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&lt;sup&gt;1&lt;/sup&gt;</th>
<th>2007 Summer&lt;sup&gt;2&lt;/sup&gt;</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&lt;sup&gt;3&lt;/sup&gt; (ppm)</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

<sup>1</sup> Samples taken in January 2007
<sup>2</sup> Samples taken in July 2007
<sup>3</sup> 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 Volume weighted, Summer 2006</th>
<th>FED ULSD(^1) Average, Summer 2007</th>
</tr>
</thead>
<tbody>
<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(^2) (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>

\(^1\) Data from “Alliance of Automobile Manufacturers’ North American Fuel Survey”

\(^2\) 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
Contact Information

• Gary Yee, Manager
  – (916) 327-5986
  – gyee@arb.ca.gov

• Dean Bloudoff, Staff
  – (916) 322-1521
  – dbloudof@arb.ca.gov