HD OBD - Agenda

- Standardization: SAE J1939-84
- Demonstration Engine Aging
- NOx Control Performance Tracking Concept
- IRAF/UAF Concept
- ARB HD OBD Confirmatory Test Program
- Other Present and Future HD OBD Related Activities
HD OBD - Agenda

- **Standardization: SAE J1939-84**
- Demonstration Engine Aging
- NOx Control Performance Tracking Concept
- IRAF/UAF Concept
- ARB HD OBD Confirmatory Test Program
- Other Present and Future HD OBD Related Activities
J1939-84 Dynamic Testing

- Will propose adding an SAE J1939-84 “dynamic test”
- Dynamic test would demonstrate production vehicles are capable of setting readiness and properly incrementing all rate-based data
- Manufacturers would be required to run the dynamic test to completion and submit logfile to ARB
- Testing has revealed that HD OBD vehicles not properly incrementing numerators and denominators and not setting readiness to ‘complete’
J1939-84 Dynamic Testing…cont.

• The requirement currently exists in section (l)(2.3.3) for verifying numerators and denominators

• The logfile would simply provide a standardized format for data submissions

• Would be post certification and the logfile should be submitted to ARB 6 months after start of production

• Same test format as found in SAE J1699 dynamic test: clear codes, run vehicle on-road until all monitors execute, overnight soak is acceptable where required by monitoring strategies

• Failures flagged if incrementing numerators or denominators too fast or too slow or readiness not set after sufficient number of drive cycles
J1939 DM7/DM30 Test Results

- Test results sent through TPCM windows have created timing errors
- TPCM windows are necessary when parameter groups contain more than 8 bytes of data
J1939 DM7/DM30 Test Results…cont.

- TPCM is a peer-to-peer transmission (not BAM or broadcast) and requires a handshaking process to initiate
J1939 DM7/DM30 Test Results…cont.

- Problems may occur when multiple TPCM windows/sessions are started simultaneously on the same network.
  - Other modules not aware of existing TPCM window
  - May result in message delays and message transmission failures
- Test result output may need to be revisited in SAE J1939
HD OBD - Agenda

- Standardization: SAE J1939-84
- **Demonstration Engine Aging**
- NOx Control Performance Tracking Concept
- IRAF/UAF Concept
- ARB HD OBD Confirmatory Test Program
- Other Present and Future HD OBD Related Activities
• Per section 1971.1 (i)(2.3.3), manufacturers are required to collect emission and deterioration data from an actual high mileage system to validate aging processes for the 2016 and subsequent model years
• Staff are not approving manufacturers use of new components or sensors to represent full useful life
• Staff are not approving a de-greened engine. Must be some hours under rated-load cycle or similar
• Minimum aging required on engine, aftertreatment, and sensors (e.g., ~1000 to 2000 hours on rated-load cycle) followed by additional aftertreatment (DOC/DPF/SCR) aging to reach full useful life
• Manufacturers also required to observe controller correction/adaptation values at full useful life and compare to rapid aging method values to ensure sufficient minimum aging on system
HD OBD - Agenda

- Standardization: SAE J1939-84
- Demonstration Engine Aging
- **NOx Control Performance Tracking Concept**
- IRAF/UAF Concept
- ARB HD OBD Confirmatory Test Program
- Other Present and Future HD OBD Related Activities
Emission Reduction Timeline

- **1990 Level**
  - **2020** Greenhouse Gas Emission Target
  - **2030** 50% Petroleum Reduction
  - **2050** Greenhouse Gas Emission Target

- **Climate**
  - **2020**
  - **2025**
  - **2030**
  - **2035**
  - **2040**
  - **2045**
  - **2050**

- **Ozone / PM2.5**
  - **2023/2025** Attainment Year for Ozone and PM2.5
  - **2032** Attainment year for 0.075ppm 8-hour Ozone Standard

- **Future Ozone Standard 2037**

**Preliminary NOX Target:**
~65-70% Below 2031
Background

- Major NOx reductions are needed from the heavy duty sector
- Better understanding needed of conditions where in use emissions are occurring and magnitude of those emissions
- As ambient air quality standards and consequent tailpipe standards become more stringent, we need to ensure we are solving the right problems
High in-use emissions compared to STD or FEL
• Needed data parameters from vehicle: NOx sensors, modeled engine out NOx, SCR temp, modeled exhaust flow, modeled SCR conversion…

• Calculate NOx in g/bhp-hr

• Store weighted average NOx conversion in bins along with engine runtime

• Example:
  0 mph: 0.4 g/bhp-hr, 500 minutes, …
  1 to 25 mph: 0.3 g/bhp-hr, 40,000 minutes, …
  25 to 50 mph: 0.2 g/bhp-hr, 120,000 minutes, …

• Could look at other metrics for binning the data for characterizing in use NOx control
• Standardization: SAE J1939-84
• Demonstration Engine Aging
• NOx Control Performance Tracking Concept
• IRAF/UAF Concept
• ARB HD OBD Confirmatory Test Program
• Other Present and Future HD OBD Related Activities
Current Status

- \( EF_A = EF_L \times (1 - F) + EF_H \times F \)
- Staff have discovered unrealistic proposals in IRAF/UAF calculations
- Manufacturers are using regeneration frequency factors, \( F \), that are not represented by any in-use driving (e.g., regen frequencies that are far less than highway/SET)
- Is \( EF_L \) hot or cold? Is \( EF_L \) equal to FTP emissions?
- OBD requires accurate calculations for UAF so that emissions threshold monitors can be properly calibrated
Concept Proposal

- Staff are proposing that a composite frequency, \( F' \), be calculated using SET and FTP frequencies

\[
F' = F_{ftp} \times \text{offset} + F_{set} \times (1 - \text{offset})
\]

- Offset = % city driving (determined by vehicle application, such as long haul versus vocational)
- \( F_{ftp} \) = frequency on FTP
- \( F_{set} \) = frequency on SET

- This equation sufficiently bounds \( F' \)
  - such that: \( F_{ftp} > F' > F_{set} \)

- Provides a more realistic approximation for the in-use regeneration frequencies
- The table below demonstrates that the calculations for $F'$ are bounded by $F_{ftp}$ and $F_{set}$ for all in-use driving conditions (0% city driving to 100% city driving)

<table>
<thead>
<tr>
<th>City Driving %</th>
<th>F-ftp</th>
<th>F-set</th>
<th>$F'$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.20</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>10</td>
<td>0.20</td>
<td>0.05</td>
<td>0.065</td>
</tr>
<tr>
<td>20</td>
<td>0.20</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>30</td>
<td>0.20</td>
<td>0.05</td>
<td>0.095</td>
</tr>
<tr>
<td>40</td>
<td>0.20</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>50</td>
<td>0.20</td>
<td>0.05</td>
<td>0.125</td>
</tr>
<tr>
<td>60</td>
<td>0.20</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>70</td>
<td>0.20</td>
<td>0.05</td>
<td>0.155</td>
</tr>
<tr>
<td>80</td>
<td>0.20</td>
<td>0.05</td>
<td>0.17</td>
</tr>
<tr>
<td>90</td>
<td>0.20</td>
<td>0.05</td>
<td>0.185</td>
</tr>
<tr>
<td>100</td>
<td>0.20</td>
<td>0.05</td>
<td>0.20</td>
</tr>
</tbody>
</table>
HD OBD - Agenda

- Standardization: SAE J1939-84
- Demonstration Engine Aging
- NOx Control Performance Tracking Concept
- IRAF/UAF Concept
- **ARB HD OBD Confirmatory Test Program**
- Other Present and Future HD OBD Related Activities
• Staff are currently testing five major HD truck manufacturers over local city and highway drive cycles
• Concerns that many major monitors may not be executing over the road
• Staff verifies monitor performance using readiness data, test results, and IUMPR
• Manufacturers should test their OBD systems on the road before releasing into production, especially monitors that were calibrated to run on the RMC cycle
• Monitors that do not run in-use may be subject to remedial action
• Staff noticed that some vehicles may not be properly setting readiness to ‘complete’
• Readiness criteria are not always identical to IUMPR reporting criteria
• Regulation (section (j)(2.18)) requires certification documents to include a list of all components/systems required to track and report in-use performance noted by fault code used to increment the numerator for each component/system
# HD OBD – Confirmatory Test Program

<table>
<thead>
<tr>
<th>Monitoring Group</th>
<th>HD OBD regulation</th>
<th>Monitor</th>
<th>IUMPR</th>
<th>Readiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel System Monitoring</td>
<td>(e)(1.2.1)</td>
<td>Fuel System Pressure Control</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(1.2.2)</td>
<td>Injection Quantity</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(1.2.3)</td>
<td>Injection Timing</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td>Diesel Misfire Monitoring</td>
<td>(e)(2.2.1)</td>
<td>Continuous Misfire During Idle</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td>EGR/VVT System Monitoring</td>
<td>(e)(3.2.1)</td>
<td>EGR Low Flow</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.2)</td>
<td>EGR High Flow</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.3)</td>
<td>EGR Slow Response</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.5)</td>
<td>EGR Cooler Performance</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.6)</td>
<td>EGR Catalyst Performance</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(10.2)</td>
<td>VVT Target Error, Slow Response</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td>Boost Pressure Control System</td>
<td>(e)(4.2.1)</td>
<td>Underboost</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(4.2.2)</td>
<td>Overboost</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(4.2.3)</td>
<td>Boost Slow Response</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(4.2.4)</td>
<td>Charge Air Undercooling</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td>NMHC Converting Catalyst</td>
<td>(e)(5.2.2)</td>
<td>NMHC Conversion Efficiency</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(5.2.3)(A)</td>
<td>Exotherm for PM Filter Regeneration</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(5.2.3)(B)</td>
<td>Feedgas to Assist SCR System</td>
<td>Required</td>
<td>Not Included</td>
</tr>
<tr>
<td></td>
<td>(e)(5.2.3)(C)</td>
<td>NMHC Conversion Capability for PM Filter Regeneration</td>
<td>Required</td>
<td>Not Included</td>
</tr>
<tr>
<td></td>
<td>(e)(5.2.3)(D)</td>
<td>Ammonia Slip Catalyst</td>
<td>Required</td>
<td>Not Included</td>
</tr>
<tr>
<td>NOx Converting Catalyst</td>
<td>(e)(6.2.1)</td>
<td>NOx Conversion Efficiency</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td>NOx Adsorber Monitoring</td>
<td>(e)(7.2.1)</td>
<td>NOx Adsorber Capability</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(7.2.2)</td>
<td>Active/Intrusive Desorption</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td>PM Filter Monitoring</td>
<td>(e)(8.2.1)</td>
<td>Filtering Performance</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(8.2.2)</td>
<td>Frequent Regeneration</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(8.2.5)</td>
<td>Missing Substrate</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(8.2.6)</td>
<td>Active/Intrusive Injection for PM Filter Regeneration</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td>Exhaust Gas Sensor Monitoring</td>
<td>(e)(9.2.1)(A)(i)</td>
<td>Upstream Sensor Performance Faults</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(9.2.1)(A)(iv)</td>
<td>Upstream Sensor Monitoring Capability</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(9.2.1)(B)(i)</td>
<td>Downstream Sensor Performance Faults</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(9.2.1)(B)(iv)</td>
<td>Downstream Sensor Monitoring Capability</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(9.2.2)(A)</td>
<td>NOx and PM Sensor Performance Faults</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(9.2.2)(D)</td>
<td>NOx and PM Sensor Monitoring Capability</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td>Monitoring Group</td>
<td>HD OBD regulation</td>
<td>Monitor</td>
<td>IUMPR</td>
<td>Readiness</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------</td>
<td>----------------------------------------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>EGR/VVT System Monitoring</td>
<td>(e)(3.2.1)</td>
<td>EGR Low Flow</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.2)</td>
<td>EGR High Flow</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.3)</td>
<td>EGR Slow Response</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.5)</td>
<td>EGR Cooler Performance</td>
<td>Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(3.2.6)</td>
<td>EGR Catalyst Performance</td>
<td>Not Required</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>(e)(10.2)</td>
<td>VVT Target Error, Slow Response</td>
<td>Required</td>
<td>Included</td>
</tr>
</tbody>
</table>
HD OBD – Confirmatory Test Program

- Staff also studying on-road emission impacts of malfunctions using PEMS
- This emissions data cannot be used for compliance but may help to compare on-road malfunction emissions to OBD demonstration data collected during engine dyno testing
- Might also provide better understanding of emission impact of malfunctions real world conditions in whole vehicle applications.
HD OBD - Agenda

- Standardization: SAE J1939-84
- Demonstration Engine Aging
- NOx Control Performance Tracking Concept
- IRAF/UAF Concept
- ARB HD OBD Confirmatory Test Program
- Other Present and Future HD OBD Related Activities
HD OBD Regulatory Update

• Timing: to be determined, following completion of light duty update

HD OBD for Alternative Fuel Implementation

• HD OBD begins in 2018 MY
• Potential market growth
  • Interest in low NOx engines, renewable fuels, petroleum reduction
HD In Use Inspection Programs

Near Term Activity

- **Periodic Smoke Inspection Program (PSIP)**
  - Existing annual fleet self inspection program
  - SAE J1667 opacity test and equipment
  - DPF equipped vehicles with visible smoke shall be inspected and repaired to manufacturer’s specifications by authorized service facilities
  - ARB is planning revisions to set appropriate opacity limits for J1667 test for trucks with particulate filters
  - Incorporation of EMD/HD OBD?

Longer Term Activity

- HD Inspection and Maintenance program development
- Will use HD OBD for vehicles meeting HD OBD
- OBD staff will continue to test as many trucks as possible to facilitate program implementation
Innovative Technology Regulation

Background
• Provide certification/OBD approval flexibility to facilitate market launch of zero and near zero emission truck and bus technologies while maintaining ability to ensure anticipated air quality benefits

Concept
• Tiered approach would allow most flexibility for the initial introduction with decreasing flexibility through progressive tiers
• Tiers defined by time and/or volumes
Other Present and Future HD OBD Related Activities

Innovative Technology Regulation

Next Steps

• Workshop scheduled for September 28, 2015
• Board Hearing tentative target is early 2016
• Webpage
  
  www.arb.ca.gov/msprog/itr/itr.htm

• Contact Info:
  Joe Calavita, Lead Staff
  phone: 916-445-4586
  jcalavit@arb.ca.gov
OBD Program Contacts

Mike Regenfuss
- OBD Branch Chief
- mregenfu@arb.ca.gov

Leela Rao
- OBD Program Development Section Manager
- lrao@arb.ca.gov

John Ellis
- Gasoline OBD Section Manager
- jellis@arb.ca.gov

Thomas Montes
- Diesel OBD Section Manager
- tmontes@arb.ca.gov