System Power Determination Validation Program

Status of EPA testing

28th EVE, Ottawa, October 2018
Numbers don’t lie!

2.8%
EPA test vehicles

• 2013 Malibu Eco
  • Mild HEV (BAS)
  • Engine: 136 kW @ 6200 rpm (est.)
  • Motor: 11 kW
  • Battery: 0.5 kWh
  • Odometer: 5400 miles (8700 km)

• 2013 Chevrolet Volt
  • OVC-HEV (series with power split)
  • Engine: 63 kW @ 4800 rpm
  • Drive motor: 111 kW; generator: 55 kW
  • Battery: 16.5 kWh
  • Odometer: 11100 miles (17,870 km)
Test protocol - General

• Identify speed of maximum power by conducting speed sweep
  • Day 1: Run constant speeds from 50 to 130 kph in 10 kph increments
    • Perform two 15-second accel pulses at each speed
    • Examine dyno logs to see power delivered to dynamometer rolls at each speed
  • Day 2: Conduct second, finer speed sweep
    • As indicated by Day 1 results
    • The speed of maximum power is likely to be one of the speeds swept
    • The data collected at that speed can then be used to perform TP1 and TP2

• Rate of accel was varied slightly for some pulses (no effect seen)
• Temperatures were monitored to stay within design range
• SOC restored after each pulse by light braking or coasting
  • Attempted to limit charging to 1C but this was difficult to control
  • Often, coasting at constant speed was sufficient to restore SOC
Instrumentation

• EPA utilizes Southwest Research Institute (SwRI) for instrumentation services
• Data collected by Rapid Prototyping Electronic Control System (RPECS)
• SwRI was limited in ability to instrument high voltage battery
  • Lack of standard procedure (SOP) would have added to development time
  • We decided to see if CAN signals for voltage and current would be adequate (10-sec acceleration is relatively steady state)
• For expediency, most signals were collected from CAN except manifold air pressure
Example of signals collected (Malibu Eco)
# 2013 Malibu Eco – test configuration

<table>
<thead>
<tr>
<th>Vehicle ID</th>
<th>GHGMAL</th>
<th>Front: 2250 lb.</th>
<th>Rear: 1744 lb. (with 2 occupants as tested)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>2WD</td>
<td>ETW 3875 lbs (3994 actual)</td>
<td></td>
</tr>
<tr>
<td>Model Year</td>
<td>MY2013</td>
<td>Coefficients</td>
<td>Target</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>GM</td>
<td>Dyno Set</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>Malibu Eco</td>
<td>A 26.48</td>
<td>lb</td>
</tr>
<tr>
<td>VIN</td>
<td>1G11D5RR3DF109037</td>
<td>B 0.2366</td>
<td>lb/mph</td>
</tr>
<tr>
<td>Drive axle</td>
<td>FWD</td>
<td>C 0.01659</td>
<td>lb/mph²</td>
</tr>
<tr>
<td>Dyno conf.</td>
<td>FWD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tire pressure</td>
<td>Front 35 psi</td>
<td>Rear 35 psi</td>
<td></td>
</tr>
<tr>
<td>Tire size:</td>
<td>P225/55R17 (nominal diameter 26.74 inches, radius 0.3396 m)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Fuel tank volume**: 15.8 gallons
- **Fill amount**: 100%
- **Fuel Type**: Tier 2 test fuel
- **FTAG**: 26864

- **Fan Type and position:**
  - a) US06 fan on engine (40 mph).
- **Hood**: Hood open
2013 Malibu Eco – Test cell setup
Identifying speed of maximum power
Day 1: Initial speed sweep – 60 to 130 kph
Identifying speed of maximum power

Day 2: Second speed sweep – 90 to 100 kph

Power at dyno rolls - Malibu Eco
Wheel power at 93.0 kph - Malibu

(Engine speed is about 6000 rev/min)

6200 rpm = 136 kW
Wheel power at 93.5 kph - Malibu

(Engine speed is about 6000 rev/min)

6200 rpm = 136 kW
Measured battery power – 93 kph
Measured battery, fuel, MAP – 93 kph

111 kW at road / (135 kW + 5 kW) at engine/battery = ~ 80% downstream efficiency
Conclusions – Malibu Eco

• Speed of maximum power: ~93 kph (expect 111-112 kW at wheels)
• Shape and magnitude of each power pulse are similar
• CAN data for current and voltage is stable and repeatable during steady state portion of pulse
• Fuel flow and MAP signals appear reasonable
• Power calculations should be achievable with this data  
  • TP1 depends on availability of engine test data (equivalent to ISO 1585)  
  • TP2 depends on availability of tire data (equivalent to RRC class in WLTP)
## 2013 Chevy Volt – test configuration

<table>
<thead>
<tr>
<th>Vehicle ID</th>
<th>EPA3047</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>2WD</td>
</tr>
<tr>
<td>Model Year</td>
<td>MY2013</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>GM</td>
</tr>
<tr>
<td>Model</td>
<td>Chevy Volt</td>
</tr>
<tr>
<td>VIN</td>
<td>1G1RA6E41DU102286</td>
</tr>
</tbody>
</table>

**Conditioning cycle:** “Hold Mode”  
**Power cycle:** “Normal Mode”

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Target</th>
<th>Dyno Set (4WD dyno)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>26.05 lb</td>
<td>2.88 lb</td>
</tr>
<tr>
<td>B</td>
<td>-0.0120 lb/mph</td>
<td>-0.072 lb/mph</td>
</tr>
<tr>
<td>C</td>
<td>0.01820 lb/mph²</td>
<td>0.01712 lb/mph²</td>
</tr>
</tbody>
</table>

- **ETW** 3750 lbs (4169 actual)
- **Front:** 2465 lb, **Rear:** 1704 lb (with 2 occupants as tested)

- **Drive axle:** FWD  
- **Dyno conf.:** 4WD  
- **Tire pressure:** Front 38 psi, Rear 38 psi  
- **Tire size:** P215/55R17 (nominal diameter 26.31 inches, radius 0.33414 m)

- **Fuel tank volume:** 11 gallons  
- **Fill amount:** 100%  
- **Fuel Type:** Tier 2 test fuel  
- **FTAG:** 26967

**Fan Type and position:**  
(a) Road speed fan on engine.  
**Hood:** Hood closed

**Conditioning cycle:** “Hold Mode”  
**Power cycle:** “Normal Mode”
2013 Chevy Volt – Test cell setup
Identifying speed of maximum power
Day 1: Initial speed sweep – 50 to 130 kph
Power at wheels varies little with speed
Identifying speed of maximum power
Day 2: Speed sweep from 66 to 90 kph @ 4 kph
Wheel power at 82 kph – Chevy Volt

![Graph showing power at dyno rolls, 82 kph - Chevrolet Volt](image-url)

- 93.52 kW
- 92.7 kW
- 93.53 kW
- 92.6 kW
Wheel power at 86 kph – Chevy Volt

![Graph showing power at 86 kph for Chevrolet Volt]

- 93.58 kW
- 93.5 kW
- 93.72 kW
- 93.5 kW
Measured battery power - 86 kph

93.5 kW at road / 110.25 kW at battery = \(84.8\%\) battery-to-road efficiency
Conclusions – Chevy Volt

• Speed of maximum power: ~ 86 kph (expect 93.5 kW at wheels)
• Shape and magnitude of each power pulse are similar
• CAN data for current and voltage is stable and repeatable
• Fuel flow and MAP signals not needed (CD = no engine operation)
• Power calculations should be achievable with this data
  • TP2 depends on availability of tire data (equivalent to RRC class in WLTP)
Other observations

• Canada, JRC, and EPA found that constant speed mode is rarely used
  • Dynamometer staff needed to review how to operate in constant speed mode
  • Controlling speed in response to sudden loading requires some attention
  • EPA found that speed control under loading was not a difficulty (+/- 0.5 kph)

• 20 min conditioning cycle was not sufficient for transmission oil temperature to fully stabilize
  • Temperature continues to creep up during testing
  • Temperature is still within design range, just higher than at end of conditioning
  • Strict interpretation of test procedure would require a return to conditioning cycle, but this is not effective at reducing oil temperature