Biodiesel and Renewable Diesel Research Study

April 10, 2008

California Environmental Protection Agency

Air Resources Board
Introductions
Agenda

• Introduction
• Summary of previous workgroup discussions
  • Fuels
  • Engine selection
  • Vehicle Selection
  • Test Matrix
• Test Protocol
• Test schedule
• NOx Migration Update
• Biodiesel Multimedia Tier Evaluation
• Open discussion

• Comparison of Emission Benefits of CARB Diesel vs. Federal Diesel
  • Open discussion
• Executive Order S-1-07 Low Carbon Fuel Standard (LCFS)
  – Reduce at least 10 percent of the carbon intensity of California's transportation fuels by 2020.
  – Early action item with a regulation to be adopted and implemented by 2010.
• Executive Order S-06-06, establishing targets for the use and production of biofuels and biopower
  – Includes biodiesel and ethanol.
  – California shall produce a minimum of 20 percent of its biofuels within California by 2010, 40 percent by 2020, and 75 percent by 2050.
• Low Carbon Fuels Standard
  – Biofuels Specifications adopted by the first quarter of 2009
  – Biodiesel and renewable diesel research study is needed
Biodiesel and Renewable Diesel Research Study

- Biodiesel and renewable diesel emissions evaluation
- NOx formation and mitigation evaluation
- Transportation Refrigeration Units (TRUs)
- Light duty vehicles
- Durability study
- Multi-Media evaluation
**Funded Research Update**

- **Biodiesel and Renewable Diesel Research Study**
  - Biodiesel and renewable diesel characterization and NOx mitigation study-$1,689,000
  - Biodiesel and renewable diesel multimedia study-$400,000
  - Total cost $2,189,000
- **Other contributors**
  - South Coast Air Quality Management District-$150,000
  - National Biodiesel Board-$50,000
  - WSPA provided the CARB diesel
  - Innerstate Oil is providing transportation, short term storage of fuels, and the facility to blend fuels
  - Neste has provided the renewable diesel and funding
  - Discussions on-going with other contributors
Biodiesel and Renewable Diesel Emissions Characterization and NOx Mitigation Research

“Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California- Biodiesel Characterization and NOx Formation and Mitigation Study”

Principal Investigators: Thomas D. Durbin (UCR) and J. Wayne Miller (UCR)
University California Riverside-CE-CERT
University California Davis
Scope of Work

Task 1: Biodiesel and Renewable Diesel Emissions Evaluation Study
- Evaluate emissions and health effects
- Evaluate NOx impact

Task 2: NOx Formation and Mitigation Study
- Investigate the mechanism of NOx formation and evaluate possible NOx mitigation options
  - Changes in fuel specifications-match blending
  - Refinery process
  - Additives
Summary of previous workgroup discussions
Fuels Update-Specifications

Initial base fuel specifications analysis

- CARB diesel fuel-ASTM D975
- Renewable diesel fuel ASTM D975
- Biodiesel feedstocks-D6751
- Samples from multiple drums were pooled
- All analyses conducted in triplicate
  - Where available, the certificate of analysis will count as one replicate.
Fuels Update-Biodiesel Additive

- Bioextend 30 (Tenox) treat rate
  - Based on oxidative stability and duration of storage
  - Recommended 600-700 ppm
  - Added directly to biodiesel feedstock not to finished fuel blend
Fuels Update-Blending

- Initial blend: 300 gallons of animal feedstock B20
- Blend level check by ASTM D7371-07
  - Samples were collected at various depths in the tote to check for uniform mixing
  - Samples will be sent to Magellan Laboratories for analysis
- Main blending of all blend levels and feedstocks to be conducted in mid-April
Fuels Update-Blending

• Main blending conducted in totes
• Gravimetric blending
• Add biodiesel last
• Biodiesel blend will be stirred for one hour
• Four totes needed per biodiesel blend
  – Mixing between totes will be done by electric pumps
  – Blend level will be measured
Fuel Storage Update

- On-going search for suitable long term storage facility
  - Located a non-temperature controlled storage facility on the coast where there is smaller temperature swings
Test Engine Update

• Engine secured for testing
  – 2006 11 L Cummins ISM purchased
• Other engines under consideration
  – 2007 15 L Detroit Diesel 15 (DD15)
    • Smallest DD15 engine at maximum horse power rating of the dynamometer (1550 ft-lb limitation)
  – 2007 11 L Detroit Diesel series 60 engine
  – 2007 International
Test Vehicle Update

• Vehicle one secured for testing
  – Purchased a heavy-Duty Truck equipped with a 2006 11 L Cummins ISM

• Rent/lease second vehicle
  – Heavy-duty diesel truck equipped with a 2007 Caterpillar C15 engine

• Vehicle three
  – Medium duty truck or bus
Test Vehicle Update - Aftertreatment Selection for Vehicle Three

- Cleaire Longview
  - Significant market share for buses
  - Controls both NOx and PM

- Johnson Matthey reformulated CRT
  - Expected to have significant market share
  - PM only
Discussion
Test Design

• Task 1: Biodiesel and Renewable Diesel Characterization Study
  – NOx Impact
  – Unregulated emissions and health effects

• Task 2: NOx Mitigation Study
  – Phase one
  – Phase two
Biodiesel and Renewable Diesel NOx Impact Study

Biodiesel and Renewable Diesel Characterization Study

On-Road Engines Tests
NOx Impact Study

CE-CERT

NOx Pretest
Engine Dynamometer

MTA Lab
On-Road Vehicles

Pre-Test
Transfer Chassis Cycles into Engine Cycles
Toxics Pre-test

NOx Main Test
Engine Dynamometer

Main Test
Emissions and Health Effects

Chassis Test
Emissions and Health Effects Study

Stockton Lab
Off-Road Vehicles/Engines

Off-Road Engines/Vehicles
Criteria Emissions Characterization

Main Test
Chassis
Possible Biodiesel NOx Impacts

- Evaluate test cycle load effects on NOx
- Evaluate biodiesel level effects on NOx
Biodiesel NOx Effect-Average Cycle Power

Figure 1: B20 and B50 Effects on NOx Emissions
MY 2004 Cummins ISB Engine

\[ y = -5.576 + 0.445x \]
\[ y = -2.094 + 0.17x \]

- EPA CBET Program
CE-CERT NOx Impact Study: Main Test

- Build upon USEPA and NREL studies
- Test conducted on an engine dynamometer
  - Engine dynamometer is suited to conduct the NOx impact study study
  - Provides precision necessary to distinguish small differences in NOx i.e. 2% change at B20
- Engines
  - 2006 Cummins ISM and 2007 engine
- Test cycles
  - FTP, UDDS light, HHDDT cruise
CE-CERT Main Test Protocol

• Received no comments
Discussion
On-Road Biodiesel and Renewable Diesel Characterization Study Conducted at ARB’s Heavy Duty Dynamometer Facility’s (MTA) Chassis Dynamometer Test Laboratory in Los Angeles
On-Road Biodiesel and Renewable Diesel Characterization Study

• Objective:
  – Test on-road vehicles
  – Emissions and health effects characterization
    • In-depth toxics characterization
    • Greenhouse gas emissions
    • Ultrafines and other species

• Conducted at MTA
Test Protocol

• Revised Draft test protocol posted
  – Table 2: revised some of the estimated target detection limits

• Issues to be resolved
  – Regeneration events
    • Record regeneration events
    • Include as part of data
  – Crankcase emissions
Discussion
Off-Road Vehicle Test Conducted At Stockton’s Emission Test Facility

– Obtained engine dynamometer
NOx Mitigation Study

– No updates at this time
## Test Schedule - Emissions Characterization and NOx Mitigation Tests

<table>
<thead>
<tr>
<th>Logistics</th>
<th>Fuel Delivered</th>
<th>Fuel specs Fuel blend</th>
<th>Pretests</th>
<th>CeCERT Engine tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biodiesel Emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'2006</td>
<td>Eng 2006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'2007</td>
<td>Eng 2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTA tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle 2007</td>
<td>Veh 2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxics emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxics and health effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle w/wo retrofit</td>
<td>Veh w/woRet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxics emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxics and health effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Dec-07 | Jan-08 | Feb-08 | Mar-08 | Apr-08 | May-08 | Jun-08 | Jul-08 | Aug-08 | Sep-08 | Oct-08 | Nov-08 | Dec-08 | Jan-09 | Feb-09 | Mar-09 | Apr-09 | May-09 | Jun-09 | Jul-09 |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |

- **Duration of emissions tests**
- **Expected range when analytical results will be completed**
Test Schedule

• Goal is to adopt the low carbon fuel standard in December of 2008
  – Requires “critical mass” of biodiesel and renewable research be completed before December 2008
  – Options
    • Increase number of emissions tests per day
      – Require revision to test protocol
      – Pretest will determine if this is a suitable option
    • Completely characterize one engine before starting second engine
Discussion
Light-Duty Diesel Vehicle Testing

• To be conducted in collaboration with ARB’s Research Division Light-Duty Test Program
• Two vehicles
  – One passenger car
  – One pick-up truck/SUV/minivan
• Start date delayed to late 2008
Durability Study

- Request for proposal
  - Literature search
  - Survey
- CRC advisory role
TRU Research

- TRUs
  - Test B100 on TRU engines
  - Proposed test will be conducted at the small engine dynamometer facility in El Monte
  - Estimated to be conducted in the Summer 2008
Biodiesel Multimedia Assessment

• Principle Investigators
  – Dr. Tom McKone, University CA Berkeley
  – Dr. Tim Ginn University CA Davis

• Biodiesel and renewable diesel
  – Assesses impacts on water, soil, air, human health, and the environment
  – Compared to CARB diesel
  – Evaluation includes a range of feedstocks, blend levels, and additives
Biodiesel Multimedia Assessment Protocol

• Draft Multimedia Guidance Document
  – Tier one: Establishes the risk assessment elements and issues (scope of work)
  – Tier two: Development of the experimental design
  – Tier three: Multimedia risk assessment submittal, review, and recommendation

• Goal to present Draft Tier one at the next advisory group meeting
# Test Schedule

## Biodiesel Studies by Tasks

|------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|

## Biodiesel Emissions

- Regulated emissions
- Toxic emissions
- Toxic and health effects

## Biodiesel Mitigation

- Planning
- Phase one Emissions test
- Phase two Emissions test
- Final Report
- Light Duty
- Multimedia
- Funded
- Tier one
- Tier two
- Tier three
- Peer Review
- EPC

## Biodiesel Durability

- 06 Jun 2007-06 Jun 2008
- 08 Dec 2007-08 Dec 2008
- 09 Feb 2008-09 Feb 2009
- 10 Apr 2008-10 Apr 2009
- 11 Jun 2008-11 Jun 2009

## Duration of emissions tests

- Expected range when analytical results will be completed
- Tentative schedule to complete task

---

**Notes:**
- Color codes: Yellow = in progress
- Green = completed
- Red = not completed

**Timeline:**
- 06 Jun 2007-06 Jun 2009
- 08 Dec 2007-08 Dec 2009
- 09 Feb 2008-09 Feb 2009
- 10 Apr 2008-10 Apr 2009
- 11 Jun 2008-11 Jun 2009

---

**Report:**
- Final Report
- Light Duty
- Multimedia
- Funded
- Tier one
- Tier two
- Tier three
- Peer Review
- EPC

**Biodiesel Mitigation:**
- Planning
- Phase one Emissions test
- Phase two Emissions test
- Final Report
- Light Duty
- Multimedia
- Funded
- Tier one
- Tier two
- Tier three
- Peer Review
- EPC
Future Discussion Topics

• UL certification of biodiesel pumps
• Guidelines for converting a diesel engine to biodiesel
Biodiesel and Renewable Diesel Advisory Group

- Next meeting in June 2008