2013 Nissan Leaf BEV – VINs 0545, 0646, 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
VIN: 1N4AZ0CP0DC405045; 1N4AZ0CP2DC420646; 1N4AZ0CP5DC417885; 1N4AZ0CP0DC419270

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
Rated Pack Energy/Capacity: 24.0 kWh/66.2 Ah
Thermal Management: Passive – Air

Test Dates by VIN

	0646	5045	7885	9270
0 °C	5/22/2014	4/29/2014	5/16/2014	5/4/2014
25 °C	5/23/2014	5/1/2014	5/15/2014	5/5/2014
50 °C	5/24/2014	5/3/2014	5/17/2014	5/6/2014

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)								
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)								
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)								
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 objectives of this testing are 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 the Intertek Center for Evaluation of Clean Energy Technology (CECET).

Test Results: Energy and SOC

Figures 1a, 1b, and 1c shows each vehicle's energy transferred 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. The end of the initial charge is denoted by a dashed oval.[8,9] 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.

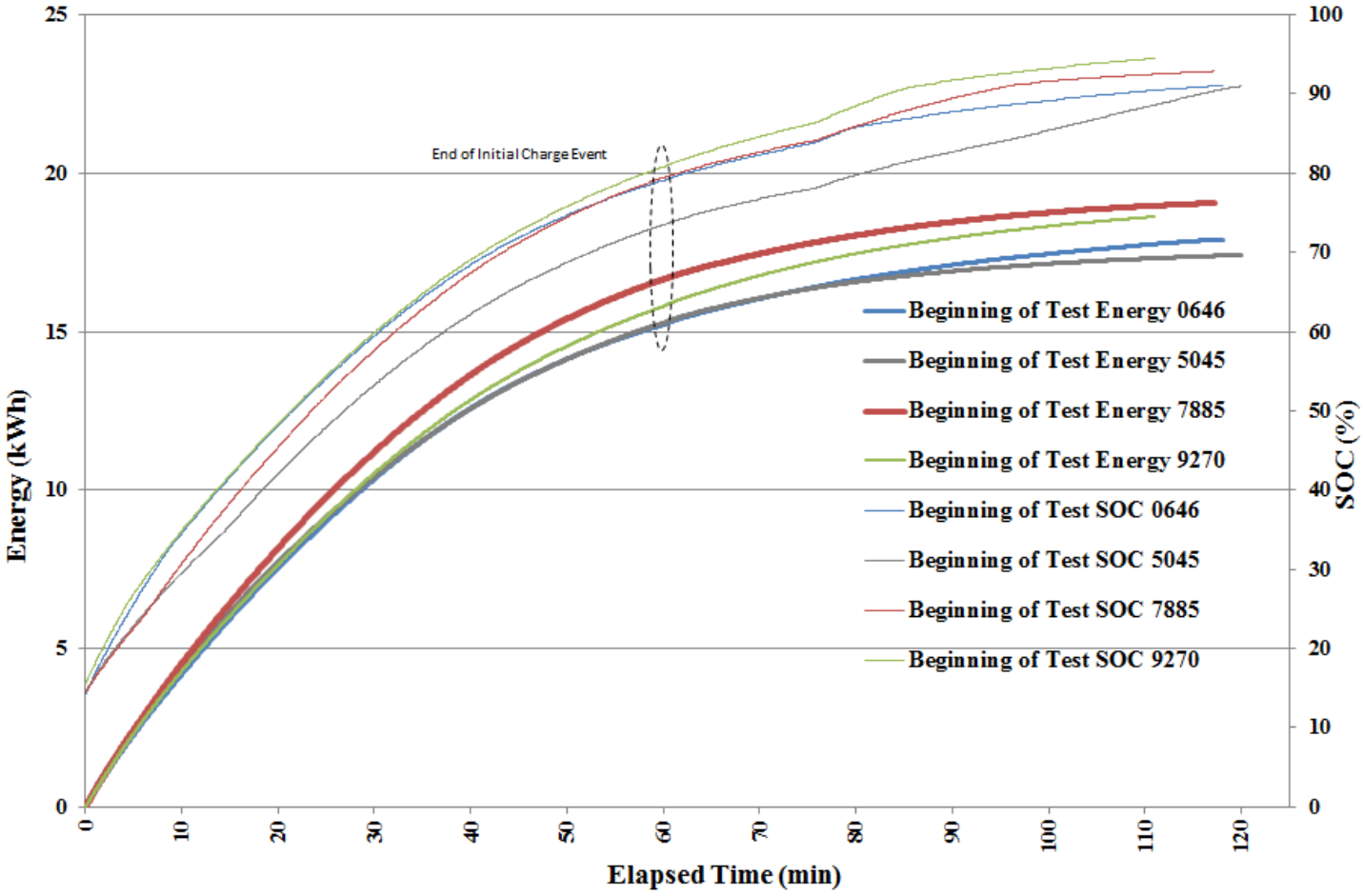

Figure 1a. 0 °C charge energy and SOC versus time

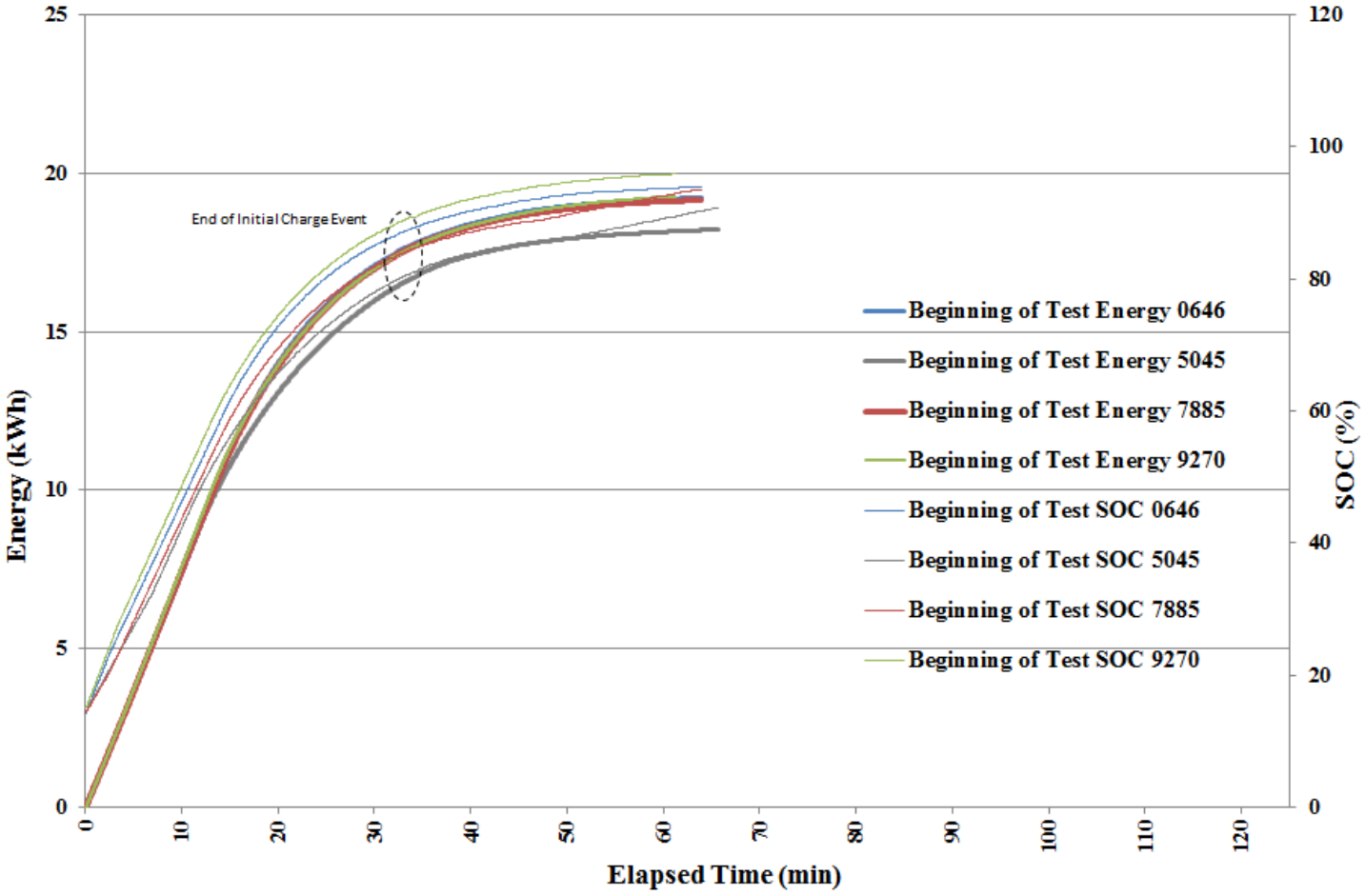

Figure 1b. 25 °C charge energy and SOC versus time

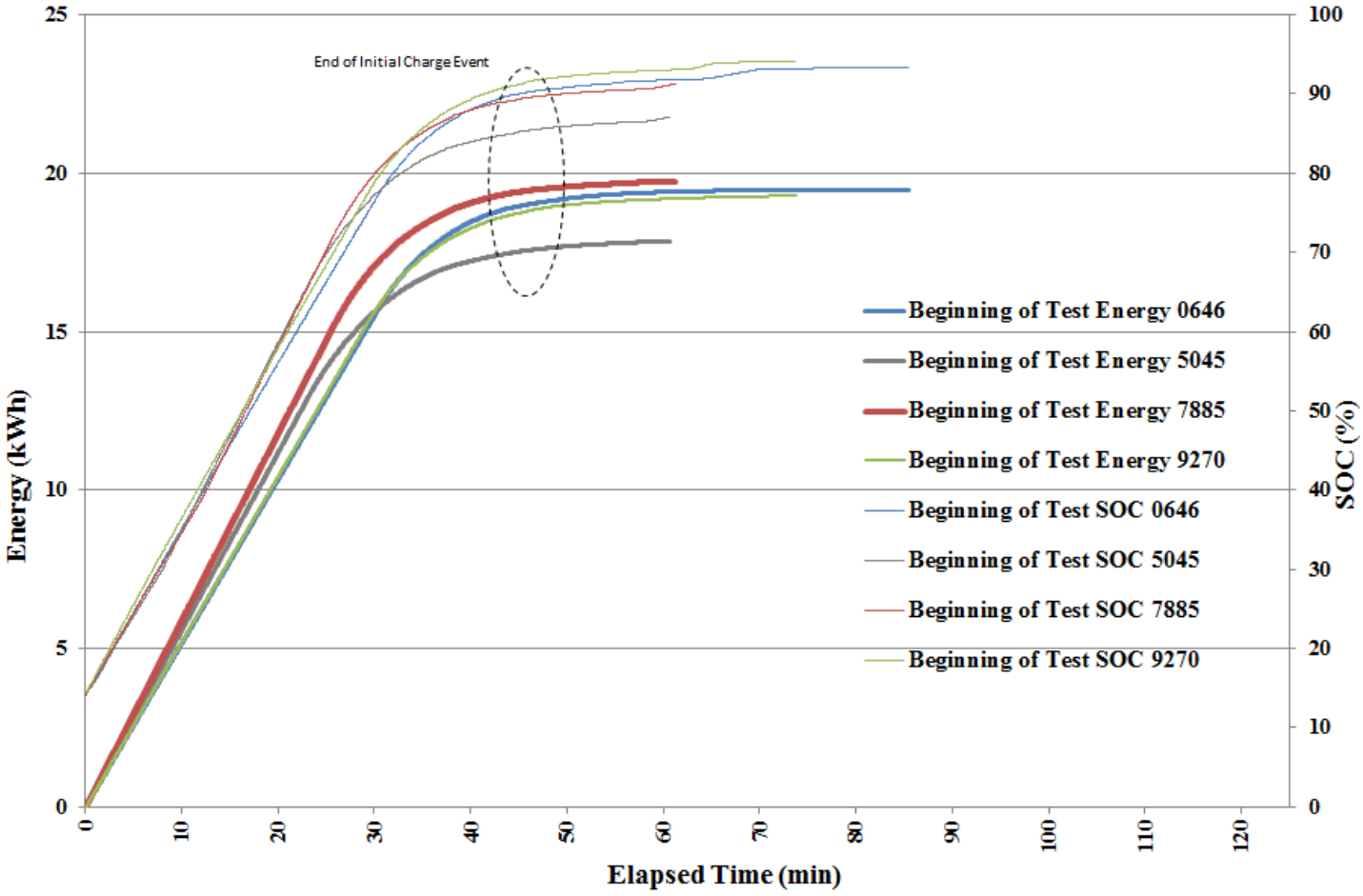

Figure 1c. 50 °C charge energy and SOC versus time

Test Results: Temperatures

The enclosure temperatures were not measured during the initial testing of the 2013 Nissan Leaf, but they will be recorded in future testing.

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.

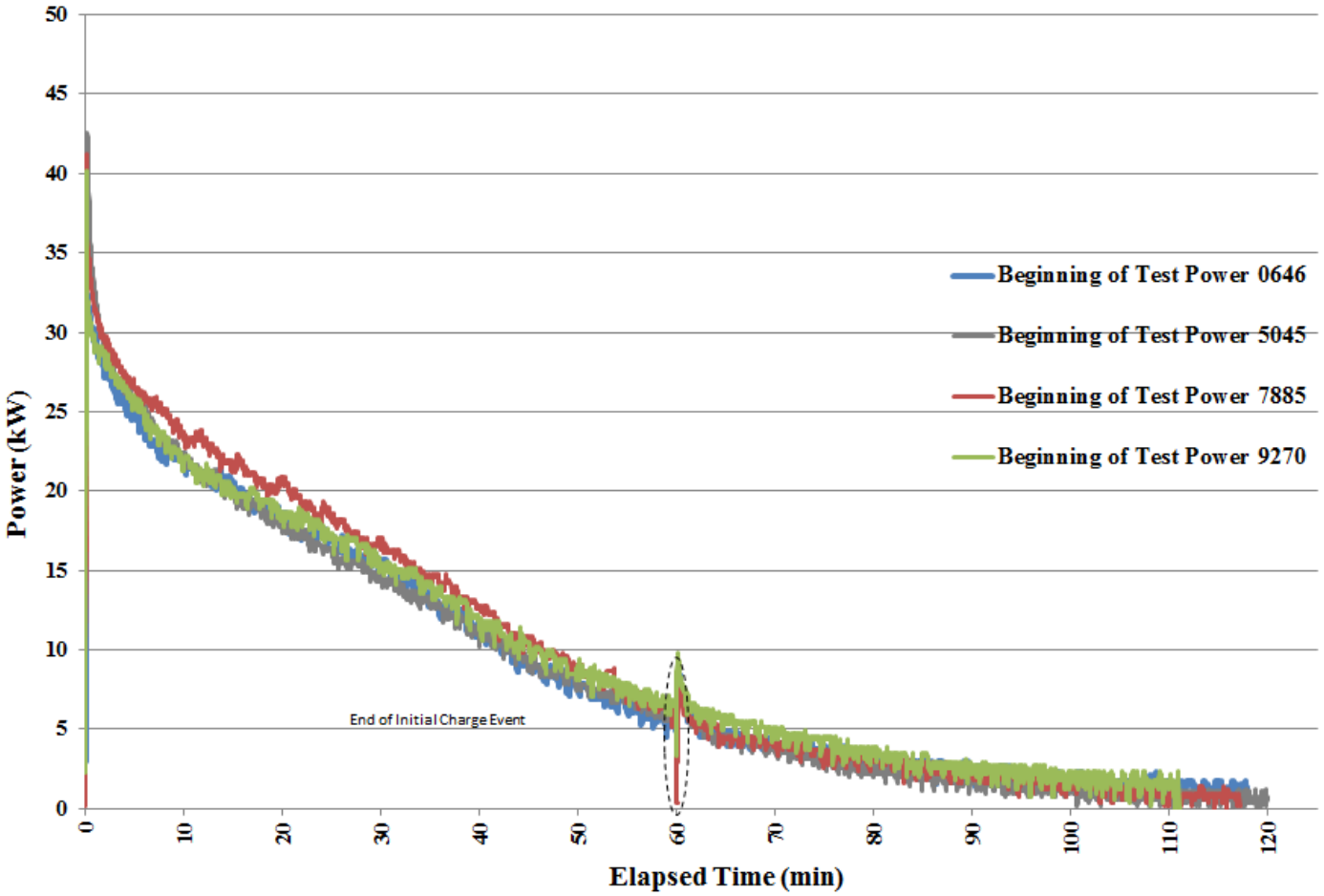

Figure 2a. 0 °C charge power profiles

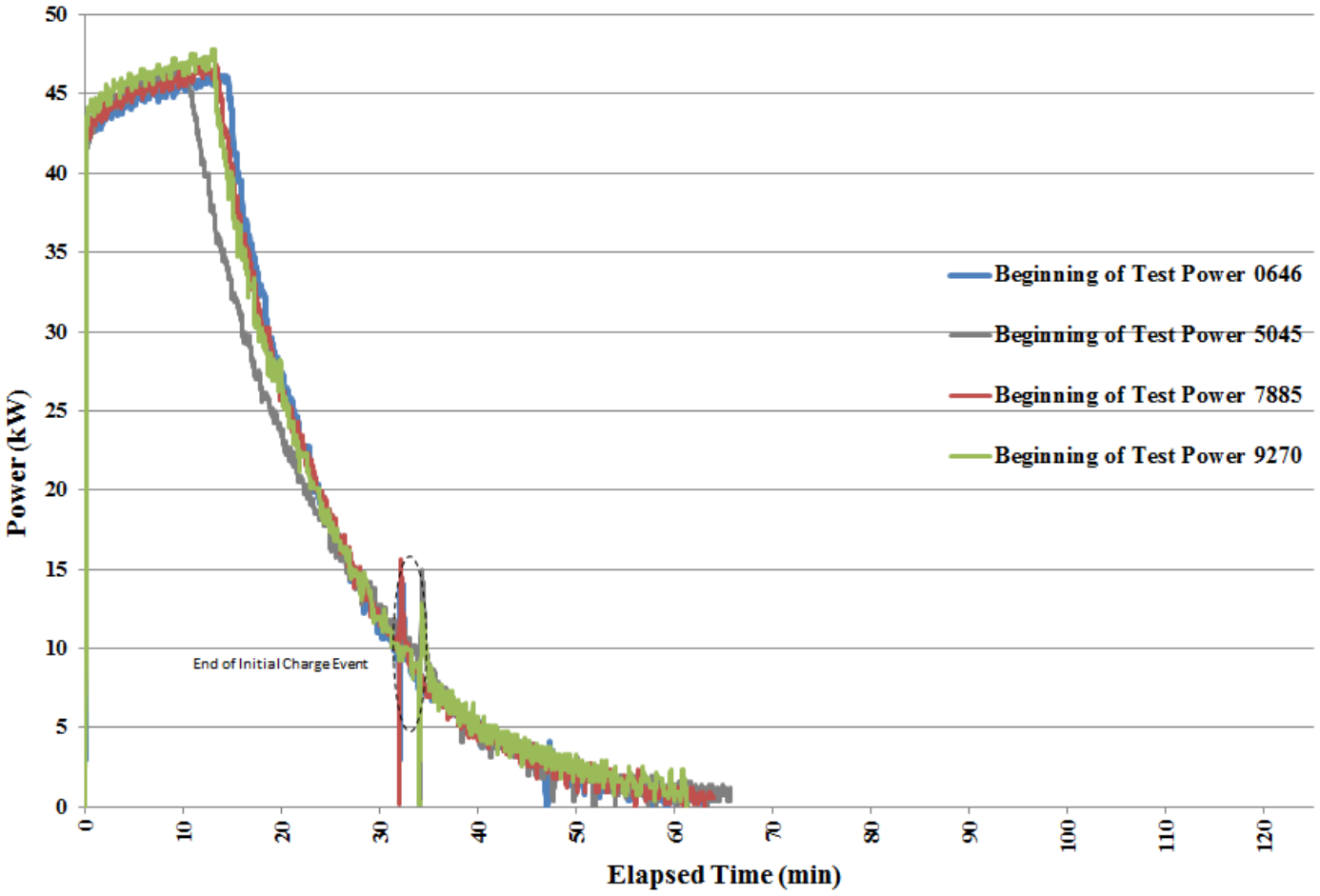

Figure 2b. 25 °C charge power profiles

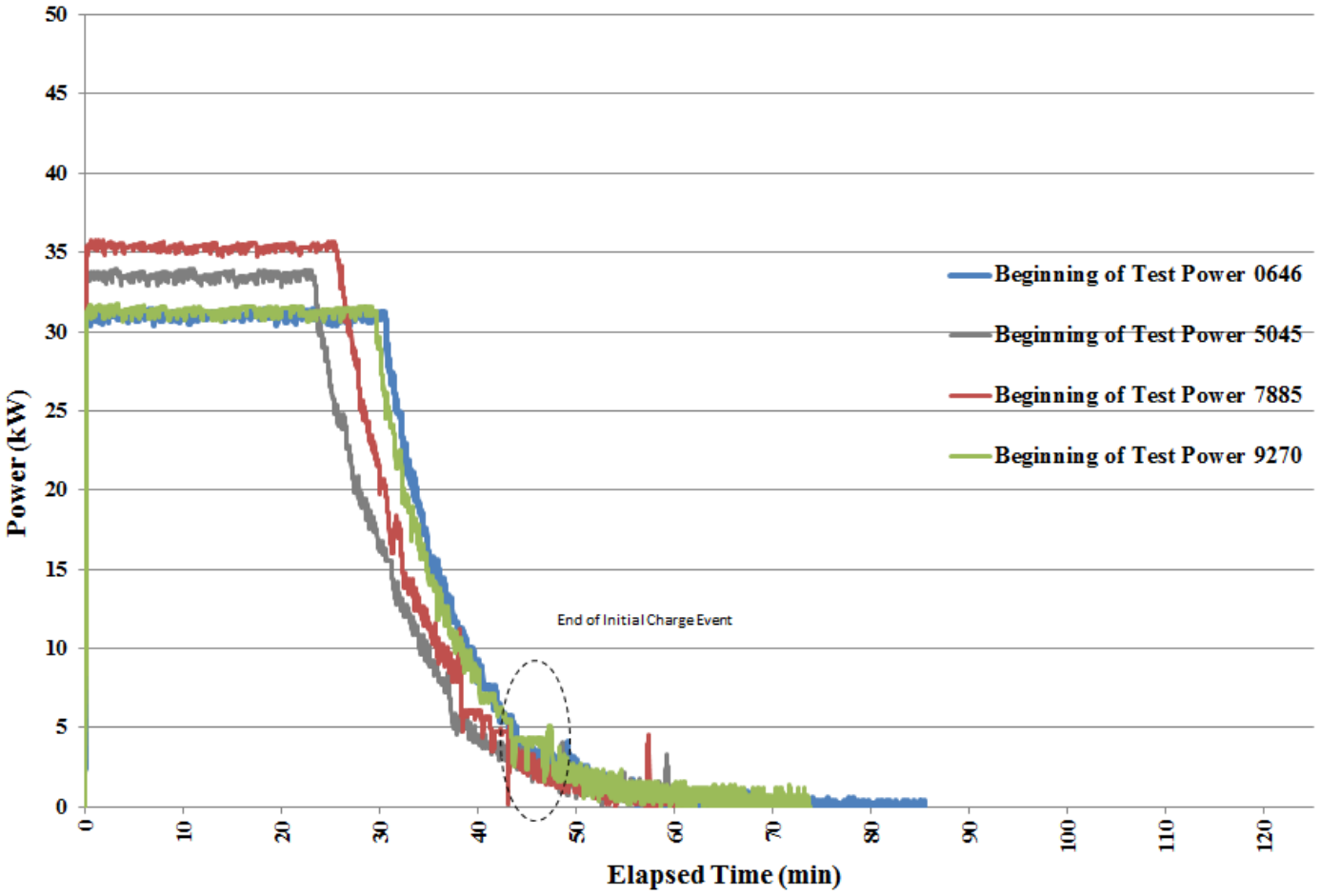

Figure 2c. 50 °C charge power profiles

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.
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 deemed sufficient 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 test
   VIN 5045:
   0 °C: Not recorded for this test | 25 °C: Not recorded for this test | 50 °C: Not recorded for this test
   VIN 7885:
   0 °C: Not recorded for this test | 25 °C: Not recorded for this test | 50 °C: Not recorded for this test
   VIN 9270:
   0 °C: Not recorded for this test | 25 °C: Not recorded for this test | 50 °C: Not recorded for this test
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 the figures.
   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

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