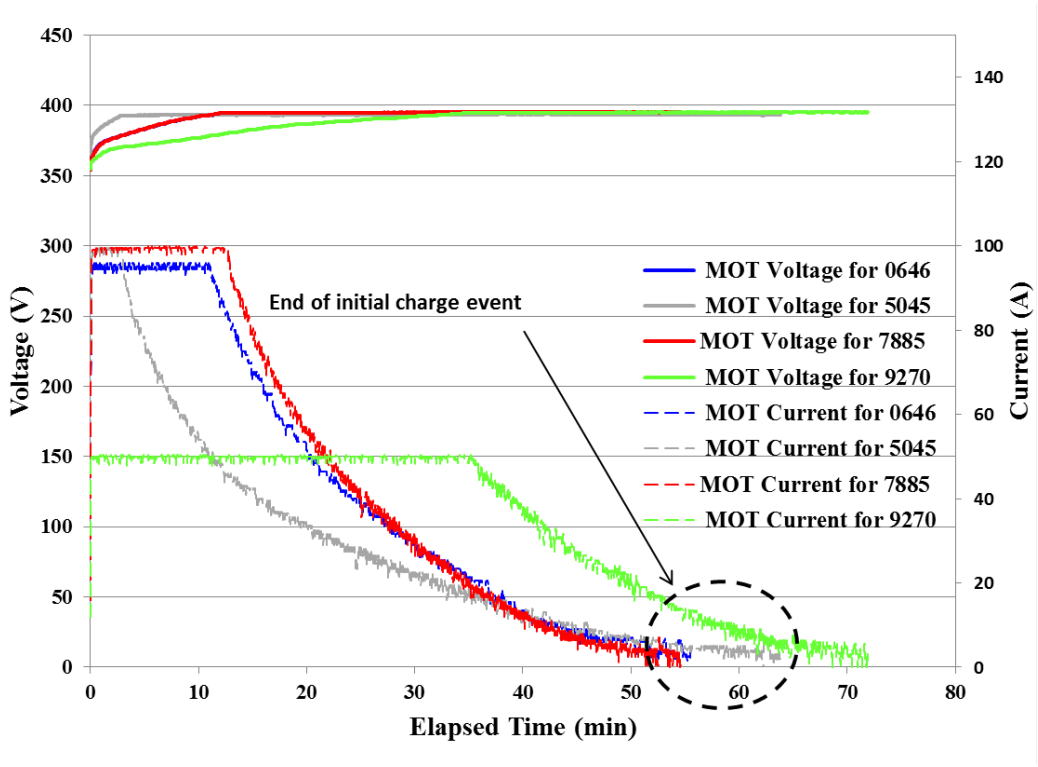

Figure 3c. 25 °C charge voltage and current profiles

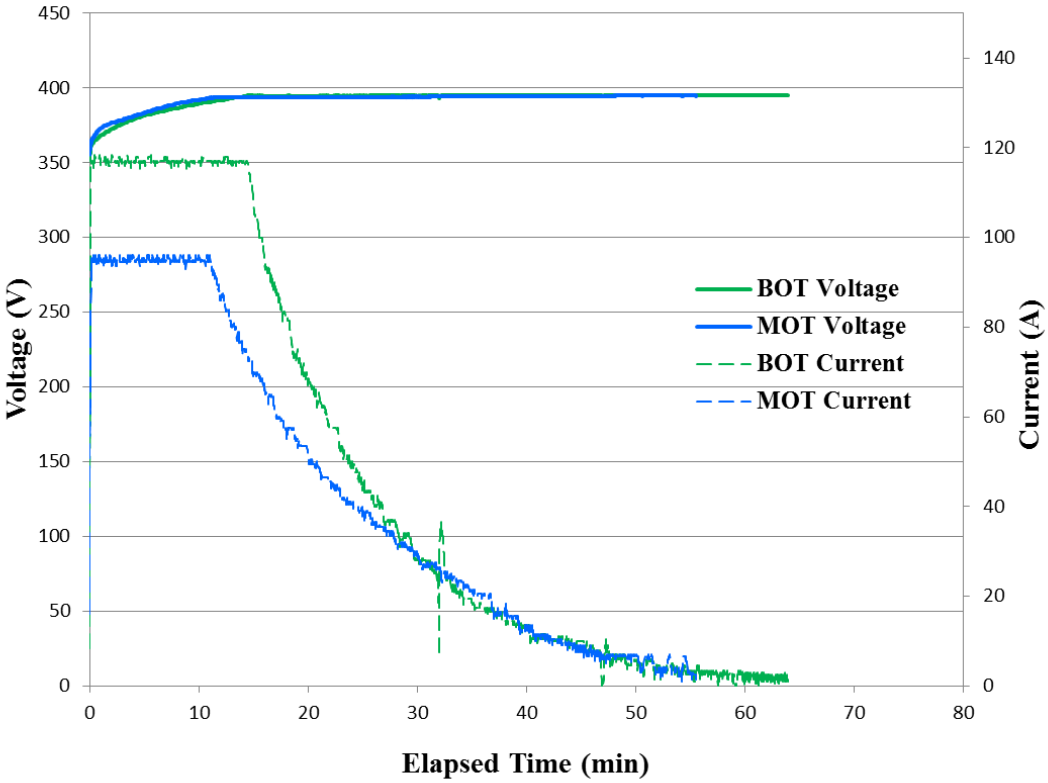

Figure 3d. 25 °C VIN 0646 BOT & MOT charge voltage and current profiles

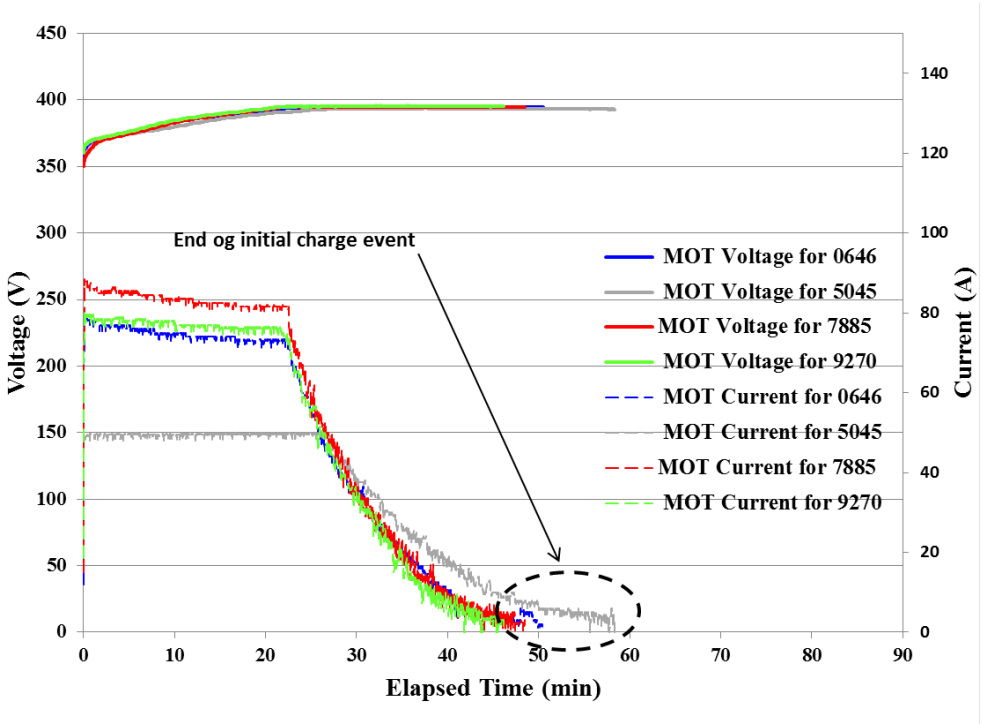

Figure 3e. 50 °C charge voltage and current profiles

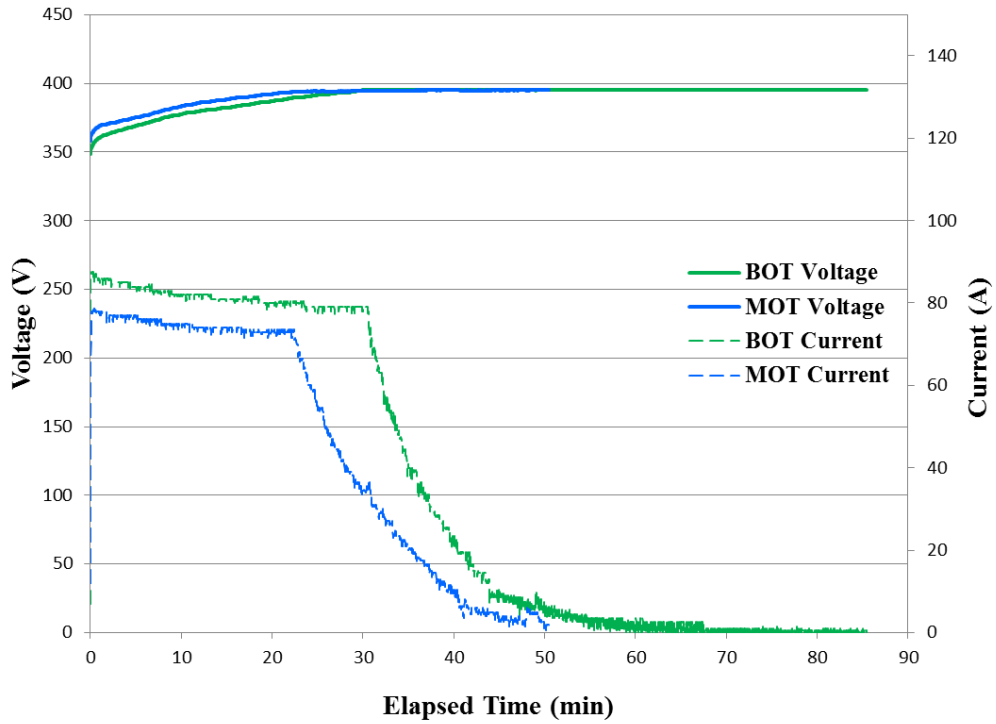

Figure 3f. 50 °C VIN 0646 BOT & MOT charge voltage and current profiles

NOTES:

1. Vehicle, ESS, and DCFC details were either supplied by the manufacturer or derived from a literature review.
2. The BTC DCFC is rated at 100 Adc output. Previous Beginning of Test (BOT) testing was performed with a Hasetec DCFC limited to 120 Adc output.
3. The ESS SOC is recorded from the vehicle controller area network (CAN) bus. The SOC displayed on the dashboard is also recorded for comparison and corroboration when available. In the case of the Nissan Leaf EV, the CAN SOC correlates with the SOC revealed by a diagnostic scan tool. Refer to Note 8 for details concerning top-off charge events.
4. The "ESS ΔT During Test" is the difference in the temperature of the ESS between start and end of test. This parameter is calculated using the vehicle CAN message for battery temperature when available. When the CAN message is not available, the ESS enclosure temperature is measured by placing a thermocouple on the enclosure of the battery pack. This vehicle did not have CAN temperature messages for battery temperature available, and therefore a thermocouple measurement was used.
5. The thermal regulation load is an approximate calculation of the amount of energy used by the vehicle to regulate ESS temperature, where applicable. The 2013 Nissan Leaf is equipped with a battery heater that activates when the battery temperature reaches -20 °C or less. The temperature setpoints were above this threshold, and so the heater did not affect this test.
6. Each fast charge-capable vehicle is chamber tested three times over the course of its test life. Under normal circumstances for EVs, the temperature chamber testing will take place at the same mileage target as the ESS Beginning of Test (BOT) test at 400 miles. The Middle of Test (MOT) takes place at the same mileage target as the ESS Interim Component Durability 3 (ICD3) test that is conducted at 24,000 miles. Finally, the End of Test (EOT) is conducted at the same mileage target as the ESS EOT test that is conducted at 36,000 miles. In the case of the 2013 Nissan Leaf, the decision to run the chamber testing at the same mileage target as the ESS BOT test was made after the ESS Testing had been completed.
7. Each test consists of a soak period necessary to ensure the vehicle ESS is at the target test temperature; the soak period is a minimum of 21 hours.
8. One top-off charge is conducted per test regardless of the ESS SOC reading at the end of the initial and top-off charge events. The battery management system (BMS) determines the stopping point of the initial and top-off charge events. The dashboard Vehicle Energy Indicator (VEI) for each vehicle at the start/end of each test was as follows:
   VIN 0646:
   0 °C: 1bar / 12 bars | 25 °C: 1bar / 12 bars | 50 °C: 1bar / 12 bars
   VIN 5045:
   0 °C: 1bar / 12 bars | 25 °C: 1bar / 12 bars | 50 °C: 1bar / 12 bars
   VIN 7885:
   0 °C: 1bar / 12 bars | 25 °C: 1bar / 12 bars | 50 °C: 1bar / 12 bars
   VIN 9270:
   0 °C: 1bar / 12 bars | 25 °C: 1bar / 12 bars | 50 °C: 1bar / 12 bars
9. Time (in seconds) between the end of the initial charge and beginning of the top-off charge is collected for each test. This delay has not been included in Figures 1 through 3.
   VIN 0646:
   0 °C: 105 s | 25 °C: 108 s | 50 °C: 233 s
   VIN 5045:
   0 °C: 60 s | 25 °C: 65 s | 50 °C: 71 s
   VIN 7885:
   0 °C: 22 s | 25 °C: 81 s | 50 °C: 45 s
   VIN 9270:
   0 °C: 74 s | 25 °C: 51 s | 50 °C: 89 s
10. Maximum charge power for initial and top-off charges:
    VIN 0646:
    0 °C: 27.6 / 4.3 kW | 25 °C: 37.7 / 2.6 kW | 50 °C: 29.0 / 2.4 kW
    VIN 5045:
    0 °C: 21.6 / 2.2 kW | 25 °C: 39.1 / 2.4 kW | 50 °C: 19.7 / 2.4 kW
    VIN 7885:
    0 °C: 35.8 / 9.5 kW | 25 °C: 39.3 / 2.8 kW | 50 °C: 32.3 / 2.0 kW
    VIN 9270:
    0 °C: 29.0 / 3.0 kW | 25 °C: 19.9 / 2.4 kW | 50 °C: 30.2 / 1.6 kW
11. Voltage at end of initial charge / voltage at end of top-off charge / maximum charge voltage / voltage at initial current drop off:
    VIN 0646:
    0 °C: 392.5 / 392.5 / 393.0 /375.5 V | 25 °C: 395.0 / 394.5 / 395.0 / 393.5 V | 50 °C: 395.0 / 395.0 / 395.0 /394.0 V
    VIN 5045:
    0 °C: 392.0 / 392.0 / 392.0 / 384.5 V | 25 °C: 393.0 / 393.5 / 394.0 / 393.0 V | 50 °C: 393.0 / 393.0 / 394.0 / 393.5 V
    VIN 7885:
    0 °C: 392.5 / 394.5 / 395.0 / 371.5 V | 25 °C: 395.5 / 395.5 / 395.5 / 395.0 V | 50 °C: 395.0 / 395.0 / 395.5 / 395.0 V
    VIN 9270:
    0 °C: 394.0 / 394.0 / 394.5 / 377.0 V | 25 °C: 395.0 / 395.5 / 395.5 / 394.5 V | 50 °C: 395.5 / 395.5 / 396.0 /395.5 V

APPENDIX A

The following pages contain a copy of original Beginning of Test (BOT) report. It is included to allow for easy comparison between BOT and MOT results.

VEHICLE, ENERGY STORAGE SYSTEM, AND DCFC DETAILS[1]

Vehicle Details

Base Vehicle: 2013 Nissan Leaf
Vehicle Type: BEV
VINs: 1N4AZ0CP0DC405045; 1N4AZ0CP2DC420646; 1N4AZ0CP5DC417885; KNDJX3AE7F7001920

DCFC Details

Manufacturer: Hasetec
Model/Type: HQC31-125-03AB/CHAdeMO
Rated DC Charge Power: 50 kW
De-Rated DC Current[2]: 120 A

Energy Storage System Specifications

Manufacturer: Automotive Energy Supply Corp.
Type: Lithium-ion (LMO)
Rated Pack Energy/Capacity: 24 kWh/66.2 Ah
Thermal Management: Passive – Air cooled

Test Dates by VIN

	0646	5045	7885	9270
0 °C	5/22/14	4/29/14	5/16/14	3/18/15
25 °C	5/23/14	5/1/14	5/15/14	3/20/15
50 °C	5/24/14	5/3/14	5/17/14	3/22/15

TEST RESULTS SUMMARY

Test Temp. (°C)	Total Charge Duration (hh:mm:ss)	End of Charge Range (mi)	Total DC Charge Energy (kWh)	Initial Charge Start/End SOC[3] (%)	Top-Off Charge Start/End SOC[3] (%)	Initial/Top-Off Charge Avg. Power (kW)	ESS ΔT[4] (°C)	ESS Thermal Regulation Energy[5] (kWh)
VIN 0646 - Beginning-of-Test (at 4,610 miles)[6]								
0 °C	01:58:04	Not Recorded	17.9	14.3 / 79.0	79.0 / 91.1	15.2 / 1.1	N/A	N/A
25 °C	01:03:57		19.2	14.1 / 86.4	86.3 / 93.9	32.7 / 3.4	N/A	N/A
50 °C	01:25:27		19.5	14.2 / 90.7	90.6 / 93.3	23.5 / 0.6	N/A	N/A
Middle-of-Test								
0 °C								
25 °C								
50 °C								
End-of-Test								
0 °C								
25 °C								
50 °C								
VIN 5045 - Beginning-of-Test (at 10,712 miles)[6]								
0 °C	01:59:57	82	17.4	14.4 / 73.4	73.4 / 91.0	15.3 / 1.2	N/A	N/A
25 °C	01:05:40	77	18.2	14.4 / 81.0	80.9 / 90.7	29.4 / 2.9	N/A	N/A
50 °C	01:00:38	65	17.9	14.1 / 84.7	84.7 / 87.1	24.3 / 1.5	N/A	N/A
Middle-of-Test								
0 °C								
25 °C								
50 °C								
End-of-Test								
0 °C								
25 °C								
50 °C								

Test Temp. (°C)	Total Charge Duration (hh:mm:ss)	End of Charge Range (mi)	Total DC Charge Energy (kWh)	Initial Charge Start/End SOC[3] (%)	Top-Off Charge Start/End SOC[3] (%)	Initial/Top-Off Charge Avg. Power (kW)	ESS ΔT[4] (°C)	ESS Thermal Regulation Energy[5] (kWh)
VIN 7885 - Beginning-of-Test (at 4,606 miles)[6]								
0 °C	01:57:14	Not Recorded	19.0	14.4 / 79.4	79.4 / 92.9	16.6 / 2.5	N/A	N/A
25 °C	01:03:57		19.1	14.3 / 83.2	83.1 / 93.4	32.5 / 3.4	N/A	N/A
50 °C	01:01:19		19.7	14.1 / 89.0	88.9 / 91.3	26.9 / 1.4	N/A	N/A
Middle-of-Test								
0 °C								
25 °C								
50 °C								
End-of-Test								
0 °C								
25 °C								
50 °C								
VIN 9270 - Beginning-of-Test (at 4,945 miles)[6]								
0 °C	01:51:02	Not Recorded	18.6	15.6 / 80.8	80.7 / 94.4	15.8 / 3.3	N/A	N/A
25 °C	01:01:16		19.3	15.0 / 89.4	89.3 / 95.9	31.0 / 3.6	N/A	N/A
50 °C	01:13:47		19.3	14.4 / 91.7	91.6 / 94.1	24.1 / 1.0	N/A	N/A
Middle-of-Test								
0 °C								
25 °C								
50 °C								
End-of-Test								
0 °C								
25 °C								
50 °C								

Test Results Analysis

DC fast charging at temperature testing includes tests that measure the charge duration, energy transfer, and energy used to thermally regulate the energy storage system (ESS) for charge events at 0, 25 and 50 °C.[7] The objective of this testing is to provide analysis about the effects of ambient temperature on DC fast charge-capable vehicles. These tests were performed as part of the US Department of Energy Advanced Vehicle Testing Activity, which is conducted by Idaho National Laboratory and Intertek Center for Evaluation of Clean Energy Technology (CECET).

Test Results: Energy and SOC

Figures 1a, 1b, and 1c show the energy transferred to each vehicle and the change in state of charge (SOC) over the duration of each charge event for each of the specified temperatures. Each DC fast charge event consists of an initial charge event and a top-off charge event.[8,9] The end of the initial charge is denoted by a dashed oval. Many vehicle manufacturers report the time required for a charge of the ESS to 80% SOC as being 30 minutes; for VIN 0646, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 59.4%, 85.0%, and 76.4%, respectively. For VIN 5045, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 53.3%, 77.9%, and 77.2%, respectively. For VIN 7885, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 57.6%, 81.8%, and 79.8%, respectively. For VIN 9270, the SOCs recorded at the 30-minute mark for the 0, 25, and 50 °C tests were 59.8%, 86.6%, and 78.8%, respectively.

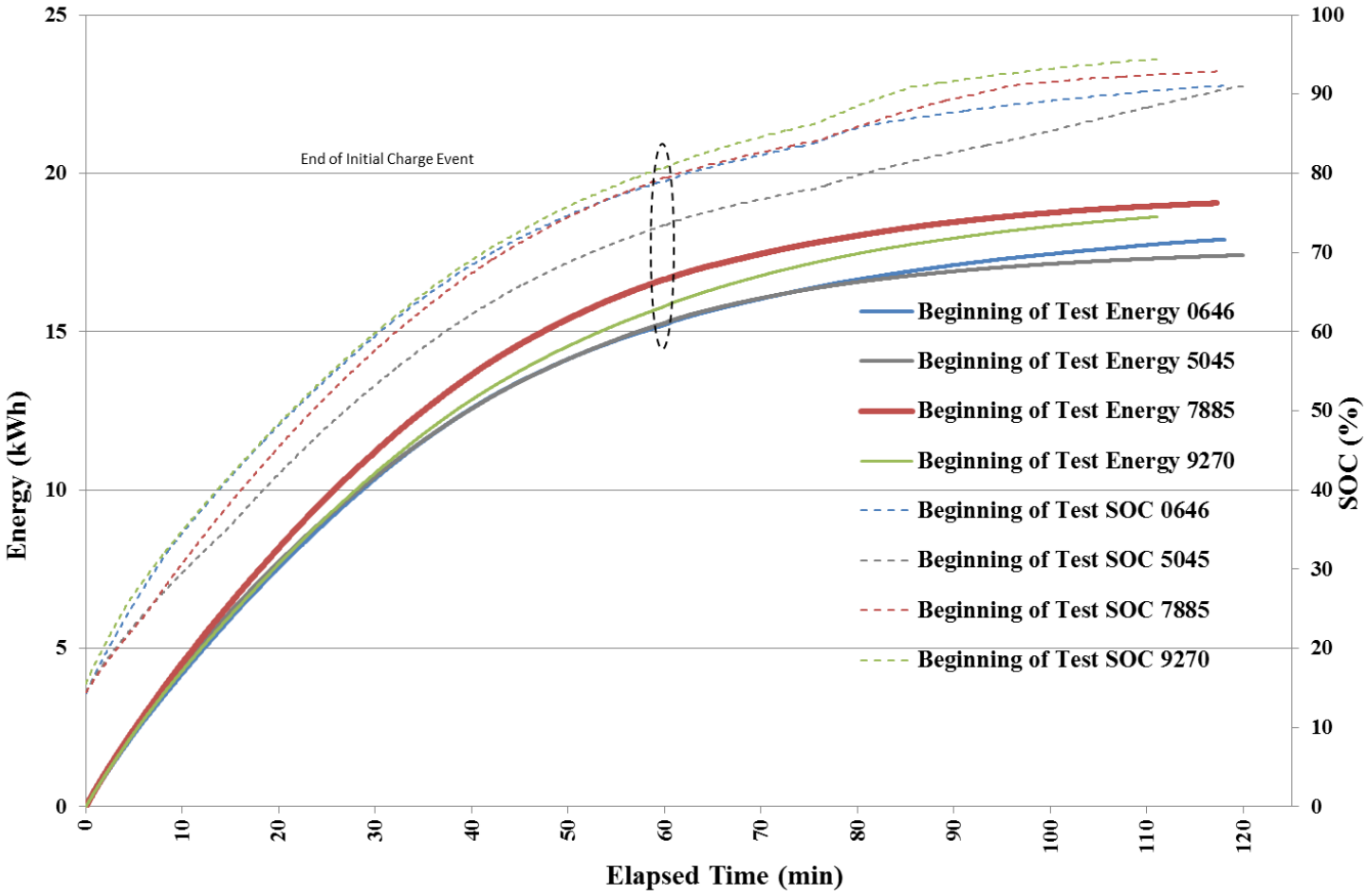

Figure 1a. 0 °C charge energy and SOC versus time

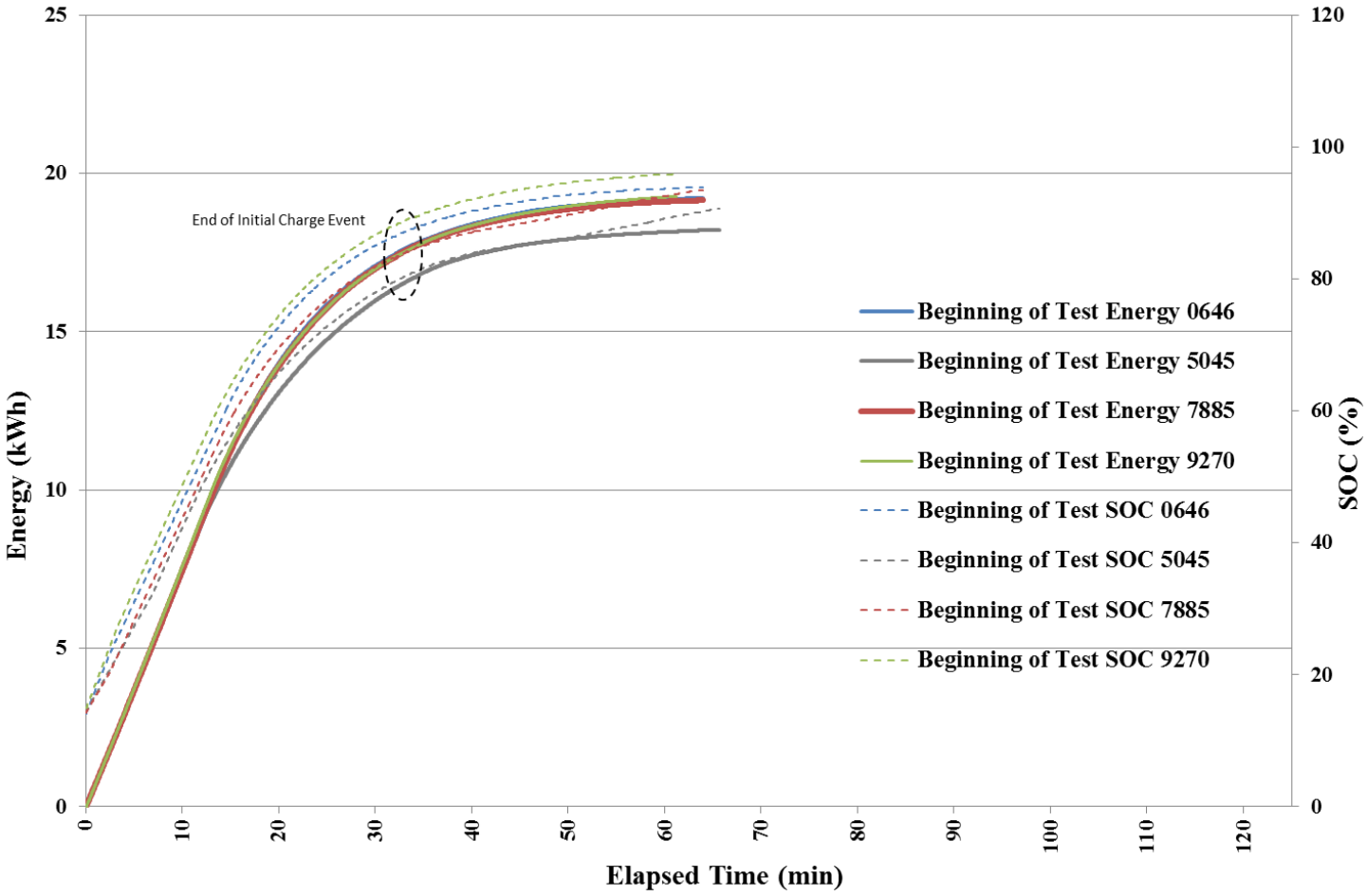

Figure 1b. 25 °C charge energy and SOC versus time

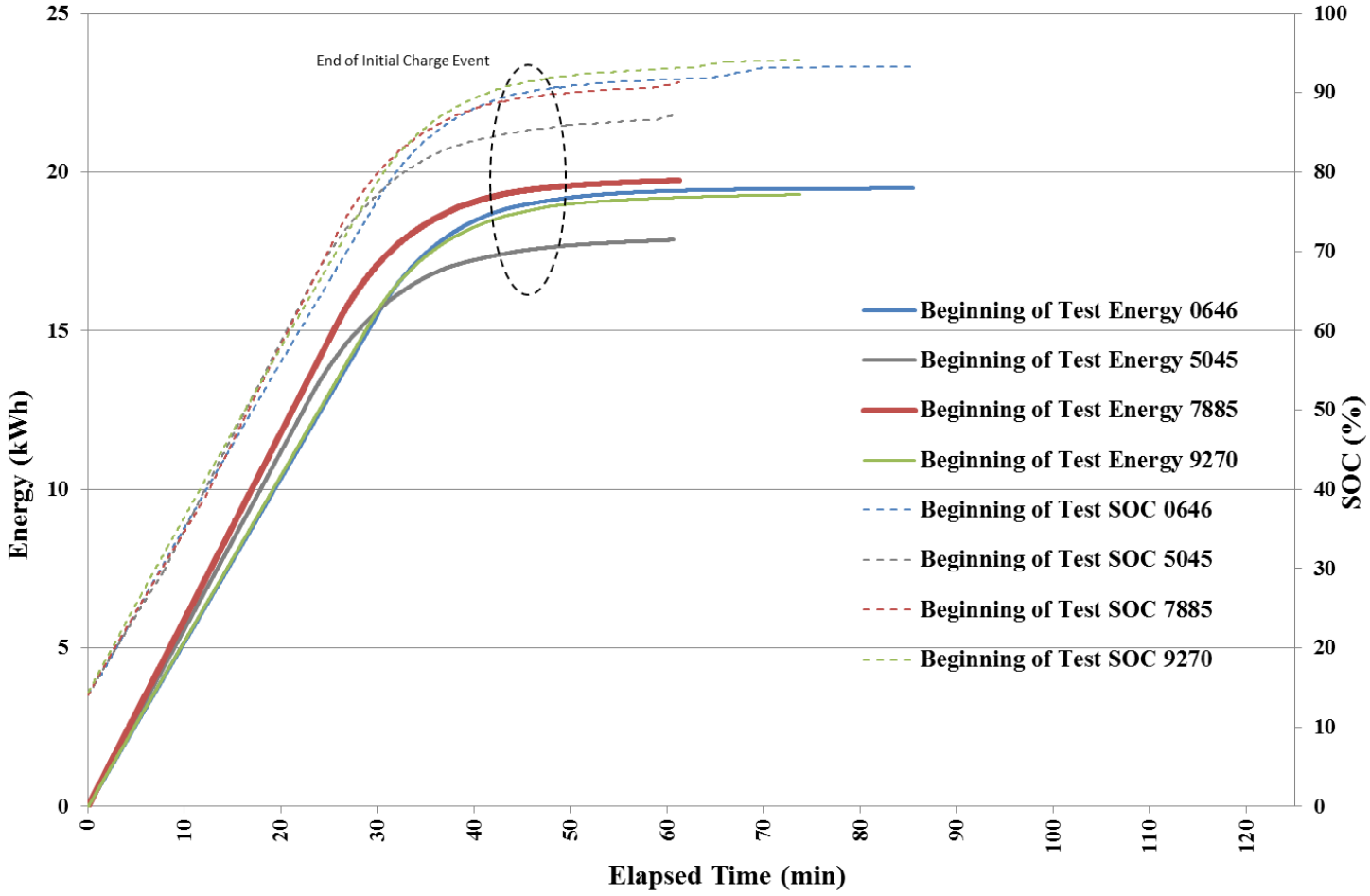

Figure 1c. 50 °C charge energy and SOC versus time

Test Results: Temperatures

Tables 1,2,3 and 4 show the initial and final ESS enclosure temperatures of each vehicle's ESS during charging events.

Table 3. VIN 0646 ESS enclosure temperature during test

Test Temperature (°C)	ESS Enclosure Initial Temp. (°C)	ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured
25 °C	Not Measured	Not Measured
50 °C	Not Measured	Not Measured

Table 4. VIN 5045 ESS enclosure temperature during test

Test Temperature (°C)	ESS Enclosure Initial Temp. (°C)	ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured
25 °C	Not Measured	Not Measured
50 °C	Not Measured	Not Measured

Table 3. VIN 7885 ESS enclosure temperature during test

Test Temperature (°C)	ESS Enclosure Initial Temp. (°C)	ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured
25 °C	Not Measured	Not Measured
50 °C	Not Measured	Not Measured

Table 4. VIN 9270 ESS enclosure temperature during test

Test Temperature (°C)	ESS Enclosure Initial Temp. (°C)	ESS Enclosure Maximum Temp. (°C)
0 °C	Not Measured	Not Measured
25 °C	Not Measured	Not Measured
50 °C	Not Measured	Not Measured

Test Results: Charge Power[10,11]

Figures 2a, 2b, and 2c show the power at which each vehicle's ESS was being charged for each of the specified temperatures. As before, the end of the initial charge event is denoted by a dashed oval.

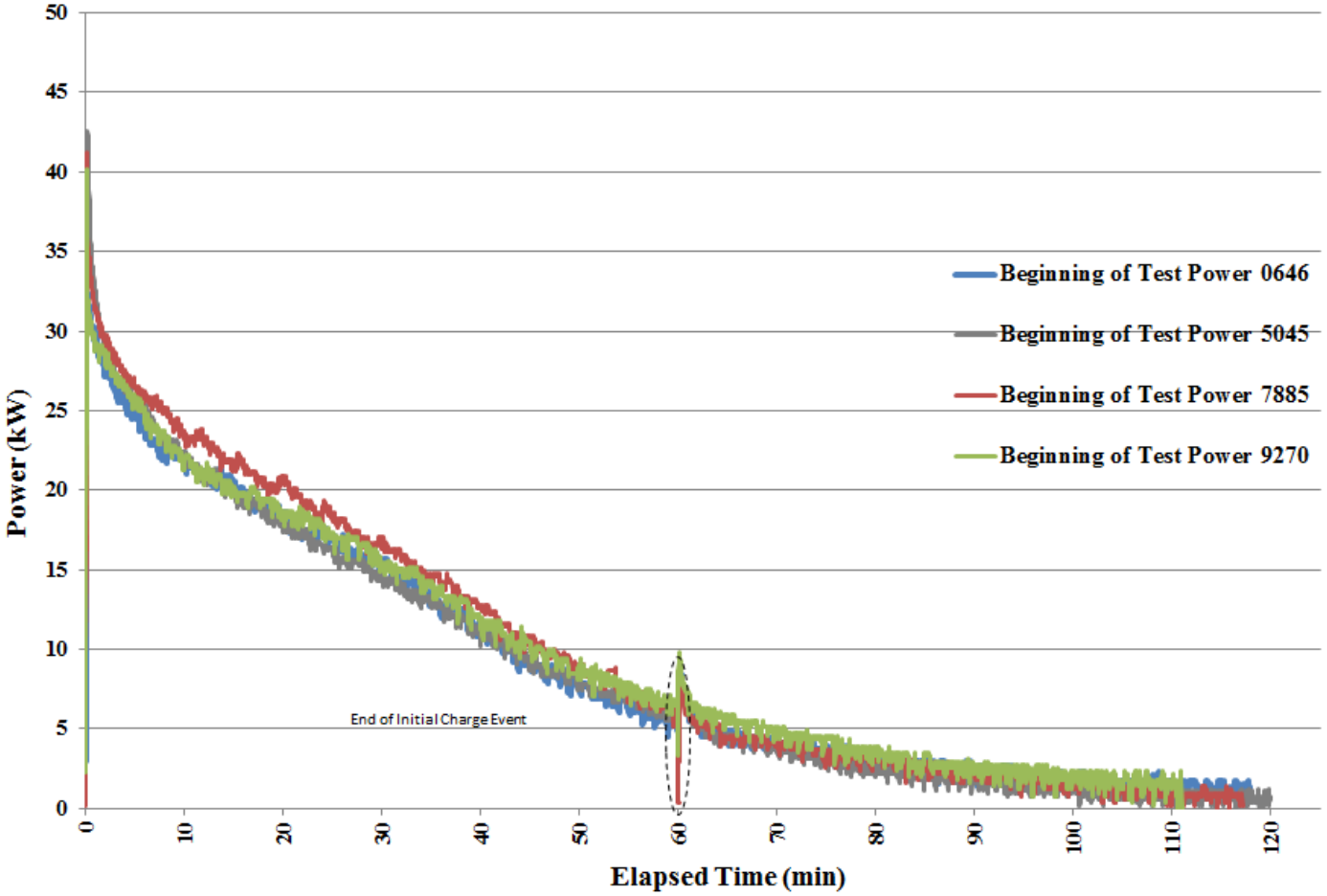

Figure 2a. 0 °C charge power profiles

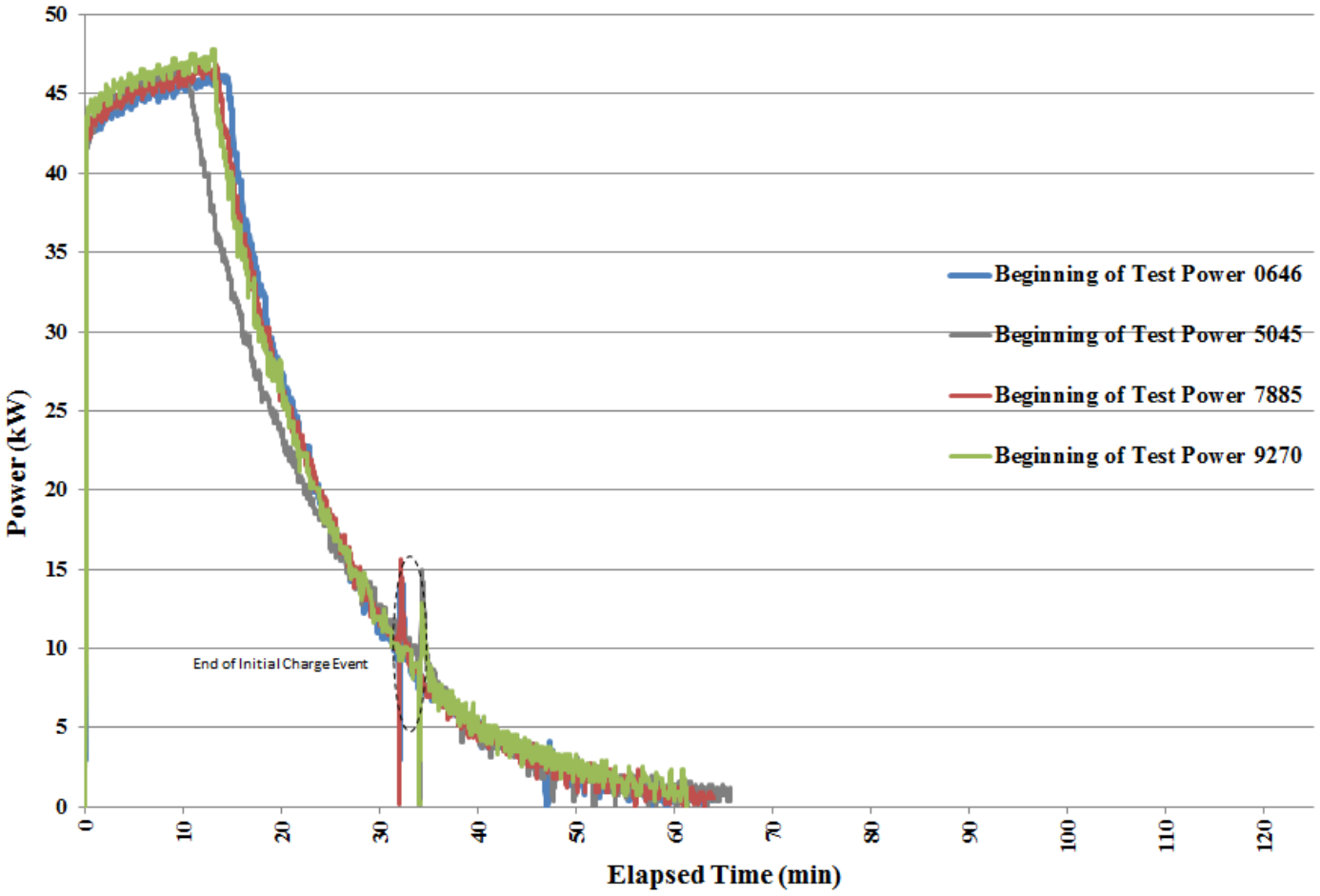

Figure 2b. 25 °C charge power profiles

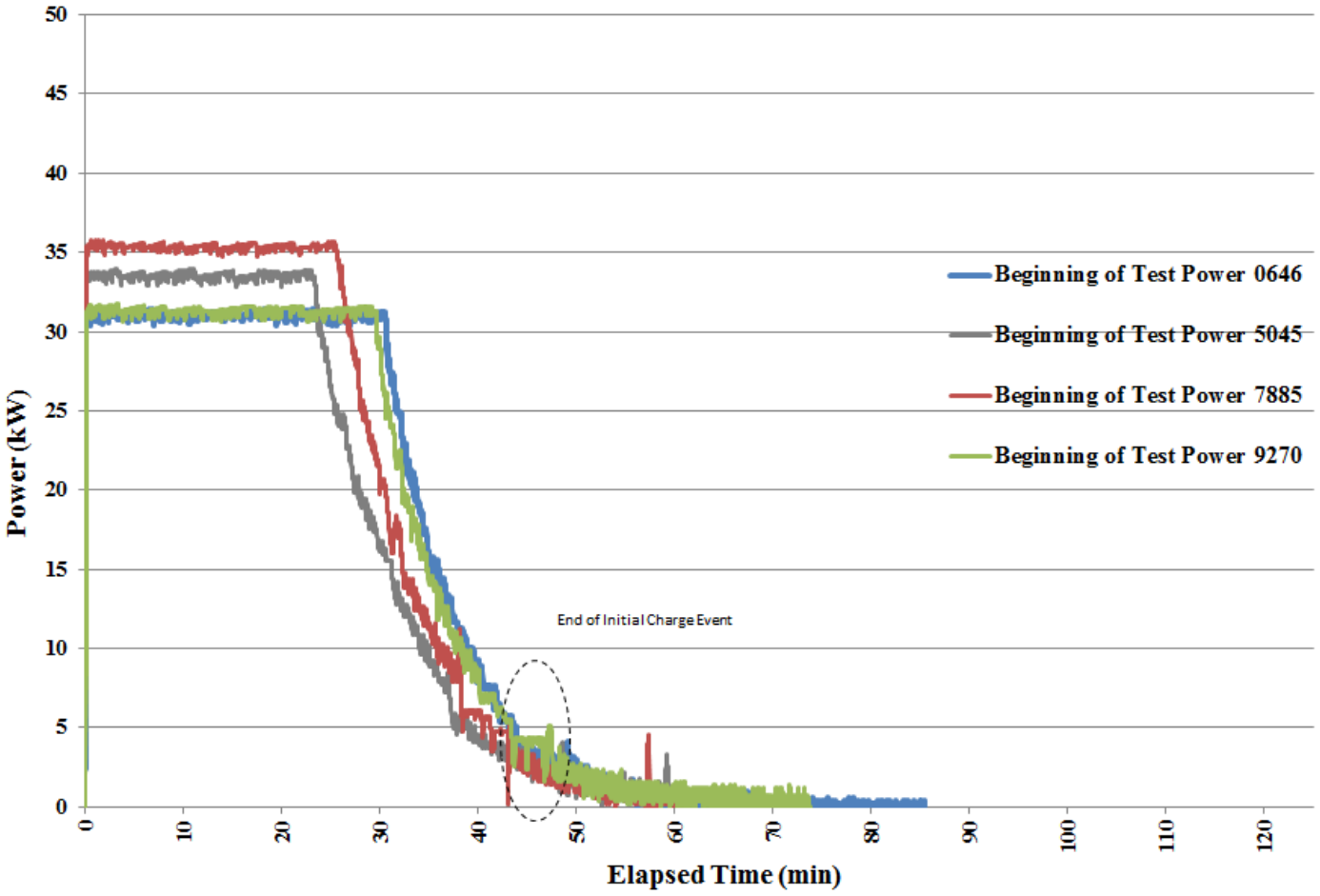

Figure 2c. 50 °C charge power profiles

Test Results: Charge Voltage and Current

Figures 3a, 3b, and 3c show the voltage and current during each vehicle's ESS charging for each of the specified temperatures. As before, the end of the initial charge event is denoted by a dashed oval.

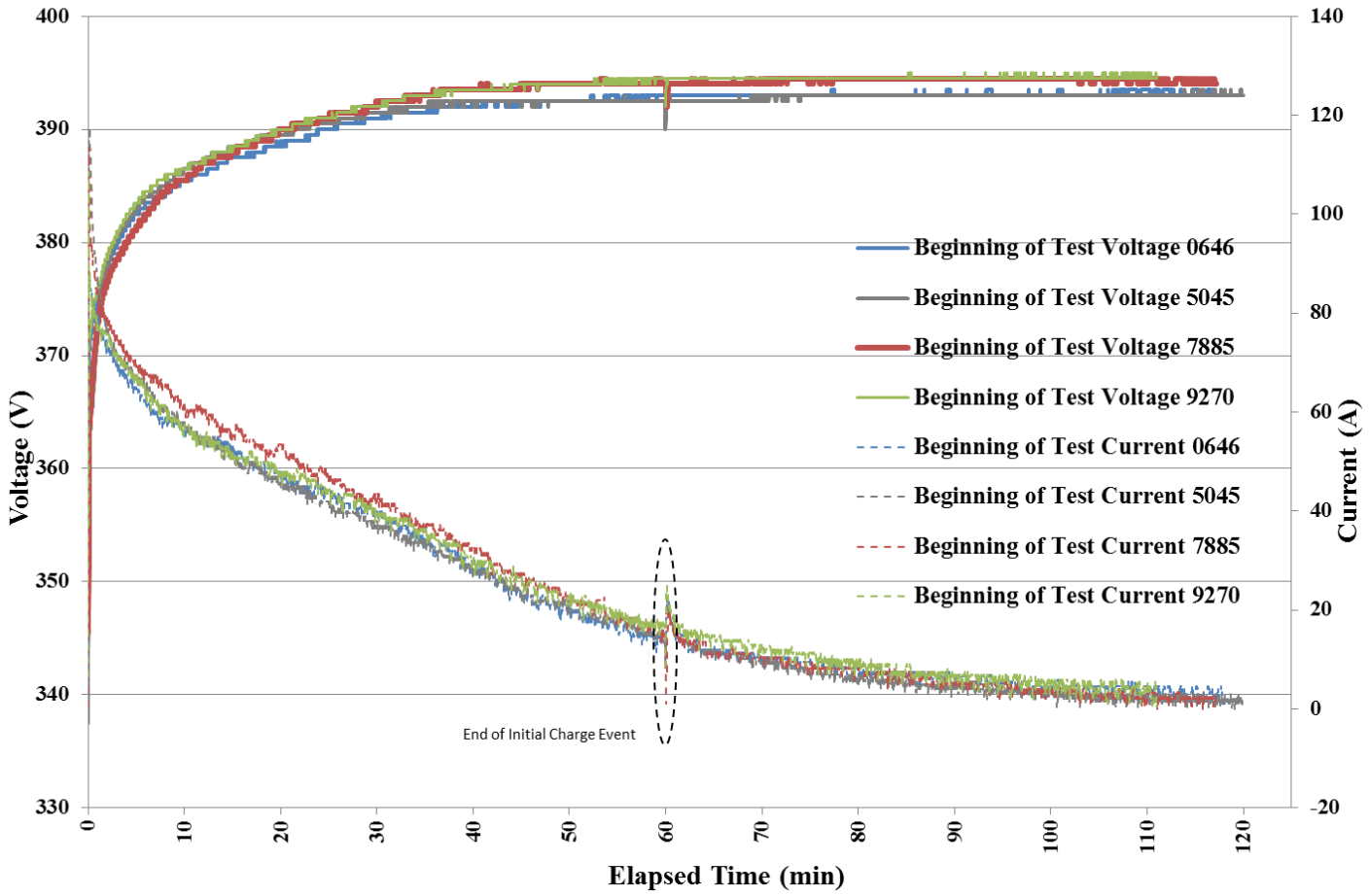

Figure 3a. 0 °C charge voltage and current profiles

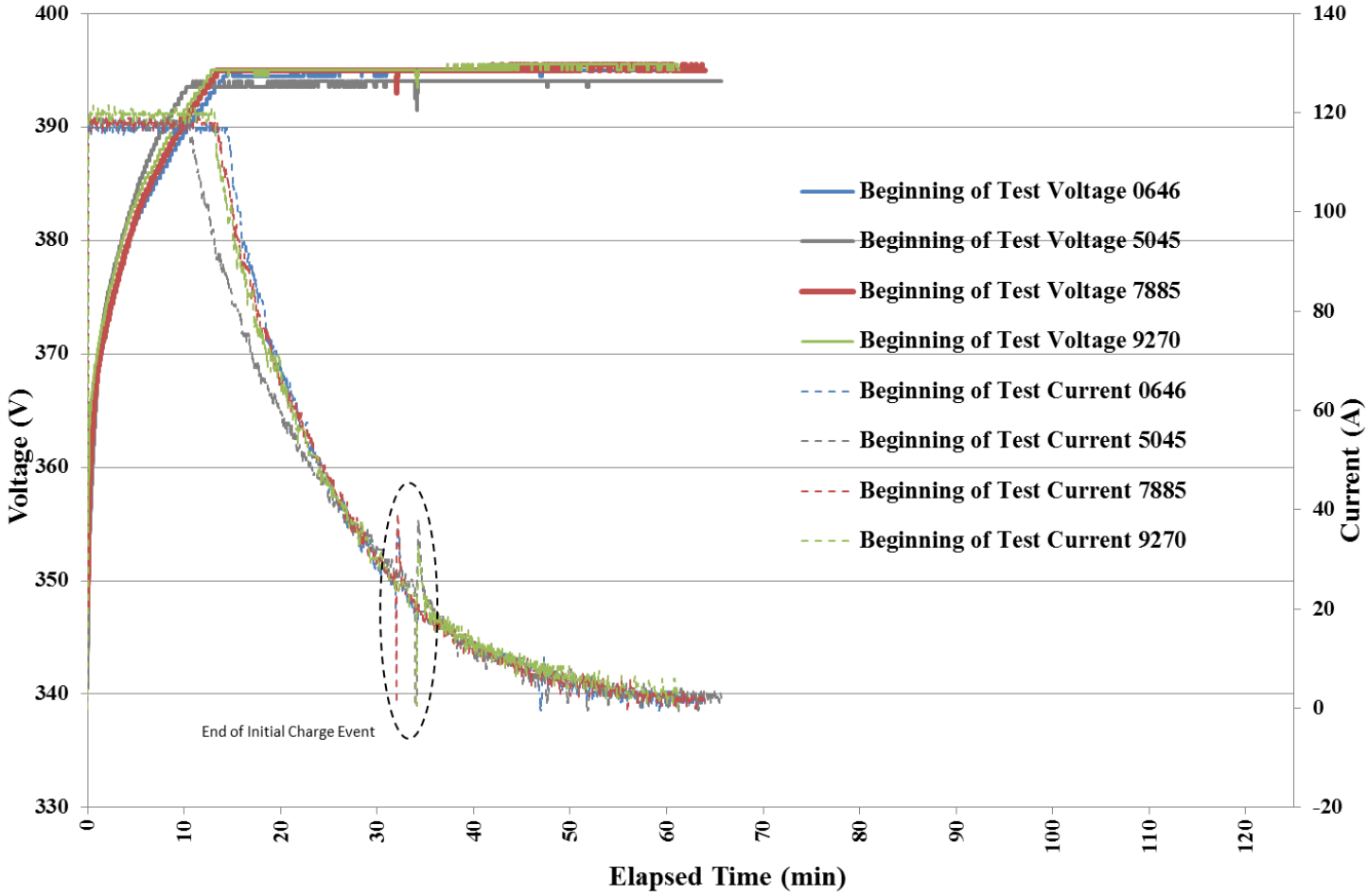

Figure 3b. 25 °C charge voltage and current profiles

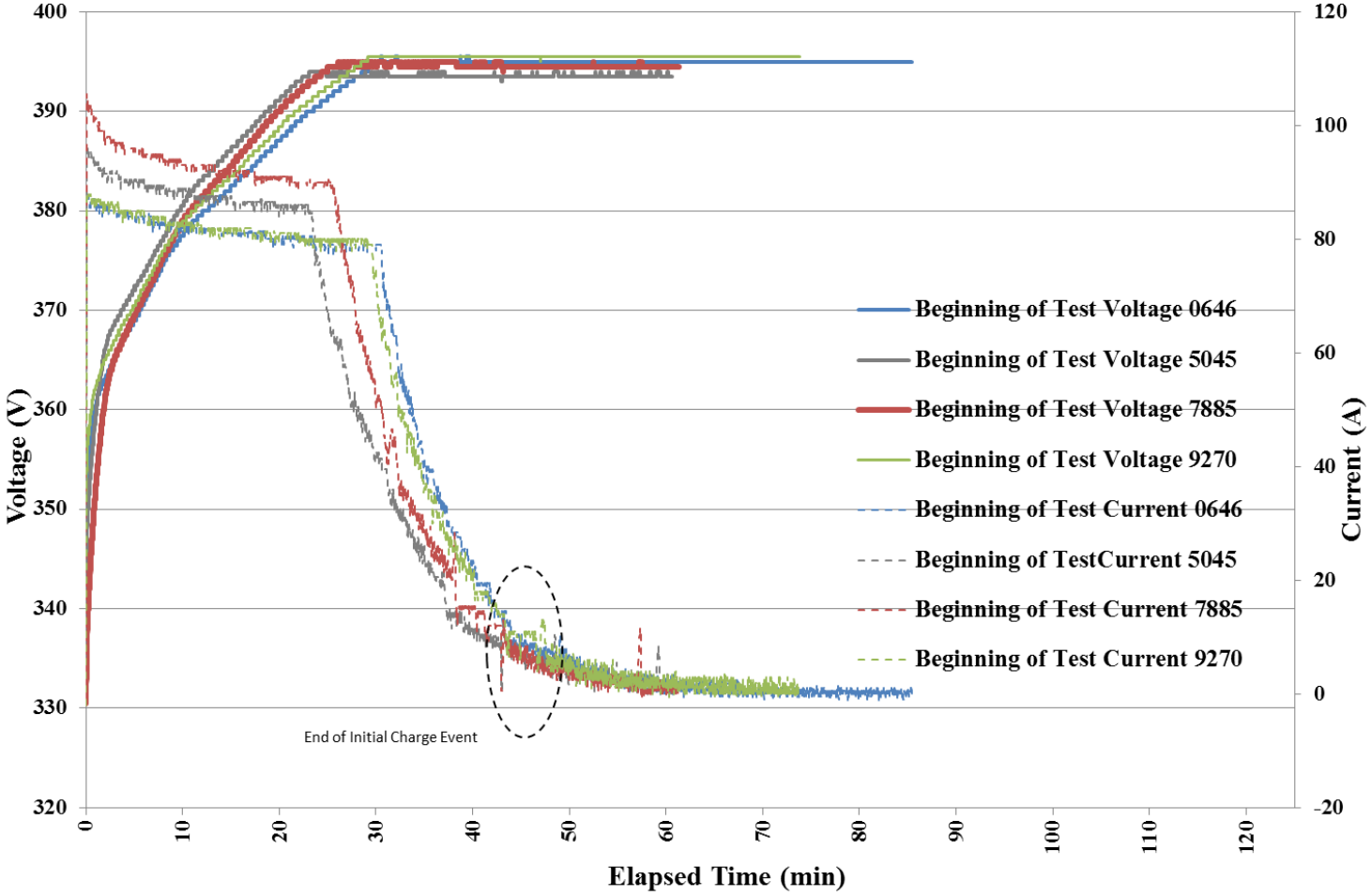

Figure 3c. 50 °C charge voltage and current profiles

NOTES:

1. Vehicle, ESS, and DCFC details were either supplied by the manufacturer or derived from a literature review.
2. The Hasetec DCFC was de-rated from 125 A to 120 A for all testing.
3. The ESS SOC is recorded from the vehicle controller area network (CAN) bus. The SOC displayed on the dashboard is also recorded for comparison and corroboration when available. In the case of the Nissan Leaf EV, the CAN SOC correlates with the SOC revealed by a diagnostic scan tool Refer to Note 8 for details concerning top-off charge events.
4. The "ESS ΔT During Test" is the difference in the temperature of the ESS between start and end of test. This parameter is calculated using the vehicle CAN message for battery temperature when available. When the CAN message is not available, the ESS enclosure temperature is measured by placing a thermocouple on the enclosure of the battery pack. This vehicle did not have CAN temperature messages for battery temperature available, and a thermocouple measurement was not possible either for this test.
5. The thermal regulation load is an approximate calculation of the amount of energy used by the vehicle to regulate ESS temperature, where applicable. The 2013 Nissan Leaf is equipped with a battery heater that activates when the battery temperature reaches -20 °C or less. The temperature setpoints were above this threshold, and so the heater did not affect this test.
6. Each fast charge-capable vehicle is chamber tested three times over the course of its test life. Under normal circumstances for EVs, the temperature chamber testing will take place at the same mileage target as the ESS Beginning of Test (BOT) test at 400 miles. The Middle of Test (MOT) takes place at the same mileage target as the ESS Interim Component Durability 3 (ICD3) test that is conducted at 24,000 miles. Finally, the End of Test (EOT) is conducted at the same mileage target as the ESS EOT test that is conducted at 36,000 miles. In the case of the 2013 Nissan Leaf, the decision to run the chamber testing at the same mileage target as the ESS BOT test was made after the ESS Testing had been completed.
7. Each test consists of a soak period necessary to ensure the vehicle ESS is at the target test temperature; the soak period is a minimum of 21 hours.
8. One top-off charge is conducted per test regardless of the ESS SOC reading at the end of the initial and top-off charge events. The battery management system (BMS) determines the stopping point of the initial and top-off charge events. The dashboard Vehicle Energy Indicator (VEI) for each vehicle at the start/end of each test was as follows:

   VIN 0646:
   - 0 °C: Not recorded for this test
   - 25 °C: Not recorded for this test
   - 50 °C: Not recorded for this tes

   VIN 5045:
   - 0 °C: Not recorded for this test
   - 25 °C: Not recorded for this test
   - 50 °C: Not recorded for this tes

   VIN 7885:
   - 0 °C: Not recorded for this test
   - 25 °C: Not recorded for this test
   - 50 °C: Not recorded for this tes

   VIN 9270:
   - 0 °C: Not recorded for this test
   - 25 °C: Not recorded for this test
   - 50 °C: Not recorded for this tes

9. Time (in seconds) between the end of the initial charge and beginning of the top-off charge is collected for each test. This delay has not been included in Figure 1 and Figure 2.

   VIN 0646:
   - 0 °C: 41 s
   - 25 °C: 35 s
   - 50 °C: 41 s

   VIN 5045:
   - 0 °C: 47 s
   - 25 °C: 46 s
   - 50 °C: 51 s

   VIN 7885:
   - 0 °C: 27 s
   - 25 °C: 37 s
   - 50 °C: 31 s

   VIN 9270:
   - 0 °C: 51 s
   - 25 °C: 39 s
   - 50 °C: 47 s

10. Maximum charge power for initial and top-off charges:

    VIN 0646:
    - 0 °C: 32.5 / 8.4 kW
    - 25 °C: 46.3 / 14.4 kW
    - 50 °C: 31.4 / 4.1 kW

    VIN 5045:
    - 0 °C: 42.6 / 8.6 kW
    - 25 °C: 46.7 / 15.0 kW
    - 50 °C: 34.0 / 5.1 kW

    VIN 7885:
    - 0 °C: 41.2 / 7.9 kW
    - 25 °C: 46.8 / 15.6 kW
    - 50 °C: 35.8 / 5.1 kW

    VIN 9270:
    - 0 °C: 40.1 / 9.9 kW
    - 25 °C: 47.8 / 12.8 kW
    - 50 °C: 31.8 / 5.1 kW

11. Voltage at end of initial charge / voltage at end of top-off charge / maximum charge voltage / voltage at initial current drop off:

    VIN 0646:
    - 0 °C: 395.0 / 395.0 / 395.0 / 371.0 V
    - 25 °C: 395.0 / 395.0 / 395.0 / 395.0 V
    - 50 °C: 395.0 / 395.0 / 395.5 / 395.5 V

    VIN 5045:
    - 0 °C: 392.5 / 393.0 / 393.5 / 363.0 V
    - 25 °C: 394.0 / 394.0 / 394.0 / 393.5 V
    - 50 °C: 393.5 / 393.5 / 394.0 / 393.5 V

    VIN 7885:
    - 0 °C: 394.0 / 394.0 / 394.5 / 364.5 V
    - 25 °C: 395.0 / 395.0 / 395.5 / 395.0 V
    - 50 °C: 395.0 / 394.5 / 395.0 / 394.5 V

    VIN 9270:
    - 0 °C: 394.5 / 394.5 / 395.0 / 373.0 V
    - 25 °C: 395.0 / 395.0 / 395.5 / 395.0 V
    - 50 °C: 395.5 / 395.5 / 395.5 / 395.5 V