Biodiesel and Renewable Diesel Emissions Study (Regulated Emissions)

Dec. 8th, 2010

Kwangsam Na

Heavy Duty Diesel Emission Testing Laboratory
Mobile Source Control Division

Objective:

To look at the impact of blend levels, feed stocks, and driving cycles on regulated emissions and a global warming gas.

- Blend Levels (20%, 50%, 100%)
  - Soy-based biodiesel
  - Animal fat biodiesel
  - Renewable diesel

- Feed Stocks
- Driving Cycles (UDDS, Cruise)

Regulated Emissions (PM, NOx, CO, THC)
Global Warming Gas (CO2)
Vehicles Tested

Veh. #1: 2000 Freightliner C15 Caterpillar

Veh. #2: 2006 International ISM 370

Veh. #3: 2008 Freightliner Mercedes Benz MBE 4000

Description on vehicles and fuels tested

<table>
<thead>
<tr>
<th>Make/model/year</th>
<th>Emission Control Devices</th>
<th>Displacement (liter)</th>
<th>Inertia weight (lbm)</th>
<th>Horsepower Torque</th>
<th>Test fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 Freightliner C15 Caterpillar</td>
<td>EGR</td>
<td>28.794</td>
<td>43,681</td>
<td>590 at 1850 rpm</td>
<td>CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), Renewable diesel (R20, R50, R100)</td>
</tr>
<tr>
<td>2006 International ISM 370</td>
<td>EGR</td>
<td>35.189</td>
<td>43,480</td>
<td>370 at 1850 rpm</td>
<td>CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), Renewable diesel (R20, R50, R100)</td>
</tr>
<tr>
<td>2008 Freightliner Mercedes Benz MBE 4000</td>
<td>EGR, DOC, DPF</td>
<td>21.100</td>
<td>43,480</td>
<td>450 at 1850 rpm</td>
<td>CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), Renewable diesel (R20, R50, R100)</td>
</tr>
</tbody>
</table>

Driving Cycles Tested

I. Urban Dynamometer Driving Schedule (UDDS): low load cycle

II. 50 mph Highway Cruise: High load cycle
Emission Data Measured

<table>
<thead>
<tr>
<th>Regulated components</th>
<th>Non-regulated components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Oxides of Nitrogen (NO\textsubscript{x})</td>
<td>• Carbon Dioxide (CO\textsubscript{2})</td>
</tr>
<tr>
<td>• Particulate Matter (PM)</td>
<td>• Nitrous Oxide (N\textsubscript{2}O)</td>
</tr>
<tr>
<td>• Total Hydrocarbons (THC)</td>
<td></td>
</tr>
<tr>
<td>• Carbon Monoxide (CO)</td>
<td></td>
</tr>
<tr>
<td>NO\textsubscript{2} fractions in NO\textsubscript{x}</td>
<td></td>
</tr>
</tbody>
</table>

Constant Volume Sampling (CVS) Dilution Tunnel and PM sampling Conditions

- Horiba full flow dilution tunnel
- Horiba PM filter unit

- Dilution air temp.: 25±5 °C
- Heated filter temp.: 47±5 °C
- Filter face velocity: 100±10 cm/s\textsuperscript{2}

PM and Gas Analysis

- PM: Mettler Toledo UMX2 Micro Balance
- Gases: Horiba MEXA 7200D Exhaust Gas Analyzer

- Detector for Gas Analysis
  - CO, CO\textsubscript{2}, NDIR (Non-dispersive infrared)
  - THC: FID (Flame Ionization detector)
  - NOx: CLD (Chemiluminescence detector)
Test Results

Drift of NO\textsubscript{X} Emission for 2000 Vehicle UDDS Cruise Cycles & Fuel Blends

Testing date

NO\textsubscript{x} emissions (g/mile)

CARB Diesel

PM Emissions

Soy base
Animal base
Renewable Soy base
Animal base
Renewable

Double UDDS 50 MPH Highway Cruise

Emission rate for PM (g/mi)
Summary

- Average PM, THC and CO emission rates decreased with increasing blend level of biodiesel regardless of the driving cycles and the vehicle model year.

- For the 2008 vehicle, THC and CO emissions sharply dropped when the DOC is warmed up and were not affected by biodiesel concentration. PM emissions were close to or below detection limit. In other words, the use of biodiesel did not show any benefits in the reduction of THC, CO and PM emissions when used with DOC/DPF.

- The 2008 vehicle equipped with DOC and DPF showed the lowest regulated pollutant emissions among the vehicles tested. However, this vehicle was not effective at reducing CO₂ emissions.
Summary (Contd)

• NOx significantly increased for 50% and higher biodiesel blends regardless of the driving cycles and the vehicle model year. Increase in NOx emission was most noticeable for the 2008 vehicle.

• For renewable diesel, NOx shows a decreasing trend with increasing blend level for both driving cycles. However, its significant increase was observed for pure renewable diesel.

• For the 2000 vehicle with no NOx control device (EGR), more NOx was emitted for the highway cruise cycle (having high load) than the UDDS cycle (with lower load). However, this emission pattern was opposite for vehicles equipped with EGR, showing a better NOx reduction efficiency under higher load driving cycle.

Summary (contd)

• CO2 emissions were not significantly impacted by biodiesel blend levels for different vehicle model year except for renewable diesel blend levels higher than 50% which significantly decreased CO2 emissions for both driving cycles.

• No significant impact of biodiesel was found on NO2 fractions for all vehicles tested. The NO2 fractions were the highest for the 2008 vehicle equipped with a DOC. The 2006 vehicle equipped with EGR showed a higher NO2 fraction than the 2000 vehicle with no EGR.

Thank you for your attention !!!