OBD II - Agenda

• OBD II Regulatory Schedule
• Highlights of Proposed OBD II Changes
• Recent Modifications to Proposal
  – LEV III Malfunction Thresholds
  – Standardization: Fault Codes & New PIDs
• Other Monitoring Challenges
  – Purge Monitoring
  – Crankcase Ventilation Monitoring
• Freeze Frame Data
• Case Study on Monitoring Robustness vs. Monitoring Frequency
Schedule (subject to change)

- Public Workshop – El Monte, CA
  - Date: Thursday, October 30, 2014

- Finalization of OBD II Regulatory Package
  - Finalize proposal in March/April timeframe
  - All proposed OBD II amendments frozen May 2015

- 45-Day Notice Package
  - Projected publication date: August 4, 2015
  - Includes notice, staff report, and proposed regulatory language

- Board Hearing
  - Projected date: September 24-25, 2015
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OBD II - Highlights of Proposed Changes

**Highlights**

- *LEV III emission malfunction thresholds*
  - NMOG + NOx thresholds
  - Includes proposed PM thresholds for diesel and gasoline vehicles
- A/F cylinder Imbalance monitor requirements
- Changes to hybrid vehicle requirements
  - More details regarding monitoring requirements of hybrid components
  - Plug-in hybrid-related changes
  - Changes related to IUMPR/data stream for hybrids
- Non MIL provisions
  - Includes components related to safety
- Smart devices
- Comprehensive component monitoring
  - Test-out requirements
- *Standardization: Fault codes and new PIDs*
- *Purge and PCV*
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## Proposed LEV III Thresholds for Gasoline

<table>
<thead>
<tr>
<th>Exhaust Standards</th>
<th>Monitor Thresholds (except catalyst monitor)</th>
<th>Catalyst Monitor Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle Type</strong></td>
<td><strong>Vehicle Emission Category</strong></td>
<td><strong>NMOG + NOx Mult.</strong></td>
</tr>
<tr>
<td>Passenger Cars, Light-Duty Trucks, and Chassis Certified Medium-Duty Passenger Vehicles</td>
<td>LEV160</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>ULEV125</td>
<td>2.00⁴</td>
</tr>
<tr>
<td></td>
<td>ULEV70</td>
<td>2.00⁴</td>
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<tr>
<td></td>
<td>ULEV50</td>
<td>2.50⁵</td>
</tr>
<tr>
<td></td>
<td>SULEV30</td>
<td>2.50⁵</td>
</tr>
<tr>
<td></td>
<td>SULEV20</td>
<td>2.50⁵</td>
</tr>
<tr>
<td>Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)</td>
<td>All Medium-Duty Vehicle Emission Categories</td>
<td>1.50</td>
</tr>
</tbody>
</table>

1. Applies to 2019+MY LEV III vehicles
4. Have an interim in-use threshold of 2.50 the first three years a ULEV50 or ULEV70 is certified through 2019MY.
5. SULEV20 vehicles may use a 3.25 threshold for the first 3 years a vehicle is certified up to the 2025MY.
# Proposed LEV III Thresholds for Chassis Certified Diesels

<table>
<thead>
<tr>
<th>Exhaust Standards</th>
<th>Monitor Thresholds¹</th>
<th>Aftertreatment Monitor Thresholds²</th>
<th>DPF Filtering Performance Monitor Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle Type</strong></td>
<td><strong>Vehicle Emission Category</strong></td>
<td><strong>NMOG + NOx Mult.</strong></td>
<td><strong>CO Mult.</strong></td>
</tr>
<tr>
<td>Passenger Cars, Light-Duty Trucks, and Chassis Certified Medium-Duty Passenger Vehicles</td>
<td>LEV160</td>
<td>1.50</td>
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</tr>
<tr>
<td></td>
<td>ULEV125</td>
<td>2.00⁶</td>
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<tr>
<td></td>
<td>SULEV20</td>
<td>2.50⁷</td>
<td>2.50⁷</td>
</tr>
<tr>
<td>2016MY-2018MY Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)</td>
<td>All Medium-Duty Vehicle Emission Categories</td>
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<td>1.50</td>
</tr>
<tr>
<td>2019+MY Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)</td>
<td>All Medium-Duty Vehicle Emission Categories</td>
<td>1.50</td>
<td>1.50</td>
</tr>
</tbody>
</table>

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2. Applies to (f)(1)-(f)(2), (f)(8), and (f)(9.2.4)(A)
3. Applies to 2019+MY LEV III Vehicles
4. Applies to vehicles not included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
5. Applies to vehicles included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
6. Have an interim in-use threshold of 2.50 the first three years a ULEV50 or ULEV70 is certified through 2019MY.
7. SULEV20 vehicles may use a 3.25 threshold for the first 3 years a vehicle is certified up to the 2025MY.
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Standardized Fault Codes and Fault Code Services (pending, confirmed, and permanent)

- SAE J2012 has defined fault codes using a 2-byte structure (e.g., P0100)
- P/U/B/C are the main groups and 100s, 200s,… are the categories
- **What’s the problem?**
  - With growth in powertrain technologies and regulatory requirements for pinpointing, about half of the generic fault codes have been used
- **How are we going to fix this problem?**
  - Short-term Solution: SAE J2012 committee will continue to assign fault codes as usual until current categories are full, then assign codes to *other* categories as needed
  - Long-term Solution: ARB is committed to working with manufacturers to develop a solution; specifically, working with industry to develop and improve the UDS specification before transitioning to the UDS protocol
OBD II – New PID’s

Additional Datastream Parameters to assist in PEMs testing

- Engine Reference torque (PID $63/SPN 544)
- Friction Losses (PID $8E/SPN 514)
- Parasitic losses (PID $?/SPN 2978)
- Actual Engine Percent torque (PID $62/SPN 513)…already in regulation
- DEF dosing status %Duty Cycle (PID/SPN ?)
- DEF dosing rate in ml/sec (PID/SPN ?)
- Cylinder fuel rate in mg/stroke (PID A2/SPN ?)
- Engine fuel rate in g/s (PID 9D/SPN ?)
- Vehicle fuel rate in g/s (PID 9D/SPN ?)
- NOx sensor correction in ppm (PID A1/SPN ?)
Datastream Parameters to Characterize Vehicle CO$_2$ Emissions

- Track CO$_2$ (via fuel consumption) in the real-world
  - Store aggregate data, not just enable easier data logging

Why do we need this?

- Possible uses:
  - Future CO$_2$ standards development
  - CO$_2$ standards compliance
    - Indicator of potential noncompliance
    - Help verify consumers getting benefit they paid for
  - Evaluation of Off-cycle CO$_2$ credits
  - FE label evaluations
  - Refine vehicle CO$_2$ inventory models
  - Manufacturer protection
    - Provide context for actual FE to resolve consumer complaints
Datastream Parameters to Characterize Vehicle CO\textsubscript{2} Emissions

Proposed PIDs (for all vehicles)

– Cumulative Distance
– Cumulative Fuel consumed
– Cumulative PKE (positive kinetic energy)
  • Approximated as sec by sec summation of (accel*velocity)
– Cumulative number of stops
– Cumulative calculated vehicle (ICE+motor) output torque

NOTE: All PIDs stored in NVRAM and are cumulative ‘since ECU reflash/replacement/NVRAM clear’ to maintain correlation between the parameters.
OBD II – New PID's

Datastream Parameters to Characterize Vehicle CO₂ Emissions

Proposed PID's (for all vehicles) cont.

- Cumulative Propulsion System Active (PSA) time
- Cumulative PSA time @ “idle” (vehicle speed (VS) ≤ 1mph)
- Cumulative PSA time @ 1 < VS ≤ 25mph
- Cumulative PSA time @ 25 < VS ≤ 50mph
- Cumulative PSA time @ ambient temperature < 50° F (10° C)
- Cumulative PSA time with Air Conditioning on
- Engine run time (currently defined as SAE J1979 PID $7F)
  - Cumulative engine run time
  - Cumulative engine run time @ “idle” (VS ≤ 1mph)
Datastream Parameters to Characterize Vehicle CO\textsubscript{2} Emissions

• As noted previously, parameters would be stored in NVRAM
• Proposing to require a second set of these parameters to provide a ‘recent history’ snapshot of the vehicle
  – Not required in NVRAM, could be cleared on code-clear events, etc.
  – TBD on format/length of time but intent is to capture the most recent several weeks or months of driving (e.g., last 2,000 miles?)
  – Provide quicker moving feedback to repair technicians and/or vehicle owners after fault occurrence, repair, alteration of driving style, etc.
Datastream Parameters to Characterize PHEV $\text{CO}_2$ Emissions

Additional Proposed Plug-in Hybrid Electric Vehicle (PHEV) PIDs

- Cumulative Distance (same as all cars)
  - Cumulative Charge-sustaining (Cs) distance
  - Cumulative Charge-depleting (Cd) w/ IC engine-off distance
  - (Differential of distance would be Cd w/ IC engine-on distance)

- Cumulative Fuel Consumed (same as all cars)
  - Cumulative Cs fuel consumed
  - (Differential would be Cumulative Cd fuel consumed)

- (Cumulative Grid Power Consumed (kWh) = sum of below)
  - Cumulative Cd w/ IC engine-off consumed Grid Power
  - Cumulative Cd w/ IC engine-on consumed Grid Power
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Purge monitoring during normal and boost conditions
• Current requirement: monitor all purge flow paths on a vehicle
  – e.g., turbocharged engines with low pressure and high pressure purge lines, both need to be monitored
  – High load purge lines are commonly added and designed to ensure sufficient purging under high load driving conditions (e.g., US06 conditions)

What’s the problem?
• Monitoring challenges for vehicles with high load purge lines
  – Frequent and robust monitoring can be a challenge
  – Some failure modes cause extreme evaporative emissions
  – Monitoring between the ejector and intake air system can be difficult
  – Ejector designs directly mounted to the intake system often require extensive design review
Proposal being considered:
• Protect against designs that can have failure modes that can result in gross emissions
  – e.g. relatively low-powered boosted engines that are frequently boosted under FTP drive conditions
• Test out requirement to exempt purge lines
  – Specify test-out criteria in regulation to exempt monitoring of these lines that are not expected to be used frequently in use
• Exempt high load purge line monitoring
  – High load purge mass flow < 1% on US06 test cycle and = 0% on Unified test cycle
Proposal being considered:

- Allow *design* solution through the 2019 model year in lieu of monitoring high load purge lines for all malfunctions that can prevent purge delivery to the engine.
  - Criteria for approval:
    - Purge mass flow of the un-monitored purge line should be small relative to the fully monitored purge line
    - The high load purge system design is inherently resistant to deterioration and/or failures of the un-monitored purge line
  - For 2020 and subsequent model year vehicles, the Executive Officer may not approve monitoring strategies that cannot detect disconnections, broken lines, blockages, or any other malfunctions that prevent purge flow delivery to the engine
Proposal under consideration (cont.)

- An example of a high-load purge design that can meet the 2020+ MY requirements
- The system can detect disconnections and broken lines for all purge lines upstream of the venturi and blockages of all purge lines
- Disconnections or broken lines downstream of the venturi would not affect purge flow to the engine
Proposed in-use monitor performance requirements

- Numerator – Separate numerators for high load purge monitor and low load purge monitor
- Denominator – Separate denominators for high load purge monitor and low load purge monitor
  - Currently required to increment based on cold start criteria
  - Propose to remove cold start criteria for high load purge monitor denominator.
  - Propose to add 2 activations (>2s each) or 10s cumulative activation/operation for high load purge monitor denominator.
- Minimum in-use ratios for Purge Monitors
  - Currently 0.520 for both purge monitors
  - Propose 0.336 for high load purge monitor
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CV System Monitor
• Current Requirement: Monitor the CV system for disconnections or use robust connections

What’s the problem?
• This approach targets CV connections but not overall system integrity
  – Promotes robust connections but may not detect all system malfunctions and may hinder in-use CV system repairs
  – Objectivity in reviewing CV systems can be difficult and resource intensive
    • Time consuming review
    • Hands-on review of sample CV system parts
Proposal being considered:

- Prefer a solution that does not have design criteria for compliance
- Require monitoring of CV system for leaks
  - Leak detection size would the minimum cross sectional area of CV hoses and lines
  - Some manufacturers have already added sensors/algorithms to their systems to detect disconnected lines
  - Exceptions to leak detection monitoring
    - All internal CV lines exempt; e.g., internal machined passages
    - CV lines in which leaks would result in a rapid oil loss, engine stall, or other overt indication such that a vehicle operator would be certain to respond
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Freeze Frame Data

- Current requirement: Store and erase freeze frame data with storage and erasure of either pending DTC or confirmed DTC

What’s the problem?

- No freeze frame data to assist repair technicians with troubleshooting/repairing pending DTCs if freeze frame data stored with confirmed DTC
- Proposal: Align with HD OBD regulation - Freeze frame data stored with pending DTC storage starting in 2019MY
  - Erase freeze frame data if pending DTC erased in next driving cycle
  - If pending DTC matured to confirmed DTC, may keep pending DTC freeze frame data or update with confirmed DTC
  - Clearing of freeze frame data would be tied to clearing the confirmed DTC

Other Freeze Frame Changes

- Previously proposed storage of 4 freeze frames, reverting back 1 frame
- Reconsidering storage of multiple freeze frames until communication protocol updated (i.e., UDS)
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What must to be considered in monitor design?

1) Make good decisions
   • (d)(3.1) ‘…define monitoring conditions that are technically necessary to ensure robust detection of malfunctions’

2) Meet in-use monitoring frequency
   • (d)(3.2) ‘…define monitoring conditions that yield an in-use performance ratio that meets or exceeds the minimum required ratio,’ (e.g., 0.336) and should only increment when monitor is capable of detecting a failure

Both of the above need to hold true simultaneously
OBD II - Case Study: Monitor Robustness vs Frequency

• Demo testing observations
  – Monitors do not consistently fail during demonstration testing
  – Mode $06$ results do not show consistent failing values with the failed part installed
  – Numerators increment when falsely passing

• Confirmatory testing observations
  – Fail on demo cycle on chassis dyno, but pass off cycle (e.g., on road)
OBD II – The End

• Official ARB documents available from
  – www.arb.ca.gov
• Direct link to OBD page
  – http://www.arb.ca.gov/msprog/obdprog/obdprog.htm

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