Comparison of Emissions Benefits of CARB Diesel vs Federal Diesel

April 10, 2008
Agenda

Background
• AB679 (Calderon)
  • Legislative Intent
• Test Schedule
• Funding
• Proposed Test Engine Selection
• Proposed Test Vehicle Selection
• Proposed Test Cycle Selection
• Fuel Properties
  • Federal ULSD
  • CARB ULSD
  • Unified Modal Results
• Future Discussion Topics
• Next Meeting
• Assembly Bill 679 (Calderon)
  – Requires ARB to convene a technical advisory panel to develop a test protocol
  – Test program shall measure the emissions benefits of CARB diesel fuel
  – Conduct test program
  – Report the results to the Senate Committee on Environmental Quality, the Senate Committee on Transportation and Housing, and the Assembly Committee on Transportation
• Legislative Intent
  – Federal ultralow may produce emissions benefits closer to those of CARB diesel
  – Thought to be especially significant for HD diesel engines employing new technology (e.g. EGR)
  – Higher cost of CARB diesel is a competitive disadvantage for CA trucking industry
  – Develop and implement test protocol to measure differences in NOx & PM emissions between CARB diesel and Federal ultralow diesel
Test Schedule

- Emissions Testing – Scheduled to begin in Fall 2008
  - Test protocol development
    - Technical advisory panel, stakeholders
    - Currently soliciting input
    - Draft test protocol – in progress
    - Coordinating schedules with Biodiesel Research Program
Funding

• Test program currently funded for $1M
  – Proposed scope:
    • Engine dyno – 3 test engines, multiple test cycles
    • Chassis dyno – 12 to 15 test vehicles, multiple test cycles
    • Fuels – 1 ‘representative’ CARB diesel, 2 Federal diesel ‘blends’
    • Emissions measurements – THC, NMHC, CO, CO2, NOx, PM
• Currently, no additional funding is available to expand scope
  – Additional test engines/vehicles, gas-phase toxic HC's, carbonyl compounds, polycyclic aromatic hydrocarbons, elemental and organic carbon and size-resolved PM
Proposed Test Engine Selection -
Engine Dynamometer Testing

• Test Engine 1
  – 2006 Cummins M11, 10.8 liter
  – EFN: 6CEXH0661MAT

• Test Engine 2
  – 1991 DDC Series 60, 11.1 liter
  – EFN: MDD11.1FZAZ

• Test Engine 3
  – 2007 Engine, to be determined
  – Possibly DD15
Proposed Test Vehicle Selection - Chassis Dynamometer Testing

- Propose testing a matrix of 12 – 15 vehicles
  - Matrix should be based on CA’s in-use HD on-road fleet
  - Should incorporate a range of technologies if possible
  - Final matrix to be determined

- Vehicle acquisition
  - Advertisement
  - Rental / lease
  - Private owners

- Resources available for vehicle recruitment
Proposed Test Cycle Selection

- Propose using ‘Translated’ test cycle developed as part of the Biodiesel Research Program
  - Would allow comparison of engine dyno results with chassis dyno testing
  - Engine dyno results could be confirmed by chassis testing of in-use HD fleet

- Proposed Engine Dynamometer Test Cycles
  - FTP Transient
  - ARB Highway

- Proposed Chassis Dynamometer Test Cycles
  - UDDS
  - ARB HHDDT
# Federal Diesel Fuel Properties

“ Alliance of Automobile Manufacturers’ North American Fuel Survey”

Summary Statistics for Selected Properties from the Winter 2007 & Summer 2007 Surveys

Note: Statistics are based on data from 18 U.S. cities, including Los Angeles

<table>
<thead>
<tr>
<th>#2 Regular Diesel S15</th>
<th>2007 Winter(^1)</th>
<th>2007 Summer(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min</td>
<td>avg</td>
</tr>
<tr>
<td>Rel Density (60/60° F)</td>
<td>0.8217</td>
<td>0.8461</td>
</tr>
<tr>
<td>T50 (°F)</td>
<td>442</td>
<td>500</td>
</tr>
<tr>
<td>Aromatics (v/v)</td>
<td>16.8</td>
<td>28.7</td>
</tr>
<tr>
<td>Cetane Number</td>
<td>41.1</td>
<td>42.8</td>
</tr>
<tr>
<td>Sulfur(^3) (ppm)</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

\(^1\) Samples taken in January 2007

\(^2\) Samples taken in July 2007

\(^3\) Using ASTM D5453 on S15 samples only
CARB Diesel Fuel Properties
Average Pool Properties\(^1\): Summer 2006\(^2\)

<table>
<thead>
<tr>
<th>Property</th>
<th>CARB ULSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>38.5</td>
</tr>
<tr>
<td>Rel Density (60/60° F)</td>
<td>0.8324</td>
</tr>
<tr>
<td>T50 (°F)</td>
<td>479.3</td>
</tr>
<tr>
<td>Aromatics (v/v)</td>
<td>17.6</td>
</tr>
<tr>
<td>Cetane Number (additized)</td>
<td>51.3</td>
</tr>
<tr>
<td>Cetane Number (clear)</td>
<td>49.1</td>
</tr>
<tr>
<td>Sulfur (ppm)</td>
<td>4.4</td>
</tr>
</tbody>
</table>

\(^1\) All data represent volume weighted averages.
\(^2\) Summer 2006: Refers to the period from June 1 through September 20, 2006.
## Comparison of CARB and Federal Diesel Fuel Properties

**Volume Weighted Summer 2006 vs. Average Sampled Summer 2007**

<table>
<thead>
<tr>
<th>Properties</th>
<th>CARB ULSD</th>
<th>FED ULSD&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volume weighted, Summer 2006</td>
<td>Average, Summer 2007</td>
</tr>
<tr>
<td>Rel Density (60/60° F)</td>
<td>0.8324</td>
<td>0.8463</td>
</tr>
<tr>
<td>T50 (°F)</td>
<td>479.3</td>
<td>504</td>
</tr>
<tr>
<td>Aromatics (v/v)</td>
<td>17.6</td>
<td>27.5</td>
</tr>
<tr>
<td>Cetane Number&lt;sup&gt;2&lt;/sup&gt; (additized)</td>
<td>51.3</td>
<td>46.9</td>
</tr>
<tr>
<td>Sulfur (ppm)</td>
<td>4.4</td>
<td>6</td>
</tr>
</tbody>
</table>

<sup>1</sup> Data from “Alliance of Automobile Manufacturers’ North American Fuel Survey”

<sup>2</sup> Assumes FED ULSD samples are additized
## Results from EPA’s Unified Model

CARB ULSD, Average Summer 2006 vs. Federal ULSD, Average Summer 2007

<table>
<thead>
<tr>
<th>EPA’s Unified Model Results</th>
<th>Default NOx (g/bhp-hr)</th>
<th>Group L NOx (g/bhp-hr)</th>
<th>Default PM (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal ULSD</td>
<td>4.787</td>
<td>2.524</td>
<td>0.149</td>
</tr>
<tr>
<td>CARB ULSD</td>
<td>4.578</td>
<td>2.435</td>
<td>0.140</td>
</tr>
<tr>
<td>Emission Change</td>
<td>- 4.4%</td>
<td>- 3.5%</td>
<td>- 6.0%</td>
</tr>
</tbody>
</table>
Future Discussion Topics

- Additional data and analysis needed regarding range of fuel properties from commercially available Federal ultralow diesel fuel
- Determine vehicle/engine matrix for emissions testing
- Selection of appropriate Test cycle(s)
- Schedule coordination with Biodiesel research project
Next Meeting

• Tentatively scheduled for May, 2008

• Visit our web site
  – http://www.arb.ca.gov/fuels/diesel/dieselcomp/dieselcomp.htm
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