Proposed Test Procedure Modifications and Certification Requirements to Address Plug In Hybrid Electric Vehicles

California Air Resources Board

Public Workshop
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1

Scope

- Incorporate Test Procedures for Off Vehicle Charge Capable Conversion Systems
  - Evaporative emissions
  - Exhaust emissions
- Aftermarket Parts
  - Certification and Installation Procedures
- ZEV Range Testing Option

2

Schedule

- Workshops April 8, July 16, September 24
- Staff Report Released October 24, 2008
- Board Hearing December 11-12, 2008

3

Agenda

- Aftermarket Parts Certification
  - Requirements
  - OBD Impacts
  - Exhaust Emission Test Procedures Overview
  - Evaporative Emission Test Procedures Overview
- Modifications to Evaporative Emission Related Test Procedures
- ZEV Range

4

Aftermarket Parts

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California Air Resources Board

5

Objectives

Address off-vehicle charge capable (OVCC) conversion systems

- Applicability
- Certification & Installation Procedures
- Emission Issues
  - Exhaust emission issues, examples
  - Evaporative emission issues, examples

6

Applicability

Certification & Installation Procedures

- Applies to OVCC conversion systems designed for installation on 2000 and subsequent MY HEVs
- Conversions not eligible for ZEV credits

7

Requirements

Certification & Installation Procedure

- Emission Testing
- Durability
- Warranty
- In Use Testing

8

Emission Testing Requirements

Certification & Installation Procedures

- Conversion system must meet emission standards of OEM vehicle
- Test procedures used to determine emissions same as for OEM vehicles
  - OVCC exhaust emissions
  - Evaporative emissions
  - Overviews of both presented separately

9

Durability Testing

Certification & Installation Procedures

- Similar to other retrofit kit certification
- OVCC conversion system must be durable for useful life of converted vehicle
- Durability demonstration to be proposed by the manufacturer
- May be performed through bench aging or mileage accumulation

10

Durability Testing
Certification & Installation Procedures

- Typical conversion system, i.e. battery with controller
  - Apply OEM deterioration factors
  - Emissions not to exceed original certification standards
  - Cycle battery equivalent to vehicle useful life
  - Show EAER and/or battery SOC
  - Bench testing of other electrical components
- Other more extensive conversions
  - OEM deterioration factors may not be appropriate
  - May require aging/mileage accumulation of emission control parts/vehicle
  - Emission test converted vehicle with aged/mileage accumulated emission control parts
  - Emissions not to exceed original certification standards
  - Battery/electrical component tests similar to typical conversions

11

Warranty
Certification & Installation Procedures

- OEM SULEV (3 years / 50,000 miles and 7 years / 70,000 miles)
  - Same warranty requirements as OEM if installed within first four years of date vehicle is first acquired
  - If installed after four years, warranty period is three years or half the applicable warranty period
- OEM PZEV (10 years / 150,000 miles)
  - Same warranty requirements as OEM if installed within first six years of date vehicle is first acquired
  - If installed after six years, warranty period is five years or half the applicable warranty period

12

In Use Testing

Certification & Installation Procedures

- ARB may select up to five conversion systems per manufacturer per year
  - Testing at ARB or other designated lab
  - Compare to original certification standards
  - Testing costs covered by ARB unless vehicles fail to meet emission standards

13

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14

OBD Impacts of Aftermarket Hybrid Type Conversions

Mike Regenfuss
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15

On Board Diagnostics (OBD) Background

- OBD systems required on all vehicles
  - Predominantly added software in the relevant powertrain control modules
  - Monitors virtually every component that can cause an emission increase
    - Data are collected from the sensors and actuators on the car as the vehicle is being driven in-use
    - Data are evaluated against pass/fail criteria to assess whether malfunctions are present
  - Stores info pinpointing likely root cause to assist repair techs
  - Alerts driver by dashboard warning light (“check engine” light)
  - Stores data to demonstrate diagnostic system compliance to ARB
- OBD is dominant mechanism used in Smog Check program to identify cars in need of emission repairs

16

OBD Requirements

- Equally important as other emission requirements
  - Tailpipe standards, evap standards, etc
  - Cannot compromise OBD capabilities to meet other ARB requirements and vice versa
- Components that must be monitored
  - All emission controls
  - All electronic components (sensors, actuators, etc.) that affect emissions or are used to monitor other emission controls
    - 'Affect emissions' means cause a measurable increase under any reasonable driving condition

17

OBD Requirements (cont.)

- Malfunction criteria
  - Emission threshold (e.g., 1.5 x HC, CO, NOx standards)
  - Affects emissions (measurable increase)
- Monitoring frequency: monitors must run with a specified minimum frequency in-use
  - Driver habits/patterns can make this difficult
  - OE has to design monitors to run under as broad of driving conditions as it can to ensure this happens
  - Data logged in the engine control module (ECM) to demonstrate compliance
- SAE standardization
  - To output data to scan tools and assist repair techs in finding and fixing faults

18

Impacts Aftermarket Hybrids Likely Have to Account For

- Difficult to accurately predict impact until host vehicle and exact hybrid modifications are specified
  - OE hybrid systems are incredibly complex
  - In an OE ECM, amount of OBD software much more than control software.
  - In depth understanding of the OE control system and diagnostic system is mandatory to successfully add the aftermarket system
- Likely to have adverse impact on monitoring frequency
  - Could make necessary conditions to run specific monitors encountered less often
    - e.g., a monitor that runs at a city cruise type condition might be encountered much less on a more capable all electric range hybrid,
  - Could eliminate necessary conditions
    - e.g., a monitor that runs at warmed-up idle might never be able to run on a car that has idle shut-off, a monitor that can only run on cold starts may be disabled by early idle off occurrences.
- Minimum frequencies established to ensure timely detection and repair of malfunctions
  - Modified systems must still meet regulatory minimums for frequency
  - Monitoring frequency also directly impacts SmogCheck
    - (e.g., consumers preparing for inspection after repair)

19

Other Impacts

- Aftermarket systems that add components that affect emissions when they malfunction
  - Temp, voltage, current sensors, battery pack itself, etc.
  - 'Affects emissions' defined as back to back comparison with component working and malfunctioning, not comparison to OE configuration.
- Any added electronic components need to be monitored to OBD requirements
  - Pinpoint likely root cause (separate faults for opens, shorts, rationality, functional faults, etc.)
  - Fault handling (Two-in-a-row logic to illuminate MIL, etc.)
  - Fault information has to be output in SAE standardized formats
  - Standardized warning light (MIL) must be illuminated
    - Need to tie into OE MIL and OE communication network to comply

20

OBD Principles

- Proper OBD system operation for the life of the vehicle is critical to California's clean air goals
- Aftermarket systems must keep OBD compliance in mind
  - Will likely need to integrate heavily with the OE system to make it work acceptably.

21

Proposal for OBD Requirements on Aftermarket Hybrid Systems

- Near term:
  - Aftermarket needs to have viable road map to achieving full OBD compliance
    - Likely require support from OEs, OE suppliers, and OE engineering contractors to ensure integration of aftermarket system
  - ARB will consider limited reduction of OBD capability
    - Example: reduced monitoring frequency until in-use experience is gained
  - ARB will not allow systems that prevent a vehicle from receiving a valid Smog Check or effectively disable monitors
    - Example: hybrid design precludes monitors from running
- Long term:
  - Aftermarket needs to achieve full OBD compliance of their systems

22

Exhaust Emission Test Requirements for Aftermarket PHEV Conversions

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California Air Resources Board
Aftermarket Parts PHEV Workshop
September 24, 2008

23

Basic Test Requirements for Aftermarket PHEV Kits

PHEV kit manufacturers must emission test a vehicle after PHEV conversion according the proposed PHEV procedures for the urban cycle only

The PHEV conversion must meet the same exhaust emission standards for the baseline vehicle prior to conversion

24

Aftermarket PHEV Exhaust Emission Testing

Perform - Vehicle Preconditioning Vehicle (Drain/Fill w/test fuel, load evap canister perform at least one UDDS test in charge sustaining operation, charge battery)

- Urban Charge Depleting Range Test (multiple UDDS tests)

- Urban Charge Sustaining Emission Test (2 UDDS tests)

- AC Charging

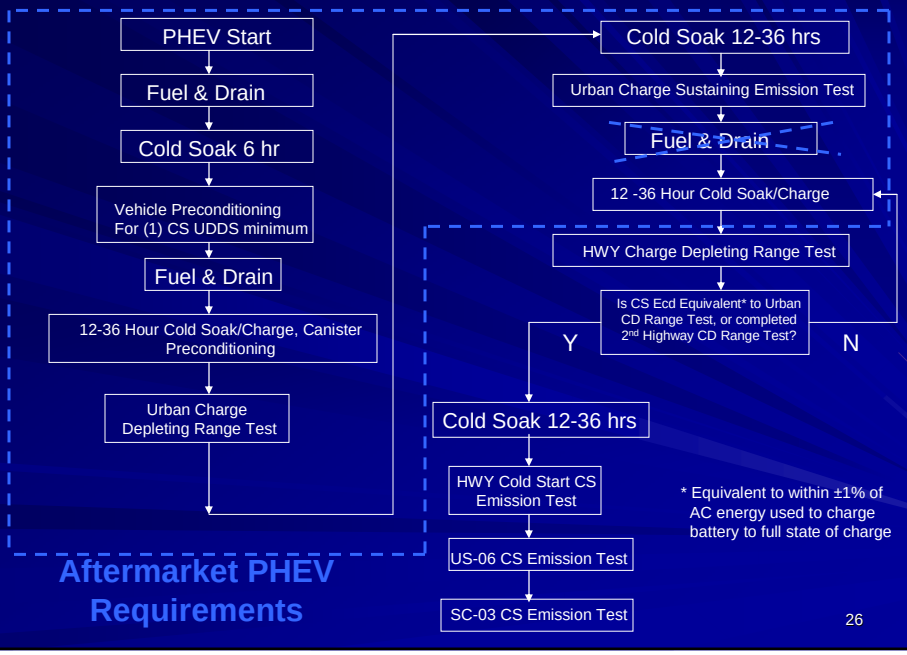
Determine - Compliance with Emission Standards

- Equivalent All-Electric Range

- Energy Consumption AC, DC Wh/mi

25

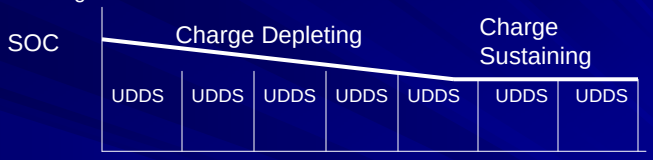
Proposed PHEV Exhaust Emissions Test Sequence



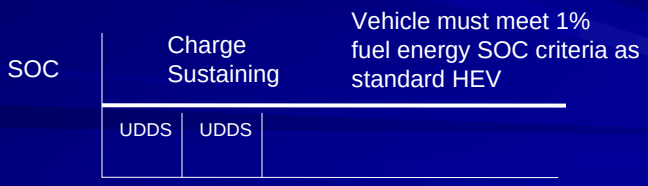
26

Proposed PHEV Emissions City Test Procedure

Day1:
Cold Soak and fully charge vehicle. Perform continuous UDDS test(s) followed by a 10-20 minute soak period until charge sustaining operation is achieved for 2 UDDS tests. Soak vehicle overnight.

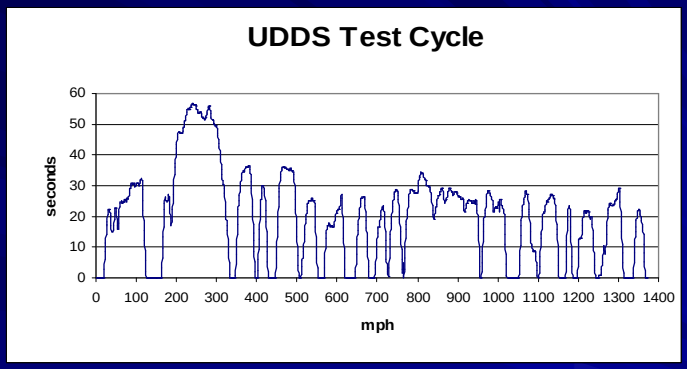


Day 2:
Perform one cold UDDS CS test. The test shall not exceed the emissions standard. The certification emissions value will be the worst case of either the CD or CS test.



27

Urban Test Cycle



Test Length: 7.5 miles
Duration: 1372 seconds
Maximum speed: 56.7 mph
Average speed: 19.5 mph
Average Acceleration: 3.3 mph/sec

28

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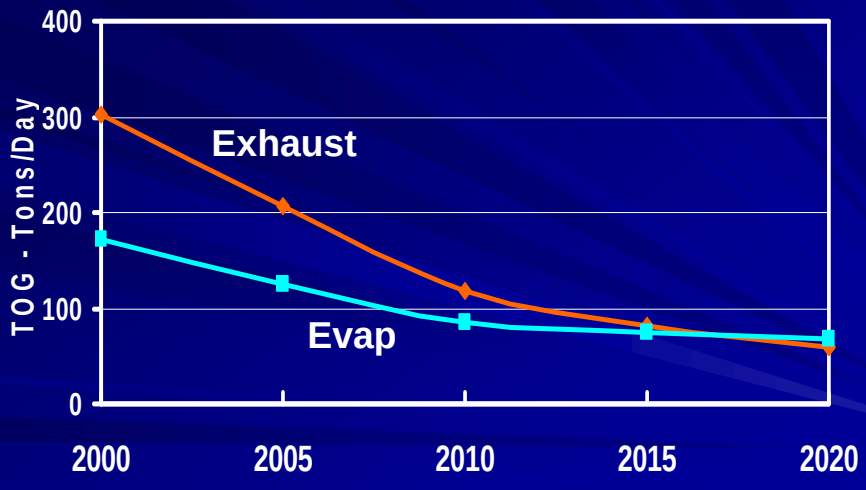
29

Evaporative/ORVR Test Procedures

Ron Haste

30

On-Road Hydrocarbon Trends



TOG = Total Organic Gas

South Coast Air Basin

31

New Vehicle Certification Evap

Demonstrate compliance w/applicable std.

- 3-day diurnal test
  - Ability to contain vapors for a 3-day period
- 2-day diurnal test
  - Ability to purge vapors under a short-drive event
- On-board Refueling Vapor Recovery (ORVR) test
  - Ability to control vapors during a refueling event

32

Plug-In HEV Issues

- Vehicle preconditioning
  - UDDS must be in charge-sustaining mode
- "Worst-case" evap battery SOC is max. level
  - For Evap 2-day & 3-day and ORVR testing
- "Non-integrated refueling canister-only" systems
  - "Sealed Fuel System" exemption ambiguity
  - What is proper canister loading?
- Canister-purge capability
  - By 2-day test

33

Proposed Test Procedure Changes: "Worst-case" Battery SOC

- Set SOC at max before FTP
  - 2- & 3-day and ORVR tests
  - No SOC reqmt at end of FTP or RL test
  - In ORVR non-integrated systems option
- Vehicle preconditioning
  - At least 1 UDDS in Charge-Sustaining mode
  - No SOC reqmt
- ARB cert confirmatory/in-use compliance tests
  - Test PHEVs w/SOC set at max/min/in-between

34

Aftermarket Plug-In HEV Evap Requirements

- Vehicle preconditioning
  - UDDS in charge-sustaining mode
- Evap 2-day testing
  - "Worst-case" SOC (at max. before FTP)

35

Proposed Test Procedure Changes: "Non- Integrated Refueling Canister-Only System"

- Add new system definition
  - Subclass of "Non-integrated refueling emission control system"
- Add "sealed fuel system" definition
  - Highly pressurized, non-liquid systems are exempted
- Add "fuel-tank-refill canister-loading" method
  - Based on ORVR test refueling method
  - "Isolate" canister during routine drain & fills
  - Vent tank vapors when canister is isolated
- Allowance to set SOC lower/No SOC reqmt

36

Proposed Test Procedure Changes: Canister-Purge Capability

- Demo of canister purge in 2-day test FTP
  - Set SOC at "low" level
  - Maximize charge-sustaining mode (purge)
- Or do optional engineering evaluation
  - Submit info if requested
- Applies to Plug-In HEVs

37

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38

Proposed Test Procedure Modifications to Address Fuel Cell Vehicle Range Testing

Craig Childers

39

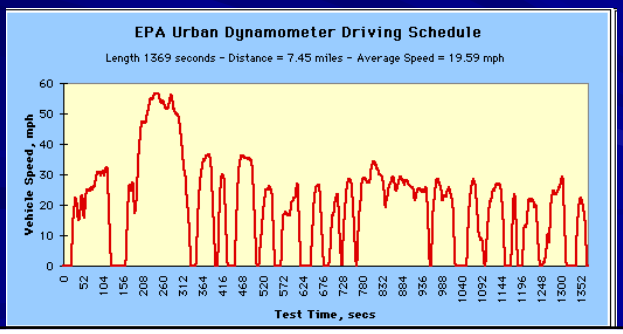
Where ZEV Range Used:

- Range of ZEVs is reported by automakers as an ARB certification requirement, and
- Also used in ZEV Regulation Credit determination

40

Need for Alternative ZEV Range TP

- No existing TP where ARB specifies how to test range of hydrogen ZEVs
- ZEV range testing challenging now that ZEVs can travel 200-300+ miles



41

Existing UDDS ZEV Range TP

- Existing Range TP in Section E
  - EX: Honda Clarity @ 283 miles range
    - Cold soak
    - 7.45 mile UDDS w 10 min Soaks in between =
      - 40 x 1369 sec / cycle (22 min)= 880 minutes
      - 39 x 10 minute soaks = 390 minutes
      - TOTAL = 1,270 minutes = 21 HOURS DYNO TIME
- REVISED TP: in Section E, per SAE J2572
  - Same 7.45 mile UDDS, but only 2 cycles with one 10 min soak
    - 2 x 1369 sec / cycle (22 min)= 44 minutes
    - 1 x 10 minute soak = 10 minutes
    - TOTAL = 54 minutes DYNO TIME

42

Proposed J2572 SAE TP

- Measure fuel capacity of fuel system:
  Total Capacity – Unusable = Usable amount
- Evaluate fuel consumption:
  - 2X UDDS cycles w 600 s soak @ off
    - Total test monitoring fuel = 14.9 miles
  - 2X HFEDS “back to back”, 1 warm up, 1 monitored
    - Total test monitoring fuel = 10.2 miles
  - Mass of h2 evaluated to +/- 1 %
- Also monitor electric energy storage device (battery) to compensate overall results
- Calculate range:
  Range = Usable fuel amount/ Fuel consumption

43

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44