Electric Vehicle Field Operations Program

Chevrolet S-10 Electric with NiMH Battery

PERFORMANCE CHARACTERIZATION

U.S DEPARTMENT OF ENERGY
Agreement No. DE-FC07-96ID13474

SOUTHERN CALIFORNIA EDISON

An *EDISON INTERNATIONAL* Company

ELECTRIC TRANSPORTATION DIVISION

Report prepared by: Alvaro Mendoza, Jordan Smith, Juan Argueta, Michel Wehrey, Tom Knipe.

September 1999

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS REPORT WAS PREPARED BY THE ELECTRIC TRANSPORTATION DIVISION OF SOUTHERN CALIFORNIA EDISON, A SUBSIDIARY OF EDISON INTERNATIONAL.

NEITHER THE ELECTRIC TRANSPORTATION DIVISION OF SOUTHERN CALIFORNIA EDISON, SOUTHERN CALIFORNIA EDISON, EDISON INTERNATIONAL, NOR ANY PERSON WORKING FOR OR ON BEHALF OF ANY OF THEM MAKES ANY WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, PRODUCT, PROCESS OR PROCEDURE DISCUSSED IN THIS REPORT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE UPON OR INTERFERE WITH RIGHTS OF OTHERS, INCLUDING ANOTHER'S INTELLECTUAL PROPERTY, OR (III) THAT THIS REPORT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE.

NEITHER THE ELECTRIC TRANSPORTATION DIVISION OF SOUTHERN CALIFORNIA EDISON, SOUTHERN CALIFORNIA EDISON, EDISON INTERNATIONAL, NOR ANY PERSON WORKING ON BEHALF OF ANY OF THEM ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER RESULTING FROM YOUR SELECTION OR USE OF THIS REPORT OR ANY INFORMATION, PRODUCT, PROCESS OR PROCEDURE DISCLOSED IN THIS REPORT.

PURPOSE

The purpose of the evaluation of electric vehicles (EVs), EV chargers, batteries, and related items by SCE is to support their safe and efficient use and to minimize potential utility system impacts.

The following supports this purpose:

- As a fleet operator and an electric utility, SCE uses EVs to conduct business.
- In order to make informed decisions in the purchase of EVs, batteries, and charging equipment, SCE must evaluate them.
- SCE must determine if there are any safety issues with the related equipment or their usage.
- SCE has a responsibility to educate and advise customers about efficient and safe operation of EVs.

Table of Contents

I. INTRODUCTION

This report characterizes the performance of the Chevrolet S-10 Electric equipped with Nickel-Metal Hydride (NiMH) batteries. The tests performed were: weight certification, range, battery capacity, state of charge meter evaluation, sound level, acceleration, maximum speed, braking, and charger performance.

Southern California Edison (SCE), in cooperation with the U. S. Department of Energy (DOE), has been evaluating S-10 EV performance and reliability under the Field Operations Program since August 1997. The vehicle used for this performance characterization is one of two 1998 S-10s purchased by SCE that were originally equipped with lead-acid battery packs. The original lead-acid battery packs of these vehicles were replaced with production Ovonic Energy Products NiMH battery packs. The vehicles were then tested for maximum range under similar conditions. The vehicle selected for performance characterization was the one that obtained the longest range (72.7 miles). The other vehicle's range was 68.0 miles.

Testing was performed at the Electric Vehicle Technical Center (EV Tech Center), on the Urban and Freeway Pomona Loops, and the Pomona Raceway in Pomona, California.

For detailed procedures used for the testing, please refer to the *SCE Electric Vehicle Test Procedure* in Appendix H, page 67.

II. MANUFACTURER'S SPECIFICATIONS

Vehicle Make:	Chevrolet
Model:	S-10 Electric/NiMH
Range:	60-70 miles
Maximum Speed:	70 mph (governed)
Motor Type:	AC Induction, liquid cooled
System Power:	85 kW (114 hp)
Transmission:	Single Speed, front wheel drive
Battery Type:	Nickel-Metal Hydride (NiMH)
Manufacturer:	Ovonic Energy Products
Weight:	40.12 lbs.
Capacity:	85 Ampere-hour
Battery Pack Weight:	1043 lbs.
Number of Modules:	26
Nominal Pack Voltage:	343 V
Cu*rb Weight:*	4200 lb.
GVWR:	5150 lb.
Payload:	948 lb.
Dimensions	
Wheelbase:	108.3 in.
Length:	188.7 in.
Width:	67.9 in.
Height:	63.8 in.
Ground Clearance:	7.5 in.

III. DEVIATIONS FROM THE SCE ELECTRIC VEHICLE TEST PROCEDURE

1. The battery capacity test was not performed at C/3 rate, it was instead done at a 25 Amps constant discharge in order to follow GM's procedures.
2. Recharge data was not recorded after the battery capacity test.
3. The recharging sound test was not performed.
4. The stand-by energy consumption test with the vehicle off charge was not performed.

IV. RESULTS

A. Weight Certification

Table 4-1. Weight Results

	Front Axle	Rear Axle	Total Weight
GVWR (lb)	2700	2900	5150
Curb Weight (lb)	2100 [1]	2130 [1]	4230
Available Payload (lb)	600	770	**920** [2]

[1] Front and rear axle weights are not certified.

[2] Specified payload on vehicle door sticker: 948 lb.

B. Range Tests

B1. Urban Range Tests

Table 4-2. Urban Range Test Results

Tests	UR1**	UR2*	UR3**	UR4*
Range (mi.)	70.4	63.0	63.0	60.4
Payload (lb.)	180	180	920	920
Avg. Amb. Temp. ^{o} F	63.4	65.5	62.5	50.3
AC kWh Recharge [1]	54.93	57.09	54.98	51.34
AC kWh/mile	0.780	0.906	0.873	0.850
DC kWh Used (drive)	23.93	23.28	24.45	N/A
DC kWh/mile	0.340	0.369	0.388	N/A
DC kWh Recharge	32.79	31.56	31.96	31.97
% Charge Returned (DC in/DC out)	137.0	135.6	130.7	N/A

* Average of two tests **Average of three tests

[1] From BMI Power Profiler

UR1: Pomona loop range test with minimum payload
UR2: Pomona loop range test with minimum payload and auxiliary loads
UR3: Pomona loop range test with maximum payload
UR4: Pomona loop range test with maximum payload and auxiliary loads

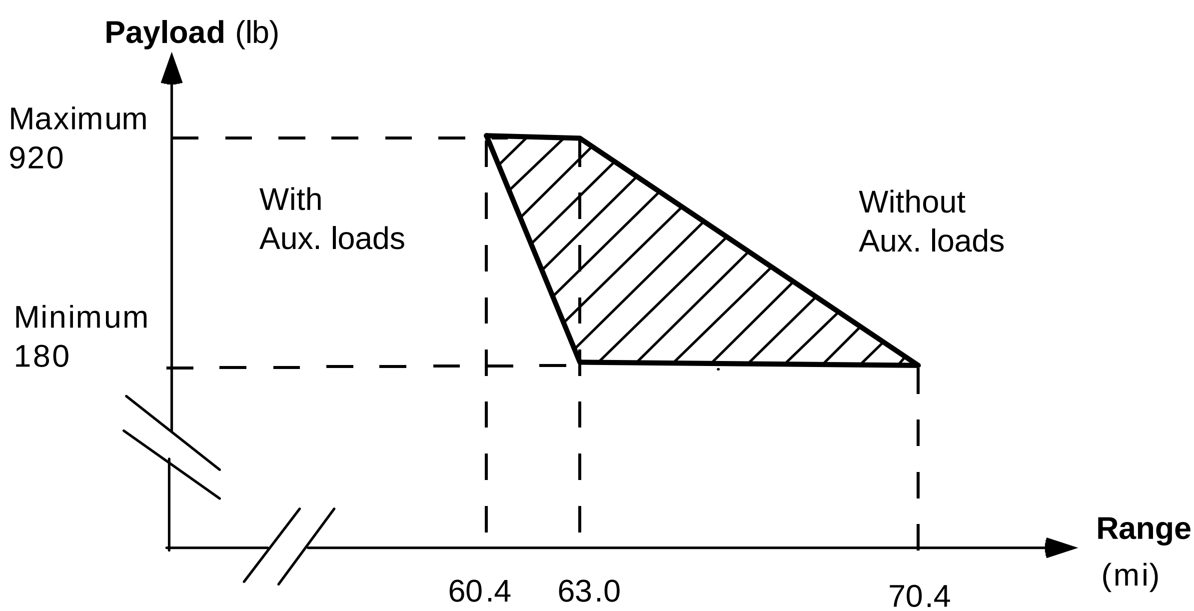


Figure 4-1. Urban Range Envelope

B2. Freeway Range Tests

Table 4-3. Freeway Range Test Results

Tests	FW*	FW2*	FW3**	FW4**
Range (mi.)	84.2	79.9	75.5	73.1
Payload (lb.)	180	180	920	920
Avg. Amb. Temp. °F	67.5	56.8	59.3	54.7
AC kWh Recharge [1]	56.35	53.29	51.01	57.44
AC kWh/mi.	0.686	0.667	0.675	0.785
DC kWh Used (drive)	23.93	24.19	24.09	24.04
DC kWh/mile	0.284	0.303	0.319	0.329
DC kWh Recharge	31.05	32.98	30	31.19
% Charge Returned (DC in/DC out)	129.7	136.3	124.5	129.7

*Average of two tests **Average of three tests

[1] From BMI Power Profiler

FW1: Freeway loop range test with minimum payload
FW2: Freeway loop range test with minimum payload and auxiliary loads
FW3: Freeway loop range test with maximum payload
FW4: Freeway loop range test with maximum payload and auxiliary loads

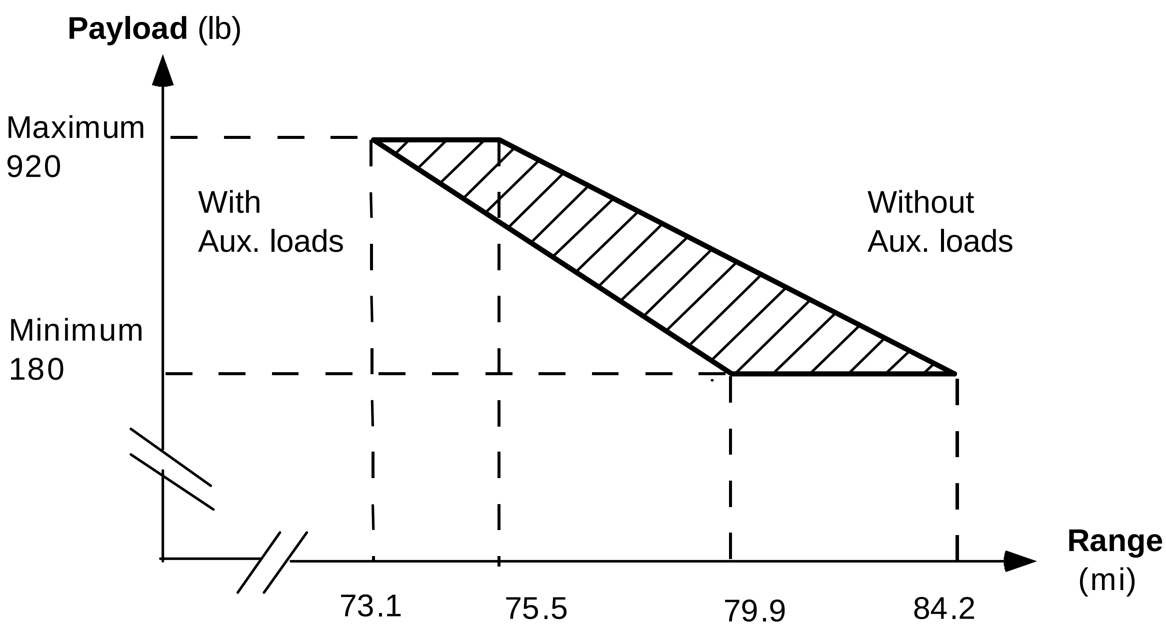


Figure 4-2 Freeway Range Envelope

C. State of Charge (SOC) Meter Evaluation

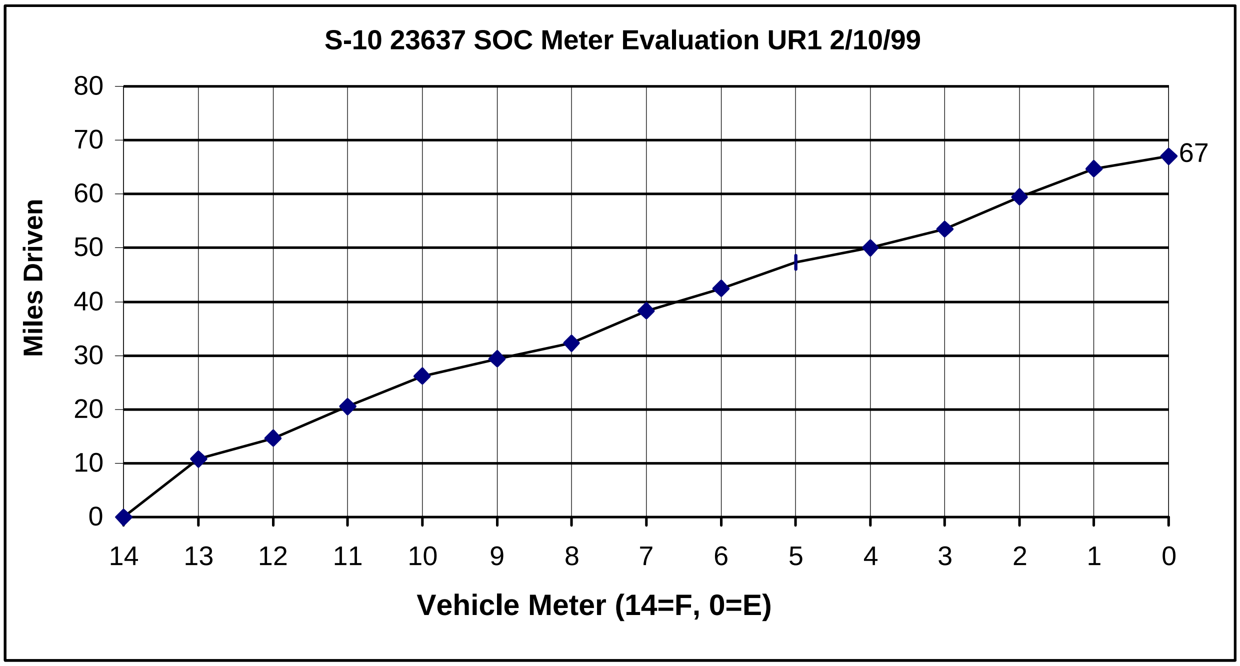


Figure 4-3. State of Charge meter readings as a function of miles driven.

Figure 4-4. S-10 EV State-of-Charge gage.

Note: The number labels on this figure were added.

D. Battery Capacity Test

See Appendix D, page 34, for a graphical depiction of the GM Ovonic NiMH capacity test.

Table 4-4. Battery Capacity Test Data

Discharge Rate	25 A
Duration of Discharge	3.4 hours
kWh Out	30.04 kWh
Amp-hour Out	85.62 Ah
Manufacturer's Rating	85 Ah @ C/3[1]

[1]According to the manufacturer, the discharge rate (e.g. C/3, C/2, C/1) does not greatly affect the capacity.

Note: The end of the test was determined when the vehicle battery pack manager (BPCM) opened the pack disconnect.

E. Acceleration, Maximum Speed, and Braking Tests.

Table 4-5. Summary of Acceleration, Maximum Speed, and Braking Tests[1]

Performance Testing Data	**100% SOC**	**80% SOC**	**60% SOC**	**40% SOC**	**20% SOC**
0 to 30 mph (sec.)	5.06	4.99	5.28	5.30	5.33
30 to 55 mph (sec.)	7.45	7.81	8.06	8.17	8.91
0 to 60 mph (sec.)	14.45	14.73	15.15	15.34	16.12
Max Speed (mph)	73.00	N/A	N/A	N/A	72.50
Braking (25-0 mph) (ft.)	N/A	N/A	26.80	N/A	N/A

[1]Average values (ambient temperature 64.5-76° F). (180 lb. Payload)

F. Charger Performance / Profile Test

Table 4-6. Charger Profile Data

Note: Refer to Appendix G, page 59 for BMI Power Profiler graphical data.

Measured Value[1]	
Voltage	233.3 V_{rms}
Current	30.17 A_{rms}
Real Power[2]	6.988 kW
Reactive Power	793.8 VAR
Apparent Power	7.038 kVA
Total Power Factor	0.99 PF
Displacement Power Factor	0.99 dPF
Voltage THD	1.00%
Current THD	3.20%
Current TDD	3.19%
Total Charging Time[3]	6 hours, 59 minutes
Total Energy Consumption	56.06 kWh AC
Time Observed on Stand-by	24 hr
Energy Consumption	5.475 kWh AC
Average AC Power	228.11 W AC
Average Power into Batt. Pack (DC)	163.2 W DC

Data was recorded after the first UR1 test.

[1]Values recorded with charger near maximum power on the AC (input) side of the charger (240 V)

[2] Maximum recorded instantaneous real power was 7.2 kW

[3] Ambient Temperature: at start =76.7°F, at end=68.5°F, Ave.=73.7°F

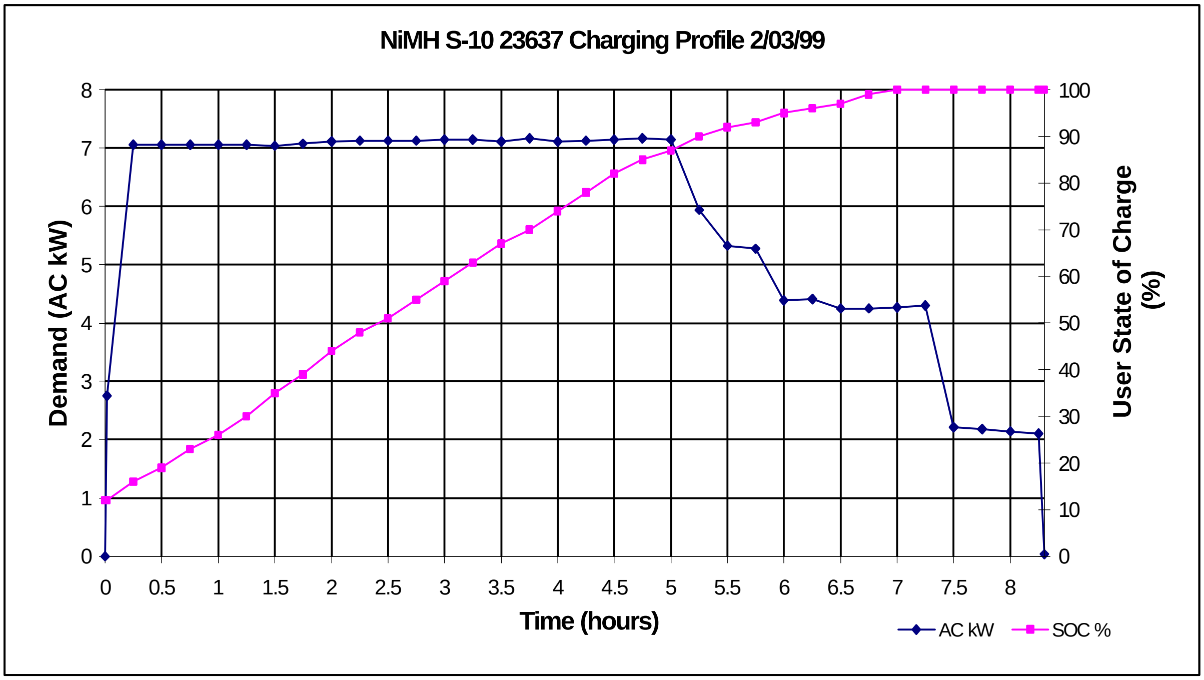


Figure 4-5. AC charging profile from ABB meter (recorded after the 3rd UR3 test). The state of charge was obtained using the GM data acquisition software.

G. Sound Level Tests

G1. Freeway Sound Level Test

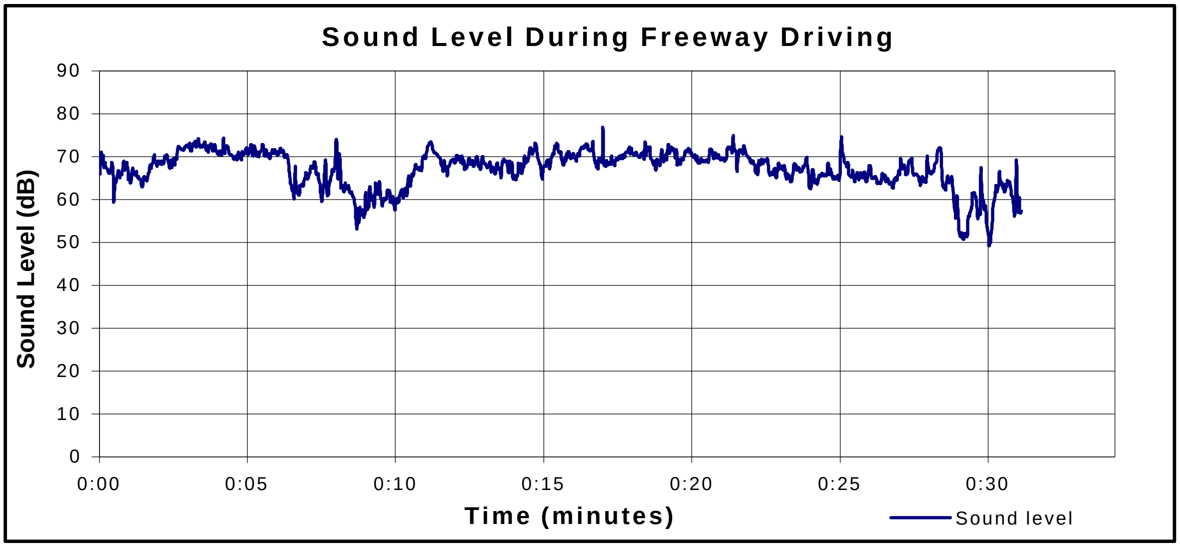


Figure 4-6. Sound intensity in dBs recorded during a driving test on the Freeway Loop.

The average sound intensity was 67.05 dBs

G2. Urban Sound Level Test

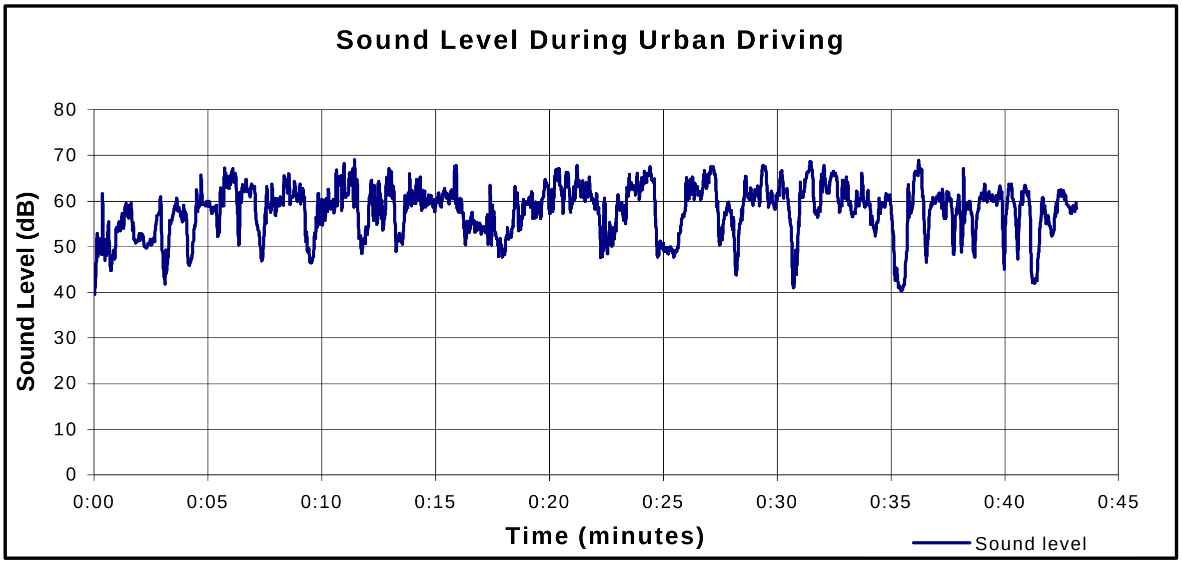


Figure 4-7. Sound intensity in dB recorded during a driving test on the Urban Pomona Loop.

The average sound intensity was 57.84 dBs

V. DISCUSSION

A. Weight Certification

The vehicle was taken to a certified scale to measure the total weight, and the front and rear axle weight. The measured total curb weight was 4230 pounds. The manufacturer's gross vehicle weight rating (GVWR) label on the vehicle was 5150 pounds, and the specified payload was 948 pounds. The GVWR minus the total curb weight yielded a payload of 920 pounds, which was the weight used for the maximum payload tests. Table 4-1 on page 3 shows an available front axle payload of 600 pounds, and an available rear axle payload of 770 pounds. When the vehicle was loaded to its maximum legal weight (920 pounds), the load was evenly distributed, with weight added to the passenger compartment, as well as the cargo bed (see Figures 5-1 and 5-2). The load added to the cargo bed was 630 pounds, and the load added to the passenger compartment, including the driver, was 290 pounds.

Both the 1997 and the 1998 S-10 models have the same weight ratings as indicated by the vehicle door sticker. However, the measured curb weight of the 1998 model resulted higher than that of the 1997 model by 60 lbs.. This difference in measured curb weight could have resulted because the 1998 model is equipped with a NiMH battery pack, while the 1997 model is equipped with a lead acid battery pack which is lighter than the NiMH pack.

Figure 5-1. Testing at maximum payload.

B. Range Tests

To range test this vehicle, it was driven in a manner that was safe and compatible with the flow of traffic at or below the posted speed limits. Software created by GM (General Motors) was used with a laptop computer and a special interface cable made by GM for the purpose of recording drive and charge energy data. GM's software is a data acquisition and control program that reads, displays, and records data from the battery management system. Since the SOC needle dropped quickly as it approached the empty position, the vehicle was driven until the user SOC, as indicated by GM's software, was 5%.

Acceleration and braking of this vehicle seemed responsive. The vehicle never had trouble keeping up with the flow of traffic during the range tests. However, acceleration seemed slower when the vehicle was driven with maximum payload. Braking time and stopping distance seemed to increase slightly at maximum payload. The road condition was dry except for the following three tests: second UR3, first UR4, and second FW2. During the second UR3 test, rain was present for about 1 ½ hours, but for the other two tests, rain was consistent throughout the drive and the wipers were used constantly.

Figure 5-2. Test equipment used during charger and vehicle testing.

B1. Urban Range Tests

For the drives on the Pomona loop, the maximum speed of the vehicle varied between 30 mph and 50 mph. At least three loops were completed for each drive. Variations in payload and auxiliary loads (air conditioning and headlights) clearly affected the range of the vehicle, as seen in Figure 4-1. The effect from auxiliary loads was more pronounced for the tests at minimum payload (UR1, UR2) than at maximum payload as the range declined from an average of 70.4 to 63.0 miles (10.5%). At maximum payload, the effect of auxiliary loads was less noticeable (only 4.1% decline) as the range decreased from

63.0 miles (UR3), to 60.4 miles (UR4). This small decline in range during the UR4 tests, could have been affected by the low ambient temperatures at the time of the tests (50.3°F average).

The effect of maximum payload on range was more significant without auxiliary loads (UR1, UR3) as the range decreased from 70.4 to 63.0 miles (10.5%). With auxiliary loads, the effect of maximum payload was less remarkable with a decrease of only 4.1% from 63.0 miles (UR2) to 60.4 miles (UR4).

AC Energy consumption was similar for most of the recharging cycles because the vehicle was always driven until the SOC decreased to the same point (5% SOC). The average energy used by the vehicle after urban driving testing was 54.58 AC kWh. The largest deviation from this value was 5.9% (UR4 test).

Air conditioning temperatures, as measured from the AC outlet air from the center cabin vent, behaved in an unpredictable way. They increased and decreased throughout the drives, although the biggest temperature decrease observed during most drives occurred within the first 25 minutes of driving. Usually, the AC temperature at the end of the driving tests was higher than that measured at 10 minutes from start. This is as expected, as the vehicle may be sending most of the cold air to the battery pack as opposed to the cabin.

The urban range tests also included collection of DC energy used by the vehicle during recharge, and energy used during the drives (except for the UR4 test). The average DC energy usage per drive was 23.87 DC kWh, while the average for the recharge was 32.07 DC kWh. As Table 4-2 on page 4 indicates, the percentage of charge returned using DC data obtained during the tests was not consistent. The average percentage charge returned for the four test scenarios was 134.4%.

B2. Freeway Range Tests

Traffic conditions were good on the freeway for most of the driving tests, and the speed was kept as close to 65 mph as traffic would allow. During one driving test (1st FW4), "stop-and-go" traffic was encountered for a few miles. The recorded range included urban driving of approximately 4 miles to access the freeway and ½ mile each loop to transition between freeways.

At minimum payload without auxiliary loads (FW1), the range was 84.2 miles, and at minimum payload with auxiliary loads (FW2), the range reduced to 79.9 miles (5.1% decrease). The effect of auxiliary loads on range was less significant at maximum payload; the range only declined 3.2%, from 75.5 miles (FW3) to 73.1 miles (FW4). Due to low ambient temperatures, the auxiliary loads had a minimum impact on range. The recorded ambient temperature was 56.8°F during the FW2 test, and 54.7°F during the FW4 test. Usually, the vehicle's AC system requires a warmer ambient temperature for proper operation.

The effect of maximum payload was considerable without auxiliary loads (FW1, FW3) as the range decreased from 84.2 to 75.5 miles (10.3%). However, the effect of maximum payload was somewhat smaller with auxiliary loads (FW2, FW4) as the range decreased from 79.9 to 73.1 miles (8.5%). From our results, we can see that at higher payloads more power is required to accelerate the vehicle.

While power demand varies during urban driving, it stays relatively constant during freeway driving. The average energy usage per mile on the freeway loop was 0.703 kWh/mile, while on the urban loop it was 0.852 kWh/mile. These results indicate higher overall discharge rates for urban driving than for freeway driving. Tables 4-2 and 4-3 indicate that the driving ranges obtained from freeway driving were higher than the respective ones obtained from urban driving under similar conditions. The range was much greater on the freeway probably because the vehicle requires more energy to accelerate during urban driving since the vehicle has to stop continuously, while on the freeway, the need to accelerate is not encountered as often. The range obtained on the freeway also suggests that the aerodynamic characteristics of the vehicle are good.

Air conditioning temperatures behaved unpredictably as during the urban driving tests. On some occasions, such as the first FW2 test, the A/C temperature did not decrease much from the start. This situation could have been caused by low ambient air temperature (54° to 55° F) while the air conditioner vent temperature was relatively warmer (61° to 66° F). These temperatures could be a sign that the air conditioning system was either not operating at full power, or not operating at all.

Unlike the urban range tests, DC energy data was collected for all four tests scenarios. The values obtained from freeway tests were also as inconsistent as in the urban range tests. The average DC energy used by the vehicle during the drives on the freeway was 25.06 DC kWh, whereas during recharge the average was 31.30 DC kWh. The average charge returned on the four freeway test scenarios was 124.9%. This average value is smaller than the average value obtained from the urban tests (134.4%) by 7.06%.

C. State of Charge Meter Evaluation

The state of charge (SOC) meter (Figure 4-4, page 6) is located on the left side of the instrument panel. As in the S-10 model equipped with a lead acid battery pack, the SOC meter consists of seven major lines with half lines in between. The SOC meter contains a red zone at the left end occupying the area from "E" (Empty) to the first major line. For practical convenience, Figure 4-4 was marked with numbers starting from 0 at E, and ending with 14 at "F" (Full). The SOC needle rotates in a counterclockwise direction during driving.

GM's software was also used to determine the point at which the battery life light illuminated. When the needle reached the top of the red zone, the user SOC% as indicated by GM's software always showed 16%. When the needle reached line 1 in the middle of the red area, the battery life light illuminated consistently at 10% user SOC. The SOC meter corresponded closely to actual SOC except at the beginning and end of the discharge. It took longer for the needle to move from the F mark to line 13 (10.8 miles) as compared to the rest of the drive (refer to Figure 4-3, page 6). The drop from F to line 13 took 13% SOC as compared to an average of 6% SOC for every line drop (except from line 2 to line 0). The needle takes a sudden drop as it goes from line 1 to line 0 without affecting the vehicle's performance. For this reason, the vehicle was always driven a little further (down to 5% actual SOC) after the needle reached line 0 (7% SOC).

Figure 5-3. S-10 instrument panel

The electric S-10 also has a power meter in the instrument panel that indicates the percentage instantaneous flow of power. This indicator moved faster to the negative side as the SOC dropped to a low level. A battery pack voltage meter is also included in the instrument panel to the right side of the speedometer. It gave a good approximation of the actual voltage of the battery pack.

D. Battery Capacity Test

The GM Ovonic NiMH batteries in the electric S-10 were rated at 85 Amp-hours. According to the manufacturer, unlike the lead acid batteries previously installed in this vehicle, the discharge rate does not greatly affect the capacity of the NiMH batteries. According to the SCE test procedure, the capacity test is done at a C/3 discharge rate. However, this vehicle was discharged at a constant discharge current of 25 Amps to correspond to standard GM capacity tests. Ideally, at a constant discharge of 25 Amps, and considering the manufacturer's rating of 85 Amp-hour, a complete capacity test would take 3.4 hours. This is obtained by dividing 85 Amp-hours by the current discharge rate of 25 Amps. The values obtained from this capacity test indicate that the pack was in good health since the duration of discharge was the ideal (3.4 hours), and 85.62 Amp-hours were delivered. This deviated from the manufacturer's rating by only 0.73%.

The discharge was stopped when the battery pack control module (BPCM) opened the pack disconnect. At the start of the test, the pack voltage was 402.7 Volts. The pack voltage at the end of the capacity test was 292.7 Volts, the total energy delivered was 30.04 kWh, and 85.62 Amp-hours were delivered.

It should be noted that high levels of overcharge were encountered during tests. Recharge levels as high as 37% were recorded using DC energy data. This information was passed on to GM engineers for evaluation.

E. Acceleration, Braking, and Maximum Speed Tests

The acceleration, braking, and maximum speed tests were conducted at the Pomona Race Track test site. These tests were performed with a replaced battery pack module that was changed as a consequence of a "quit-on-road" incident that took place after most of the vehicle testing was conducted, except for the acceleration, braking and maximum speed tests. At the time the vehicle was taken to the Pomona Race Track for testing, the track was dry, and the ambient temperature ranged from 54.5°F at the start to 73°F at the end of the test session. The vehicle's response to the accelerator pedal input felt consistent throughout the test. As shown in Table 4-5, page 7, acceleration time increased slightly almost every time as state of charge decreased. The results in this table also indicate that acceleration is good from 0 to 30 mph, but it slows down from 30 to 55 mph. This reduction in acceleration rate could be affected by the increase of wind resistance at higher speeds.

The vehicle's acceleration time increase is more noticeable by comparing the average results from tests performed at 20% SOC to those at 100%. This time increase was greater on tests when the vehicle accelerated from 30 to 60 mph (11.6%) than when it accelerated from 0 to 30 mph (5%). These results confirm that the acceleration decreases as the vehicle reaches higher speeds.

The 30 to 55 mph test was conducted just after the 0-30 and 30-60 mph tests. The average maximum vehicle speed was 73.0 mph at 100% SOC, and 72.5 mph at 20% SOC.

The average of ten runs of the braking tests from 25 to 0 mph was 26.8 feet. This result is very close to the one obtained from another S-10 with NiMH battery pack tested in November 1997. On that occasion, the average braking distance was 24.9 feet. The four-wheel ABS brakes did not seem to work very effectively since the vehicle tended to skid at times when the brakes were applied not severely.

F. Charger Performance Test

Charging of the S-10 was done with a standard off-board 6.6 kW Magne Charge inductive charger (Figure 5-4). The average charging time from 5% to 100% SOC was about 8 hours. During charging, the vehicle's thermal control system monitors the temperature of the batteries in order to provide either cooling or heating to the battery pack. This process has some effect on the charging time and energy used by the vehicle during charging.

As shown in Table 4-6, page 8, the instantaneous peak power recorded with a snapshot was 6.988 kW, with a current of 30.17 A, and a voltage of 233.3 V. The power factor was 0.99, the voltage total harmonic distortion (THD) was1.0%, and the current total harmonic distortion (THD) was 3.2%. The vehicle charged for 6 hours and 59 minutes from 5% to 100% SOC during this particular test and the energy delivered to the charger was 56.06 AC kWh.

Figure 5-4. Charger testing with BMI Power profiler.

The vehicle was monitored for periods of 24, 48, and 72 hours. During this time, the vehicle would request additional charge after being fully charged (100% SOC) for small periods of time. This seemed to happen about every seven to nine hours. For example, after a few hours of being completely charged, the vehicle's SOC would drop to around 97%, and it would recharge to 100% SOC. It was observed that when the vehicle was on stand-by for longer periods of time
(e.g. 48, and 72 hrs.), the vehicle's SOC would occasionally drop to around 95%. Also, when the vehicle's doors were opened after the vehicle was fully charged overnight, the charger would restart automatically even when the charger was displaying a full charge. According to the manufacturer, charge retention becomes a concern only when the vehicle stands without charging for an extended period of time. They also claim that in NiMH batteries, charge retention varies with temperature. When the batteries are kept at moderate temperatures, they maintain good capacity for two weeks after they have been charged.

G. Sound Level Tests

Sound level tests were conducted with the use of a sound level meter set at a frequency range of 20 Hz to 8 kHz. The measuring level was adjusted to measure sound intensity from 30 dB to 130 dB, and the sampling rate was two seconds. The sound level meter was mounted on a tripod, as seen in Figure 5-5, and placed on the vehicle's passenger seat near the center at ear level.

Figure 5-5. Sound level meter inside S-10.

As indicated by Figures 4-6 and 4-7(pages 9 and 10 respectively), the sound level during the urban test varied over a broader range than the freeway test. The average sound level recorded during the freeway sound level test was 67.05 dBs, while during the urban sound level test, the average was 57.84 dBs. The sound level recorded during the range tests does not necessarily represent the noise emitted solely from the vehicle. Although the vehicle's windows were up throughout the tests, ambient noise is also recorded by the sound level meter, including other vehicles' noise, voices from people on the street, etc.. This outside noise was not as prevalent during the freeway tests because when the vehicle is driven at constant speed, wind noise is moderately constant. For this reason, the plot of the freeway driving test (Figure 4-6), shows a more consistent noise level as compared to that from the urban test.

VI. CONCLUSION

Handling of this vehicle on both freeway and urban driving environments was very stable and comfortable. One area where the vehicle needs some improvements is the turning radius. It was more difficult to make a U-turn on an ordinary street with this vehicle as compared to the Ford Ranger EV. The vehicle's driving qualities are acceptable, even at maximum payload. The acceleration and braking controls were very responsive. Stopping response was affected at maximum payload, but not to an extreme extent.

One important advantage that the NiMH battery pack offers over the lead-acid battery is the increase in range. According to SCE testing, the lead-acid battery provides the S-10 with an average range of about 40 miles on urban driving, and 45 miles on freeway driving, while the NiMH offers an average of 64 miles on urban driving, and 78 miles on freeway driving.

The amount of energy delivered to the vehicle during recharge, as well as charging time was very consistent for all charges. The average energy used per recharge was 54 AC kWh, and the highest deviation from this average was only about 5.5%.

Overall, the vehicle responded well during most of the tests. However, the vehicle experienced a "quit-on-road" incident following a freeway sound level test. It occurred when the vehicle was on its way back to the EV Technical Center. The vehicle's power was suddenly reduced, and the service soon light illuminated, followed by the service now light. The vehicle was then pulled over to the side of the road and then turned off. Several attempts were made to re-start the vehicle but it did not respond. When the vehicle was brought back to the EV Technical Center and examined, it was determined that one of the modules in the battery pack registered excessive voltage change, and high temperatures during driving. The APCM (Auxiliary power Control Module), which was also causing trouble, was replaced along with the damaged module.

In order to continue supporting the use and acceptance of EVs, SCE will incorporate this vehicle into its fleet. As with other EVs currently used by fleet operators, this electric S-

10 could be possibly used in the near future by the SCE field services representatives or the meter reading technicians.

APPENDIX A

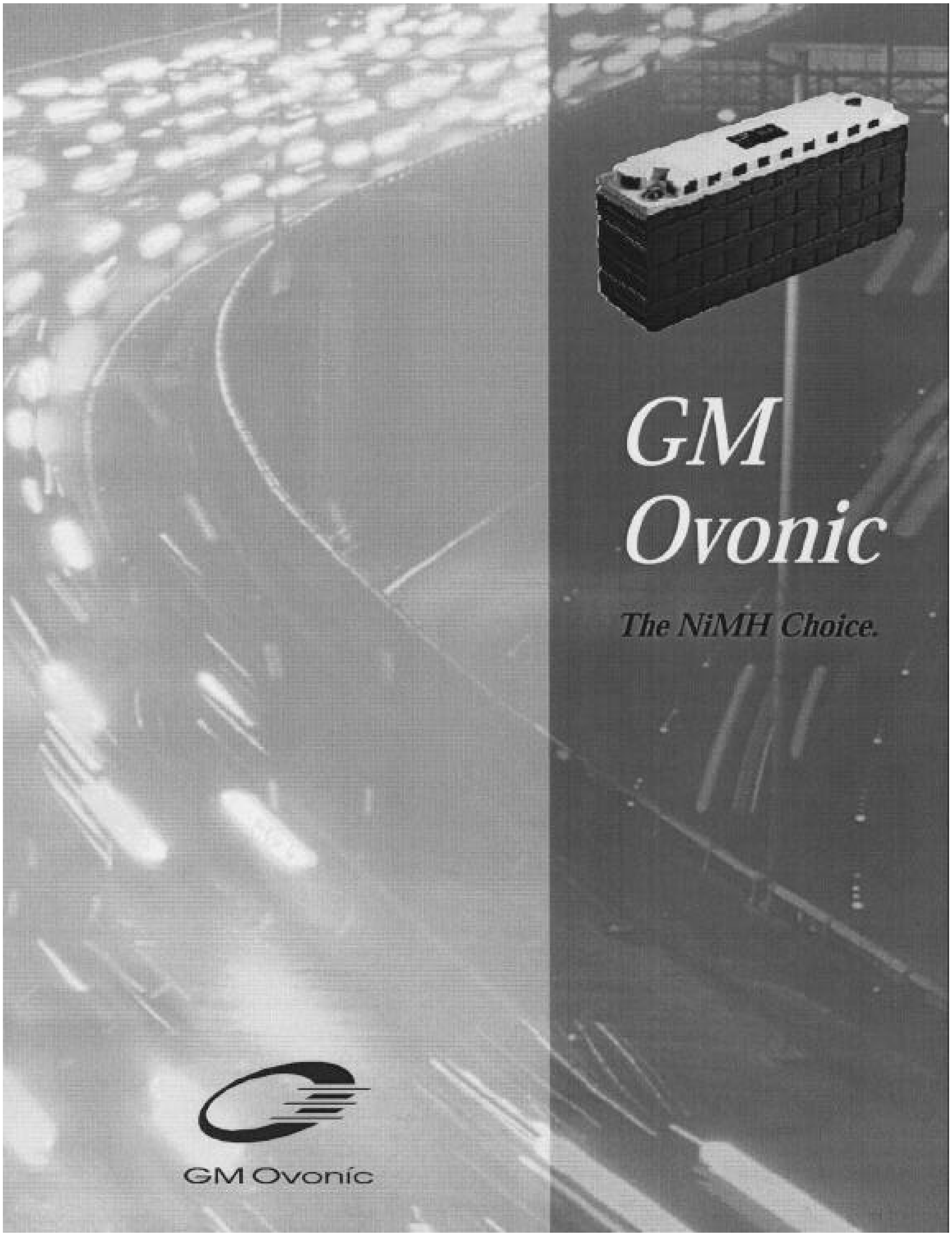
VEHICLE MANUFACTURER'S FACT SHEET

VEHICLE’S MANUFACTURER’S FACT SHEET

NOT AVAILABLE AS OF TIME OF PRINT

APPENDIX B

BATTERY MANUFACTURER'S FACT SHEET


GM
Ovonic
The NiMH Choice.
GM Ovonic

GM Ovonic Electric Vehicle Batteries

Module Performance

Specific Energy: 70 Wh/Kg

Energy Density: 165 Wh/liter

Specific Power:
220 W/Kg @ 50% DOD
200 W/Kg @ 80% DOD

Module Specifications

Physical

- 18.2 Kg
- 102 mm x 176 mm x 409 mm physical package (7.3 liters)

Electrical

- 13.2 V nominal (16.0 V max charging, 11.0 V min discharging)
- 1.2 kWh
- 85 Ah

Life

- >600 cycles to 80% DOD

Operating Temperatures

- <45°C to achieve maximum life
- <55°C to obtain 80% of performance
- <65°C to avoid damage
- Temperature variation in module strings: <8°C

Charging

- Voltage Lid: 14 to 16 V, with temperature compensation
- Normal Charge from 20% to 98% SOC: <6 hours
- Fast Charge from 0% to 80% SOC: 35 minutes

Environmental Safety

- 100 percent recyclable

Les batteries GM Ovonic pour véhicules électriques

Performance du module

Énergie spécifique : 70 Wh/kg

Densité énergétique : 165 Wh/litre

Puissance spécifique :
220 W/kg à une profondeur de décharge de 50 %
200 W/kg à une profondeur de décharge de 80 %

Caractéristiques du module

Caractéristiques physiques

- 18,2 kg
- Volume : 102 mm x 176 mm x 409 mm (7,3 litres)

Caractéristiques électriques

- 13,2 V, charge nominale (16,0 V, maximum, charge, 11,0 V, minimum, décharge)
- 1,2 kWh
- 85 Ah

Longévité

- >600 cycles à profondeur de décharge de 80 %

Températures d'exploitation

- <45° C pour une longévité utile optimale
- <55° C pour obtenir une performance de 80 %
- <65° C pour éviter tout dommage
- Variation de température dans les batteries : <8° C

Charge

- Tension maximale : de 14 à 16 V, avec compensation de température
- Charge normale de 20 à 98 % État de charge : <6 heures
- Charge rapide de 0 à 80 % État de charge : 35 minutes

Protection de l'environnement

- Batterie recyclable à 100 %

Batterien für Elektrofahrzeuge von GM Ovonic

Batterieleistung

Spezifische Energie: 70 Wh/kg

Energiedichte: 165 Wh/liter

Spezifische Leistung:
220 W/kg bei 50 % DOD (Entladungstiefe)
200 W/kg bei 80 % DOD (Entladungstiefe)

Technische Daten der Batteries

Mechanisch

- 18,2 kg
- 102 mm x 176 mm x 409 mm Raumvolumen (7,3 Liter)

Elektrisch

- 13,2 V Nennspannung (16,0 V max. Aufladung, 11,0 V Mindestentladung)
- 1,2 kWh
- 85 Ah

Lebensdauer

- >600 Zyklen bis 80 % DOD (Entladungstiefe)

Betriebstemperaturen

- <45 °C zur Erzielung der maximalen Lebensdauer
- <55 °C zur Erzielung 80%iger Leistung
- <65 °C zur Vermeidung von Schäden
- Temperaturvariation in der Batterie: <8 °C

Ladung

- Höchstspannung: 14 bis 16 V, mit Temperaturausgleich
- Normale Ladung von 20 % bis 98 % SOC (Ladungszustand): <6 Stunden
- Schnelladung von 0 % auf 80 % SOC (Ladungszustand): 35 Minuten

Umweltschutz

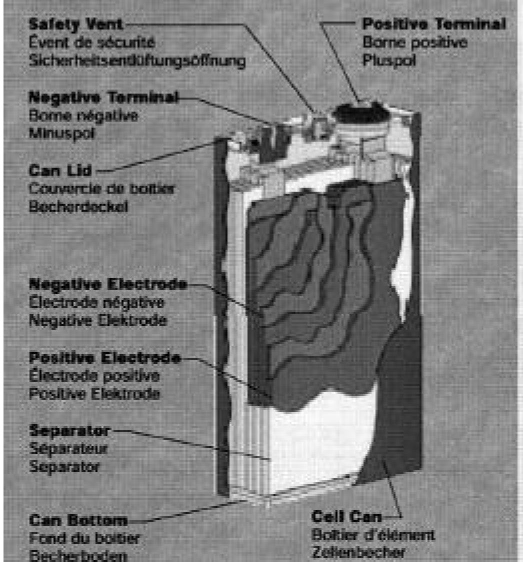
- 100 % wiederverwertbar

NiMH

Individual battery cell cut-away

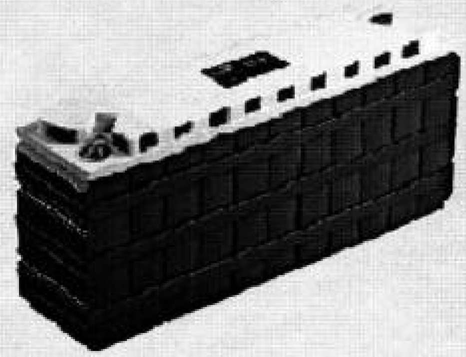
Vue éclatée d'un élément individuel de batterie

Schnittdarstellung einer einzelnen Batteriezelle

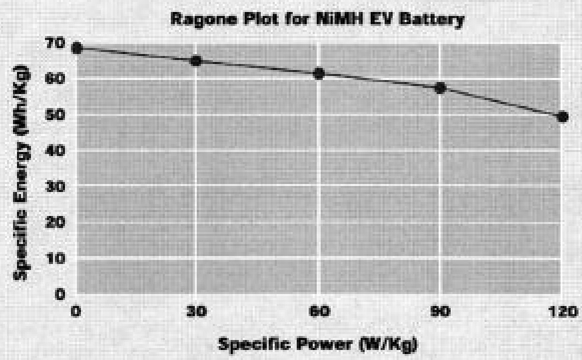


Generation 1

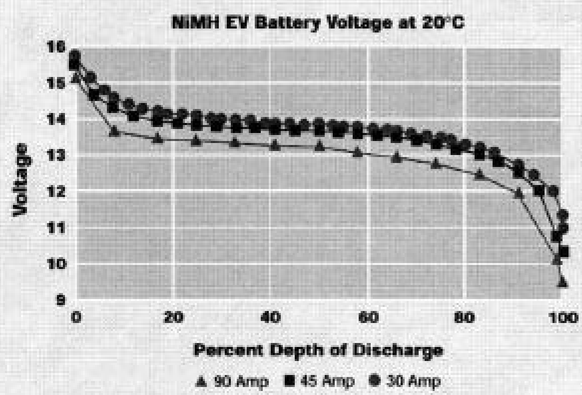
Génération 1 / Generation 1



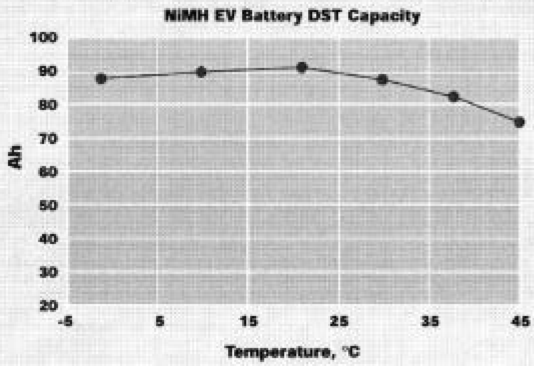
Ragone Plot



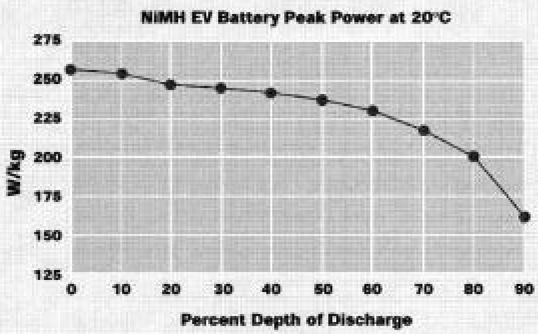
Discharging Characteristics



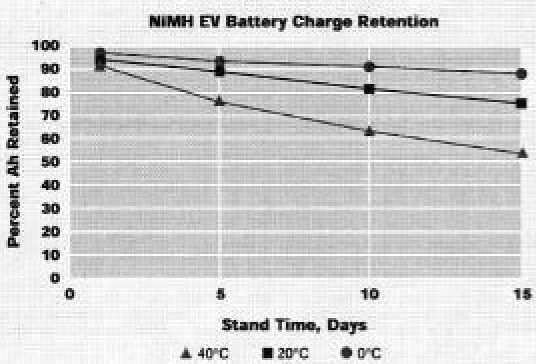
Dynamic Stress Test Capacity



Specific Power vs. Depth of Discharge



Charge Retention



Generation 2
Génération 2 / Generation 2

A 10-cell battery due in 1999.

Batterie à 10 éléments prévue pour 1999

Eine Batterie mit 10 Zellen, die 1999 auf den Markt kommt

NiMH

The NiMH Choice.

Mission Statement

The mission of GM Ovonic is to manufacture and offer the best state-of-the-art nickel metal-hydride (NiMH) batteries to:

- Enable automotive manufacturers to offer electric vehicles with performance that satisfies customer demands in the marketplace
- Ensure our leadership in the continued development of NiMH technology

Milestones

Beginning in the late1980's, the first Ovonic NiMH batteries were commercialized under license from Ovonic Battery Company and introduced into the marketplace for portable electronics applications.

In 1993, Ovonic Battery Company delivered its first electric vehicle (EV) battery packs for test and evaluation by vehicle manufacturers.

In 1994, General Motors Corporation and Ovonic Battery Company formed a manufacturing joint venture, GM Ovonic, to commercialize NiMH batteries for electric vehicles.

In 1996, GM Ovonic began production of its first generation of NiMH EV batteries using prototype manufacturing equipment and began developing high-volume processes for battery production.

GM Ovonic also manufactures NiMH batteries to customer specifications for non-automotive applications.

GM Ovonic plans to introduce a second generation of NiMH EV batteries with up to 30 percent more performance accompanied by increased production capability and reduced battery cost.

Énoncé de mission

La mission de la société GM Ovonic est de fabriquer et de fournir les meilleures batteries à hydrure métallique de nickel (NiMH) à la fine pointe du progrès afin d'atteindre les objectifs suivants :

- permettre aux constructeurs automobiles d'offrir des véhicules électriques d'une performance répondant aux exigences du marché;
- assurer notre position de tête dans le développement continu de la technologie NiMH.

Dates importantes

Vers la fin des années 80, les premières batteries NiMH Ovonic furent commercialisées sous licence de la société Ovonic (Ovonic Battery Company) et introduites sur le marché pour les besoins d'applications électroniques portatives.

En 1993, la société Ovonic produisit ses premières batteries pour véhicules électriques (V.É.) destinées à être testées et évaluées par les constructeurs de véhicules.

En 1994, la General Motors Corporation et la société Ovonic formèrent une société d'exploitation conjointe, GM Ovonic, afin de commercialiser les batteries NiMH pour les véhicules électriques.

En 1996, GM Ovonic commença la production de sa première génération de batteries NiMH pour V.É. à l'aide d'équipement de fabrication prototype et entama le développement de procédures de fabrication de batteries en grandes quantités.

GM Ovonic fabrique également des batteries NiMH sur spécifications de nos clients pour des applications non automobiles.

GM Ovonic prévoit présenter sa deuxième génération de batteries NiMH pour V.É. qui se caractériseront par une amélioration de performance atteignant 30 %, accompagnée d'une augmentation de nos capacités de production et d'une réduction du coût des batteries.

Zielsetzung

Das Ziel von GM Ovonic besteht darin, die besten Nickel-Metallhydrid-Batterien (NiMH-Batterien) nach dem neuesten Stand der Technik herzustellen, damit:

- Automobilhersteller Elektrofahrzeuge mit einer Leistung anbieten können, die den Kundenanforderungen entspricht;
- unsere Führungsrolle in der weiteren Entwicklung der NiMH-Technologie gewährleistet ist.

Wichtige Daten

In den späten 80er Jahren wurden die ersten NiMH-Batterien von Ovonic in Lizenzvergabe von Ovonic Battery Company auf dem Markt für tragbare Elektronikgeräte angeboten.

1993 lieferte Ovonic Battery Company seine erste Batterie für Elektrofahrzeuge (EV) für Test- und Bewertungszwecke.

1994 bildeten General Motors Corporation und Ovonic Battery Company das Herstellungs-Gemeinschaftsunternehmen GM Ovonic mit dem Ziel der Kommerzialisierung von NiMH-Batterien für Elektrofahrzeuge.

1996 begann GM Ovonic mit der Produktion der ersten Generation von NiMH-EV-Batterien unter Verwendung von Prototypen-Herstellungsgeräten sowie mit der Entwicklung von Großproduktionsgeräten.

GM Ovonic stellt außerdem NiMH-Batterien nach Kundenspezifikationen für Einsatzgebiete außerhalb des Automobilbereichs her.

GM Ovonic plant die Einführung einer zweiten Generation von NiMH-EV-Batterien mit einer bis zu 30 % besseren Leistung bei höherer Produktionsfähigkeit und niedrigeren Batteriekosten.

GM Ovonic


HEV Batteries—
The Next Step
GM Ovonic first developed NiMH batteries for zero-emission vehicles. Now it offers a family of batteries that also address the unique needs of parallel and series HEVs and fuel-cell vehicles.
Current HEV batteries provide high power for acceleration and passing and the energy storage required for extended driving as a pure EV only. Enhancements will enable hybrid vehicles that need very high power with minimum energy storage, a compact design and low weight.
Batteries V.É.H. - l'étape suivante
La société GM Ovonic développa initialement des batteries NiMH pour des véhicules sans émission. Nous offrons aujourd'hui toute une gamme de batteries qui répondent également aux exigences spécifiques des véhicules électriques hybrides (V.É.H.) parallèles et de série ainsi que des véhicules à piles à combustible.
Les batteries V.É.H. actuelles fournissent une puissance élevée destinée aux accélérations et au dépassement ainsi que le stockage d'énergie requis pour les trajets prolongés par les véhicules purement électriques. Nos perfectionnements permettront aux véhicules hybrides requérant une puissance très élevée de bénéficier d'un stockage d'énergie minimal, d'une conception compacte et d'un poids modéré.
HEV-Batterien - der nächste Schritt
GM Ovonic entwickelte zuerst NiMH-Batterien für Fahrzeuge ohne Emissionen. Jetzt bietet das Unternehmen eine Batteriefamilie für Hybrid-Elektrofahrzeuge (HEVs) mit Parallel- und Reihenbatterien und Brennstoffelementfahrzeuge an, die ganz eigene Anforderungen haben.
HEV-Batterien bieten eine hohe Leistung zum Beschleunigen und Überholen sowie den Energiespeicher, der für längere Fahrten als ausschließliches Elektrofahrzeug erforderlich ist. Dank der geplanten Verbesserungen werden hybride Fahrzeuge, die eine sehr hohe Leistung mit minimaler Energiespeicherung benötigen, eine kompakte Größe und ein geringes Gewicht aufweisen.
GM Ovonic
GM Ovonic L.L.C.
1334 Maplelawn
Troy, Michigan 48084 U.S.A.
Phone / Téléphone / Telefon: 248.637.7400
Fax / Télécopieur / Fax: 248.637.7474
e-mail: nimh@ovonic.com
This paper meets or exceeds EPA guidelines for recycled papers.

APPENDIX C

EQUIPMENT LIST AND NAMEPLATE DATA

VEHICLE TEST EQUIPMENT AND NAMEPLATE DATA SHEET

Project: NiMH S-10 Performance Charact.
Test: Complete test
Date(s): 01/05/99 - 02/12/99
File Name(s):
Vehicle #: 23637
Technician: Alvaro Mendoza

VEHICLE

Manufacturer: General Motors
VIN: 1GCDE14H4W8117552
Model: S-10 Electric
Model Year: 1998
Date of Manufacture: Oct-97
GVWR: 5150 lbs.
Front AWR: 2700 lbs.
Rear AWR: 2900 lbs.
Motor Manufacturer: General Motors
Type: 3-phase, AC induction, liq. cooled
Motor Rating/Speed: 85 kW
Version/Serial No.: H
EPA Label Fuel Economy: City: 45 kW*hr/100m Hwy: 41 kW*hr/100m
Controller Version/Serial No.: Delco electronics / System 110
Battery Pack Type/Version/Serial No.: NiMH / N/A
Tire Manufacturer: Uniroyal
Model: Tiger Paw
Tire Size: P205/75/R15
Maximum Pressure: 51 PSI
Maximum Tire Load: 1598 lbs.
Treadwear Rating: 480

CHARGER

Off-board
Manufacturer: Delco Electronics
Model: Magne Charge
Serial Number: EVC-0
Charger Type/Version: Inductive / WM200
EVSE Manufacturer: N/A
EVSE Model/Version: N/A
Serial Number: N/A
EVSE Software Version: N/A
Charge Port Manufacturer/Model/Version/SN: N/A

TEST EQUIPMENT

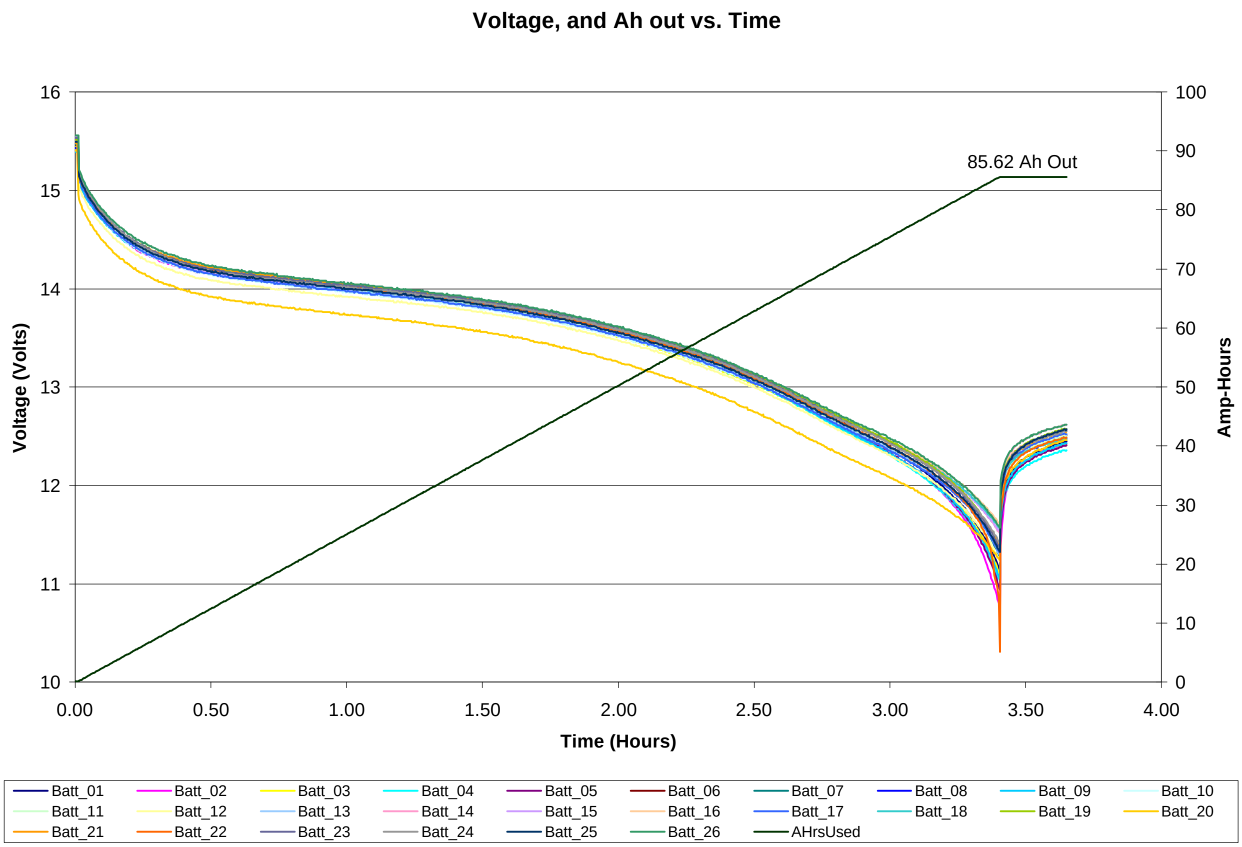
BMI Power Profiler 3030A EVTC Number: BMI-001
ABB kWh Meter Serial Number: 01 139 878
Thermometer EVTC Number: THR-008
Optical Meter Probe EVTC Number: OPB-001
Laptop Computer EVTC Number: LPC-001
Desktop Computer EVTC Number: 8YS2R
Stopwatch EVTC Number: STW-001
Digital multimeter EVTC Number: N/A
ABC-150 EVTC Number: AVI-002
Smart Guard Interface Serial Number: N/A
Smart Guard Numbers: N/A
Sound Level Meter EVTC Number: SMR-001
Measuring Wheel EVTC Number: MMW-001
Other Equipment:

WEIGHT CERTIFICATION

Scale Location and Proprietor: Mission Recycling Center, Pomona California
Examiner: Alvaro Mendoza
Date: 1/21/99
Notes:

APPENDIX D

BATTERY CAPACITY TEST GRAPHICAL DATA


Voltage, and Ah out vs. Time
Voltage (Volts)
Amp-Hours
Time (Hours)
85.62 Ah Out
16
15
14
13
12
11
10
100
90
80
70
60
50
40
30
20
10
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Batt_01
Batt_02
Batt_03
Batt_04
Batt_05
Batt_06
Batt_07
Batt_08
Batt_09
Batt_10
Batt_11
Batt_12
Batt_13
Batt_14
Batt_15
Batt_16
Batt_17
Batt_18
Batt_19
Batt_20
Batt_21
Batt_22
Batt_23
Batt_24
Batt_25
Batt_26
AHrsUsed

APPENDIX E

RANGE TEST DATA SHEETS

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/05/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	UR1	30-55	1139878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:10	1936	100	0	N/A	68 F	N/A	T>10 min
Stop	12:05	2011	5	57.67	N/A	77 F	N/A	N/A
Net	2:55	74.8	95%	57.67				

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
8	13		
11.2	12		
18.5	11		
25.5	10		
29.8	9		
34	8		
42.5	7		
47.3	6		
50.8	5		
55	4		
62	3		
68.2	2		
72.7	1		Mile 72.7; Battery life light on (10% SOC)
74.8	0		Mile 74.8; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/05/1999	12:56	5134	0	N/A	N/A	76.7 F
Stop	01/12/1999	9:50	5190	56.06	N/A	N/A	60 F
Net		20:54	56.06	56.06			

Comments: ALDL software was used to collect data during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/12/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	UR1	30-55	1139878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:00	2012	100	0	0	60 F	N/A	T>10 min
Stop	12:40	2080	5	67.93	23.70	69 F	N/A	N/A
Net	2:40	68.1	95%	67.93	23.70			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
8.7	13		
12.3	12		
18.5	11		
23.3	10		
28	9		
31.3	8		
36	7		
42.2	6		
46.5	5		
49.5	4		
53.2	3		
59	2		
64	1		Mile 64.2; Battery life light on (10% SOC)
	E		Mile 68.1; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
Comments:
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/12/1999	12:55	5395	0	0	0	66.7 F
Stop	01/13/1999	8:35	5453	53.73	32.11	79.68	53.3 F
Net		19:40	58	53.73	32.11	79.68	

Comments: ALDL software was used to collect data during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
2/10/99	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	UR1	01 223 629			

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:35	3302	100	0	0	48.8 F		T>10 min
Stop	12:10	3370	5	70.09	23.94	56.5 F		
Net	2:35	68.3	95	70.09	23.94			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
		SOC %	SOC is measured with the ALDL program
0	F	100	
10.8	13	83	
14.7	12	77	
20.5	11	71	
26.2	10	65	
29.4	9	58	
32.3	8	53	
38.3	7	46	
42.5	6	40	
47.3	5	34	
50	4	28	
53.5	3	22	
59.5	2	16	
64.7	1	10	Mile 64.7; Battery life light on (10% SOC)
67	E	7	Mile 67; State of charge gauge points at E (7% SOC)
68.3	E	5	Mile 68.3; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	2/10/99	12:20	7416	671.2	0	0	57 F
Stop	2/12/99	8:26	7472	726.2	33.46	84.90	N/A
Net			56	55	33.46	84.90	

Comments: ALDL software was used to collect data during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/15/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	UR2	30-55	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:25	2249	100	0	0	61.5 F	60.5 F	T>10 min
Stop	11:20	2313	5	70.16	23.92	71 F	47 F	48 F
Net	2:55	63.8	95%	70.16	23.92			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		A/C temperature 10 minutes into drive = 48 F
9.6	13		
12.8	12		
19	11		
24	10		
27.5	9		
30.2	8		
35.2	7		
41.3	6		
45.8	5		
47.5	4		
50.7	3		
56	2		
60.6	1		Mile 60.6; Battery life light on (10% SOC)
	E		Mile 63.8; End of testing

Accessories: Radio, lights, A/C set on high

Drive / Regen: Regular Drive

Comments:

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/15/1999	11:35	5568	112.27	0	0	71 F
Stop	01/16/1999	9:00	5637	171	30.38	77.14	62.5 F
Net		21:25	59	58.73	30.38	77.14	

Comments: ALDL software was used to collect data during drive and charge

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/18/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	UR2	30-55	01 039 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:10	2313	100	0	0	64.5 F	65 F	T>10 min
Stop	11:50	2375	5	69.04	22.64	65 F	47.5 F	62 F
Net	2:40	62.2	95%	69.04	22.64			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
9.5	13		
12.5	12		
17.8	11		
24.2	10		
26.4	9		
29.8	8		
34	7		
39.5	6		
43.2	5		
47.2	4		
49.5	3		
52.3	2		
57.5	1		Mile 57.5; Battery life light on (10% SOC)
62.2	E		Mile 62.2; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high
Drive / Regen: Regular Drive
Comments:
Ride, Braking: Stable ride; good braking
Handling" Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/18/1999	11:55	5637	178.44	0	0	65 F
Stop	01/19/1999	9:15	5692	234.3	32.13	78.05	54 F
Net		21:20	55	55.86	32.13	78.05	

Comments: ALDL software was used to collect data during drive and charge

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/21/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	UR3	30-55	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	11:10	2542	100	N/A	N/A	62 F	N/A	T>10 min
Stop	13:55	2610	5	N/A	N/A	64 F	N/A	N/A
Net	2:45	68	95%					

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
10.5	13		
14.5	12		
20.8	11		
25.8	10		
29.5	9		
33.5	8		
39	7		
45.2	6		
49	5		
51	4		
355	3		
61.5	2		
65.4	1		Mile 65.4; Battery life light on (10% SOC)
68	E		Mile 68; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/21/1999	13:55	5810	50.89	0	0	66 F
Stop	01/22/1999	9:00	5865	114	33.67	82.73	67 F
Net		19:05	55	63.11	33.67	82.73	

Comments: ALDL software was used to collect data during charge only

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/25/1999	A. Mendoza	Wet						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	UR3	30-55	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:20	2689	100	N/A	N/A	46 F	N/A	T>10 min
Stop	11:50	2750	5	N/A	N/A	52 F	N/A	N/A
Net	2:30	61	95%					

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
9.5	13		
12.5	12		
17	11		
23.5	10		
27.5	9		
30	8		
33.3	7		
39.8	6		
43.5	5		
47	4		
49.8	3		
52.5	2		
56.4	1		Mile 56.4; Battery life light on (10% SOC)
61	E		Mile 61; End of testing (5% SOC)

Accessories: Radio,wipers
Drive / Regen: Regular Drive
Comments:
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/25/1999	11:50	5929	173.13	N/A	N/A	52 F
Stop	01/26/1999	10:00	5981	223.7	N/A	N/A	64.4 F
Net		22:10	52	50.57			

Comments: Rainy day, wipers were used for about 1.5 hr.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
2/03/99	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	UR3	30-55	01 223 624		

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:35	3090	100	0	0	73 F		T>10 min
Stop	13:20	3150	5	69.79	24.45	78 F		
Net	2:45	60	95	69.79	24.45			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
9.8	13		
13.5	12		
17.5	11		
20.8	10		
25.5	9		
29.5	8		
33	7		
37.5	6		
42.5	5		
46.2	4		
49	3		
51.8	2		
56.2	1		Mile 56.2; Battery life light on (10% SOC)
60	E		Mile 60; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	2/03/99	16:15	7244	491.75	0	0	73.2 F
Stop	2/04/99	9:20	7295	543.2	30.28	73.3	64.5 F
Net		17:05	51	51.45	30.28	73.3	

Comments: New ABB meter with 1-minute interval installed.
ALDL software was used to collect data during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/26/1999	A. Mendoza	Wet, slippery						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	UR4	30-55	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:20	2750	100	N/A	N/A	44 F	64 F	T>10 min
Stop	12:50	2811	5	N/A	N/A	52 F	54.5 F	59 F
Net	2:30	60.8	95%					

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
9.2	13		
13	12		
17.3	11		
22.3	10		
26	9		
29.5	8		
32	7		
35.8	6		
40.5	5		
45	4		
48.7	3		
53.5	2		
57.6	1		Mile 57.6; Battery life light on (10% SOC)
60.8	E		Mile 60.8; End of testing (5% SOC)

Accessories: Radio, wipers, lights, A/C set on high

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/26/1999	13:05	5981	223.42	N/A	N/A	57 F
Stop	01/27/1999	8:20	6028	274.4	N/A	N/A	58 F
Net		19:15	47	50.98			

Comments: Rainy day, the road was very slippery and the wipers were used all the time.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/28/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	UR4	30-55	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:45	2884	100	N/A	N/A	52 F	50 F	T>10 min
Stop	11:05	2944	5	N/A	N/A	53 F	47 F	58 F
Net	2:20	59.9	95%					

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
9.5	13		
11.8	12		
15.8	11		
21.5	10		
26	9		
28.5	8		
31	7		
35.2	6		
40.5	5		
45.8	4		
48.5	3		
50.2	2		
54.2	1		Mile 54.2; Battery life light on (10% SOC)
59.9	E		Mile 59.9; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/28/1999	11:15	6080	321.5	0	0	55 F
Stop	01/29/1999	8:40	6132	373.2	31.91	76.60	60.5 F
Net		21:25	52	51.7	31.91	76.60	

Comments: ALDL software was used to collect data during charge only.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/13/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	FW1	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:40	2080	100	0	0	54 F	N/A	T>10 min
Stop	10:40	2164	5	69.54	24.01	64 F	N/A	N/A
Net	2:00	84.2	95%	69.54	24.01			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
12.3	13		
20.8	12		
26.8	11		
33	10		
37.5	9		
41.2	8		
45.7	7		
52	6		
59	5		
66.3	4		
70	3		
74.5	2		
79.7	1		Mile 79.7; Battery life light on (10% SOC)
84.3	E		Mile 84.3; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/13/1999	10:45	5453	0	0	0	63.8 F
Stop	01/14/1999	10:18	5510	53.73	31.04	79.19	68 F
Net		23:33	57	53.73	31.04	79.19	

Comments: ALDL software was used to collect data during drive and charge
Vehicle was driven for 2 complete loops on the Freeway Pomona Loop.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/14/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	FW1	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:20	2164	100	0	0	72 F	N/A	T>10 min
Stop	12:10	2249	5	69.35	23.85	80 F	N/A	N/A
Net	1:50	84.2	95%	69.35	23.85			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
13.3	13		
20.5	12		
26.7	11		
32.3	10		
36.5	9		
40.5	8		
48.5	7		
56.3	6		
62	5		
56.3	4		
71	3		
75	2		
79.9	1		Mile 79.9; Battery life light on (10% SOC)
84.2	E		Mile 84.2; End of testing (5% SOC)

Accessories: Radio

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/14/1999	12:15	5510	53.73	0	0	74.5 F
Stop	01/15/1999	8:20	5568	112.7	31.05	74.62	60.5 F
Net		20:05	58	58.97	31.05	74.62	

Comments: ALDL software was used to collect data during drive and charge

Vehicle was driven for 2 complete loops on the Freeway Pomona Loop.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/19/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	FW2	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:20	2375	100	0	0	54 F	66 F	T>10 min
Stop	10:45	2454	5	70.45	24.22	55 F	63.5 F	61 F
Net	1:25	78.8	95%	70.45	24.22			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
12	13		
18.5	12		
24.5	11		
29.5	10		
34.3	9		
38.3	8		
42.2	7		
48.5	6		
56.5	5		
60.3	4		
68.5	3		
71.3	2		
76	1		Mile 76; Battery life light on (10% SOC)
78.8	E		Mile 78.8; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/19/1999	10:55	5692	233.96	0	0	65 F
Stop	01/20/1999	9:00	5748	289.7	32.98	79.20	58 F
Net		22:05	56	55.74	32.98	79.20	

Comments: ALDL software was used to collect data during drive and charge

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/20/1999	A. Mendoza	Wet						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	180	FW2	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:00	2454	100	0	0	58 F	59 F	T>10 min
Stop	10:55	2535	5	70.36	24.15	60 F	49 F	51.5 F
Net	1:55	80.9	95%	70.36	24.15			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
14	13		
20.8	12		
27	11		
32.5	10		
36.3	9		
41.8	8		
47.5	7		
55.5	6		
61.5	5		
65.5	4		
70.3	3		
74	2		
78.3	1		Mile 78.3; Battery life light on (10% SOC)
80.9	E		Mile 80.9; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high,wipers.
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/20/1999	10:55	5748	0	N/A	N/A	64 F
Stop	01/21/1999	8:45	5805	50.85	N/A	N/A	65 F
Net		21:50	57	50.85			

Comments: Rainy day; wipers were used during most of the drive. ALDL software was used to collect data during drive only.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/22/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW3	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:50	2610	100	0	0	68 F	N/A	T>10 min
Stop	12:30	2689	5	70.02	24.01	70 F	N/A	N/A
Net	1:40	78.8	95%	70.02	24.01			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
13.2	13		
20.5	12		
26.8	11		
31.5	10		
35.8	9		
40.3	8		
44.5	7		
53.5	6		
58.5	5		
64	4		
68.8	3		
73	2		
75.6	1		Mile 75.6; Battery life light on (10% SOC)
78.8	E		Mile 78.8; End of testing (5% SOC)

Accessories: Radio
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/22/1999	12:35	5865	113.62	N/A	N/A	69.5 F
Stop	01/25/1999	9:20	5929	167	N/A	N/A	46 F
Net			64*	53.38			

Comments: ALDL software was used to collect data during drive and charge.
* This value is high compared to the BMI's values obtained because it was recorded during a weekend.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/27/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW3	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:25	2811	100	N/A	N/A	52 F	N/A	T>10 min
Stop	10:05	2884	5	N/A	N/A	54 F	N/A	N/A
Net	1:40	72.6	95%					

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
8.3	13		
15.5	12		
21	11		
26.5	10		
31.5	9		
35.5	8		
40.2	7		
44	6		
50	5		
55	4		
59	3		
64.5	2		
69.8	1		Mile 69.8; Battery life light on (10% SOC)
72.6	E		Mile 72.6; End of testing (5% SOC)

Accessories: Radio

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/27/1999	10:10	6028	274.02	0	0	54 F
Stop	01/28/1999	8:40	6080	321.8	27.25	68.75	56 F
Net		22:30	52	47.78	27.25	68.75	

Comments: ALDL software was used to collect dc data during charge only.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
2/04/99	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW3	65	01 223 624		

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:35	3150	100	0	0	58 F		T>10 min
Stop	11:20	3226	5	70.31	24.17	53.5 F		
Net	1:45	75.2	95	70.31	24.17			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
10.5	13		
17	12		
24	11		
29	10		
34	9		
37.5	8		
42	7		
48.5	6		
54.8	5		
59.5	4		Mile 64.5; Exit freeway at Garey Ave. (23% SOC)
65	3		
69	2		
72.2	1		Mile 72.2; Battery life light (10% SOC)
75.2	E		Mile 75.2; End of testing (5% SOC)

Accessories: Radio

Drive / Regen: Regular Drive

Comments:

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	2/04/99	11:30	7295	542.74	0	0	63.1 F
Stop	2/05/99	9:45	7348	594	32.75	78.6	57.5 F
Net		22:15	53	51.26	32.75	78.6	

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
01/29/1999	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW4	65	01 139 878	N/A	N/A

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:50	2944	100	0	0	55 F	58 F	T>10 min
Stop	10:35	3014	5	70.26	23.76	63 F	48 F	51.5 F
Net	1:45	70.3	95%	70.26	23.76			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
11.2	13		
18.2	12		
24	11		
29.3	10		
33.5	9		Mile 34.2; Heavy traffic, speed was about 5 -15 mph.
36	8		Mile 36; Traffic back to normal
39.8	7		
43.5	6		
50.3	5		
55.7	4		
61.5	3		
64.8	2		Mile 64; Exit freeway at Reservior Ave.
67.7	1		Mile 67.7; Battery life light on (10% SOC)
70.5	E		Mile 70.5; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high

Drive / Regen: Regular Drive

~~Comments:~~

Ride, Braking: Stable ride; good braking

Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	01/29/1999	10:40	6132	372.95	0	0	64.4 F
Stop	02/01/1999	8:50	6195	425.5	30.72	73.68	62 F
Net			63	52.55	30.72	73.68	

Comments: ALDL software was used to collect during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
2/01/99	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW4	65	01 139 878		

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:55	3014	100	0	0	48 F	58 F	T>10 min
Stop	10:35	3090	5	70.53	24.10	54 F	60 F	55.5 F
Net	1:40	75.8	95	70.53	24.10			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
11.5	13		
19.5	12		
25.5	11		
30	10		
34.2	9		
38.2	8		
43	7		
49	6		
56	5		
58.8	4		
63.5	3		Mile 64.5; Exit fwy. at Garey Ave. (23% SOC)
69	2		
72.2	1		Mile 72.2; Battery life light (10% SOC)
75.8	E		Mile 75.8; End of testing on (5% SOC)

Accessories: Radio, lights, A/C set on high
Drive / Regen: Regular Drive
Comments:
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	2/01/99	10:40	6195	431.22	0	0	68.8 F
Stop	2/02/99	8:15	6249	491.1	31.66	77.88	62.7 F
Net		21:35	54	59.88	31.66	77.88	

Comments: ALDL software was used to collect data during drive and charge.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
2/05/99	A. Mendoza	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
23637	117552	51 psi	920	FW4	30-55	01 223 624		

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:50	3226	100	0	0	53.8	68.5 F	T>10 min
Stop	11:25	3299	5	70.73	24.26	54.5	66 F	63.8 F
Net	1:35	73	95	70.73	24.26			

Distance	State of Charge		Notes / Deviations
Miles	Veh meter	SCE meter	
0	F		
10	13		
16.7	12		
22	11		
27.5	10		
32	9		
36.5	8		
40.2	7		
46.5	6		
52	5		
57	4		
63	3		Mile 64.5; Exit freeway @ Garey Ave. (21% SOC)
67.3	2		
70.1	1		Mile 70.1; Battery life light (10% SOC)
73	E		Mile 73; End of testing (5% SOC)

Accessories: Radio, lights, A/C set on high
Drive / Regen: Regular Drive
~~Comments:~~
Ride, Braking: Stable ride; good braking
Handling: Good

Charger	Serial No.						
EVC-010	1378520						
Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Temp
Start	2/05/99	11:55	7348	594	N/A	N/A	57 F
Stop	2/09/99	10:00	7416	651.9	N/A	N/A	58 F
Net			68	57.9			

Comments: ALDL software was used to collect data during drive and charge.

APPENDIX F

ACCELERATION, BRAKING, AND MAXIMUM SPEED TEST DATA

ACCELERATION, MAXIMUM SPEED, AND BRAKING TESTS

Vehicle No.: 23637
Location: Pomona Dragstrip
Date: 04/02/99

	Start	Stop
Time	8:55 AM	11:36 AM
Temp.	54.5 F	73.0 F
Odometer	3551	3600

Acceleration (100% SOC)

	0-30 mph	0-60 mph	Direction	Max. Speed	30-55 mph
1	4.98	15.01	South	72	6.84
2	5.03	14.46	North	73	7.66
3	5.09	13.39	South	74	7.04
4	5.15	14.95	North	73	8.27
Average	5.06	14.45		73.00	7.45

Acceleration (80% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1	4.8	13.93	South	7.3
2	5.17	15.44	North	8.24
3	4.9	13.89	South	7.21
4	5.1	15.65	North	8.5
Average	4.99	14.73		7.81

Acceleration (60% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1	5.08	14.18	South	7.45
2	5.42	16.05	North	8.66
3	5.18	14.24	South	7.41
4	5.42	16.13	North	8.72
Average	5.28	15.15		8.06

Braking 25-0 mph, 60% SOC

	Feet	Inches	Total	Direction
1	38	7	38.6	South
2	18	2	18.2	North
3	28	1	28.1	South
4	26	1	26.1	North
5	24	7	24.6	South
6	21	5	21.4	North
7	27	0	27.0	South
8	28	11	28.9	North
9	29	1	29.1	South
#	26	1	26.1	North
		26.8	Average ft.	

Acceleration (40% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1		7.45	South	7.66
2		8.66	North	8.69
3		7.45	South	7.43
4		8.66	North	8.89
Average		8.06		8.17

Acceleration (20% SOC)

	0-30 mph	0-60 mph	Direction	Max. Speed	30-55 mph
1	5.17	14.69	South	73	7.89
2	5.39	17.02	North	72	9.47
3	5.21	14.93	South	74	8.3
4	5.53	17.83	North	71	9.97
Average	5.33	16.12		72.50	8.91

Comments: At the completion of the test, the state of charge indicated E (empty).

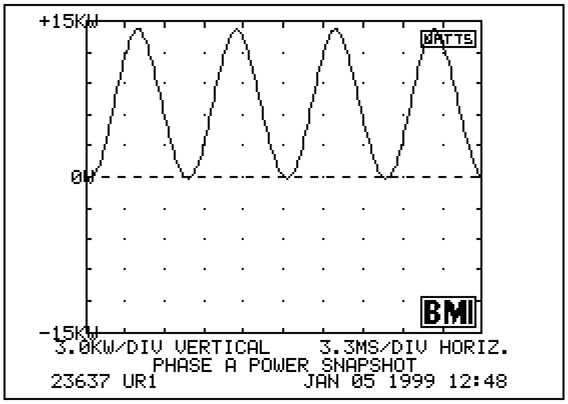
APPENDIX G

CHARGER PROFILE TEST GRAPHICAL DATA

Snapshots at Full Power

PHASE A POWER SNAPSHOT 12:48:50 PM

INSTANTANEOUS POWER: 6.988 kW



PHASE A POWER SPECTRUM 12:49:23 PM

Power: 6.988 kW

Fundamental freq: 60.0 Hz

HARM	POWER	HARM	POWER
FUND	+6.988 kW	2nd	
3rd	-0.10 W	4th	
5th	+0.17 W	6th	
7th		8th	
9th		10th	
11th	-0.01 W	12th	
13th		14th	
15th		16th	
17th		18th	
19th		20th	
21st		22nd	
23rd		24th	
25th		26th	
27th		28th	
29th		30th	
31st		32nd	
33rd		34th	
35th		36th	
37th		38th	
39th		40th	
41st		42nd	
43rd		44th	
45th		46th	
47th		48th	
49th		50th	
ODD	0.06 W	EVEN	0.00 W
THP:	0.07 W		

POWER FACTOR SNAPSHOT 12:48:53 PM

Phase A-N: 6.988 kW

Phase A-N: 7.038 kVA

Phase A-N: 793.8 VAR

Phase A-N: 0.99 PF

Phase A-N: 0.99 dPF

HARMONICS SNAPSHOT 12:48:55 PM

Fundamental freq: 60.0 Hz

Phase A-N Volts: 1.0% THD

Phase A Current: 3.2% THD

VOLTAGE & CURRENT SNAPSHOT 12:49:32 PM

Phase A-N: 233.3 Vrms, 0 (ref)
Neut-Gnd: 126.6 Vrms, 44

Phase A: 30.17 A rms, -6

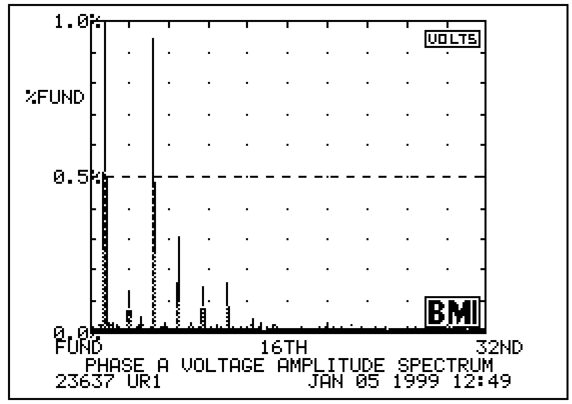
PHASE A VOLTAGE SPECTRUM 12:48:58 PM

Fundamental volts: 233.2 Vrms

Fundamental freq: 60.0 Hz

HARM	PCT	SINE PHASE	HARM	PCT	SINE PHASE
FUND	100.0%	0	2nd		
3rd	0.1%	149	4th		
5th	1.0%	39	6th		
7th	0.3%	118	8th		
9th	0.1%	117	10th		
11th	0.2%	137	12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th			30th		
31st			32nd		
33rd			34th		
35th			36th		
37th			38th		
39th			40th		
41st			42nd		
43rd			44th		
45th			46th		
47th			48th		
49th			50th		
ODD	1.0%		EVEN	0.1%	

THD: 1.0%



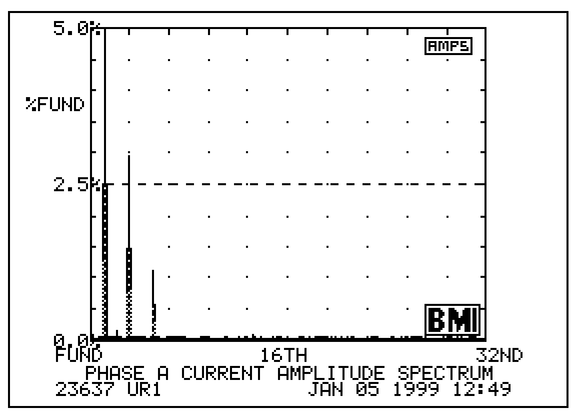
PHASE A CURRENT SPECTRUM 12:49:08 PM

Fundamental amps: 30.16 A rms

Fundamental freq: 60.0 Hz

HARM	PCT	SINE PHASE	HARM	PCT	SINE PHASE
FUND	100.0%	-6	2nd	0.1%	-87
3rd	3.0%	-100	4th		
5th	1.1%	-38	6th		
7th			8th		
9th			10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th			30th		
31st			32nd		
33rd			34th		
35th			36th		
37th			38th		
39th	0.1%	-64	40th		
41st			42nd		
43rd	0.1%	-123	44th		
45th			46th		
47th	0.1%	-179	48th		
49th			50th		
ODD	3.2%		EVEN	0.1%	

THD: 3.2%

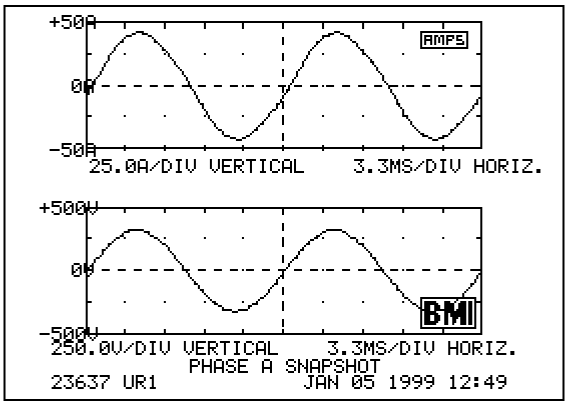


PHASE A SNAPSHOT 12:49:37 PM

Phase A-N VOLTAGE: 233.3 Vrms
1.4 Crest Factor
1.1 Form Factor

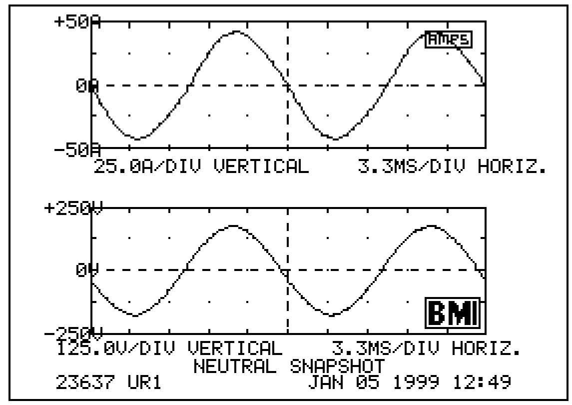
Phase A CURRENT: 30.17 A rms
1.4 Crest Factor
1.1 Form Factor

CURRENT LAGS VOLTAGE BY 6 (0.99 dPF)



NEUTRAL SNAPSHOT 12:49:46 PM

Neut-Gnd VOLTAGE: 126.6 Vrms
1.4 Crest Factor
1.1 Form Factor

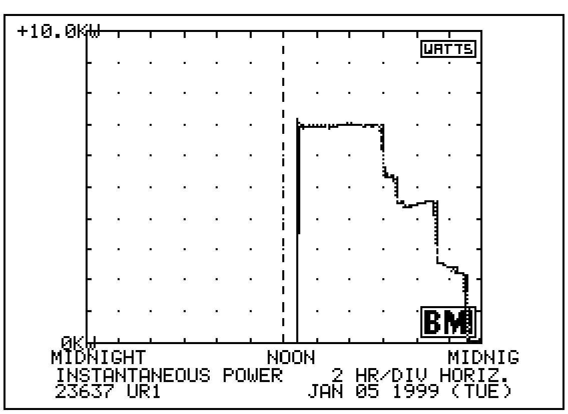


CUMULATIVE PROFILES – 24 HOURS

INSTANTANEOUS POWER MIDNIGHT

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

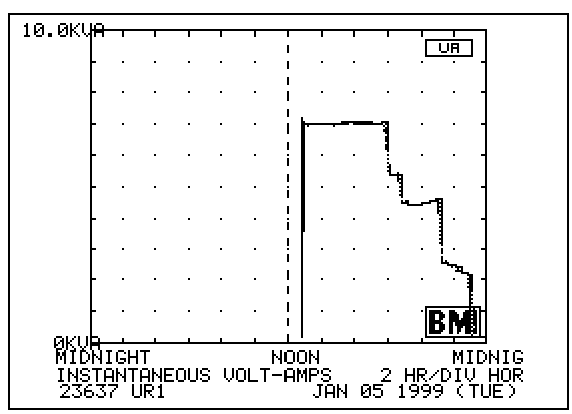
Phase A-N:
MAX: 7.2 kW, 12:48 PM
MIN: 0.0 kW, 11:05 PM



INSTANTANEOUS VOLT-AMPS 12:00:04 AM

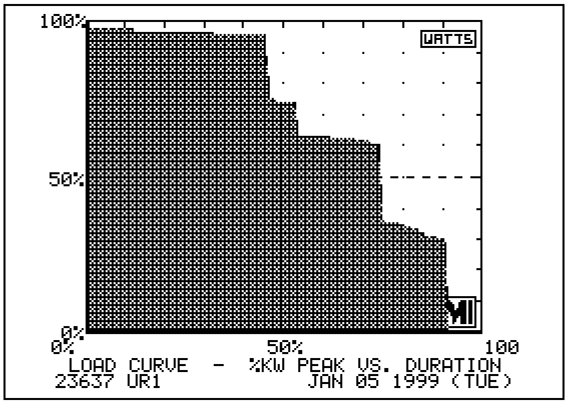
FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

Phase A-N:
MAX: 7.2 kVA, 12:48 PM
MIN: 0.1 kVA, 12:44 PM



LOAD DURATION CURVE 12:00:22 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)



TOTAL POWER CONSUMPTION 12:00:39 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

FLAT RATE: Cost: $ 0.060/kWh
Cost: $ 0.000/kWpk

BILLING DEMAND:

7.046 kW	Pk Today
7.046 kW	Pk Accumulated
$ 0.000	Today
$ 0.000	Accumulated

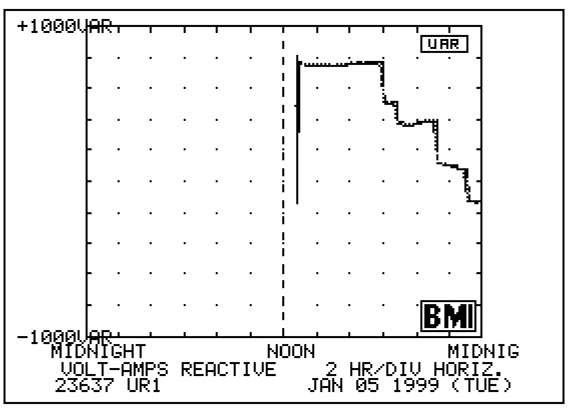
CONSUMPTION:

56.06 kWh	Today
56.06 kWh	Accumulated
$ 3.364	Today
$ 3.364	Accumulated
32.72 kQh	Today
5.407 kVARh	Today

VOLT-AMPS REACTIVE 12:00:48 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

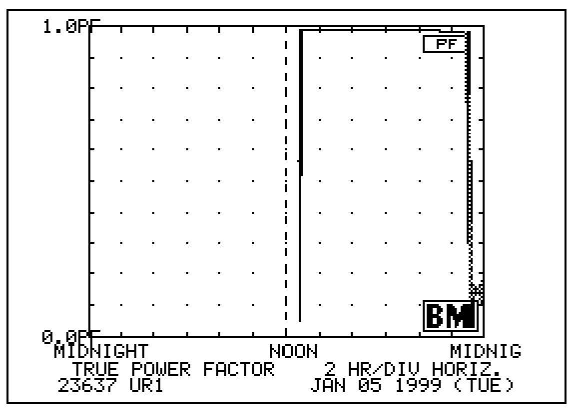
Phase A-N:
MAX: 819.9 VAR, 12:48 PM
MIN: -135.3 VAR, 11:41 PM



TRUE POWER FACTOR 12:00:59 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

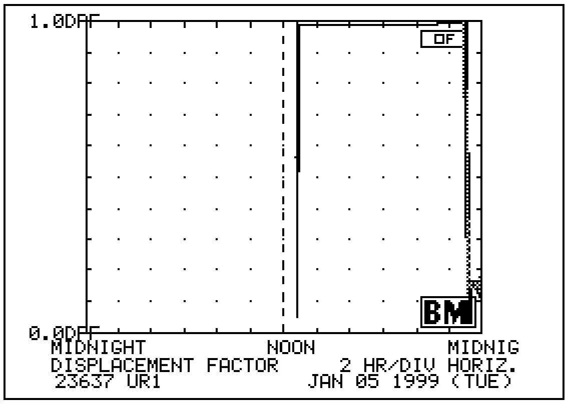
Phase A-N:
MAX: 1.00 PF, 7:27 PM
MIN: 0.03 PF, 11:05 PM



DISPLACEMENT FACTOR 12:01:06 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

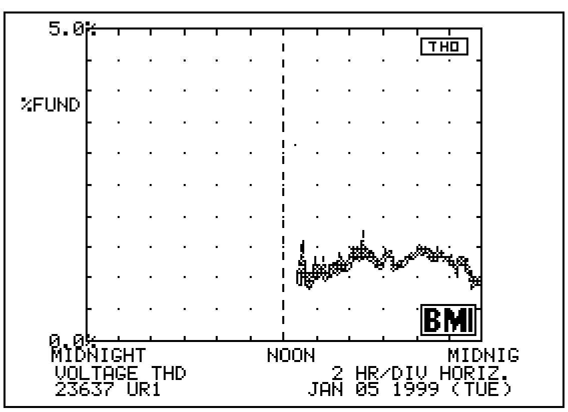
Phase A-N:
MAX: 1.00 dPF, 11:05 PM
MIN: 0.03 dPF, 11:05 PM



VOLTAGE THD 12:01:21 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

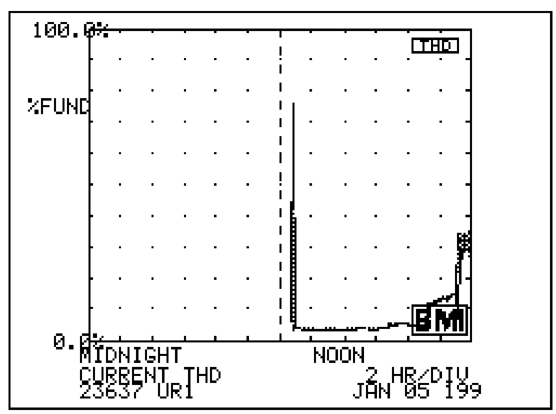
Phase A-N:
MAX: 1.8% THD, 4:45 PM
MIN: 0.8% THD, 11:22 PM



CURRENT THD 12:01:32 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

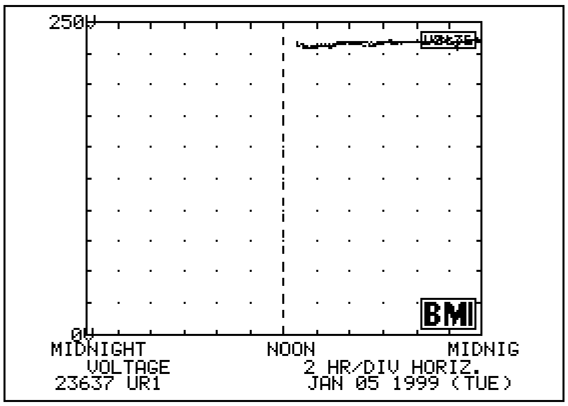
Phase A:
MAX: 75.8% THD, 12:48 PM
MIN: 3.1% THD, 3:49 PM



VOLTAGE 12:02:06 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

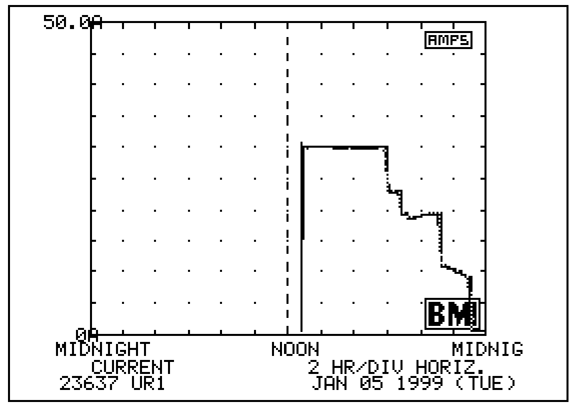
Phase A-N:
MAX: 238.9 V, 10:10 PM
MIN: 230.5 V, 10:24 PM



CURRENT 12:02:17 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

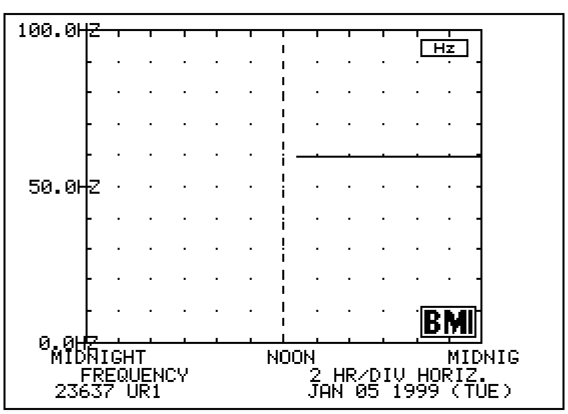
Phase A:
MAX: 31.0 A, 12:48 PM
MIN: 0.6 A, 12:44 PM



FREQUENCY 12:02:36 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

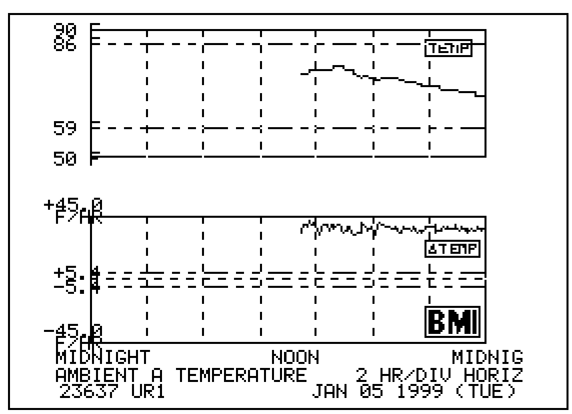
MAX: 60.1 Hz, 12:59 PM
MIN: 59.9 Hz, 5:38 PM



AMBIENT A Temperature 12:02:50 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

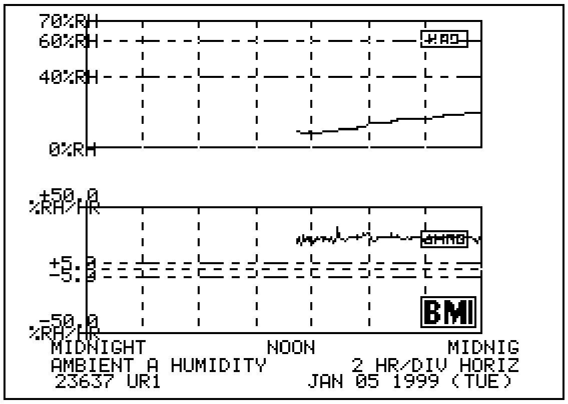
MAX: 78.9 F, 3:11 PM
MIN: 69.4 F, 11:54 PM



AMBIENT A Humidity 12:03:03 AM

FROM: MIDNIGHT Jan 04 1999 (Mon)
To: MIDNIGHT Jan 05 1999 (Tue)

MAX: 19.3 %RH, 11:28 PM
MIN: 8.0 %RH, 1:01 PM



APPENDIX H

SCE ELECTRIC VEHICLE TEST PROCEDURE

ELECTRIC VEHICLE TEST PROCEDURE

SOUTHERN CALIFORNIA
EDISON

An *EDISON INTERNATIONAL* Company

ELECTRIC TRANSPORTATION DIVISION

JUAN C. ARGUETA
NAUM PINSKY
JORDAN W. SMITH
MICHEL WEHREY

August 1999

CONTENTS

I. INTRODUCTION

Since this test procedure was originally written in 1995, the type of electric vehicle (EV) tested at the Electric Vehicle Technical Center (EV Tech Center) in Pomona, California has changed dramatically. Instead of prototypes and small-scale production models, most vehicles tested are now production vehicles from major manufacturers, and most are very refined, with acceleration and braking characteristics close to that of gasoline-powered vehicles.

At first, weight certification was mainly a safety issue, as converted vehicles sometimes exceeded their original gross vehicle weight rating (GVWR). With current production vehicles the total vehicle weight is usually well within the specified gross vehicle weight rating, and the issue is a more practical one – related to passenger and cargo capacity.

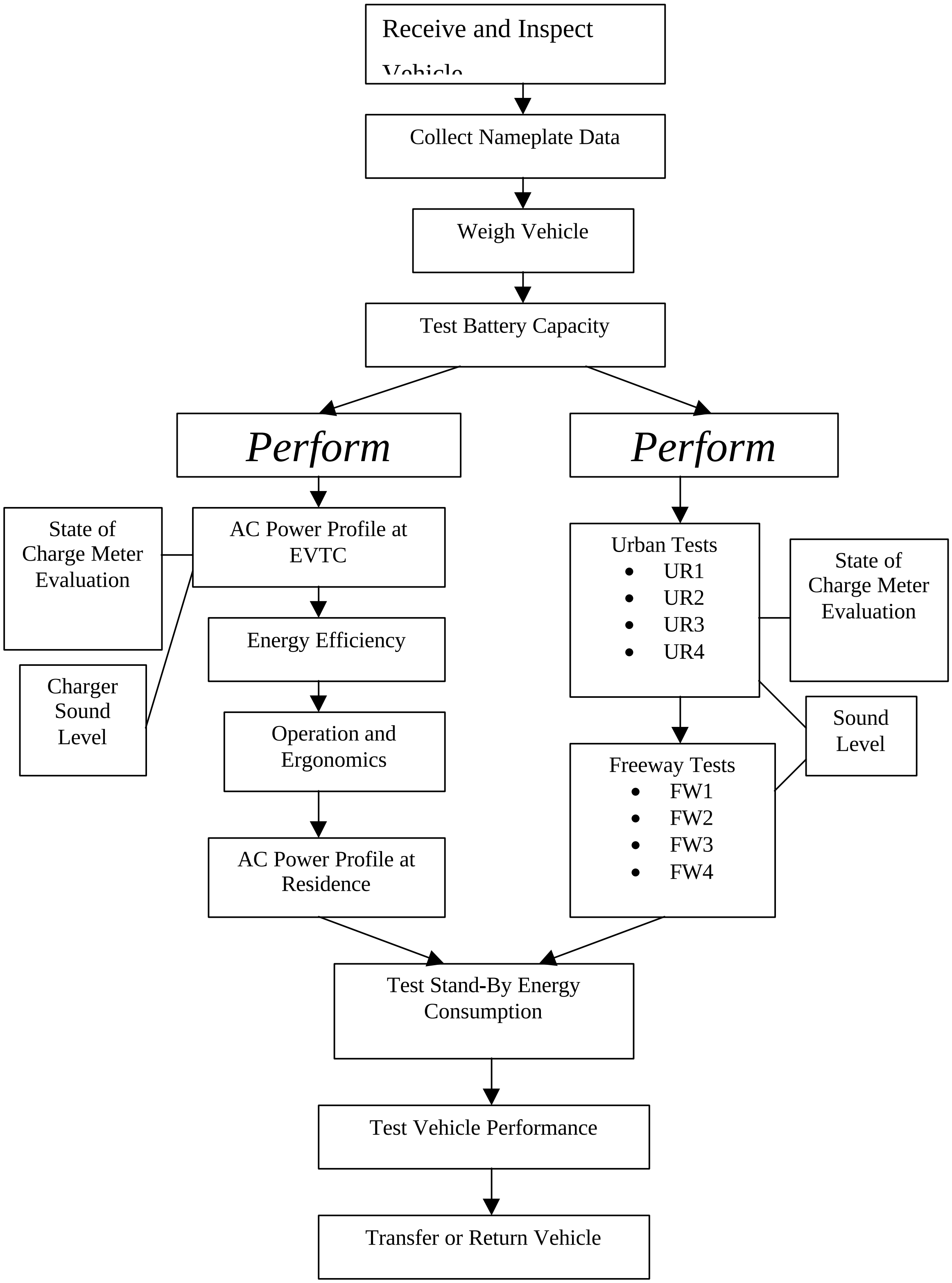
Range tests under different vehicle conditions no longer always have predictable results. Automatic climate controls limit air conditioner power on cool days, thus conserving battery energy and increasing range. The battery pack and the output side of the charger may no longer be readily accessible; some manufacturers may not allow access. Therefore, not all of the following charger and battery test procedures or efficiency measurements can be performed on all vehicles.

Since chargers are associated with each electric vehicle, the EV evaluation must include testing of the charger. As the use of EVs and their associated chargers increase, the potential for local demand and power quality problems increases. The combined impact of many chargers on the whole of the electric utility system could be detrimental. In order to plan properly, and to encourage manufacturers to build satisfactory chargers, the individual contribution of each type of charger must be determined through testing.

This publication describes testing methods and evaluation criteria used by the Electric Transportation Division of Southern California Edison to evaluate electric vehicles and chargers. These procedures are followed for each EV test unless otherwise noted in the test report. The document is divided into four main parts: Test Plan, Test Instrumentation, Test Procedure, and Appendices. The Test Plan gives an outline of tests performed and the reasons or justification for the procedures. The Test Instrumentation section is a listing of the required equipment for each procedure. The Test Procedure section gives detailed instructions on how to perform the tests. The Appendices include maps, data sheets, and diagrams.

The EV Tech Center maintains a network database (called “Project Manager”) for test reports, results, and standard forms. The intent is to allow EV Tech Center personnel access to all current and past projects and test data in the interest of sharing information. As data is gathered during a test, it is entered in the database on the standard forms mentioned in the test procedure.

SCE EV TEST PROCEDURE FLOW DIAGRAM



II. TEST PLAN

A. NAMEPLATE DATA COLLECTION

Record all applicable nameplate data, serial numbers, and ratings for all tested components. This data is important to record in order to keep track of the version of the software and hardware of the vehicle, since this technology can change rapidly.

B. WEIGHT DOCUMENTATION

At a certified scale, measure the weight of the vehicle. The curb weight is subtracted from the GVWR to determine the available payload.

C. BATTERY CAPACITY TEST

The battery capacity test should be performed before the range tests to determine the pack's health. Follow the USABC (United States Advanced Battery Consortium) procedure for constant current discharge tests. Use the ABC-150 battery tester to discharge the EV's battery pack at a constant current until a manufacturer recommended cutoff voltage is reached. At a starting battery temperature of $23^o \pm 2^o$ C, perform groups of three constant current discharge cycles at each of $C_3/3$, $C_2/2$, $C_1/1$, and $C_3/3$ Amperes. Repeat until the $C_3/3$ capacity is stable with three consecutive discharges within 2%. Construct a Peukert Curve, which shows the effect of discharge rate on capacity and can be used to determine the battery capacity at a specific rate.

D. RANGE TESTS

Repeat the tests until the range result is within 5.0% of the previous result. Report the average of the final two tests.

1. **UR1** - Urban Range Test at Minimum Payload (driver and test equipment only).
   Drive the EV on the "Urban Pomona Loop" without using auxiliary loads. Record data to determine distance per charge, AC kWh/mile, and DC kWh/mile. The "Urban Pomona Loop" is a local street route of about 20 miles with approximately 50 stop signs and traffic lights. Refer to the Appendix, p.21, for a map and elevation profile.

2. **UR2** - Urban Range Test at Minimum Payload with Auxiliary Loads.
   Repeat the above test with the vehicle's auxiliary loads on (air conditioning, lights, and radio). Record air conditioning vent temperature and cabin temperature continuously.

3. **UR3** - Urban Range Test at Maximum Payload (GVWR)
   Urban Pomona Loop range test with auxiliary loads off and with the vehicle loaded to its maximum legal weight limit.

4. **UR4** - Urban Range Test at Maximum Payload (GVWR) With Auxiliary Loads Repeat the above test with auxiliary loads on. Record air conditioning vent temperature and cabin temperature continuously.

5. **FW1** - Freeway Range Tests at Minimum Payload
   Drive the EV on the “Freeway Pomona Loop” without using auxiliary loads. Record data to determine distance per charge, AC kWh/mile, and DC kWh/mile. The Freeway Pomona Loop is a loop on four local freeways of approximately 37 miles (one transition requires one-half mile on access roads). Refer to the Appendix, p.21, for a map and elevation profile.

6. **FW2** - Freeway Range Test at Minimum Payload with Auxiliary Loads
   Repeat the above test with the vehicle’s auxiliary loads on. Record air conditioning vent temperature and cabin temperature continuously.

7. **FW3** - Freeway Range Test at Maximum Payload (GVWR)
   Pomona Freeway Loop range test with auxiliary loads off and with the vehicle loaded to its maximum legal weight limit.

8. **FW4** - Freeway Range Test at Maximum Payload (GVWR) With Auxiliary Loads
   Repeat the above test with the vehicle’s auxiliary loads on. Record air conditioning vent temperature and cabin temperature continuously.

E. SOUND LEVEL TEST

The interior cabin sound level will be measured for one urban and one freeway loop. A recorded plot from the meter and an average sound level will be reported.

F. STATE OF CHARGE METER EVALUATION

1. **Driving**
   While performing the Urban Range Tests, record data to produce a distance traveled vs. state-of-charge graph.

2. **Charging**
   While charging, record data to produce a state of charge vs. time graph. Plot with the charging profile to associate indicated state of charge with energy delivered.

G. PERFORMANCE TESTS

The acceleration tests are designed to measure peak power capability of the vehicle and battery pack on the test track. Use the accelerometer performance computer to measure the time, speed, and acceleration. The tests will be performed in the sequence and number described in the test procedure in order to minimize heating effects on the traction battery. The vehicle will be driven gently between tests to discharge.

1. Acceleration

Accelerate the EV from a stop to over 60 mph at maximum power. Repeat this procedure two times in opposite directions (to average the effects of wind and grade) at the following traction battery states-of-charge: 100%, 80%, 60%, 40%, and 20%, as measured by the EV's state of charge gage. Read the data from the computer to obtain the time for 0-30 mph and 0-60 mph.

2. Maximum Speed

Continue to accelerate the EV from the 60 mph test until the maximum speed is reached. Conduct twice in opposite directions at both 100% and 20% SOC.

3. Acceleration - 30 to 55 mph

Accelerate the EV from a steady 30 mph to 55 mph at maximum power. Perform this procedure twice in opposite directions at the following approximate traction battery states-of-charge: 100%, 80%, 60%, 40%, and 20% (after the above tests).

4. Braking

Brake the vehicle from a steady 25 mph without skidding the tires. Repeat this procedure four times in opposite directions. Use the performance computer to determine braking distance. This test will be performed between 50% and 60% SOC.

H. CHARGER PERFORMANCE/CHARGING PROFILE TEST

1. AC Input Data

Use the BMI Power Profiler to record the following on the AC (input) side of the charger for the duration of the charge at the EV Tech Center:

- Real, reactive, and apparent power
- Energy consumption
- True and displacement power factors
- Voltage and current total harmonic distortion
- Current total demand distortion
- Voltage, current, and frequency
- Ambient temperature and humidity

2. **Charging Profile**
Use the ABB Recording kWh Meter recording at one-minute intervals to collect AC demand and energy data.

3. **Charging at a Residential Setting**
While standard power quality measurements are made at SCE's EV Tech Center, it is useful to know what the effects of the charger are in a "real world" setting, as the type of service can affect results. In order to observe the power quality of the charger through a typical residential service; charge the vehicle at a designated residence. Use the BMI Power Profiler to record energy and power quality characteristics. Use the portable ABB Recording kWh Meter to collect AC demand and energy data.

4. **Charger Energy Efficiency**
If the output side of the charger is accessible, use the SmartGuard Control Center to record Voltage, current, power, and energy data. Use the results to determine the charger energy efficiency.

5. **Audible Noise Levels**
Use a sound level meter to measure charger noise intensity at maximum power from a distance of one meter.

6. **Operation and Ergonomics**
Observe these aspects of the charger's operation:
   - Charging algorithm
   - Battery monitoring
   - End point determination
   - Protective features

   Examine the user's interface with the charger:
   - Switches, indicators, displays
   - Dimensions, weight
   - Connector types
   - Ease of use

I. STAND-BY ENERGY CONSUMPTION TESTS ("HOTEL" LOADS)

1. **Vehicle on Charger**
After recharging the battery pack to 100% SOC, record the amount of AC kWh drawn by the charger and the DC kWh being delivered to the batteries for a 24 hour period.

2. Vehicle off Charger

After completing the preceding test, disconnect AC Power supply from the charger and record the amount of DC kWh consumed by the vehicle for a 24-hour period.

J. TRANSFER THE VEHICLE

Once the vehicle has undergone a full performance test, it must be transferred to the Transportation Services Department in order to place it in its intended service. If the vehicle is on loan it must be returned to the owning organization.

III. TEST INSTRUMENTATION

A. WEIGHT DOCUMENTATION

1. Certified Weight Scale

B. RANGE TESTS

1. EV odometer
2. Thermometer
3. Temperature loggers (2)
4. SmartGuard Control Center
4. Laptop computer
5. BMI Power Profiler

C. BATTERY CAPACITY TEST

1. Aerovironment ABC-150 Battery Cycler
2. SmartGuard Control Center
3. Digital multimeter
4. Thermometer

D. SOUND LEVEL TEST

1. Sound level meter
2. Laptop computer (optional)

E. STATE OF CHARGE METER EVALUATION

1. EV odometer
2. EV state-of-charge meter
3. Stopwatch

F. PERFORMANCE TESTS

1. Acceleration Tests
   a. EV speedometer
   b. Stopwatch
   c. EV state-of-charge meter
   d. Vericom VC2000PC Performance Computer

2. Maximum Speed
   a. EV speedometer

3. Braking
   a. EV speedometer
   b. Vericom VC2000PC Performance Computer

G. CHARGER PERFORMANCE/CHARGING PROFILE TEST

1. BMI Power Profiler 3030A
2. ABB Recording kWh Meter
3. Laptop computer
4. SmartGuard Control Center
5. EV state-of-charge meter
6. Stopwatch
7. Decibel Meter

H. STAND-BY ENERGY CONSUMPTION TESTS (HOTEL LOADS)

1. Vehicle on charger:
    a. BMI Power Profiler
    b. SmartGuard Control Center
2. Vehicle off charger:
    SmartGuard Control Center

IV. TEST PROCEDURE

A. NAMEPLATE DATA COLLECTION

Record all applicable nameplate data, serial numbers, and ratings for all tested components and test equipment on the Equipment and Nameplate Data Sheet (EVTC–040) (see page 35). On the vehicle, readily available data should be recorded for the controller, motor, charger, traction battery, tires, payload, etc.

B. WEIGHT DOCUMENTATION

Take the EV to a certified scale and measure the curb weight of the vehicle, as well as the weight on each axle. Enter the data on the Weight Certification form available on "Project Manager".

C. BATTERY CAPACITY TEST

Before attempting the battery capacity test, obtain documents containing specifications and recommended values and procedures from the battery manufacturer. The specifications should include a range for which the specified capacity is acceptable so that the health of the battery can be determined.

Data Acquisition Equipment
If possible, and permissible with the manufacturer, configure the vehicle with the SmartGuard Control Center (SGCS) system to record current and voltage information from the battery pack. Using piercing voltage probes and a current transformer probe on the high voltage cables on the output side of the battery pack, connect to the SGCS. If access to the battery pack is possible, configure each module with a Smart Guard unit. Connect the SGCS to the ABC-150.

Fully charge the battery pack with the vehicle's charging system (or use the battery manufacturer's charge algorithm). Take the pack off charge at least 30 minutes before beginning the discharge test. Connect the ABC-150 battery tester to the main battery pack. Record on the Vehicle Battery Capacity Test form (EVTC-060) (see page 37) the initial open circuit pack voltage, pack average temperature and ambient temperature with the SGCS. The pack average temperature can be obtained with the vehicle's diagnostic tool or with thermocouples placed on modules at various pack locations.

Use the ABC-150 battery tester to discharge the EV's battery pack at a constant current until a manufacturer recommended cutoff voltage is reached. Record the following data at 10 second intervals: pack current, pack voltage, Ah, kWh, module Voltage, module temperature.

At a starting battery temperature of $23^{o} \pm 2^{o}$ C, perform groups of three constant current discharge cycles at each of $C_3/3$, $C_2/2$, $C_1/1$, and $C_3/3$ Amperes. At the end of each test, record the following data: open circuit pack voltage (at least 30 minutes after the end of discharge), ambient temperature, average pack temperature, the Voltage difference at the stop condition, the lowest module at the stop condition, DC Ah out, and DC kWh out. Repeat until the $C_3/3$ capacity is stable with three consecutive discharges within 2%.

Charge the vehicle with the vehicle's charger, and record the AC kWh input to the charger and the DC kWh used to return the pack to a fully charged state. Divide the DC kWh returned by the DC kWh out to determine the percent overcharge.

Construct a Peukert Curve – a plot of the logarithm of the discharge rate versus the logarithm of the discharge time to a specified end-of-discharge voltage (Figure 3-1). The curve shows the effect of discharge rate on capacity and can be used to determine the battery capacity at a specific rate.

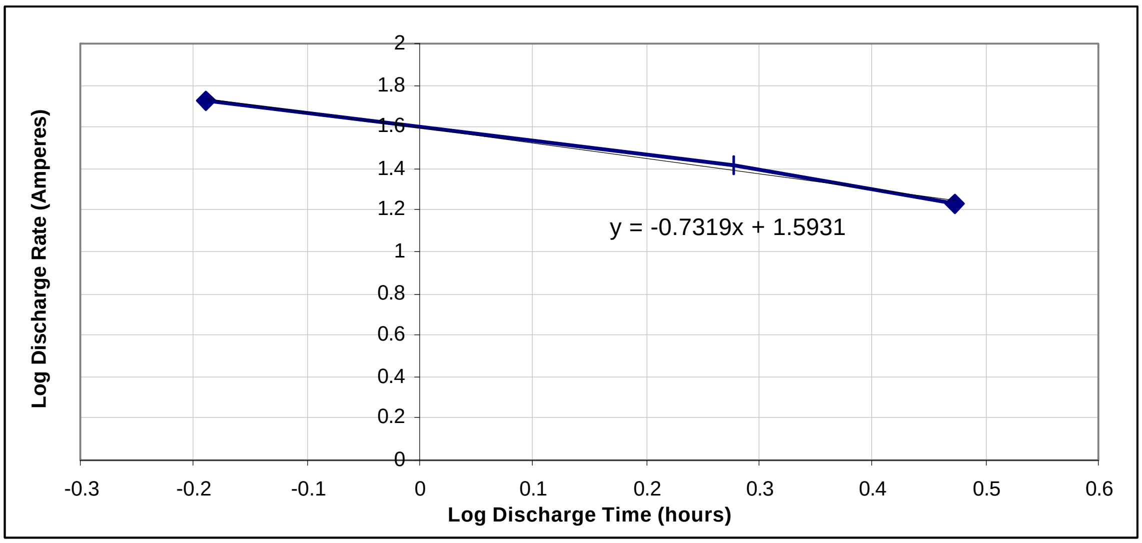


Figure 3-1. Sample Peukert Curve.

D. RANGE TESTS

Vehicle Preparation/Inspection

All new vehicles should first be inspected using the New Vehicle Turnkey Inspection form available from Transportation Services Department (TSD), Pomona. The New Vehicle Turnkey inspection is typically conducted by TSD. All other tested vehicles should be subjected to the functional testing on that form. Inflate tires to the maximum pressure indicated on the tire sidewall. Check the pressure at least once per week. Check the vehicle fluid levels once per week.

Data Acquisition Equipment

If possible, and permissible with the manufacturer, configure the vehicle with the SmartGuard Control Center (SGCS) system to record current and voltage information from the battery pack. Using piercing voltage probes and a current transformer probe on the high voltage cables on the output side of the battery pack, connect to the SGCS. Connect the SGCS to a laptop computer to record data at 30 second intervals during driving.

Stop Conditions

The maximum useable range of the EV is determined by vehicle gage indications specified by the manufacturer, or if no instructions are specified, by diminished vehicle performance such that the EV is no longer capable of operating with the flow of traffic. Typically, a vehicle will have two warning lights near the end of the vehicle's range. The first is usually a cautionary light at roughly 20% SOC. This light is usually a reminder to the driver that he should notice that the state of charge is low. The second warning usually comes on at about 10% to 15% SOC, and is an indication to charge immediately. The EV Tech Center usually uses this second warning signal, as recommended by the manufacturer, to stop the range test, so that there is no chance to harm the traction battery by overdischarge. At this point, the driver should be within a mile or two of the EV Tech Center, and he will drive it in slowly and conservatively. If the vehicle is five miles or more from the EV Tech Center, the driver will have it towed in.

1. **Urban Range Tests:**

   Record the pack voltage, odometer reading and ambient temperature on the Pomona Driving Test Data sheet (EVTC-010) (see page 32). Drive the EV on the Urban Pomona Loop in a manner that is compatible with the safe flow of traffic. Record the following data on the EVTC-010 form at five-mile intervals (or at intervals determined by the vehicle's state of charge meter, if it has sufficient graduations to correspond to about five miles driving between marks): state of charge meter reading, pack voltage, DC kWh, and odometer mileage.

   Near the end of the drive, if needed to manage the range, it is permissible to reverse direction after completing a partial loop, or to shorten the loop by using a parallel street; record this deviation (and all other deviations from the

Pomona Loop) on the EVTC-010. Record the distance traveled (to the tenth of a mile) at the stop condition and at the end of the drive.

Upon returning to the EV Tech Center, record the end of test data (odometer, state of charge, ambient temperature, DC kWh, and pack voltage after 30 minutes).
Connect the BMI Power Profiler to the AC supply side, and collect data necessary for the *Charger Performance Test* (see p. 16) after the first and second UR-1 tests. For the remaining tests, after completion of charging, record the AC kWh data from the BMI Power Profiler, and the DC data, if applicable, from the SmartGuard system.

Conduct this procedure in the following four vehicle test configurations:

UR-1 Minimum payload (driver only) with no auxiliary loads.
UR-2 Minimum payload (driver only) with the following auxiliary loads on: air conditioning set on high, fan high, low beam headlights, and radio. Use thermocouple temperature loggers to continuously record the temperature of the air-conditioned outlet air from the center cabin vent and the cabin ambient temperature at mid-cabin chest level.
UR-3 Repeat the UR-1 test at the vehicle's maximum legal weight limit (without exceeding the gross axle weight ratings).
UR-4 Repeat the UR-2 test at the vehicle's maximum legal weight limit (without exceeding the gross axle weight ratings).

Repeat the tests until the range result is within 5.0% of the previous result. Report the average of the final two tests.

2. **Freeway Range Tests:**
   Record the pack voltage, odometer reading, and ambient temperature. Drive the EV (with windows closed) on the Freeway Pomona Loop in a manner that is compatible with the safe flow of traffic. Maintain speed on the freeway as close to 65 mph as possible; drive conservatively on the transitions. Record the following data on the EVTC-010 form at five-mile intervals (or at intervals determined by the vehicle's state of charge meter, if it has sufficient graduations to correspond to about five miles driving between marks): state of charge meter reading, pack voltage, DC kWh, and odometer mileage. Note the current being delivered by the battery pack at a constant 65 mph on the 10 Freeway between Haven Street and Milliken Avenue.

   Near the end of the drive, if needed to manage the range, it is permissible to reverse direction after completing a partial loop; record this deviation (and all other deviations from the Freeway Loop) on the EVTC-010. Leave the freeway loop only at Towne Avenue or Indian Hill Boulevard, if on the 10 Freeway, or Reservoir Street if on the 60 Freeway to minimize city driving. Record the distance traveled (to the tenth of a mile) at the stop condition and at the end of the drive.

Upon returning to the EV Tech Center, record the end of test data (odometer, state of charge, ambient temperature, DC kWh, and pack voltage after 30 minutes).

Connect the BMI Power Profiler to the AC supply side to record energy data. After completion of charging, read the AC kWh data from the BMI Power Profiler, and the DC data from the SmartGuard Control Center system.

Conduct this procedure in the following four vehicle test configurations:

FW-1 Minimum payload (driver only) with no auxiliary loads.

FW-2 Minimum payload (driver only) with the following auxiliary loads on: air conditioning set on high, fan high, low beam headlights, and radio. Use thermocouple temperature loggers to continuously record the temperature of the air-conditioned outlet air from the center cabin vent and the cabin ambient temperature at mid-cabin chest level.

FW-3 Repeat the FW-1 test at the vehicle's maximum legal weight limit (without exceeding the gross axle weight ratings).

FW-4 Repeat the FW-2 test at the vehicle's maximum legal weight limit (without exceeding the gross axle weight ratings).

Repeat the tests until the range result is within 5.0% of the previous result. Report the average of the final two tests.

AC kWh per mile efficiency

To determine the AC kWh per mile efficiency, recharge the pack fully and use the BMI Power Profiler to record the energy consumption in AC kWh; this number divided by the number of total miles driven, will yield an approximate figure for AC kWh per mile efficiency.

Range Envelope

Once all the data for the range tests have been gathered, a "Range Envelope" can be created for the vehicle for both urban and freeway driving (Figure 3-2). To construct the envelope, use the range in miles recorded at the stop condition; this is a more consistent value than the total miles driven (which may vary based on the distance the driver is from the EV Tech Center when the stop condition is reached) and can be more easily used by others to estimate range. Typically, the longest range will be achieved when the vehicle is tested at minimum payload with no auxiliary loads, and conversely, the shortest range will be achieved with a fully loaded vehicle with all auxiliary loads turned on. Plotting these data should yield a chart similar to the one shown in Figure 3-2.

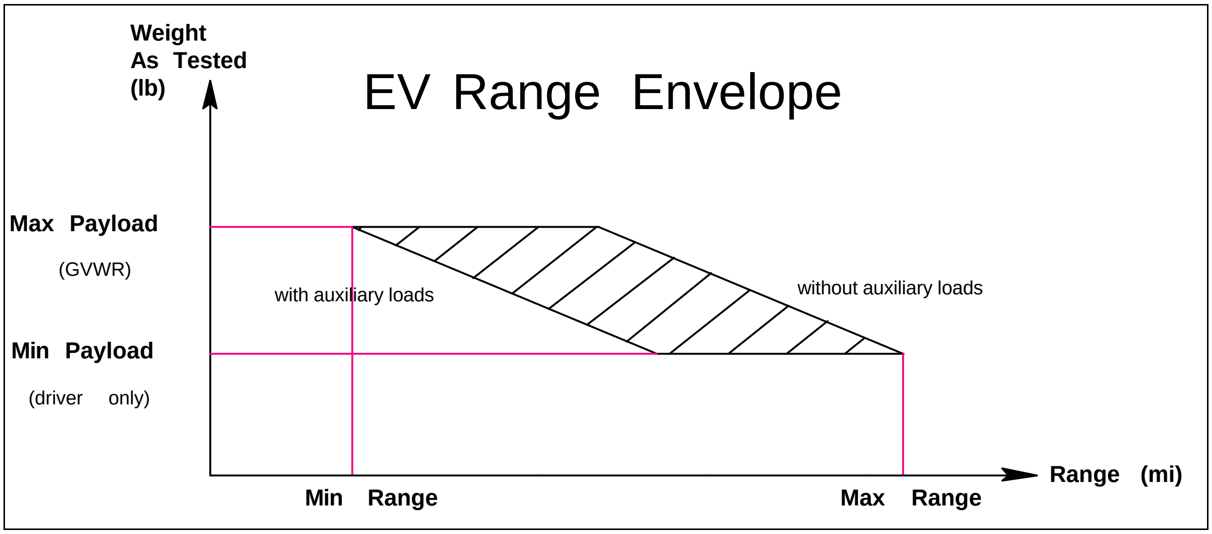


Figure 3-2. Range Envelope.

Air Conditioning Performance
Plot the two curves: air conditioning vent temperature versus time and cabin temperature versus time on the same graph.

E. SOUND LEVEL TEST

Position the sound level meter in the vehicle cabin at ear level on the passenger seat. Record the sound level for both one urban and one freeway loop. The windows will be rolled up and all interior accessories will be off. Any external noises from sources other than the test vehicle loud enough to register on the meter will be noted and reported on the Sound Level Test Data Sheet (EVTC-050) (see page 36). Report the average sound level and present the plot of the recorded data in the Performance Characterization report.

F. STATE OF CHARGE METER EVALUATION

1. Driving

While running the Urban Range Tests, record on the EVTC-010 the distance traveled using the EV’s odometer at intervals corresponding to the EV's state-of-charge meter (such as 3/4, 1/2, 1/4 and “empty”). If the vehicle has only an energy meter, record data at five-mile intervals. At the end of the trip, record the total number of miles driven. In an ideal case, the maximum range would be reached at the time that the state of charge meter indicates “empty”. An ideal state-of-charge meter would yield the following chart for an 80-mile maximum range vehicle:

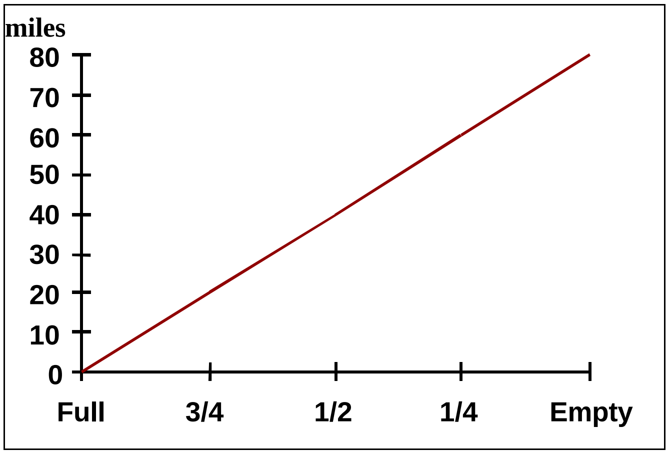


Figure 3-3. State of Charge Meter Evaluation.

2. **Charging**
During charging record on the EVTC-010 the state of charge reading on the EV's state-of-charge meter at fifteen-minute intervals. Use this data to create an indicated state of charge versus time graph, and plot with the charging profile and calculated state of charge plot. This plot will assist the user in estimating the state of charge after a certain amount of time and the energy needed to reach that state.

3. **Driving Range per Charging Time**
Use the results from (1) and (2) to estimate the vehicle range per charging time under UR1 conditions. Use the UR1 average range and state of charge data, to create a set of data points that show miles driven versus indicated state of charge. Subtract the range at each point from the maximum range at the stop condition to obtain a set of points giving the range available at each state of charge point. Use the results giving state of charge versus charging time from (2) to create a plot giving driving range available per charging time (Figure 3-4).

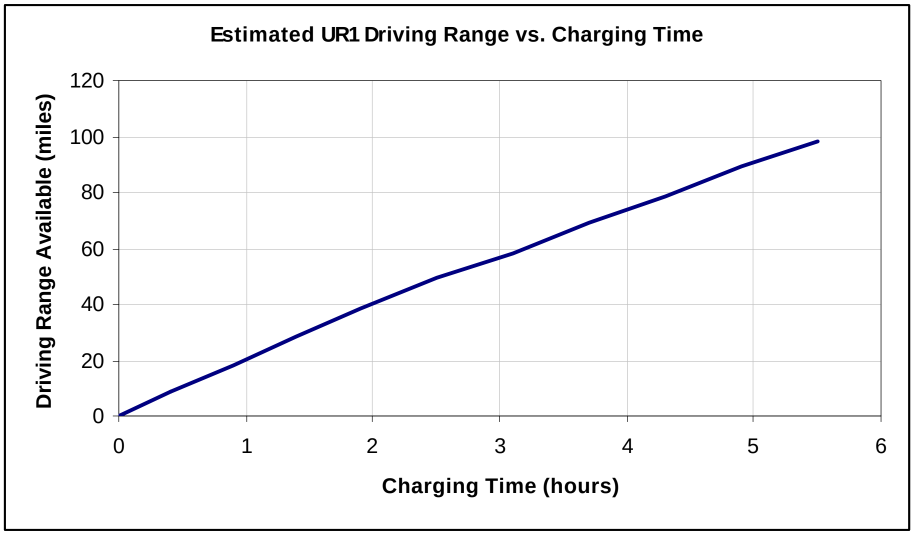


Figure 3-4. Sample plot of estimated range versus charging time.

G. PERFORMANCE TESTS

These tests will be performed with minimum payload at the Los Angeles County Fairplex drag strip in Pomona. Tires should be at maximum pressure. Record the starting and ending data on the EVTC-030 form (see page 35): odometer, ambient temperature, relative humidity, date, time, pack voltage. Note the maximum current and maximum power observed during acceleration.

1. Acceleration

Use the Vericom VC2000PC Performance Computer to measure the performance of the vehicle. Accelerate the EV from stop to over 60 mph at maximum power, and then stop. Record the time expired for 0 to 30 mph and from 0 to 60 mph on the EVTC-030 form. Repeat this procedure twice in opposite directions (to average the effects of wind and grade) at the following traction battery states-of-charge: 100%, 80%, 60%, 40%, and 20%, as measured by the EV's state of charge gage. Report the average of the readings at each state of charge level.

2. Maximum Speed

Continue to accelerate the EV from the 60 mph test until the maximum speed is reached. Conduct this procedure twice in opposite directions at both 100% and 20% SOC. Report the average of these readings. If unable to reach the maximum speed before the end of the track, note the highest speed achieved.

3. Acceleration - 30 to 55 mph

Accelerate the EV from a steady 30 mph to 55 mph at maximum power and use a stopwatch record the time expired. Repeat this procedure twice in opposite directions at the following approximate traction battery states-of-charge: 100%, 80%, 60%, 40%, and 20% (after the above tests), as measured by the EV's state-of-charge gage. Report the average of each pair of readings.

4. **Braking**
Drive the EV to a speed of 25 mph, and apply the brakes hard enough to bring the vehicle to a quick stop without skidding the tires. Use the Vericom VC2000PC Performance Computer to measure the braking distance. Make four runs in opposite directions, and report the average of these readings.

H. CHARGER PERFORMANCE/CHARGING PROFILE TEST

Enter results on form EVTC-020 (see page 33).

1. **AC Input Data**
After the first UR-1 range test, use the BMI Power Profiler to record the following on the AC (input) side of the charger for the duration of the charge at the EV Tech Center:
- Real, reactive, and apparent power
- Energy consumption
- True and displacement power factors
- Voltage and current total harmonic distortion
- Voltage, current, and frequency
- Ambient temperature and humidity

Monitor the vehicle's state of charge meter as specified for the State of Charge Meter Evaluation.
After completion of the charge note the maximum current reported by the BMI. After the second UR-1 test, set up the BMI Power Profiler to record current total demand distortion instead of harmonic distortion. Charge the vehicle and record a snapshot at maximum, intermediate and minimum power. Record data for the duration of the charge at the EV Tech Center.

2. **Charging Profile**
After the first UR-1 test use the ABB Recording kWh Meter recording at one-minute intervals to collect AC demand and energy data. Read the meter and determine the total charging time.

3. **Charger Energy Efficiency**
Use the SmartGuard Control Center as described in Range Tests to record voltage and current data on the output side of the charger. Use the results to determine the charger energy efficiency.

4. **Data Analysis/Reports**
Using the ABB Meter data and a spreadsheet program, plot the power versus time curve. Plot the instantaneous indicated state of charge on the same graph. Use the charger efficiency and energy data to plot calculated state of charge on the same graph (Figure 3-5).

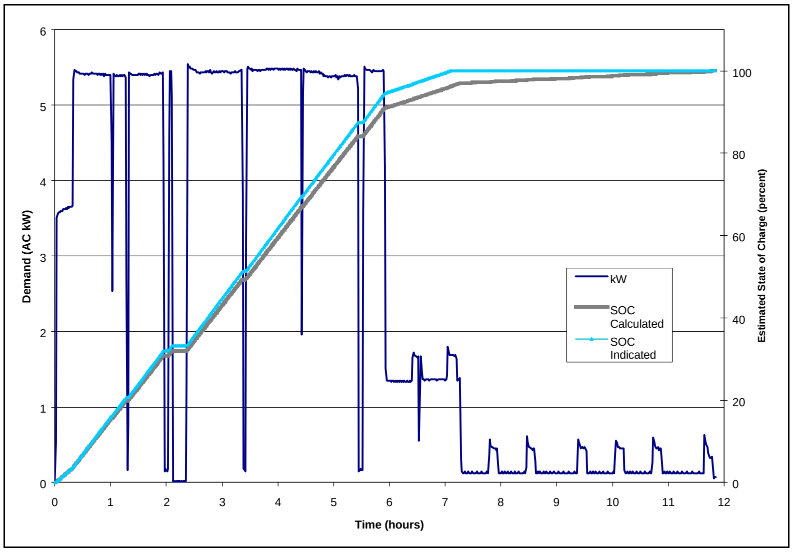


Figure 3-5. Sample AC charging profile plots.

From the BMI and SmartGuard data collected, calculate the energy efficiency for the battery/charger/vehicle system by dividing the total DC kWh delivered to the battery pack by the total AC kWh delivered to the charger. Divide the DC kW curve recorded with the SmartGuard by the AC kW curve recorded with the ABB meter to produce a power conversion efficiency curve.

Using instantaneous data captured with the SmartGuard, determine the ripple factor by dividing the AC RMS current flowing through the battery pack by the average current flowing through the pack.

Determine the overcharge factor by dividing the number of DC kWh (or Ah) returned to the battery pack during recharge by the number of DC kWh (or Ah) delivered from the battery pack during discharge.

By observing the DC current and voltage profiles obtained with the SmartGuard, determine the end of charge conditions.

Divide the current short circuit duty for the charging circuit (see page 29 for a line diagram) by the maximum load current. Use the result to apply IEEE 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.* Apply the recommendations from the National Electric Vehicle Infrastructure Working Council (October 1997) shown in Table 3-1.

Table 3-1. EPRI IWC EV Charging Standards.

	Level 1 Charging	**Level 2 Charging**
Total Power Factor (minimum)	95%	95%
Power Conversion Efficiency (minimum)	85%	85%
Total Harmonic Current Distortion (max.)	20%	20%
Inrush Current (maximum)	28 A	56 A

5. Audible Noise Levels

Charge the vehicle in a quiet room or chamber. Use a sound level meter to record (on the EVTC-050 form) the charger noise intensity from a distance of one meter from the charger. Present the plot of the recorded data and the average sound level in the Performance Characterization report.

6. Operation and Ergonomics Evaluations

Observe the operation of the charger, and use the collected data, along with information from the manufacturer to determine:

- Charging algorithm (constant current/voltage steps, etc.) – determined by viewing the charging profile.
- Battery monitoring method – from the manufacturer.
- End point determination (time, gas emission, voltage change, etc.) – from the manufacturer.
- Protective features (battery protection, GFCI, etc.)

Examine and record (objectively and subjectively) on form EVTC-020 the user's interface with the charger and any electric vehicle supply equipment (EVSE):

- Switches, indicators, displays
- Dimensions, weight
- Connector types, compatibility
- Ease of use

7. Charging at a Residential Setting

Take the vehicle to a designated residence and charge from the stop condition state of charge (see page 12) to 100% SOC (see page 29 for a line diagram of the designated residence). Use the BMI Power Profiler to record energy and power quality characteristics. Use the portable ABB Recording kWh Meter recording at one-minute intervals to collect AC demand and energy data. Construct a charging profile, as described in task 2 (page 16).

I. STAND-BY ENERGY CONSUMPTION TESTS ("HOTEL" LOADS)

1. Vehicle on Charger

After completing the *Charger Performance Test*, leave the BMI Power Profiler and SmartGuard Control Center connected to the vehicle and install the most sensitive current probes (5A) available for the BMI. For a 24-hour period, record the amount of AC kWh drawn by the charger and the amount of DC kWh delivered by the charger to the battery pack.

2. Vehicle off Charger

After completing the preceding test, disconnect the AC power supply from the charger and continue to record data on the DC side. This data will show how much energy is consumed by the vehicle's stand-by systems, such as thermal management system on high temperature batteries.

J. TRANSFER THE VEHICLE

Return control of the vehicle to Transportation Services Department if an SCE vehicle, or to its owning organization if on loan.

APPENDICES

EV PERFORMANCE CHARACTERIZATION TESTING SCHEDULE

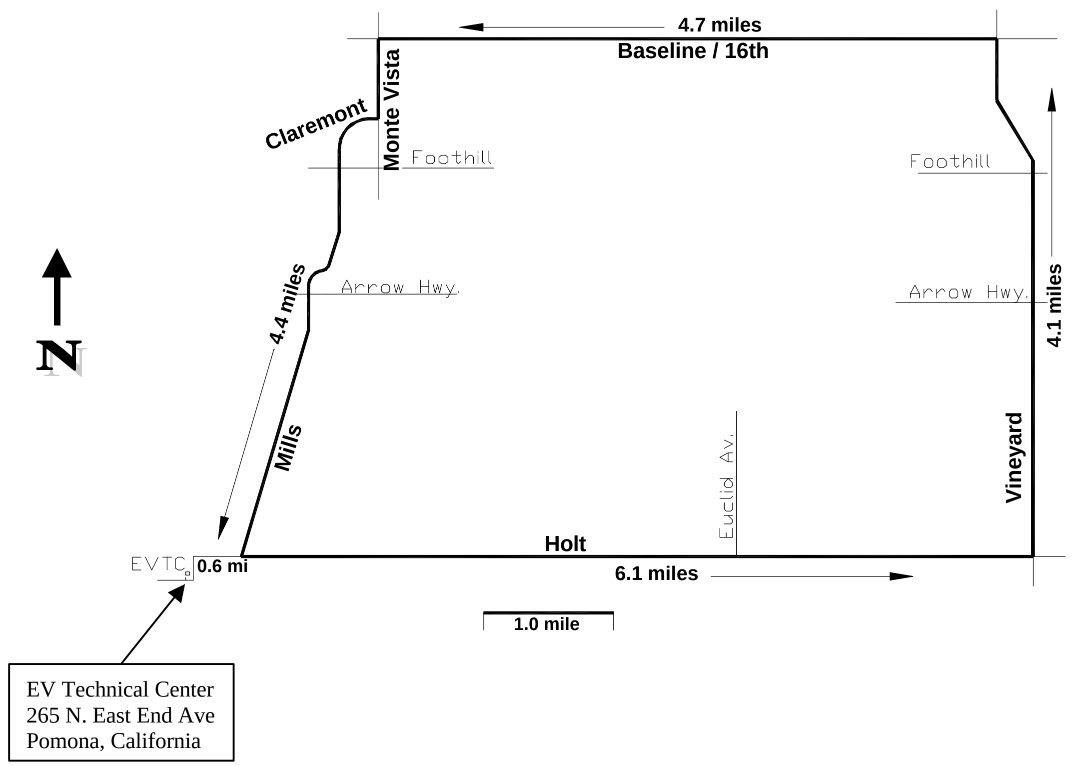
		Duration (days)
1.	Nomenclature Data Collection	½
2.	Weight Documentation - Curb (Front, Rear, Total) - GVWR (Front, Rear, Total)	½
3.	Battery Capacity Test	4
4.	Urban Range Tests - Distance per charge - AC kWh/mile - DC kWh/mile	8
5.	Freeway Range Tests - Distance per charge - AC kWh/mile - DC kWh/mile	8
6.	Sound Level Tests	3*
7.	State-of-Charge Meter Evaluation (Dynamic/Static)	2*
8.	Acceleration / Maximum Speed / Braking Tests	1
9.	Stand-by Energy Consumption Tests ("Hotel" Loads)	2
10.	Charger Performance/Charging Profile Test	3

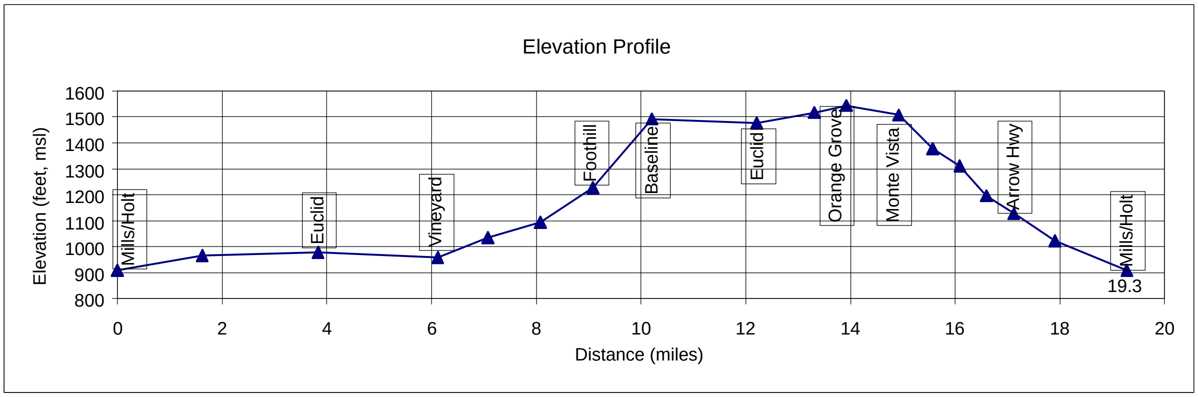
Minimum total days needed for full testing: 27

* The data gathered for these tests are recorded at the same time that other tests are in progress.

POMONA LOOP MAP

URBAN POMONA LOOP





URBAN POMONA LOOP - TABULATED DATA

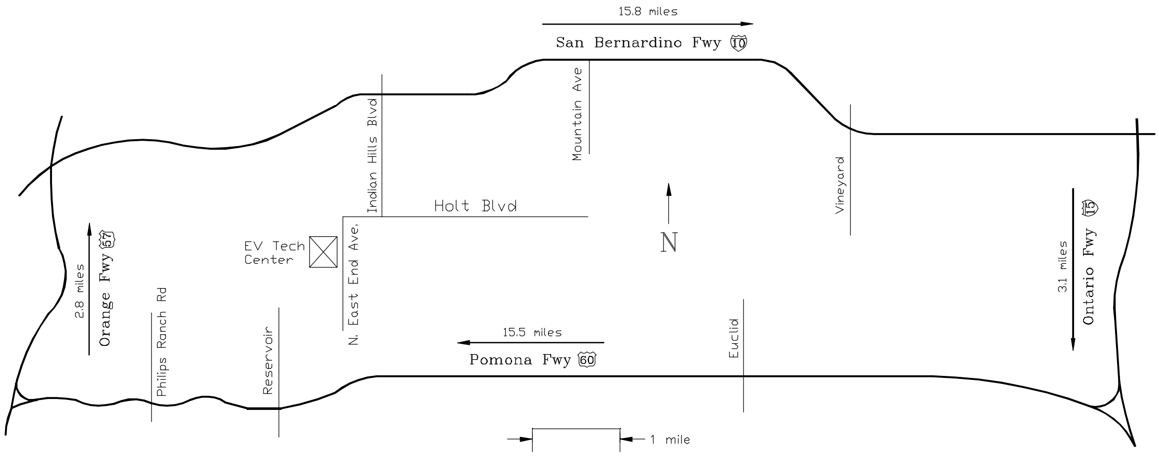
Stop No.	Distance from Start (miles)	Type	Distance from Previous stop	Comments
0	0.00	light	0.00	East End & Holt
1	0.10	light	0.10	
2	0.15	light	0.05	Mills & Holt
3	0.80	light	0.65	
4	1.30	light	0.50	
5	1.80	light	0.50	
6	2.30	light	0.50	
7	2.90	light	0.60	
8	3.50	light	0.60	
9	3.70	light	0.20	
10	4.00	light	0.30	
11	4.01	light	0.01	
12	4.30	light	0.29	
13	4.60	light	0.30	
14	4.80	light	0.20	
15	4.82	light	0.02	
16	5.30	light	0.48	
17	6.30	light	1.00	Vineyard & Holt
18	6.66	light	0.36	
19	6.70	light	0.04	
20	6.80	light	0.10	
21	6.90	light	0.10	
22	7.30	light	0.40	
23	7.80	light	0.50	
24	8.30	light	0.50	
25	8.60	light	0.30	
26	8.80	light	0.20	
27	9.30	light	0.50	
28	9.50	light	0.20	
29	9.60	light	0.10	
30	9.70	light	0.10	
31	10.40	light	0.70	Vineyard & Baseline
32	10.70	light	0.30	
33	10.90	light	0.20	
34	11.60	light	0.70	
35	11.90	light	0.30	
36	12.30	light	0.40	
37	12.50	light	0.20	
38	12.70	light	0.20	
39	13.00	light	0.30	
40	13.60	light	0.60	
41	14.10	light	0.50	
42	15.20	light	1.10	Baseline & Padua
43	16.30	light	1.10	
44	16.80	light	0.50	
45	17.10	sign	0.30	
46	17.40	light	0.30	
47	17.60	sign	0.20	

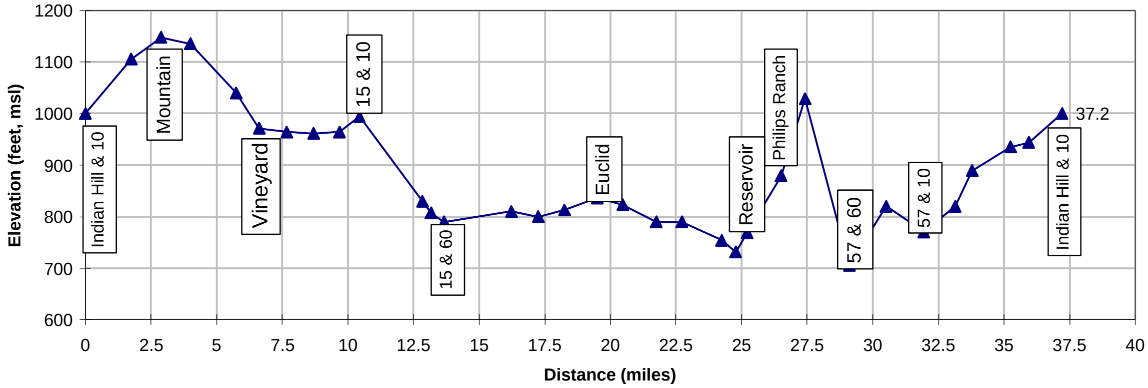
48	18.60	light	1.00	
49	18.70	sign	0.10	
50	19.00	sign	0.30	
51	19.30	light	0.30	
52	19.50	light	0.20	Holt & Mills
53	19.60	light	0.10	
54	19.80	light	0.20	Holt & East End

MCW: ttt
9/23/92

FREEWAY LOOP MAP

FREEWAY POMONA LOOP





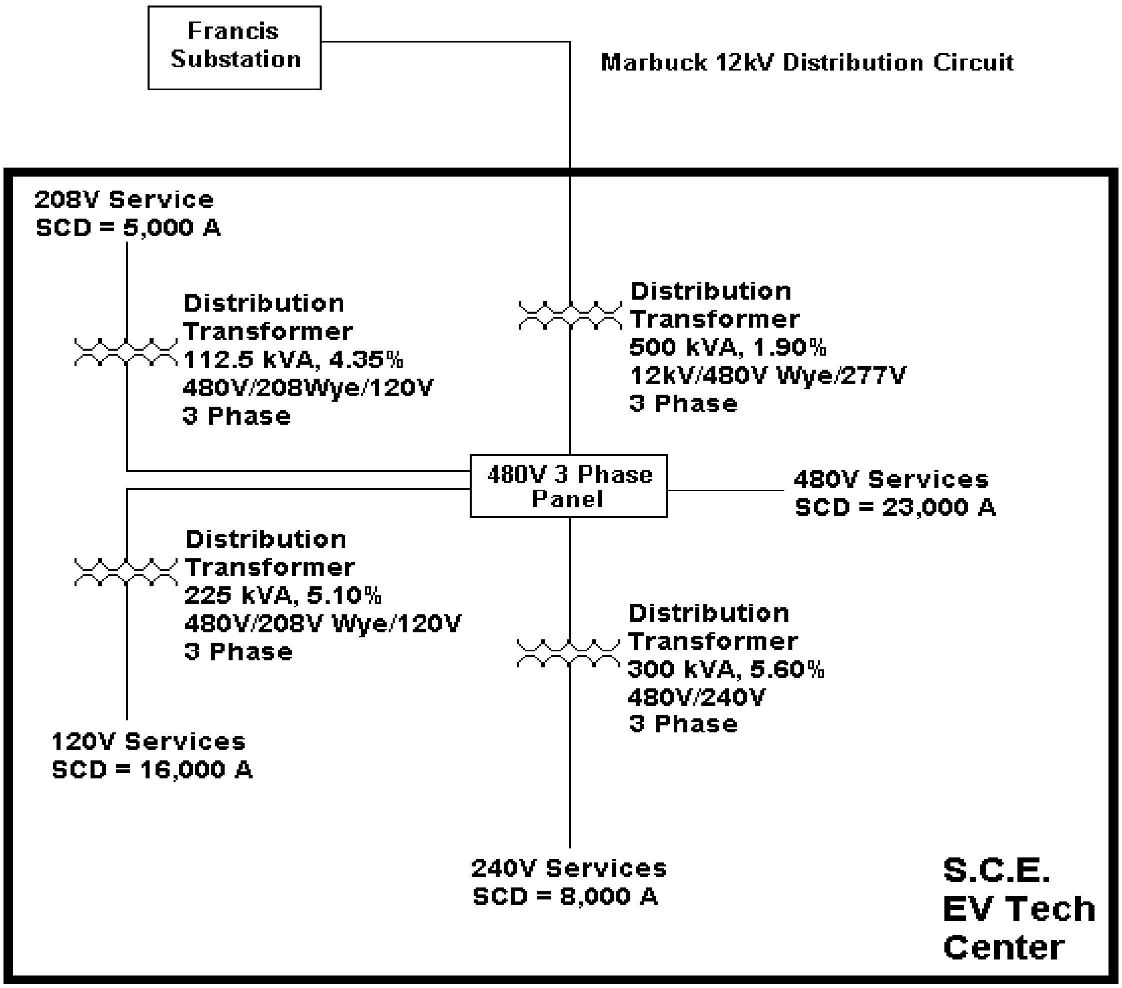
EVTC EQUIPMENT

EVTC Number	Manufacturer	Model	Description	Quantity
ABB-001	ABB	A1T-L	PORTABLE KWH METER	4
ACD-001	Various	PC140HS	DC/AC INVERTER	5
AMC-001	FLUKE	33	TRUE RMS CLAMP AMMETER	3
AVI-001	AEROVIRONMENT	ABC-150	ADVANCED BATTERY CYCLER	2
BCH-001	PHILLIPS	PM8906/003	NICD 4C 6V CHARGER	1
BMI-001	BMI	3030A	POWER PROFILER	2
CHG-001	Various	Various	PORTABLE BATTERY CHARGER	3
CHG-002	LA MARCHE	A70B-45-108LBD1	NICD BATTERY CHARGER	1
CMA-001	Various	Various	CAMERA DIGITAL/35 mm	4
CMP-001	Various	Various	DESKTOP COMPUTER	18
CPB-001	BMI	A-115	CURRENT PROBE 60A	3
CPB-004	BMI	A-116	CURRENT PROBE 600A	6
CPB-010	BMI	A-120	CURRENT PROBE 3000A	3
CPB-013	BMI	A-705	CURRENT PROBE 5A	1
CPB-014	FLUKE	80I-1000S	600A AC DMM PROBE	3
CPB-017	FLUKE	80I-500S	500A AC SCOPE PROBE	3
DAP-001	FLUKE	Y8100	DC/AC CURRENT PROBE	3
DAP-004	FLUKE	801-1010	DC/AC CURRENT PROBE	1
DAP-005	TEKTRONIX	AM503B	AC/DC CURRENT PROBE SYSTEM	1
DAP-006	TEKTRONIX	A6303	AC/DC HIGH CURRENT PROBE	1
DAP-007	FLUKE	80I-110S	100A AC/DC PROBE	2
DAQ-001	HEWLETT PACKARD	3497A	DATA ACQUISITION UNIT	1
DAQ-002	HEWLETT PACKARD	3421A	DATA AQUISITION CONTROL UNIT	6
DAQ-008	FLUKE	DAC	DATA AQUISITION CONTROL UNIT	2
DAQ-010	HEWLETT PACKARD	3498A	DATA AQUISITION UNIT	1
DAT-001	OMEGA	HH-F10	AIR SPEED INDICATOR	1
DAT-002	CHRYSLER CORP	SCAN TOOL	EPIC DIAGNOSTIC TOOL	2
DAT-004	HEWLETT PACKARD	Z1090A	GM TECH 2	1
DCG-001	PROPEL	ABT85-220	BATTERY DISCHARGER	1
DCG-002	PROPEL	ABT100-350	BATTERY DISCHARGER	1
DPM-001	YOKOGAWA	2533E43	DIGITAL POWER METER	1
DPS-001	ICC	ICC-21000005-12	DC POWER SUPPLY 13V	2
DPS-002	STANCOR	W120DUJ50-1	DC POWER SUPPLY 12V	1
DPS-004	HEWLETT PACKARD	6479C	DC POWER SUPPLY	1
DPS-005	HEWLETT PACKARD	6448B	DC POWER SUPPLY	1
DVM-001	HEWLETT PACKARD	3456A	DIGITIAL VOLTMETER	1
DYN-001	VERICOM	VC2000PC	PERFORMANCE COMPUTER	1
EDE-001	BERNOULLI	ED	EXTERNAL DRIVE	1
EMT-001	CRUISING EQUIPMENT	RS-2323	E-METER	3
ENV-001	ASSOCIATED ENV.SYS.	ZFK-5116	ENVIRONMENTAL ENCLOSURE UNIT	3
EVC-001	MAGNECHARGE	FM 100	INDUCTIVE CHARGER	3
EVC-004	MAGNECHARGE	WM 200	INDUCTIVE CHARGER	3
EVC-020	MAGNECHARGE	FM 200	INDUCTIVE CHARGER	13
EVC-042	MAGNECHARGE	P200	1.2 KW INDUCTIVE CHARGER	2
EVC-007	EVI	ICS-200	CONDUCTIVE EVSE	10
EVC-014	EVI	MCS 100-3	CONDUCTIVE EVSE (EVI-100) AVCON	2
EVC-017	SCI	GEN1	CONDUCTIVE EVSE/ODU	2
EVC-019	SCI	GEN 2	CONDUCTIVE EVSE/AVCON	7
FGE-001	SHIMPO	MF	FORCE GAUGE	1
GPB-001	HEWLETT PACKARD	GPIB-422CT	GPIB CONTROLLER	1
IST-001	BK PRECISION	1604A	ISOLATION TRANSFORMER	1
ITR-001	NEWPORT	OS520	INFRARED THERMOMETER	1
ITR-002	BMI	A-003	TEMPERATURE SENSOR	1
LPC-001	Various	Various	COMPUTER LAPTOP	9
LPP-001	TOSHIBA	PA2711U	DOCKING PORT	2

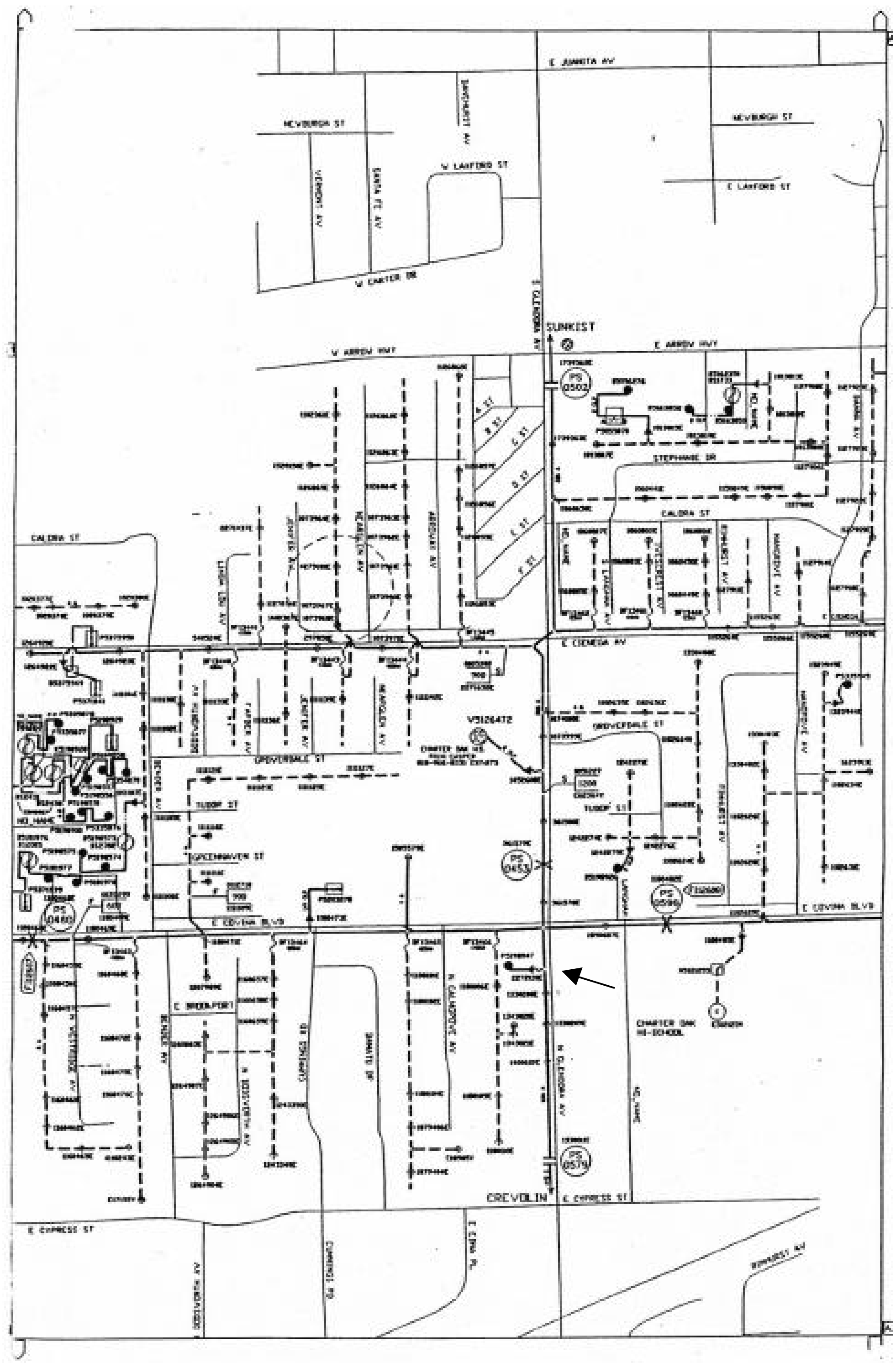
EVTC Number	Manufacturer	Model	Description	Quantity
MCR-001	OLYMPUS	MICRO-32	MICRO CASSETTE RECORDER	1
MMR-001	Various	Various	DIGITAL MULTIMETER	14
MMR-012	HEWLETT PACKARD	34401 A	MULTIMETER	1
MMW-001	ROLATAPE	MEASUMASTERMM30	MEASURING WHEEL	1
MPG-001	HEWLETT PACKARD	6942A	MULTIPROGRAMMER	1
NVK-001	NORVIK TRACTION INC.	BC-500-4	MINIT CHARGER	1
OHM-001	MEGGER	210200	OHM METER	1
OPB-001	U.S. MICROTEL	PM-500	OPTICAL PROBE	2
OSC-001	HEWLETT PACKARD	54600B	OSCILLOSCOPE	1
OSC-002	YOKOGAWA	701810-1D	DL708 DIGITAL SCOPE	1
OSC-003	YOKOGAWA	OR3412/PM-M	OSC. RECORDER H.A.	1
OVP-001	3M	9700 9000AJJ	OVERHEAD PROJECTOR	1
PHA-001	FLUKE	41	POWER HARMONICS ANALYZER	1
PHA-003,4	FLUKE	43	POWER HARMONICS ANALYZER	2
PHA-002	BMI	155	HARMONICS METER	1
PRI-001	EXTECH	480300	PHASE ROTATION TESTER	1
PRT-001	HEWLETT PACKARD	C3167A	LASERJET 5SI/MX PRINTER	1
PRT-002	HEWLETT PACKARD	C2001A	LASERJET 4M PRINTER	1
PRT-003	HEWLETT PACKARD	C4530A	2000C COLOR PRINTER	1
PSY-001	WAYNE-KERR	LS30-10	POWER SUPPLY	1
SCL-001	METTLER	FEHD-R	DIGITAL SCALE	1
SCR-001	FLUKE	97	SCOPEMETER	1
SGM-001	KEM	DA-110	DENSITY/SPECIFIC GRAVITY METER	1
SGN-001	WAVETEK	191	SIGNAL GENERATOR	1
SMR-001	EXTECH INSTRUMENTS	407762	SOUND LEVEL METER	1
STW-001	Various	Various	STOPWATCH	2
THR-001	OMEGA	PTH-1X	TEMP/HUMIDITY METER	2
THR-002	Various	Various	THERMOCOUPLE THERMOMETER	3
THR-004	SEALED UNIT PARTS	PT-100	DIGITAL THERMOMETER	1
THR-006	RADIO SHACK	63-867A	DIGITAL TEMP/HUMIDITY METER	2
WHR-001	CRUISING EQUIPMENT	KWH METER	KILOWATT-HOUR METER	2
YOK-001	YOKOGAWA	AR1100A	ANALYZING RECORDER	1
ZIP-001	IOMEGA	Z100PS	ZIP HARDWARE	3

JWS 4/15/99

EV TECH CENTER LINE DIAGRAM



RESIDENCE LINE DIAGRAM



EVTC-010 DRIVING TEST DATA SHEET

POMONA DRIVING TEST DATA

Date	Vehicle	VIN last 6	Test	Driver	Data File/Project		Volts
						Start	
Road Cond	Tire Press	Payload				Stop	
						Net	

Driving	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	A/C>10 min
Start								
Stop								Min. A/C
Net								

Distance	State of Charge		Notes / Deviations / Traffic / Weather / Performance
Miles	Veh meter	Range meter	

Accessories used: ______________________________

Drive / Regen setting: ______________________________

Handling/Braking: ______________________________

Other comments: ______________________________

____

Charger	Serial No.		AC meter#		BMI #

Charging	Date	Time	AC kWh in	BMI kWh in	DC kWh in	DC Ah in	Amb temp	Volts
Start								
Stop								
Net								

Comments: ______________________________

____

____

EVTC-010

EVTC-020 CHARGER TESTING / ANALYSIS DATA SHEET

Technician: ___________________________ Date:______________
Location:______________________________ Phone:_____________

Charger Information

Manufacturer: _____________________________________
Model No.: ____
Supply Side Voltage Rating: _________________________

After Completion of Recharging Cycle

Time of Day: _________________________
Final Pack Voltage: ___________________
AC kWh Used: ________________________ DC kWh Delivered: ____________
System Energy Efficiency: ___________________ (DC kWh/AC kWh)
Amp-hours to battery: ________________________kWh to battery: _________________
Overcharge Factor: ___________________ (Ah removed/Ah returned)
DC Output Ripple Voltage: ______________ Ripple Frequency: ____________

Charger Operation Information/Evaluation

Exterior Dimensions: ___________________ Weight: _________________
Charging Profile Type: ____
End Point Determination Method: ____
Battery Monitoring Method: ____
Programmable Charging Profiles: ____
Connector Type(s): ____
Safety Features / Protection Devices: ____
Agency/Industry Approvals: ____
Installation Techniques/Requirements: ____
Appropriate for Interior and/or Exterior Use: ____
User Interface (Switches, Indicators, Display):____
Ease of Use: ____
Current & Future Cost: ____
Warranty: ____
Reliability History / Manufacturer Reputation: ____
Maintenance Schedule: ____
Accompanying Supplies: ____
Manufacturer Support: ____
Other Notes:____
____
____
____
____

EVTC-030 PERFORMANCE TESTING DATA SHEET

ACCELERATION, MAXIMUM SPEED, AND BRAKING TESTS

Vehicle No.: ____________
Location: ____________
Date: ____________

	Start	Stop
Time:		
Temp.:		
Odometer:		

Acceleration (100% SOC)

	0-30 mph	0-60 mph	Direction	Max. Speed	30-55 mph
1					
2					
3					
4					

Average ____________

Acceleration (80% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1				
2				
3				
4				

Average ____________

Acceleration (60% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1				
2				
3				
4				

Average ____________

Braking 25-0 mph, 50% SOC

Feet	inches	Total feet	Direction	
				1
				2
				3
				4
				5
				6
				7
				8
				9
				10

________ Average ft

Acceleration (40% SOC)

	0-30 mph	0-60 mph	Direction	30-55 mph
1				
2				
3				
4				

Average ____________

Acceleration (20% SOC)

	0-30 mph	0-60 mph	Direction	Max. Speed	30-55 mph
1					
2					
3					
4					

Average ____________

Comments ____________

EVTC-040 VEHICLE TEST EQUIPMENT AND NAMEPLATE DATA SHEET

Project:_______________________________ Test:_________________________________
Date(s):________________________ File Name(s):__________________________
Vehicle Number:________________ Technician:____________________________

VEHICLE

Manufacturer: ________________________VIN:____
Model: ________________________Model Year:______ Date of Manufacture: ___________
GVWR:__________________Front AWR:____________ Rear AWR:_____________________
Motor Manufacturer:___________________ Motor Type:___________________
Motor Rating/Speed:____
Version/Serial No.:____
EPA Label Fuel Economy: ____
Controller Version/Serial No.: ____
Battery Pack Type/Version/Serial No.: _____________________________________
Tire Manufacturer: __________________________Model:_____________________________
Tire Size:______________________ Maximum Pressure:__________________
Maximum Tire Load: ___________ Treadwear Rating:___________________

CHARGER

On-board / Off-board Manufacturer:_______________________________
Model: _______________________________Serial Number:______________________________
Charger Type/Version:____
EVSE Manufacturer: ____
EVSE Model/Version:______________________________Serial Number:_________________
EVSE Software Version:____
Charge Port Manufacturer/Model/Version/SN:_______________________________________

TEST EQUIPMENT

BMI Power Profiler 3030A EVTC Number:____
ABB kWh Meter Serial Number:____
Thermometer EVTC Number:____
Optical Meter Probe EVTC Number:____
Laptop Computer EVTC Number:____
Desktop Computer EVTC Number:____
Stopwatch EVTC Number:____
Digital multimeter EVTC Number:____
ABC-150 EVTC Number:____
Smart Guard Interface Serial Number:____
Smart Guard Numbers:____
Sound Level Meter EVTC Number:____
Measuring Wheel EVTC Number:____
Other Equipment:____

WEIGHT CERTIFICATION

Scale Location and Proprietor:____
Examiner:__________________________________ Date:__________________________
Notes:____

EVTC-050 SOUND LEVEL METER DATA SHEET

Sound Level Test Data

Urban Driving Sound Level Test

Date:	
Project:	
Technician:	
Veh. No.:	
Location:	
Start odo:	
End odo:	
Trip:	

Sound Level Range(dBs):	

	Start	Stop
Recording Time:		

Put a check mark on the settings selected

	A	C
Frequency Weighting:		

	Fast	Slow
Response:		

Comments: ____________________

Freeway Driving Sound Level Test

Date:	
Project:	
Technician:	
Veh. No.:	
Location:	
Start odo:	
End odo:	
Trip:	

Sound Level Range(dBs):	

	Start	Stop
Recording Time:		

Put a check mark on the settings selected

	A	C
Frequency Weighting:		

	Fast	Slow
Response:		

Comments: ____________________

Charger Sound Level Test

Date:	
Project:	
Technician:	
Veh. No.:	
Location:	
Start odo:	
End odo:	
Trip:	

Sound Level Range(dBs):	

	Start	Stop
Recording Time:		

Put a check mark on the settings selected

	A	C
Frequency Weighting:		

	Fast	Slow
Response:		

Comments: ____________________

EVTC-060 VEHICLE BATTERY CONSTANT CURRENT DISCHARGE CAPACITY TEST DATA SHEET

Project:________________________ Test File:___________________________

Date(s):________________________ Technician:___________________________

Vehicle Number:____________________ Battery Nos.:___________________________

BATTERY SPECIFICATIONS

Manufacturer: ______________________ Model: ___________________________________

Date of Manufacture: ________________ Nominal Voltage:___________________________

Ah Rating @ C/3:____________________ Voltage Range:_____________________________

Weight/Module:______________________ Temp. Range:_______________________________

BATTERY PACK

Number of Modules:__________________ Nominal Voltage:___________________________

Configuration: ____

Location for Test:____

TEST EQUIPMENT

Discharge Unit: ___________________________ Serial No.___________________________

Charging Unit: ____________________________ Serial No.___________________________

Data Acquisition Equipment:____

____

Other Equipment:____

RESULTS

	TEST 1	TEST 2	TEST 3
DATE			
DISCHARGE (A)			
STOP CONDITION			
START TIME			
STOP TIME			
TOTAL TIME			
START TEMP.			
STOP TEMP.			
START O.C. VOLTS			
STOP O.C. VOLTS			
∆V at STOP			
Ah OUT			
kWh OUT			
LOWEST MODULE			
DATA FILE			

RECHARGE TYPE			
Ah RETURNED			
kWh RETURNED			
DATA FILE			

NOTES:____