PERFORMANCE CHARACTERIZATION

1998 FORD RANGER ELECTRIC

WITH NICKEL/METAL-HYDRIDE BATTERY

SOUTHERN CALIFORNIA EDISON

An *EDISON INTERNATIONAL* Company

ELECTRIC TRANSPORTATION DIVISION

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PURPOSE

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

The following facts support this purpose:

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

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I. INTRODUCTION

The first Ford Ranger Electric vehicles were received by SCE in February 1998. They were equipped with Delphi 8 Volt lead-acid battery modules. A full performance characterization was performed with one of these vehicles (see the report dated April 1998). In late 1998 several Rangers were delivered to SCE with nickel-metal/hydride (NiMH) batteries. In December 1998 Electric Transportation Division conducted performance characterization testing of a Ranger (Ford #A00021) on loan from Ford in accordance with the SCE Electric Vehicle Test Procedure (see Appendix E page 43) at the Electric Vehicle Technical Center (EV Tech Center).

Due to the limited availability of the vehicle, freeway testing was not completed.

A second Ford Ranger EV of the same model and year (SCE #23639) was selected for testing in March of 1999 to complete the tests.

The 1998 NiMH Ranger is identical to the lead-acid version except for the battery pack. Instead of 39 8-volt lead-acid modules it has 25 Panasonic NiMH modules in a slightly modified battery tray. This allows an increase in nominal payload from 700 pounds to 1250 pounds. In 1999 the rear suspension was modified, and the gross vehicle weight rating was reduced from 5400 pounds to 5350 pounds. The NiMH batteries increase the manufacturer-estimated range from 77 miles to 90 miles. 1999 model year NiMH Rangers will only be available in California, according to Ford.

II. MANUFACTURER'S SPECIFICATIONS

See Appendix A page 17 for the manufacturer's fact sheet.

Vehicle:		Ranger Electric Vehicle (NiMH)
Range:		90 miles
Maximum speed:		75 mph (governed)
Traction Battery		
	Type:	Nickel/Metal-Hydride
	Manufacturer:	Matsushita Battery (Panasonic)
	Model:	EV-95
	Capacity:	95 Ah (5 hour rate)
	Weight:	18.5 kg
	Nominal Voltage:	12 V
	Specific Energy:	63 Wh/kg
Number of Modules:		25
Battery Pack Weight:		950 lb
Nominal Pack Voltage :		300 V
Type of Motor:		AC Induction
	Power :	90 hp (67 kW)
	Torque:	140 ft.lb. (190 Nm)
Configuration:		Rear motor, single-speed transaxle, rear drive
Curb Weight:		4100 lb.
GVWR:		5350 lb.
Payload:		1250 lb.
Dimensions,	*Wheelbase:*	112 in
	Length:	187.5 in
	Width:	70.3 in
	Height:	62.0 in
	Ground Clearance:	7.4 in

III. DEVIATIONS FROM THE SCE ELECTRIC VEHICLE TEST PROCEDURE

1. The battery capacity test was not performed because the traction battery was not accessible.
2. The static state of charge meter evaluation was not performed because the gage does not operate while charging.

IV. RESULTS

A. Weight Certification

Table 4-1. Weight Results

	Front Axle	Rear Axle	Total Weight
GVWR (lb)	2710	3000	5400
Curb Weight (lb)	2120 *	2090 *	4210
Available Payload (lb)	590	910	**1190**

*Front and rear axle weights are not certified.

B. Range Tests

B1. Urban Range Tests

Table 4-2. Urban Range Test Results

Tests	UR1	UR2	UR3	UR4
Payload (lb)	190	190	1220	1220
Range at Stop Condition	80.6	73.2	75.3	62.7
Total Miles Driven	81.2	73.7	75.7	65.5
AC kWh recharge [1]	31.74	31.76	32.96	32.95
AC kWh/mi.	0.391	0.431	0.435	0.503
Average Speed (mph)	26	25	25	25
Avg. Amb. Temp. ^{o}F [2]	63	63	66	69

Note: These are average values of 2 drives.

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

[1] From BMI Power Profiler.
[2] Due to the ambient temperatures in November, the load placed on the A/C system was not as high as would be expected in the summer months.

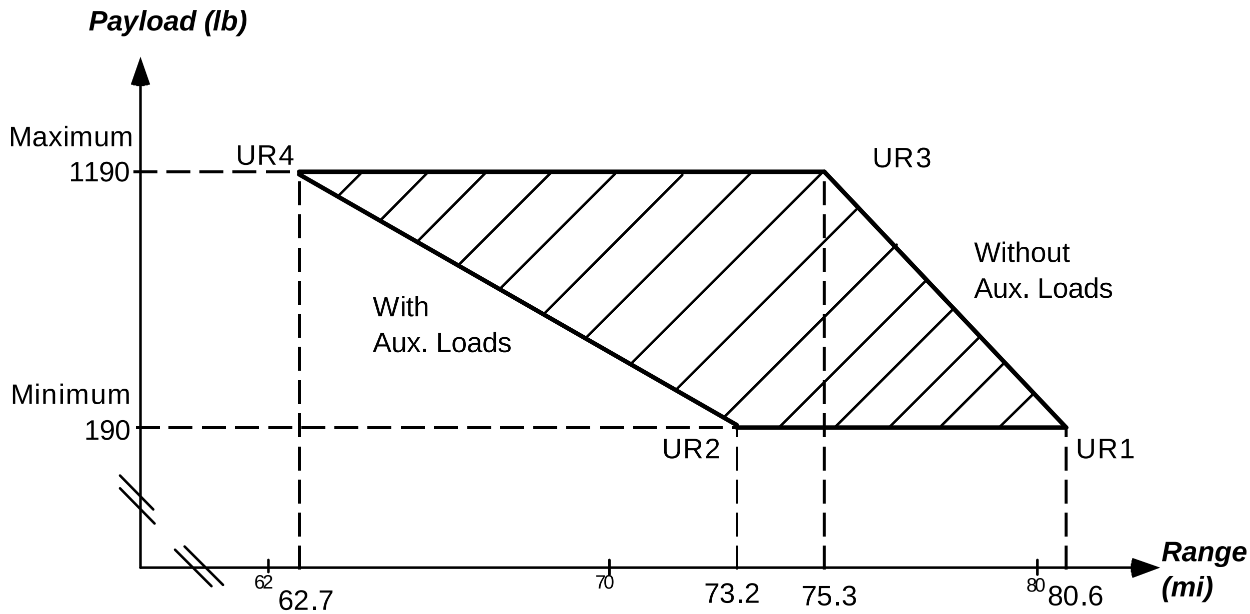

Figure 4-1. Urban Range Envelope.

B2. Freeway Range Tests

Table 4-3. Freeway Range Test Results March 1999, vehicle 23639.

Tests[1]	FW1	FW2	FW3	FW4
Payload (lb)	150	150	1190	1190
Range at Stop Condition	76.5	71.4	74.8	68.8
Total Miles Driven	78.2	77.1	76.8	69.2
ac kWh recharge [1]	31.99	35.17	36.85	33.89
Ac kWh/mi	0.409	0.456	0.480	0.490
Average Speed (mph)	45	51.4	51.2	41.3
Avg. Amb. Temp. °F[1]	61.5	65.5	73.5	51.5

Note: Different vehicle was used for the March freeway range tests. Only one drive was performed for each condition.

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

[1] From BMI Power Profiler.

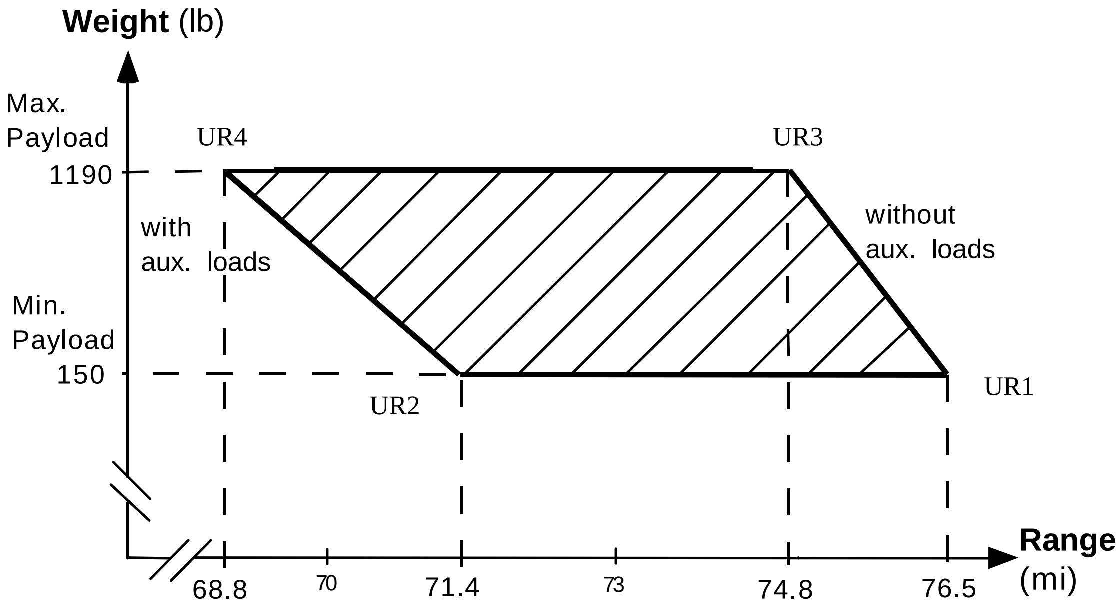

Figure 4-2. Freeway Range Envelope (March 1999).

C. State of Charge (SOC) Meter Evaluation

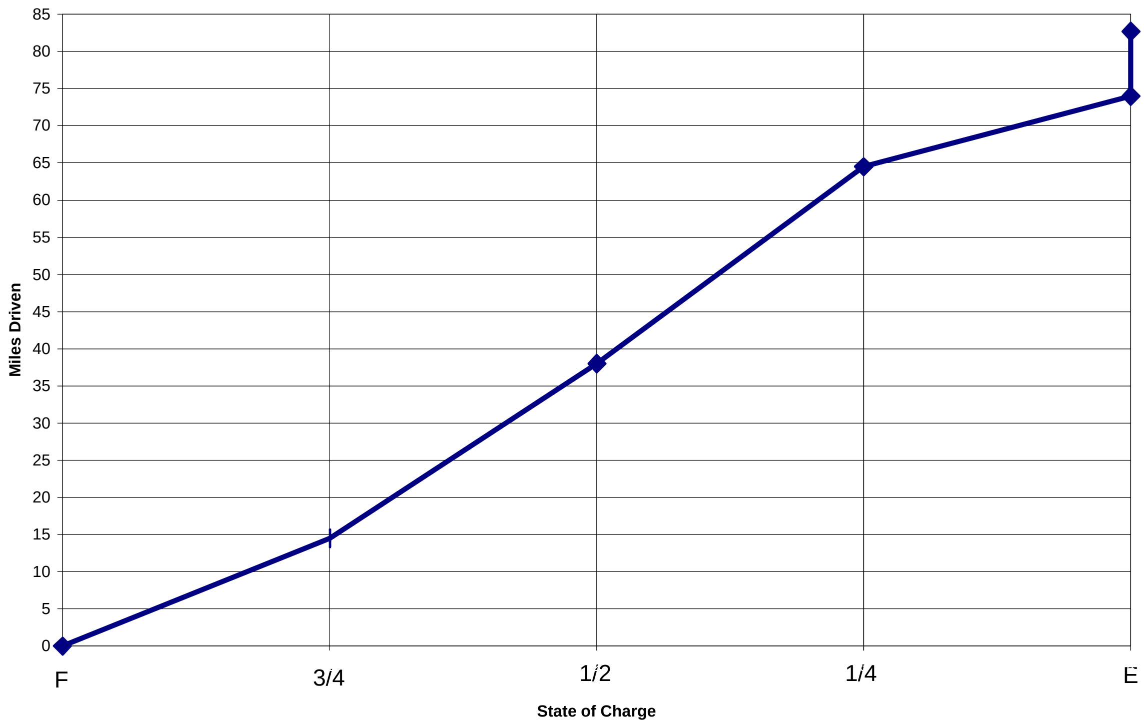

Figure 4-3. State of Charge meter readings as a function of miles driven.

[1] Due to the ambient temperatures in March, the load placed on the A/C system was not as high as would be expected in the summer months.

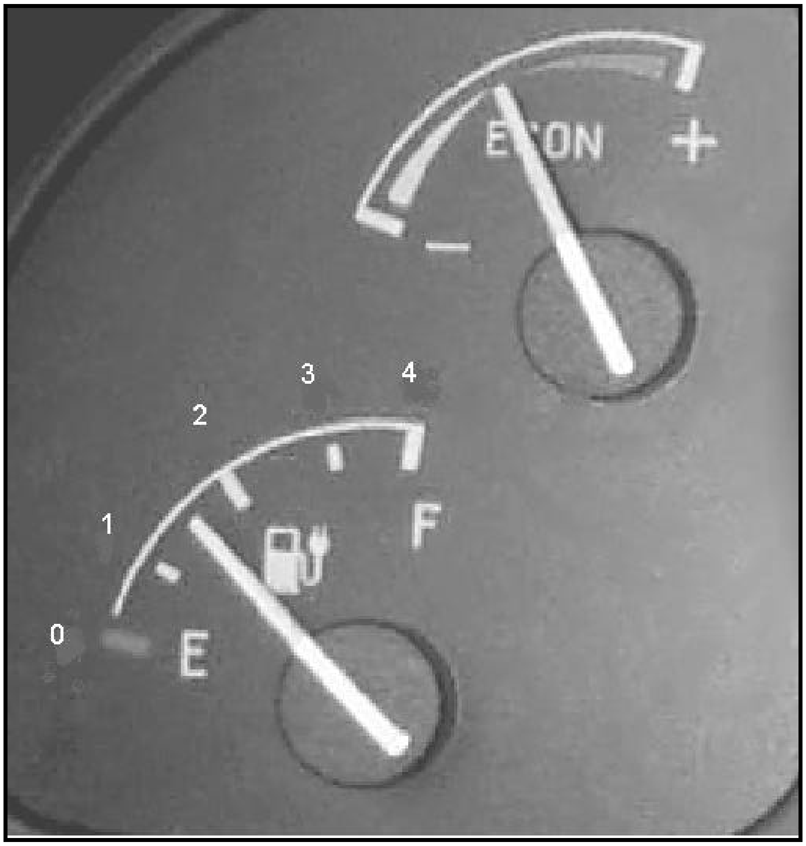

Figure 4-4. Ranger EV State-of-Charge gauge and economy gauge.
Note: Numbers labels were added to the SOC gauge for this report.

D. Acceleration, Maximum Speed, and Braking Tests[1]

Table 4-4. Performance Testing Data

Performance Testing Data	100% SOC	80% SOC	60% SOC	40% SOC	20% SOC
0 to 30 mph (s)	5.21	5.07	5.05	5.07	5.13
30 to 55 mph (s)	9.73	9.55	9.84	10.62	11.02
0 to 60 mph (s)	17.45	18.14	18.26	19.42	19.91
Max Speed (mph)	77.50	N/A	N/A	N/A	70.50
Braking (25-0 mph) (ft)	N/A	N/A	21.74	N/A	N/A

[1] Average values (ambient temperature: 52-55^{o} F). (160 lb payload)

E. Charger Performance / Profile Test

Table 4-5. Charger Profile Data

Note: Refer to Appendix D, page 36, for BMI Power Profiler graphical data.

Measured Value[1]	
Voltage	236.6V
Current	23.09 A
Real Power	5.444 kW
Reactive Power	392.3 VAR
Apparent Power	5.462 kVA
Total Power Factor	1.00 PF
Displacement Power Factor	1.00 dPF
Voltage THD	1.7 %
Current THD	3.6 %

Total Charging Time	7.25 hours (approx.)
Total Energy Consumption	31.15 kWh

Time Observed on Stand-by	24 hours
Average Power	121.375 W
Energy Consumption	2.913 kWh

[1] Value recorded at peak power on the AC (input) side of the charger (240V service).

Starting ambient temperature: 66^{o} F

Data was recorded after the UR1 test.

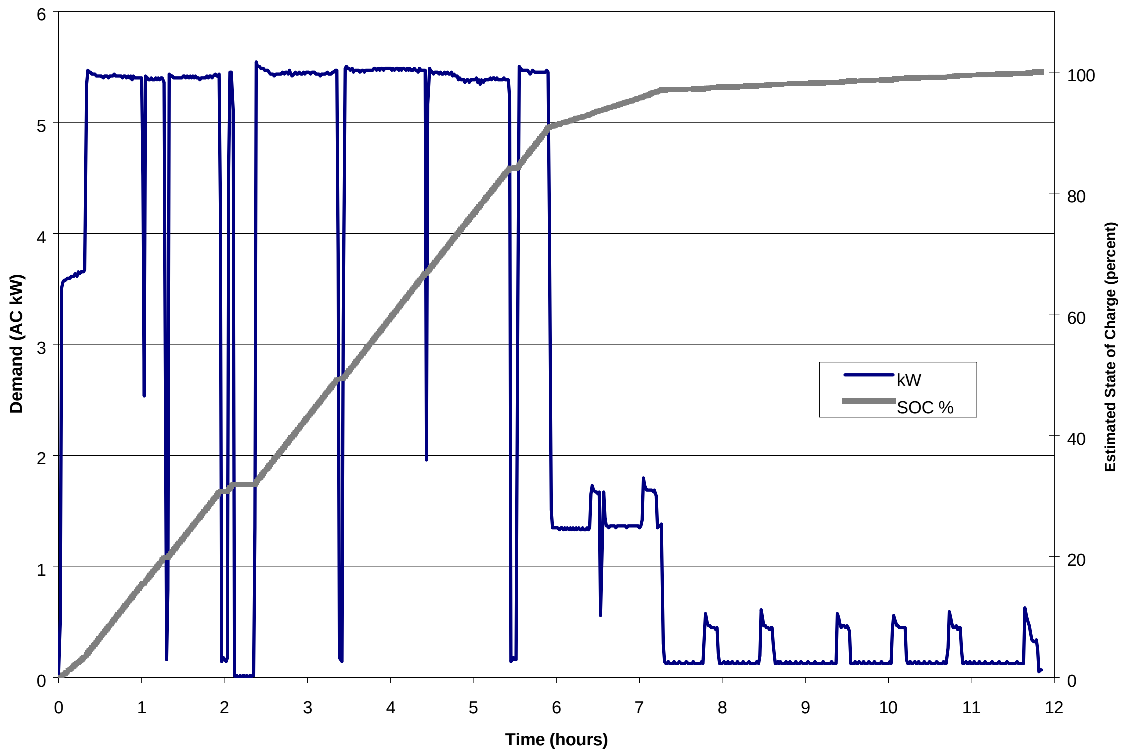

Figure 4-5. AC input charging profile from ABB meter.

V. DISCUSSION AND CONCLUSIONS

A. Weight Certification

The measured curb weight was 4210 pounds. The manufacturer's gross vehicle weight rating (GVWR) was 5400 pounds. The GVWR minus the curb weight, yielded a payload of 1190 pounds, which was the weight used for the maximum payload tests. There was a difference between Ford's GVWR specifications for the 1998 and 1999 Ranger EVs. The specification for 1999 was 5350 pounds – 50 pounds less than the 1998 model. As shown in Figures 5.1 and 5.2 below, the change was caused by differences in the rear De Dion suspension. In 1998 the Ranger used polymer flat springs and a Watts linkage to control the rear end. Steel leaf springs were used for 1999, and the linkage was removed. The front and rear axle weights listed in Table 4-1 page 3 are within 10% accuracy.

Figure 5.3 shows the reason for the increase in payload from the nominal 700 pounds for the lead-acid Ranger to the nominal 1250 pounds the NiMH model. A single layer of 25 modules sits in the slightly modified tub, rather than the double layer of 39 lead-acid modules. The battery pack weight was reduced from 1915 pounds to 1318 pounds.

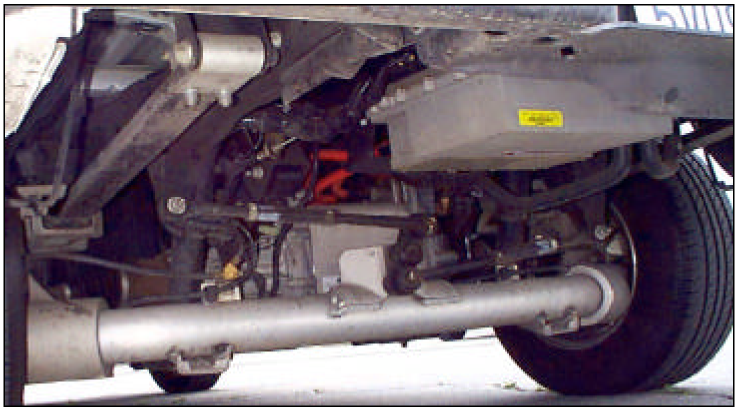

Figure 5.1.
Rear wheel configuration of 1998 Ranger EV showing De Dion rear suspension with polymer composite flat springs and Watts roll control linkage.

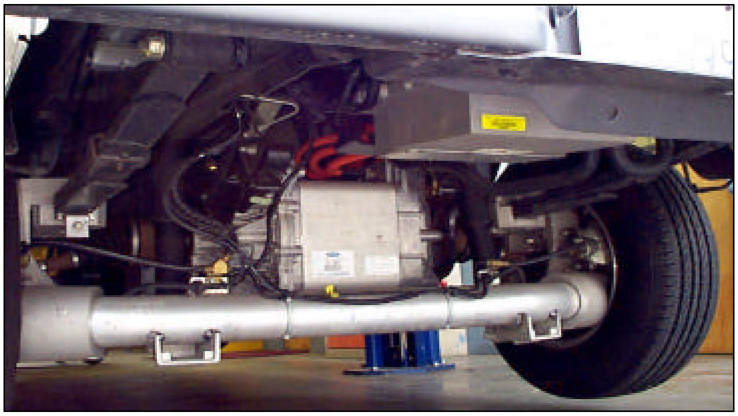

Figure 5.2.
For 1999 the Watts linkage was removed and steel leaf springs replaced the polymer springs.

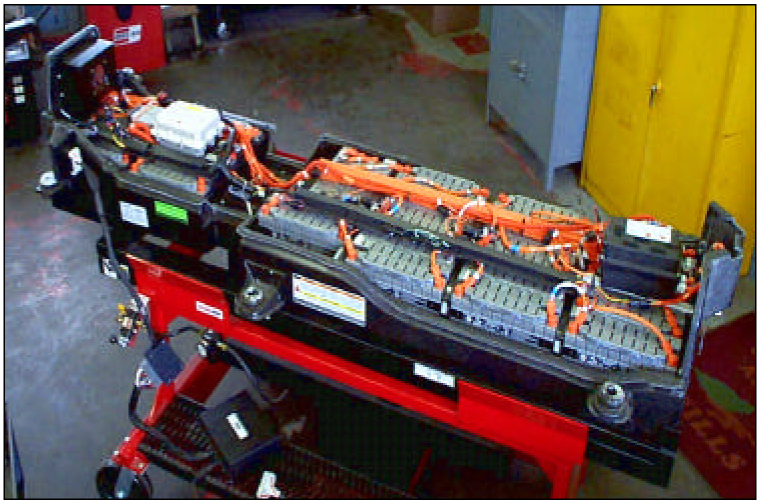

Figure 5.3.
Battery pack and tub from NiMH Ranger showing single layer of modules.

B. Range Tests

Range testing on the Urban and Freeway Pomona Loops subjects vehicles to "real world" challenges such as varying weather, heavy traffic and rough road conditions. Two Ford Ranger NiMH EV's were chosen from SCE's electric vehicle fleet. The first vehicle was tested in November 1998. Freeway testing was not completed in November 1998 which led to additional testing in March 1999. Testing took place according to the instructions in SCE's electric vehicle test procedure. The Ranger EVs were driven from full to empty in a safe manner that did not interfere with the flow of traffic. The vehicles were equipped with a low charge warning system to prevent damage to the battery pack. The first signal of low charge is a light that turns on in the instrument cluster. This light comes on at approximately 10% and starts blinking when the SOC reaches 0%. Range at stop condition was taken when the warning light began to flash.

The Ranger is equipped with two modes of driving, normal and econ. Econ-mode allows more regenerative braking than normal drive mode. Econ-mode also limits the vehicle top speed to 65 MPH as opposed to normal mode's 75 MPH. Econ-mode was used on the urban range tests and turned off for the freeway tests

Urban Range Tests

City driving took place on the Urban Pomona Loop (for a map of the Urban Loop see Appendix E, page 43). The Ranger EV was range tested at minimum and maximum payload, with and without accessories. Drives were done in econ-mode as recommended by the manufacturer.

At minimum payload the Ranger offered ample starting power from a dead stop. The low-end torque made driving at maximum payload as effortless as driving with the bed empty. Although there was no noticeable loss of power the vehicles range was affected. The cool ambient temperatures did not place a significant demand on the A/C system which could translate to lower ranges in periods of warmer weather.

The Ranger travelled an average of 80.6 miles at minimum payload with no accessories, but decreased to 75.3 with the added 1,000 lbs (Table 4-2).
The use of accessories (air conditioner, headlamps and radio) also lessened the range. A nine percent drop from 80.6 to 73.2 miles was noted. This is slightly more than the seven percent decrease between minimum and maximum payload. The ambient temperature in Pomona rose from the mid 50’s in the mornings to the high 70’s in the afternoons.

Freeway Range Tests

While power demand varies during urban driving, it stays relatively constant during freeway driving. During the freeway tests the speed was kept as close to 65 mph as traffic would allow. The access route for the freeway entailed about two miles of urban driving each way. Also, transitioning from the Pomona to the Orange Freeway required exiting, driving about one-half mile and then re-entering.
Freeway range testing is conducted with econ-mode off. Econ-mode limits the top speed at 65 MPH. Freeway driving on level roads with smooth traffic makes econ-mode uncomfortable. Scheduling conflicts did not allow completion of freeway testing in November of 1998.
The vehicle used for freeway testing was identical to the first one tested. The two trucks’ odometers were within 100 miles at the start of testing. The new truck mirrored the performance of the previous one in part due to the fact that it was part of the same group SCE had acquired in February 1998.
Driving at minimum payload with no accessories yielded a range of 76.5 miles. At maximum payload the range dropped 2.2% to 74.8 miles. With the air conditioner, headlights and radio the range dropped to 71.4 miles. With the added payload and accessories the range dropped another 3.6% to 68.8 miles (see Table 4-3 page 5).
The temperature of the air expelled by the air conditioner did not drop below the mid 60° F. This was most likely due to the cool ambient conditions during testing in March.

The results show that power demands from the accessories were still greater than any imposed by the extra payload.

C. State of Charge Meter Evaluation

The state of charge meter is located in front of the driver in the instrument cluster (Figure 4-4 page 7). The relationship between SOC displayed and miles driven, as seen in Figure 4-3 page 6, was not completely linear. Although not very linear the SOC meter helped to establish an estimate of charge remaining. The supplemental low charge light that comes on at 10% and starts flashing at 0% were very helpful in establishing a stop condition since the SOC meter had very few marks to determine how low the charge was.

Static evaluation of the state of charge meter was not performed because the meter is inactive during charging. Having and indication of state of charge during charging is very useful when the vehicle is needed before it is fully charged. It is recommended that this feature be added to future Ranger EV models.

Figure 5-4. Ranger at Pomona Raceway.

D. Acceleration, Braking, and Maximum Speed Tests

The acceleration and braking characteristics were tested at the Pomona Race Way. The track was dry, and the ambient temperature did not change much between the beginning (52° F), and ending of testing (55° F).

As shown in Table 4-4 page 7, the average acceleration time at 100% SOC was 5.21 seconds for 0 to 30 mph, and 9.73 seconds for 30 to 55 mph. The 0 to 60 mph average of four runs was 17.45 seconds. The average of two maximum speed runs was 77.5 mph. The vehicle was very stable under maximum acceleration.

The acceleration times were not very consistent throughout the vehicle's SOC range. At 60% SOC, the average time for 0-30 mph was 5.05 seconds, and 9.84 seconds for 30-55 mph. The last test was run at 20% SOC in order to complete the testing before the stop point. The 0-30 mph average time was 5.13 seconds, and the 30-55 mph average time was 11.02 seconds. Just eight hundredths of a second separated the average times at 100% and 20% SOC for 0-30 mph. The gap between 0-60 mph times was much more pronounced.

At 20% the Ranger recorded a 0-60 mph time of 19.91 seconds; an increase of 12.4% from the time recorded at 100% SOC. The lower acceleration rate is due to decreased available maximum power.

The average braking distance for 25-0 mph was 21.7 feet. The pedal feel, effort, and effectiveness were excellent. Stops were short, and the vehicle felt completely safe and stable. The ABS system worked very well, with almost no skidding noticed. During road testing in wet weather it was also noticed that it was very effective.

Figure 5-6. Ford Ranger EV front fascia with open charge port.

E. Charger Performance Test

The Ranger EV was charged with the on-board, conductive coupled charger using the EVSE (electric vehicle supply equipment) manufactured by EVI. The ICS-200 unit uses a generated voice to interact with the user and stores time and energy data for charging cycles. This unit, which interacts with the vehicle to provide power, has safety features including GFCI and tension sensors on the cables. When connected, the charger starts automatically.

A normal charge from empty to full for the NiMH batteries is estimated by Ford to take between 6-8 hours. However charge time can take as long as 10 hours for warmer or cooler battery packs. Ford recommends always connecting the vehicle to charge whenever it is not being driven. The average charging time, from approximately 0% to 100% SOC, for all tests, was about 7.25 hours.

As shown in Table 4-5 page 8, the peak instantaneous power demand was 5.444 kW, with the current at 23.09A and voltage at 236.6V. In terms of power quality, the performance of the charger was excellent. The true power factor was 1.00, the voltage total harmonic distortion (THD) was 1.7%, and the current total harmonic distortion (THD) was 3.6 % – well below limits.

The Institute of Electrical and Electronics Engineers (IEEE) 519-1992 standard, which limits harmonic emissions at the point of coupling between the utility and the consumer (considered to be at the meter), limits voltage THD to less than 5%. In general, voltage distortion mostly affects customer loads, while current distortion affects utility distribution systems in the form of power losses.

The power factor of 1.00 compares favorably for an IWC recommended minimum power factor of 0.98.

As seen in Figure 4-5 page 9, the Ranger's on-board charger was not charging correctly. The power dips are due to the faulty charger, which was eventually changed. The problem occurred throughout SCE's Ranger fleet, which led to some of the chargers being replaced.

The charger was monitored for an extended period of 24 hours. During this period the charger drew a steady amount of low-level energy which is used to cool the battery pack. The average power was 75 W, and the total "stand by" energy used was 4.173 AC kWh. According to Ford the stand-by energy will vary according to ambient temperature.

APPENDIX A

VEHICLE MANUFACTURER'S FACT SHEET

New for 1999, the Ranger Electric Vehicle Nickel-Metal Hydride

Dependable and Reliable - "Built Ford Tough"

The nickel-metal hydride (NiMH) Ranger EV is a practical, robust, light duty pick-up that balances performance, reliability and energy efficiency. Since the NiMH battery pack is lighter than the lead-acid version, the NiMH pick-up can carry an improved payload (up to 1,250lbs). Rear-wheel drive along with a rigid frame and suspension provide "Ford Tough" durability. With an attractive lease rate and a driving range of 65-85 miles, the NiMH Ranger EV can tackle a variety of real-world fleet applications.

Key Specifications

- Styleside Regular Cab 4x2 (112" wheelbase, 6' box)
- 90 horsepower; 140ft./lbs. Torque
- High-efficiency 3-phase AC electric motor/single speed transaxle
- 25 NiMH 12-volt modules; 300 volt system
- Range: 100 miles - estimated Federal Urban Driving Schedule (FUDS)*
- Energy Capacity Rating (FUDS): 28 KWH (25 KWH at 90% discharge)
- Payload: 1,250 lbs. (GVW: 5,350 lbs.)
- Zero-Emission Vehicle (ZEV) Certification - can be operated indoors as well as outdoors

Driving Range and Charging

The NiMH Ranger EV achieved a FUDS range of 100 miles @ 70° F w/o use of heater or air conditioning. The "Real World" range is approximately 65-85 miles, depending on climate and driving conditions. This range can decrease to 45 miles @ 45° F with full operation of the heater.

The vehicle can be fully charged in 6 to 8 hours depending on the ambient temperature; however, the use of opportunity charging during the day can significantly increase the range and use of the vehicle. Opportunity charging means keeping your Ranger EV "on plug" - charging whenever it's not in use. This type of charging will not harm the batteries. In fact, Ford recommends that the vehicle always be put on charge when not in use. This procedure will protect and extend battery life.

Charging is accomplished using safe and economical conductive charging infrastructure. The Power Control Station (PCS)[1] used with conductive charging is a separate piece of equipment necessary to charge the vehicle. It provides the link between the stationary electric power source and your Ranger EV. The PCS controls the power to the on-board vehicle charger and must be wired directly to a 208-240 volt, 32 amp continuous electric service source. Ford has elected to use conductive charging equipment because it is significantly less costly to purchase than the competing inductive charging equipment. Both conductive and inductive charging comply with SAE safety standards.

[1] The PCS and its installation are not included in the lease rate for the Ranger EV and must be individually contracted for by the vehicle customer. (The PCS may be included with the vehicle in a lease.) For a list of approved distributors for this equipment, please contact your Ford EV Dealer or call 1-800-ALT-FUEL

* NiMH Ranger EV FUDS testing to be completed in August, 1998

Ford ALTERNATIVE FUEL VEHICLES

▸Information Programs
▸Professional Fleet
▸Business Preferred
▸Specialty Vehicles
▾Alternative Fuel Vehicles
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•Ranger FFV
•Taurus FFV
•Contour Bi-Fuel NGV
•Crown Victoria NGV
•Econoline Bi-Fuel NGV
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Ranger Electric Vehicle Fuel Specifications (Lead-Acid)

New for 1999, NiMH Option

Warranted by Ford, the 1999 Ranger EV pickup incorporates many of the same best-in-class design features as the gasoline-powered Ranger, America's best-selling compact truck.

Battery Capacity:

- ✓ 23 kilowatt hours (18 kwh at 85% discharge)

Estimated Range:

- ✓ 77 miles metro/hwy.
  (Customer range is approximately 50 miles, depending on climate and driving conditions.)

Rated Top Speed:

- ✓ 75 mph in drive mode (governed)
- ✓ 65 mph in economy mode

0-50 Miles Per Hour:

- ✓ 12.5 seconds

Vehicle Features:

- ✓ Short wheelbase, regular-cab, styleside body style
- ✓ 90 hp, high-efficiency, 3-phase AC motor
- ✓ Single-speed, rear-wheel-drive transmission
- ✓ 4-wheel anti-lock brakes and regenerative braking
- ✓ 700-pound payload
- ✓ Dual air bags
- ✓ Electro-hydraulic power steering
- ✓ On-board charging
- ✓ Climate control
- ✓ Lightweight aluminum wheels
- ✓ Low-rolling-resistance tires

Ranger Electric Vehicle Fuel Specifications (NiMH)

New for 1999, Ford is offering the Ranger Electric Vehicle with a Nickel Metal Hydride (NiMH) option. Available in California only, the NiMH battery pack is lighter than the lead acid version. The NiMH Ranger EV can also carry an improved payload (up to 1250 lbs).

Specifications:

- ✓ 25 NiMH 12-volt Modules; 300 volt system
- ✓ Payload: 1,250 lbs. (GVW 5,350 lbs.)

Estimated Range:

- ✓ 90 miles (Est.) metro/hwy.
  (Customer range is approximately 65-85 miles, depending on climate and driving conditions. Range may decrease to 45 miles @ 45°F with full operation of heater).

Previous

APPENDIX B

BATTERY FACT SHEETS

主要諸元 Principal specifications

形式 Type	MH6-100
公称電圧 Nominal Voltage	12V
公称容量 Nominal Capacity	100Ah
外形寸法 Dimensions	W116×L388×H175
重量 Weight	17.2kg
エネルギー密度 Specific Energy	70Wh/kg

EV用ニッケル·水素蓄電池周辺機器
Peripherals for Ni/Metal-Hydride Battery for EVs

当社は、高性能ニッケル·水素蓄電池の特性をフルに発揮する電池マネジメントシステム及び充電器をセットにして、ユーザーに提供します。

Matsushita Battery provides users with the cha er and the battery management system wh maximize the performance of the Ni/MH batter

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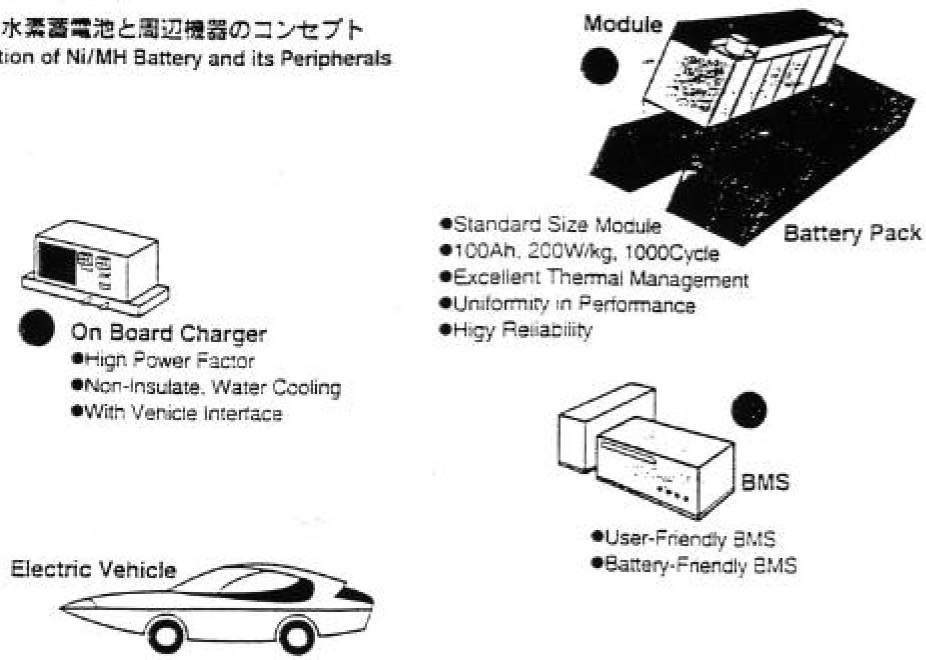
ニッケル·水素蓄電池と周辺機器のコンセプト
Configuration of Ni/MH Battery and its Peripherals



EV用ニッケル・水素蓄電池
Ni/Metal-Hydride Battery for Electric Vehicles

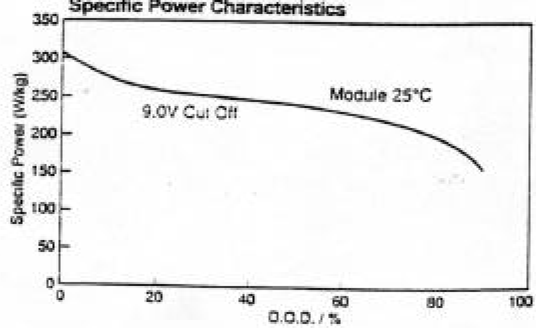
「あらゆる生命の源、母なる地球のためにいま私たちができること」松下電池工業はそんな視点から、地球環境を大切に考えた色々な活動を推進しています。
排気ガスはもちろん騒音も殆どなく、多様なエネルギー源による電気を動力源とする電気自動車(EV)が次世代の乗り物として注目を集めています。より豊かで快適な未来の創造に向けて松下電池工業は総合技術力を結集し、本格的EV用の蓄電池として、人と環境に優しい、EV用ニッケル・水素蓄電池を開発し、'98年に向けて量産化技術の開発を進めています。

"Doing what we can to protect Mother Earth, the source of all life." Based on this concept, we at Matsushita Battery Industrial Company are developing technologies and products that help protect the global environment.
An Electric Vehicle, or EV, has become the focus of attention as a next-generation vehicle, one which is powered by electricity whose energy supply is virtually unlimited, and one which generates virtually no exhaust or noise.
To help achieve a more prosperous, comfortable society, Matsushita Battery has applied its comprehensive technologies toward the mass production of Ni/MH batteries which will serve as a power source for EVs by 1998.

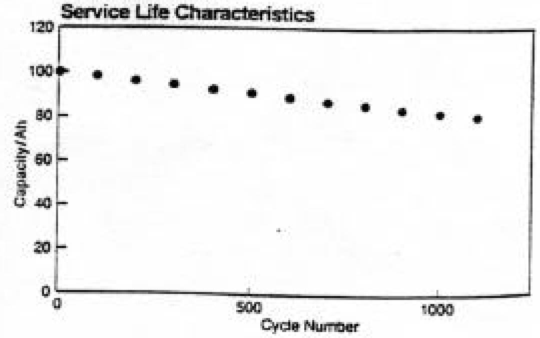
EV用ニッケル・水素蓄電池の特長
Characteristics of Ni/Metal-Hydride Battery for EVs

高エネルギー密度 High Specific Energy/ Energy Density	従来の電池では、一充電走行距離が100km未満と短く実用上課題がありました。 この電池の使用により実走行で200km程度の走行が可能になりました。	With conventional storage batteries, there are practical problems such as a car can only run up to 100 km before its battery must be re-charged. With this battery, however, up to 200 km per charge is now possible.
高出力 High Specific Power	EVの加速、登坂性能は電池の出力特性に左右されます。この電池を使用すれば最後まで走行中安定した出力が得られます。	An electric vehicle's acceleration and performance on uphill grades depend on the power output characteristics of the battery. With this battery, stable power output is maintained throughout the life of the charge.
長寿命 Long Life	従来の電池では、何回か電池交換が必要です。 この電池は1000回以上の使用が可能で、殆ど交換の必要がありません。	Existing storage batteries have to be replaced frequently. This battery can be used more than 1,000 times, however, so it rarely needs replacing.
メンテナンスフリー 高安全性 Maintenance-Free and Safety	この電池は密閉形でメンテナンスは不要です。 また、安全性について、さまざまな使用条件を予想した確認と改良を行っています。	This battery is sealed to provide maintenance-free use. Furthermore, we at Panasonic have designed the battery to operate safely under a variety of conditions.
環境に優しく リサイクルが可能 Environmentally-Friendly and Recyclable	使用材料はリサイクルが可能で貴重な地球資源を有効に活用できます。	All materials are recyclable to maximize the use of precious resources.

Ni/MH蓄電池の出力特性の一例
Specific Power Characteristics



寿命特性の一例
Service Life Characteristics



APPENDIX C

RANGE TEST DATA SHEETS

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/06/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	190 lb	UR1	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:45 AM	343	100%			NA	NA	T>10 min
Stop	11:45 AM	422	0%			64 F	NA	NA
Net	3:00	79	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
13	75%		
36	50%		Last loop came back on Arrow Highway to Euclid to Holt.
61	25%		Low charge light on at 71.0 miles.
70	0%		Low charge light started flashing at 78.5 miles.
79.1	stop		End drive.

Accessories: Radio

Drive / Regen: Econ-mode

Comments:

Ride, Braking, Good ride, excellent braking.

Handling Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/06/98	10:16 AM	2295	0	NA	NA	
Stop	11/09/98	7:26 PM	2335	31.15	NA	NA	
Net			40	31.15			

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/09/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	190 lb	UR1	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	9:00 AM	422	100%			54.5	NA	T>10 min
Stop	12:15 PM	505	0%			70.5	NA	NA
Net	3:15	83	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
14.5	75%		
38	50%		Circled EVTC at 80 miles.
64.5	25%		Low charge light on at 74.4 miles.
74	0%		Low charge light started flashing at 82.7 miles.
83.3	stop		End drive.

Accessories: Radio

Drive / Regen: Econ-mode

Comments:

Ride, Braking, Good ride, excellent braking.

Handling Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/09/98	12:37 PM	2335	0	NA	NA	68.1
Stop			2368	32.33	NA	NA	
Net			33	32.33			

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/10/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	190 lb	UR2	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:30 AM	505	100%			58	NA	T>10 min
Stop	11:30 AM	580	0%			70.2	NA	NA
Net	3:00	75	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
13	75%		
33	50%		Circled EVTC at 73 miles.
58	25%		Low charge light on at 69.7 miles.
68.5	0%		Low charge light started flashing at 74.4 miles.
74.4	stop		End drive.

Accessories: Radio, A/C, headlights on.

Drive / Regen: Econ-mode

Comments:

Ride, Braking, Good ride, excellent braking.

Handling Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/10/98	12:05 PM	2368	0	NA	NA	71.6
Stop			2405	31.76	NA	NA	
Net			37	31.76			

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/12/98	A Ly	Dry						
Vehicle	VIN	Tire Press	Payload	Test	Speed	AC meter#	DC meter#	Ah meter#
Ranger	A00021	50 psi	190 lb	UR2	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:30 AM	580	100%			56.2	52.8	T>10 min
Stop	11:30 AM	653	0%			68.5	73.9	64.4
Net	3:00	73	-100%					

Distance	State of Charge		Notes/Deviation
Miles	Veh meter	SCE meter	
0	100%		
13	75%		
31	50%		Last loop came back on Mountain Ave. Circles EVTC at 63 miles.
54	25%		Low charge light on at 68.4 miles.
68	0%		Low charge light started flashing at 72.1 miles.
73	stop		End drive.

Accessories: Radio, A/C, headlights on.

Drive / Regen: Econ-mode

Comments:

Ride, Braking, Good ride, excellent braking.

Handling Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/12/98	12:00 PM	2405	0	NA	NA	68.5
Stop	11/12/98	2:08 PM	2415	22.83	NA	NA	
Net		2:08 AM	10	22.83			

Comments: Charger stopped at 18:00 1725 kWh. Charge to 25%. Restarted 11/13 8:38 End charge at 12:39.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/18/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	1190 lb	UR3	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:00 AM	735	100%			59.5	NA	T>10 min
Stop	1:00 PM	811	0%			73.4	NA	NA
Net	3:00	76	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
10	75%		
34	50%		Last loop turned back at Vineyard.
55.5	25%		Low charge light on at 70.5 miles.
70	0%		Low charge light started flashing at 75.5 miles. Circled EVTC at 73.8 miles.
75.9	stop		End drive.

Accessories: Radio.
Drive / Regen: Econ-mode.
Comments:
Ride, Braking, Good ride, excellent braking.
Handling Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/18/98	1:07 PM	2483	0	1760	NA	73.4
Stop			2515		1788	NA	
Net			32	0	28		

Comments: Stopeed 1760 dc kWh in (11/18/98) 10:00 a.m.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/19/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	1220	UR3	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:30 AM	811	100%			54.1	NA	T>10 min
Stop	11:30 AM	886	0%			76.8	NA	NA
Net	3:00	75	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
11	75%		
34	50%		Last loop turned back at Vineyard.
53.5	25%		Low charge light on at 69.5 miles.
69	0%		Low charge light started flashing at 75 miles. Circled EVTC at 73 miles.
75.5	stop		End drive.

Accessories: Radio.

Drive / Regen: Econ-mode.

Comments:

Ride, Braking, Handling Good ride, excellent braking. Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/19/98	11:35 AM	2515	0	1788	NA	78.8
Stop			2551	33.93	1819	NA	
Net			36	33.93	31		

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/20/99	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	1220	UR4	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:30 AM	886	100%			58.5	58.6	T>10 min
Stop	11:00 AM	949	0%			77.4	78.3	68
Net	2:30	63	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
10	75%		
30.5	50%		
48.5	25%		Low charge light on at 55 miles.
54.5	0%		Low charge light started flashing at 61.4 miles. Circled EVTC at 60.5 miles.
63	stop		End drive.

Accessories: Radio, A/C, headlights on.

Drive / Regen: Econ-mode.

<u>Comments:</u>

Ride, Braking, Handling Good ride, excellent braking. Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	NA	NA	NA	0	NA	NA	NA
Stop	11/23/98	8:35 AM	2593	32	1853	NA	57
Net				32			

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
11/23/98	A Ly	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
Ranger	A00021	50 psi	1220	UR4	25-55 mph	223 620	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	8:30 AM	949	100%			66.9	64.8	T>10 min
Stop	11:15 AM	1016	0%			73	77.9	69.4
Net	2:45	67	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
11	75%		
29.5	50%		Last loop turned back on San Anotnio ave.
48	25%		Low charge light on at 59.9 miles.
59	0%		Low charge light started flashing at 64 miles.
67.9	stop		Power limit light on at 64 miles. End drive.

Accessories: Radio, A/C, headlights on.

Drive / Regen: Econ-mode.

Comments:

Ride, Braking, Handling Good ride, excellent braking. Good handling.

Charger	Serial No.						
ICS-200	EVC-007						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	11/23/98	11:21 AM	2593	0	1853	NA	NA
Stop			2628	33.9	1883	NA	NA
Net			35	33.9			

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
03/10/99	Sanchez	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
23639	A14869	50 psi	150 lbs	FW1	45-65 mph	01 223 624	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:25 AM	696	100%	NA	NA	64.4 F	NA	T>10 min
Stop	12:00 PM	774	0%	NA	NA	59.4 F	NA	NA
Net	1:35	78	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
20.4	75%		
41.5	50%		Traffic slowed down to 45 mph for five miles.
59.9	25%		Low charge light on at 71.5 miles.
78.2	0%		Low charge light started flashing at 76.5 miles.

Accessories: Radio.

Drive / Regen: No regen

Comments:

Ride, Braking, Handling Rough ride. Good brakes. Fair handling. High center of gravity lowers cornerning speed.

Charger	Serial No.						
EVC-007	1223624						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	03/10/99	12:25 PM	7637	NA	NA	NA	NA
Stop			7670	NA	NA	NA	NA
Net			33				

Comments: 31.99 kWh used per BMI

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
03/11/99	Sanchez	Wet						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
23639	A14869	50	150 lbs	FW2	50-65 mph	01 223 624	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:30 AM	774	100%	NA	NA	52.7	62.0 F	T>10 min
Stop	12:05 PM	851	0%	NA	NA	52	69.4 F	69.9 F
Net	1:35	77	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
18.9	75%		
39.7	50%		
58.4	25%		Low charge light on at 68.6 miles.
77.1	0%		Low charge light started flashing at 71.4 miles.

Accessories: Radio, Air Conditioning, Headlamps, windshield wipers.

Drive / Regen: No regen

Comments:

Ride, Braking, Handling Rough ride. Good brakes. Fair handling.

Charger	Serial No.						
EVC-007	1223624						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	03/11/99	12:10 PM	7670	NA	NA	NA	NA
Stop			7705	NA	NA	NA	NA
Net			35				

Comments:

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
03/12/99	A. Mendoza	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
23639	A14869	50	1190	FW3	50-65	01 223 624	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	11:00 AM	851	100%	NA	NA	73 F	NA	T>10 min
Stop	12:35 PM	928	0%	NA	NA	74 F	NA	NA
Net	1:35	77	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
17.8	75%		
35.8	50%		Low charge light on at 69.5 miles.
58.5	25%		Low charge light started flashing at 72.3 miles.
76.8	0%		Power limit light on at 74.8 miles.
			Mile 76.8, end of drive.

Accessories: Radio.

Drive / Regen: No regen

Comments:

Ride, Braking, Handling

Charger	Serial No.						
EVC-007	1223624						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	03/12/99	1:35 PM	7705	NA	NA	NA	NA
Stop			7757	NA	NA	NA	NA
Net			52				

Comments: 36.85 kWh used per BMI.

POMONA DRIVING TEST DATA

Date	Driver	Road Cond						
03/15/99	Sanchez	Dry						
Vehicle	**VIN**	**Tire Press**	**Payload**	**Test**	**Speed**	**AC meter#**	**DC meter#**	**Ah meter#**
23639	A14869	50 psi	1190	FW4	45-65 mph	01 223 624	NA	NA

	Time	Odom	% SOC	DC Ah	DC kWh	Amb temp	A/C temp	
Start	10:45 AM	928	100%	NA	NA	51.3 F	67.6 F	T>10 min
Stop	12:15 PM	997	0%	NA	NA	51.6 F	70.1F	69.6 F
Net	1:30	69	-100%					

Distance	State of Charge		Notes/Deviation
Miles	**Veh meter**	**SCE meter**	
0	100%		
18.5	75%		
36.2	50%		Low charge light on at 65.5 miles.
53	25%		Low charge light started flashing at 68.8 miles.
69.2	0%		End drive.

Accessories: Radio, Headlamps and Air Conditioner.

Drive / Regen: No regen.

Comments:

Ride, Braking, Rough ride, good brakes.

Handling Fair handling. No compromise in the rain.

Charger	Serial No.						
EVC-007	1223624						
Charging	**Date**	**Time**	**AC kWh in**	**BMI kWh in**	**DC kWh in**	**DC Ah in**	**Temp**
Start	03/15/99	2:30 PM	7757	NA	NA	NA	NA
Stop	03/16/99	8:34 AM	7791	NA	NA	NA	NA
Net			34				

Comments: Steady rain. 33.89 kWh used per ABB meter.

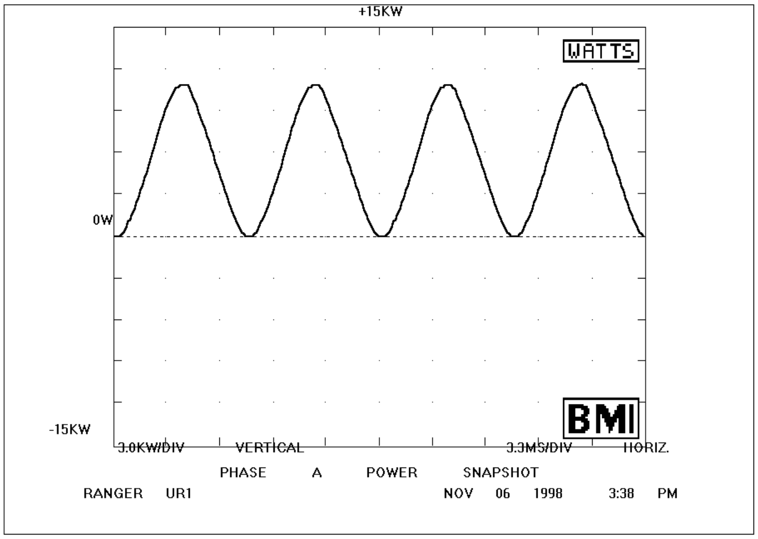
APPENDIX D

BMI POWER PROFILER GRAPHICAL DATA

Snapshots at Full Power

PHASE A POWER SNAPSHOT   3:38:00 PM

INSTANTANEOUS POWER: 5.444 kW



PHASE A POWER SPECTRUM   3:38:29 PM

Power: 5.444 kW

Fundamental freq: 60.0 Hz

HARM	POWER	HARM	POWER
FUND	+5.444 kW	2nd	
3rd	-0.19 W	4th	
5th	+1.90 W	6th	
7th	-0.01 W	8th	
9th	+0.01 W	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		40th	
41st	-0.01 W	42nd	
43rd		44th	
45th		46th	
47th	-0.01 W	48th	
49th		50th	
ODD	1.67 W	EVEN	0.00 W

THP: 1.67 W

POWER FACTOR SNAPSHOT   3:38:00 PM

Phase A-N: 5.444 kW

Phase A-N: 5.462 kVA

Phase A-N: 392.3 VAR

Phase A-N: 1.00 PF

Phase A-N: 1.00 dPF

HARMONICS SNAPSHOT   3:38:00 PM

Fundamental freq: 60.0 Hz

Phase A-N Volts: 1.7% THD

Phase A Current: 3.6% THD

VOLTAGE & CURRENT SNAPSHOT   3:38:38 PM

Phase A-N: 236.6 Vrms,   0°(ref)
Neut-Gnd: 119.1 Vrms,   89°

Phase A: 23.09 A rms,   -4°

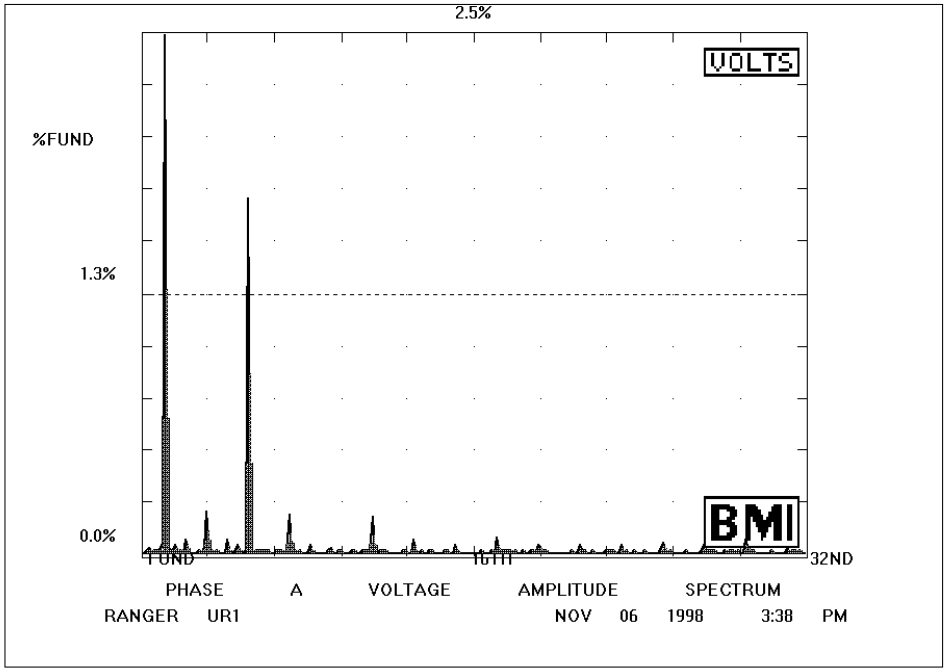
Fundamental volts: 236.6 Vrms

Fundamental freq: 60.0 Hz

HARM	SINE PCT	PHASE	HARM	SINE PCT	PHASE
FUND	100.0%	0°	2nd		
3rd	0.2%	-152°	4th		
5th	1.7%	43°	6th		
7th	0.2%	93°	8th		
9th			10th		
11th	0.2%	129°	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 1.8% EVEN 0.1%

THD: 1.7%



PHASE A CURRENT SPECTRUM 3:38:15 PM

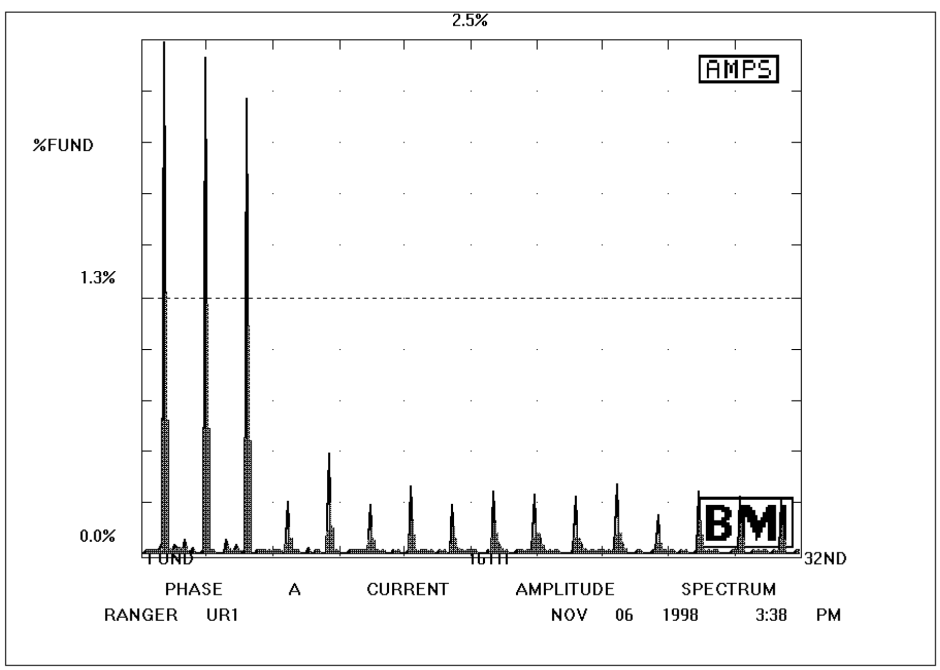
Fundamental amps: 23.07 A rms

Fundamental freq: 60.0 Hz

HARM	SINE PCT	PHASE	HARM	SINE PCT	PHASE
FUND	100.0%	-4°	2nd		
3rd	2.4%	-18°	4th		
5th	2.2%	19°	6th		
7th	0.3%	-8°	8th		
9th	0.5%	-30°	10th		
11th	0.2%	-139°	12th		
13th	0.3%	-64°	14th		
15th	0.2%	-116°	16th		
17th	0.3%	-85°	18th		
19th	0.3%	-115°	20th		
21st	0.3%	-93°	22nd		
23rd	0.3%	-108°	24th		
25th	0.2%	-118°	26th		
27th	0.3%	-108°	28th		
29th	0.3%	-145°	30th		
31st	0.3%	-113°	32nd		
33rd	0.3%	-133°	34th		
35th	0.2%	-146°	36th		
37th	0.1%	-139°	38th		
39th	0.3%	-150°	40th		
41st	0.1%	-177°	42nd		
43rd	0.2%	-163°	44th		
45th	0.2%	-169°	46th		
47th	0.2%	-172°	48th		
49th	0.2%	-163°	50th		

ODD 3.5% EVEN 0.1%

THD: 3.6%

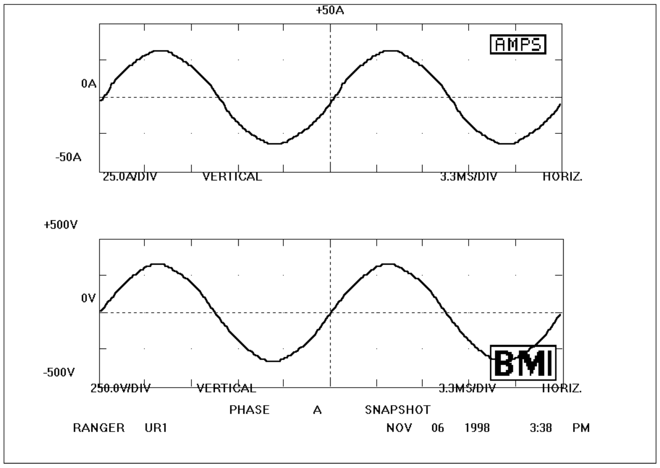


PHASE A SNAPSHOT 3:38:41 PM

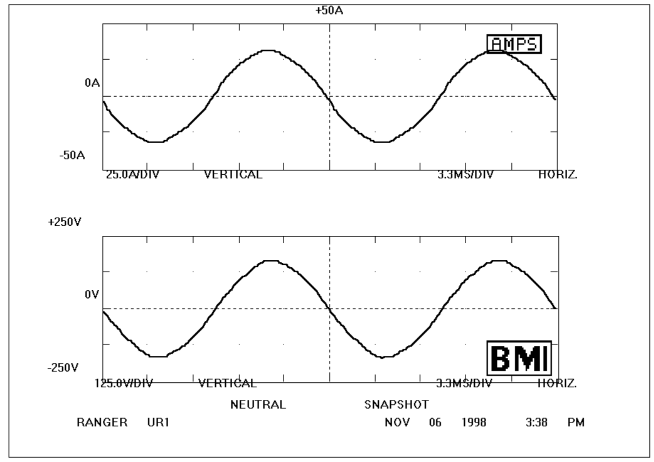
Phase A-N VOLTAGE: 236.6 Vrms
1.4 Crest Factor
1.1 Form Factor

Phase A CURRENT: 23.09 A rms
1.4 Crest Factor
1.1 Form Factor

CURRENT LAGS VOLTAGE BY 4°(1.00 dPF)



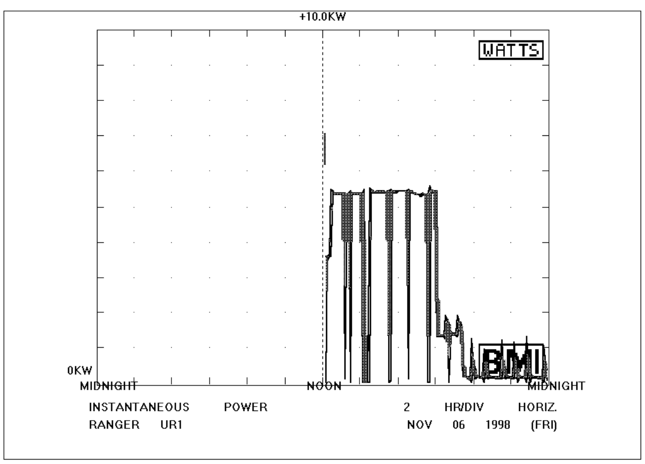
Neut-Gnd VOLTAGE: 119.1 Vrms
1.4 Crest Factor
1.1 Form Factor



CUMULATIVE PROFILES – 24 HOURS

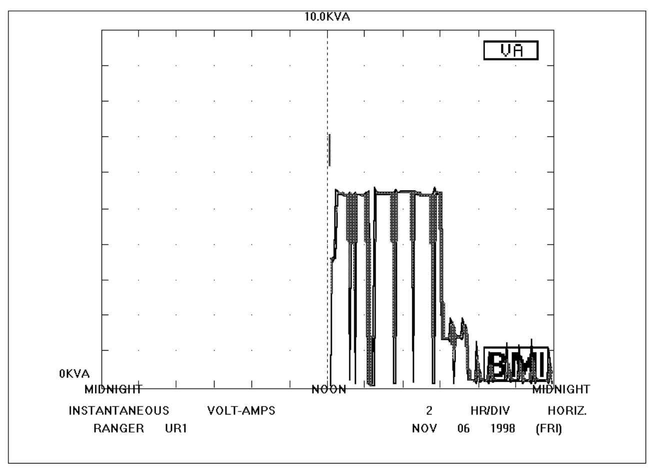
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 5.6 kW, 5:39 PM
MIN: 0.0 kW, 12:08 PM

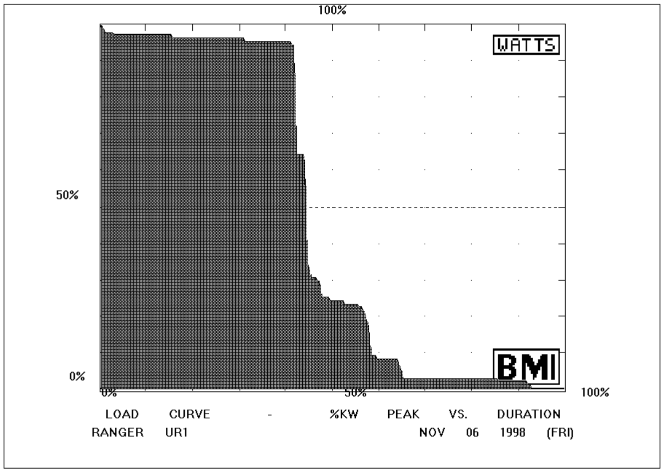


FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 5.6 kVA, 5:39 PM
MIN: 0.0 kVA, 12:08 PM



FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)



TOTAL POWER CONSUMPTION 12:00:35 AM

FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

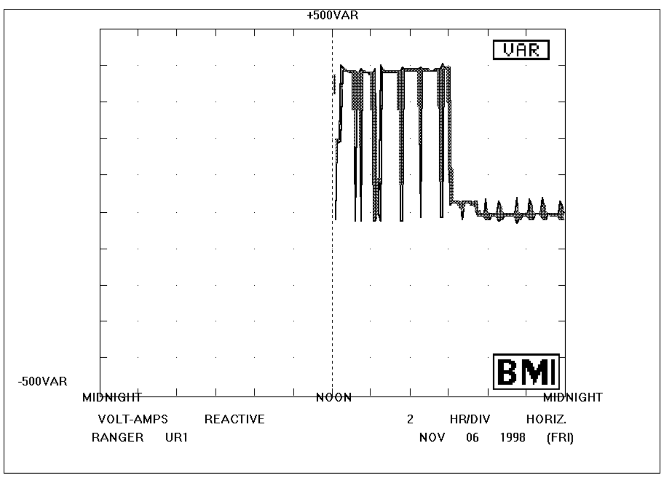
FLAT RATE: Cost: $ 0.060/kWh
Cost: $ 0.000/kWpk

BILLING DEMAND:
5.453 kW Pk Today
5.453 kW Pk Accumulated
$ 0.502 Today
$ -32.23 Accumulated
CONSUMPTION:
31.15 kWh Today
31.15 kWh Accumulated
$ 1.869 Today
$ 1.869 Accumulated

17.32 kQh Today
2.016 kVARh Today

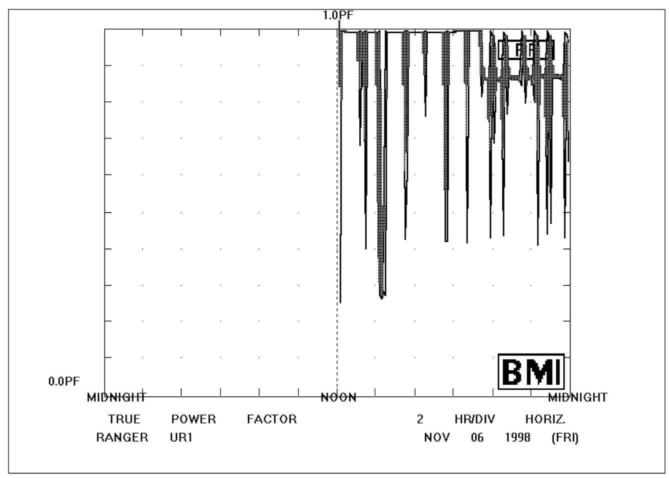
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 408.7 VAR, 5:39 PM
MIN: -28.9 VAR, 9:30 PM



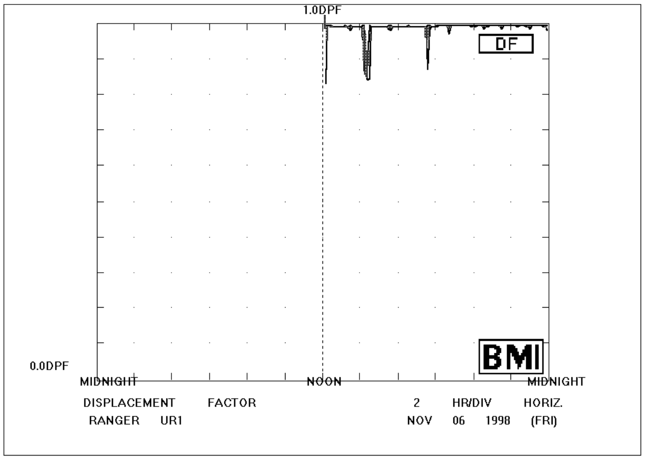
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 1.00 PF, 6:03 PM
MIN: 0.25 PF, 12:08 PM



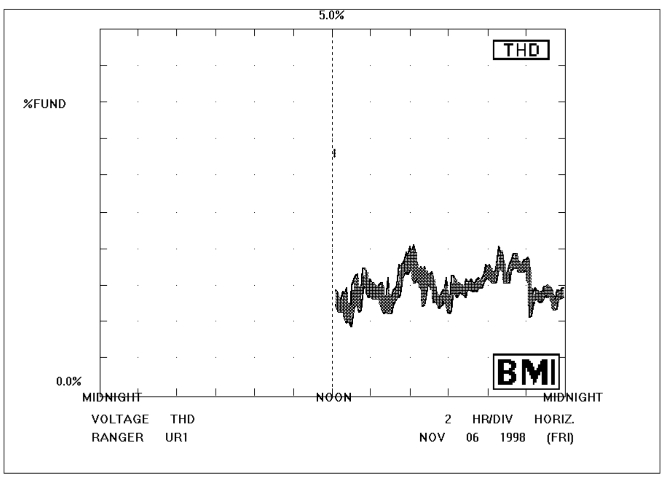
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 1.00 dPF, 2:29 PM
MIN: 0.84 dPF, 12:08 PM



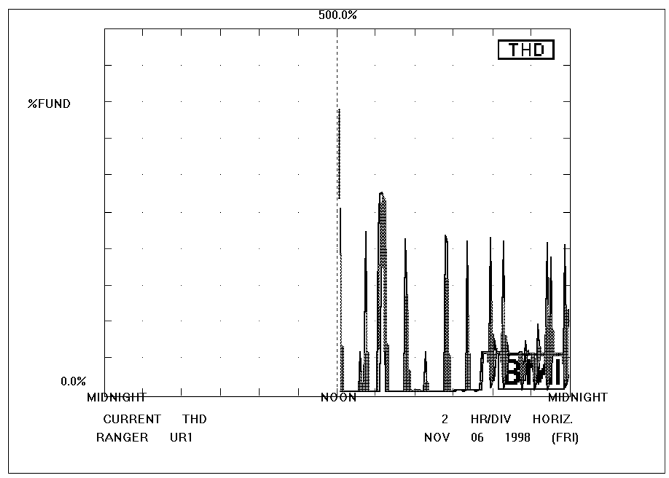
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 2.1% THD, 4:12 PM
MIN: 0.9% THD, 12:56 PM



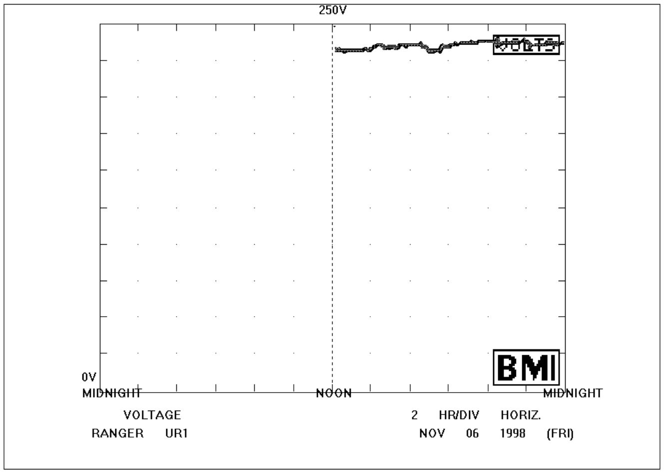
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A:
MAX: 278.7% THD, 2:16 PM
MIN: 2.7% THD, 6:03 PM



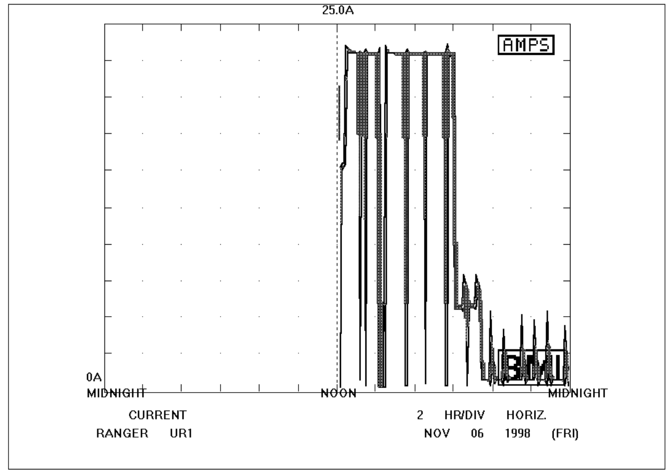
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A-N:
MAX: 242.4 V, 8:32 PM
MIN: 231.3 V, 5:12 PM



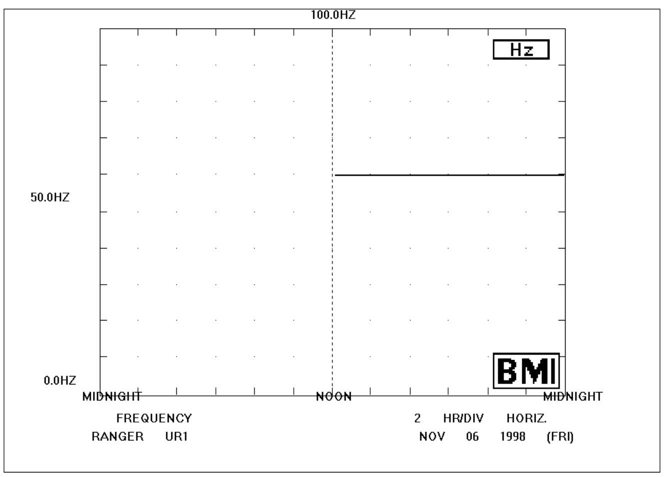
FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

Phase A:
MAX: 23.7 A, 5:39 PM
MIN: 0.1 A, 12:08 PM



FROM: MIDNIGHT Nov 05 1998 (Thu)
To: MIDNIGHT Nov 06 1998 (Fri)

MAX: 60.1 Hz, 1:15 PM
MIN: 59.9 Hz, 9:03 PM



APPENDIX E

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

TABLE OF 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.

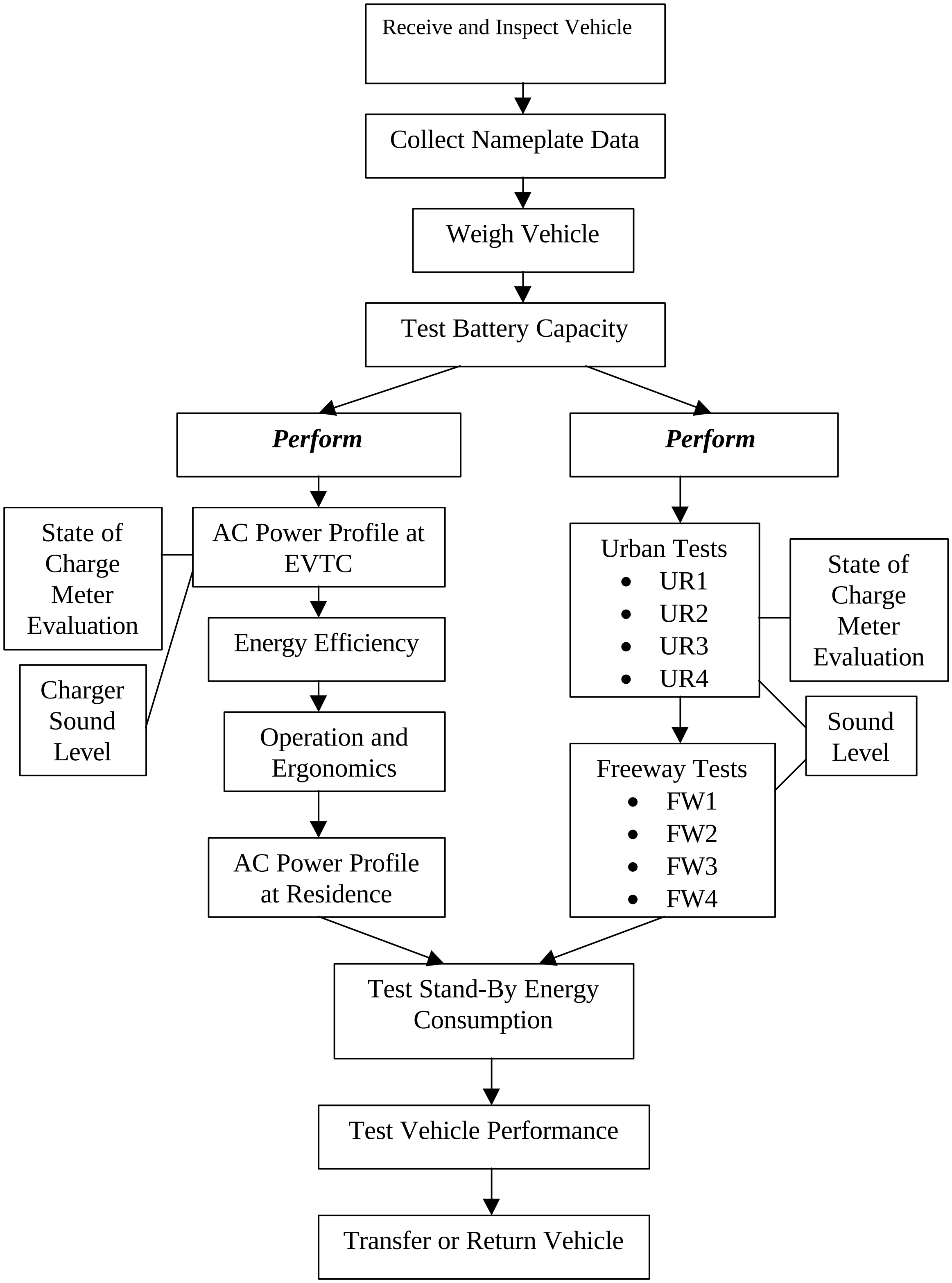
Range tests under different vehicle conditions no longer always have predictable results. Automatic climate controls limit air conditioner power on cool days, thus conserving battery energy and increasing range. The battery pack and the output side of the charger may no longer be readily accessible; 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 34). 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 36) 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.

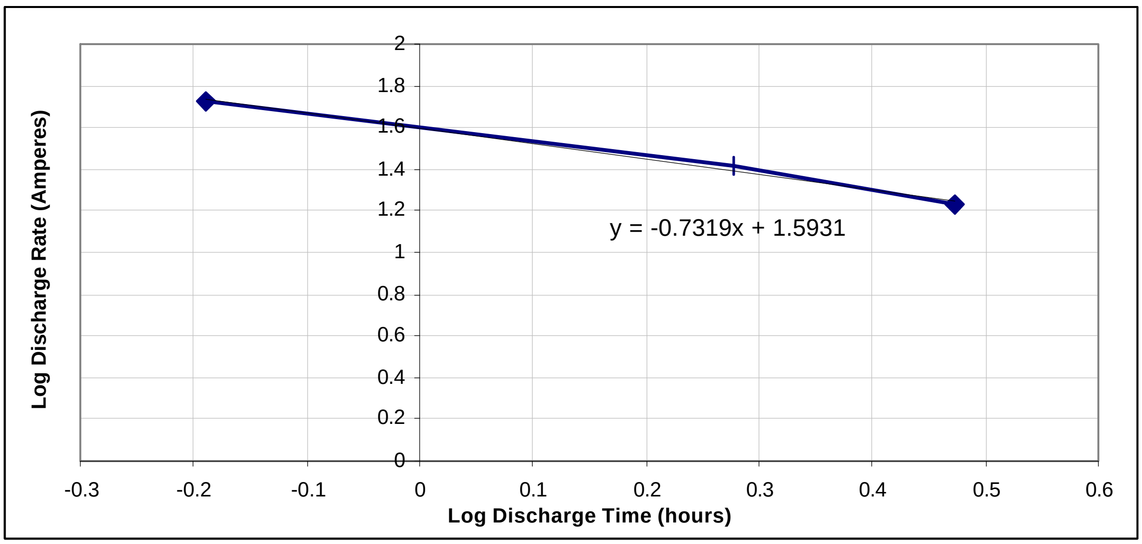


Figure 3-1. Sample Peukert Curve.

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 31). 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.

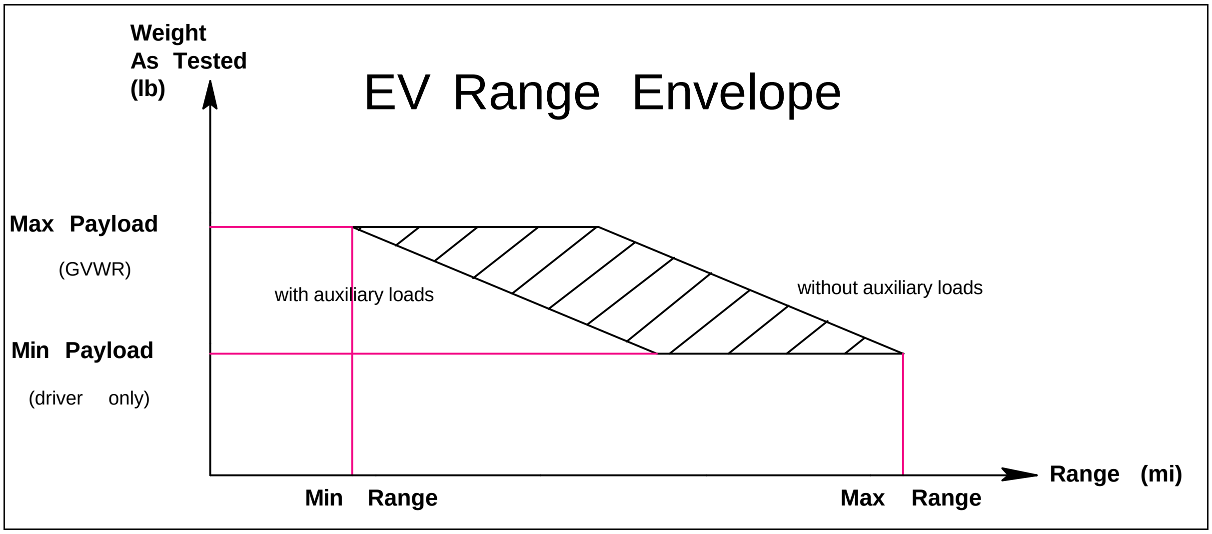


Figure 3-2. Range Envelope.

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 35). 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:

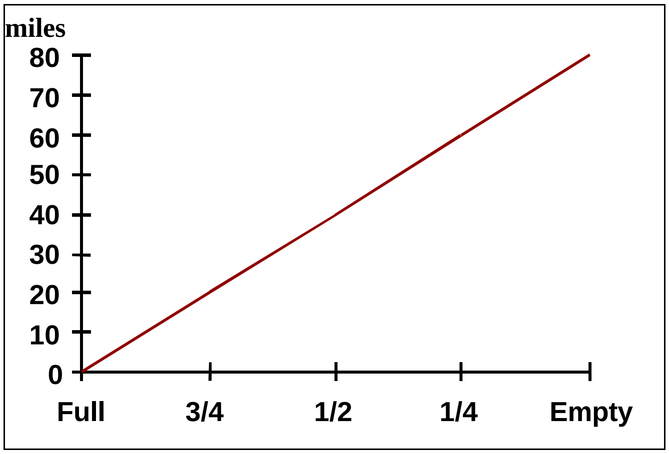


Figure 3-3. State of Charge Meter Evaluation.

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).

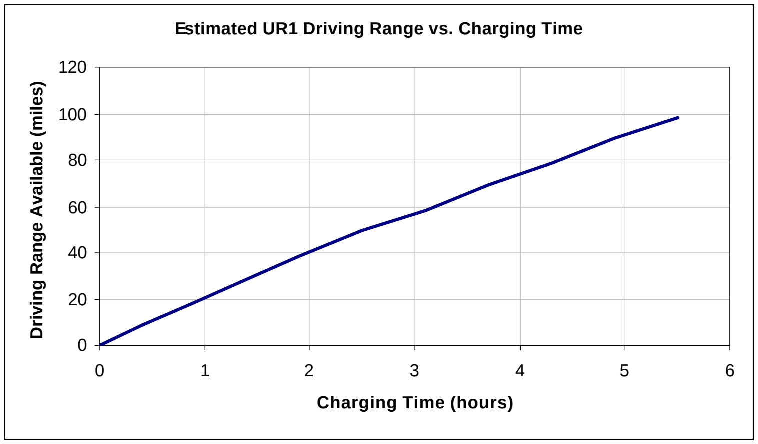


Figure 3-4. Sample plot of estimated range versus charging time.

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 33): 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 32).

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).

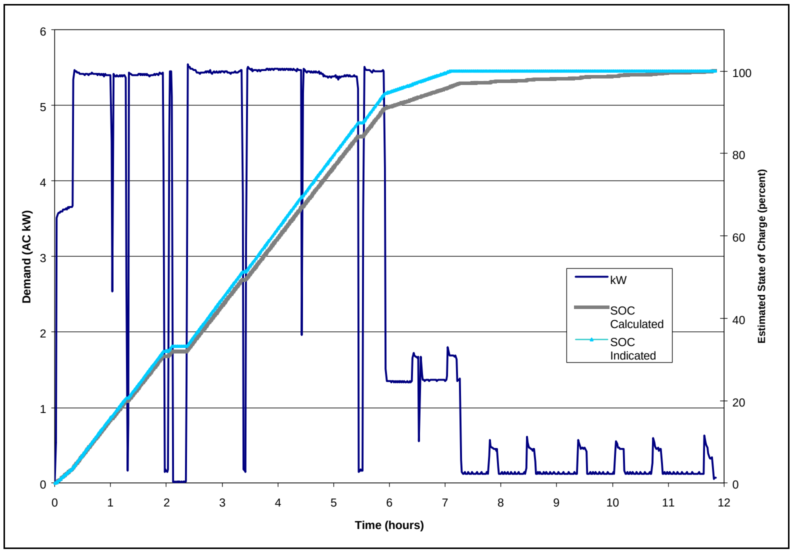


Figure 3-5. Sample AC charging profile plots.

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

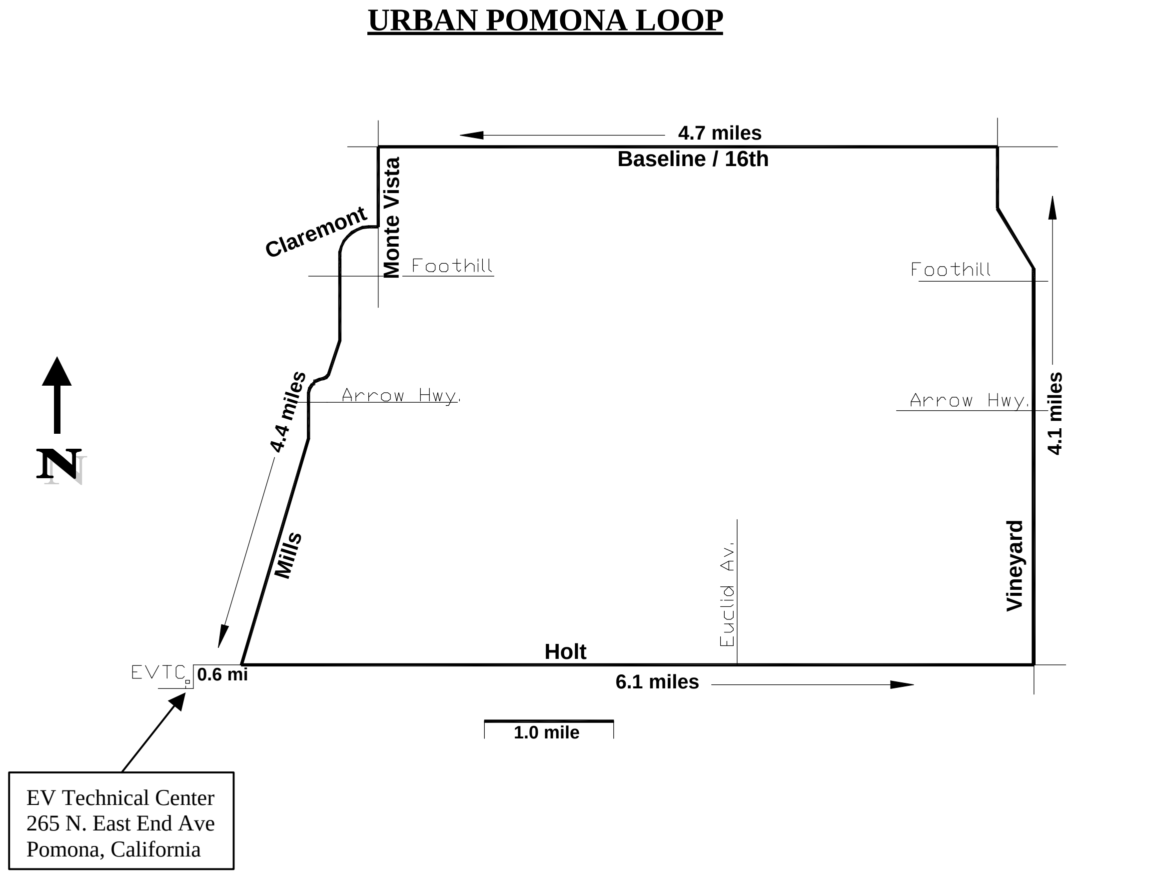
EV Performance Characterization Testing Schedule

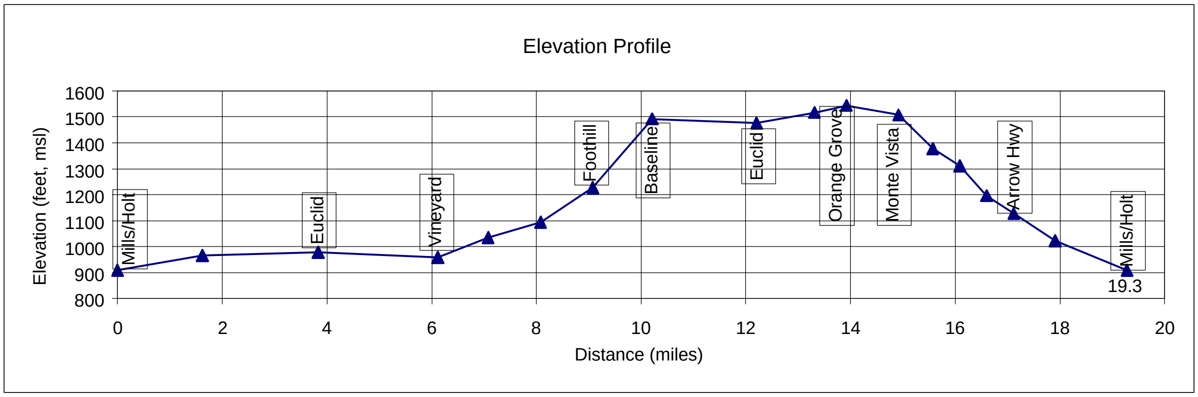
		Duration (days)
1.	Nomenclature Data Collection	½
2.	Weight Documentation - Curb (Front, Rear, Total) - GVWR (Front, Rear, Total)	½
3.	Battery Capacity Test	4
4.	Urban Range Tests - Distance per charge - AC kWh/mile - DC kWh/mile	8
5.	Freeway Range Tests - Distance per charge - AC kWh/mile - DC kWh/mile	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 - Tabulated Data

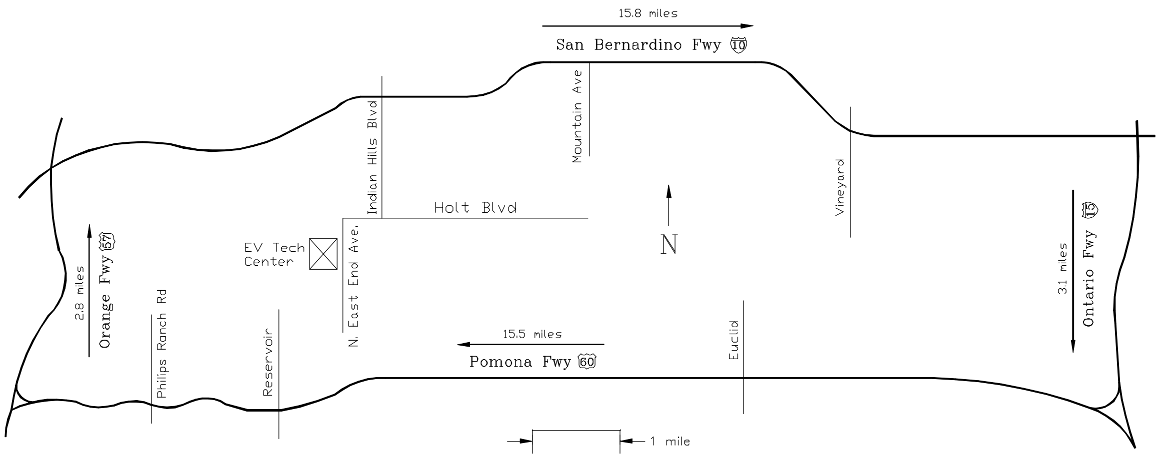
Stop No.	Distance from Start (miles)	Type	Distance from Previous stop	Comments
0	0.00	light	0.00	East End & Holt
1	0.10	light	0.10	
2	0.15	light	0.05	Mills & Holt
3	0.80	light	0.65	
4	1.30	light	0.50	
5	1.80	light	0.50	
6	2.30	light	0.50	
7	2.90	light	0.60	
8	3.50	light	0.60	
9	3.70	light	0.20	
10	4.00	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	

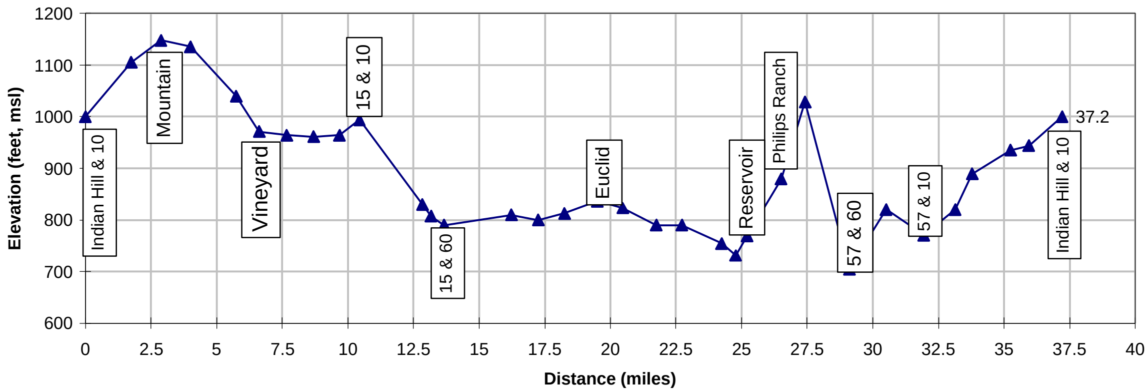
42	15.20	light	1.10	Baseline & Padua
43	16.30	light	1.10	
44	16.80	light	0.50	
45	17.10	sign	0.30	
46	17.40	light	0.30	
47	17.60	sign	0.20	
48	18.60	light	1.00	
49	18.70	sign	0.10	
50	19.00	sign	0.30	
51	19.30	light	0.30	
52	19.50	light	0.20	Holt & Mills
53	19.60	light	0.10	
54	19.80	light	0.20	Holt & East End

MCW: ttt
9/23/92

Freeway Loop Map

FREEWAY POMONA LOOP





EVTC 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

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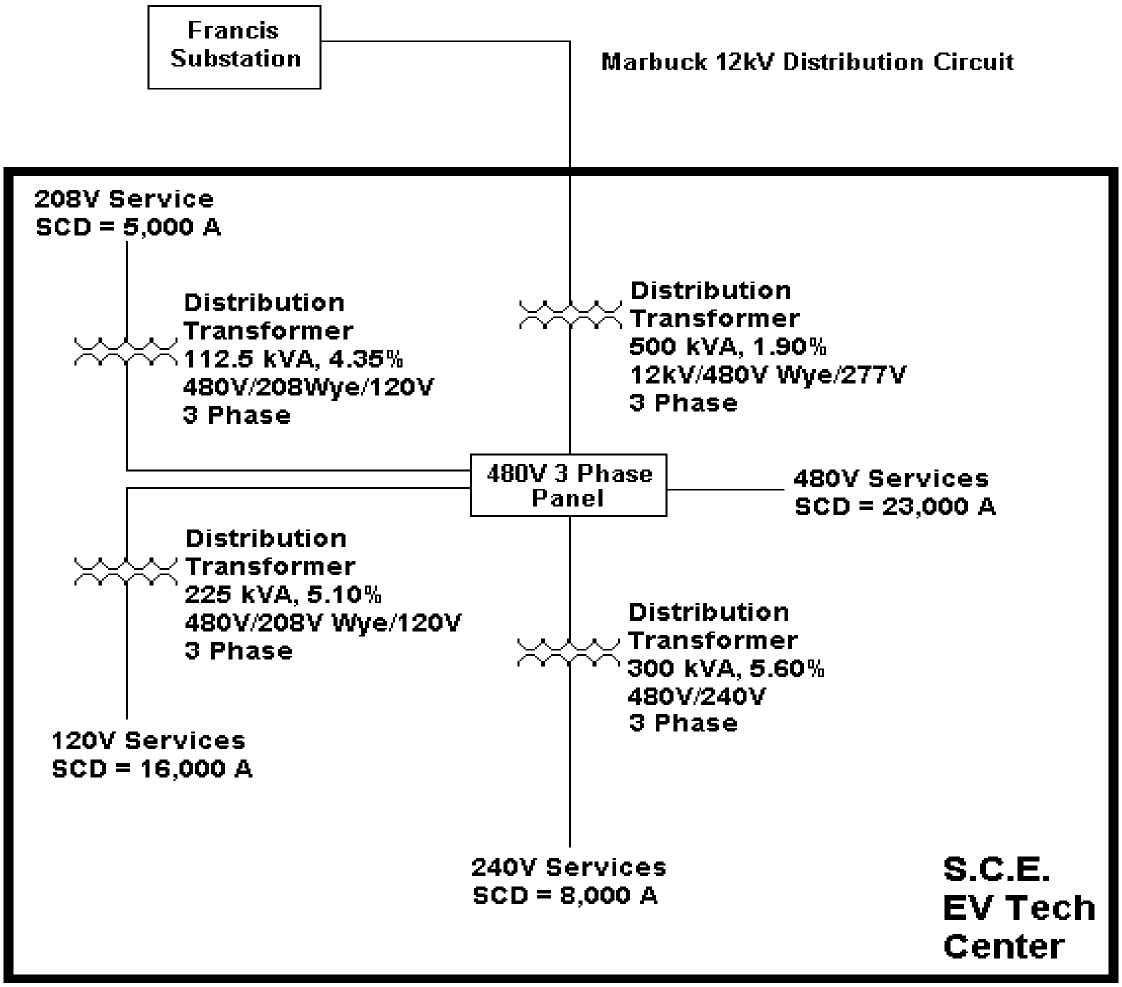
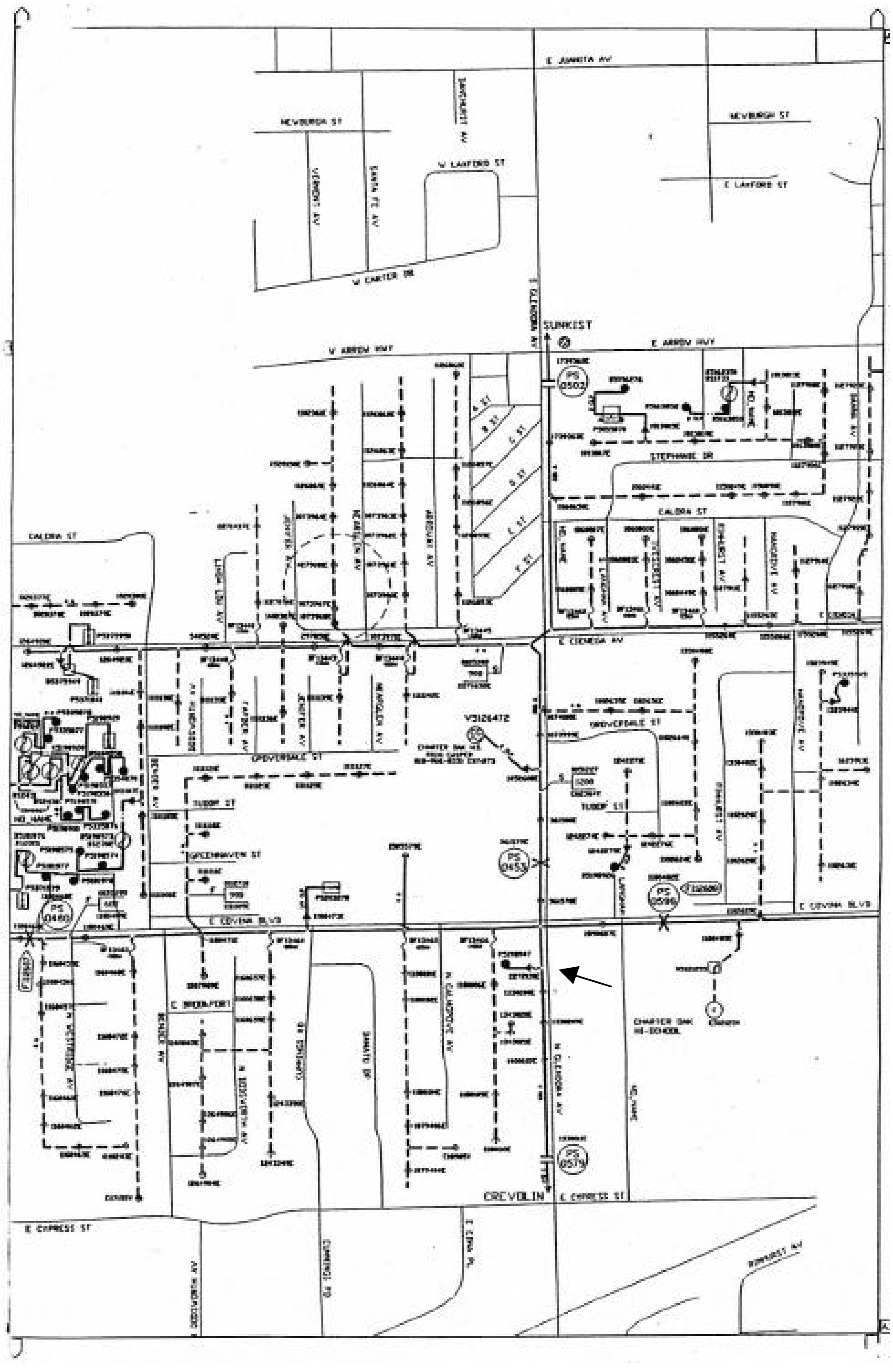
EV Tech Center Line Diagram



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			
ΔV at STOP			
Ah OUT			
kWh OUT			
LOWEST MODULE			
DATA FILE			

RECHARGE TYPE			
Ah RETURNED			
kWh RETURNED			
DATA FILE			

NOTES:____

____