Retrofit Application Engineering

Manufacturers of Emission Controls Association

Southeast Diesel Collaborative
Third Annual Partners Meeting
June 25, 2008

Application Engineering Process

• Opportunity definition
  – Information profile/documentation
• Control technology assessment
  – Verification review
  – BACT review
  – Technology options
• Exhaust temperature/duty cycle
  – Datalogging
  – Analysis/feedback
• Control technology sales/application
  – Product selection/supply
  – Installation/maintenance
Opportunity Definition

• Fleet Analysis
  – Engine/vehicle/MY
  – Engine type/configuration
  – Exhaust system details
  – Mounting hardware
• Wrong information = wrong parts

Emissions Technology Assessment

• Verification review
  – EPA listed
    (epa.gov/otaq/retrofit/verif-list.htm)
    • % Reductions of PM, NOx, HC, CO
  – CARB listed
    (arb.ca.gov/diesel/verdev/verdev.htm)
    • Level 3 (≥ 85% PM reduction)
    • Level 2 (≥ 50% PM reduction)
    • Level 1 (≥ 25% PM reduction)
### Voluntary Diesel Retrofit Program

The table shows all of the diesel retrofit products that have been approved to date in the state of California. The table includes the product name, type, and description. The table also includes the following columns: Technology, Applicability, PM reduction, NOx reduction, and HC reduction.

<table>
<thead>
<tr>
<th>Model</th>
<th>Technology</th>
<th>Applicability</th>
<th>PM Reduction</th>
<th>NOx Reduction</th>
<th>HC Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caterpillar Inc.</td>
<td>Catalyst-Less Engine</td>
<td>Heavy-duty, non-high-NOx, 4-cylinder, model years 1999-2003, low-emission diesel engine</td>
<td>50%</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td>Caterpillar Inc.</td>
<td>Catalyst-Less Engine</td>
<td>Heavy-duty, non-high-NOx, 4-cylinder, model years 1999-2003, low-emission diesel engine</td>
<td>50%</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td>Green Diesel Technologies Inc.</td>
<td>Platinum Plus Filter System</td>
<td>Heavy-duty, non-high-NOx, 4-cylinder, model years 1999-2003, low-emission diesel engine</td>
<td>50%</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td>Green Diesel Technologies Inc.</td>
<td>Platinum Plus Filter System</td>
<td>Heavy-duty, non-high-NOx, 4-cylinder, model years 1999-2003, low-emission diesel engine</td>
<td>50%</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td>Green Diesel Technologies Inc.</td>
<td>Platinum Plus Filter System</td>
<td>Heavy-duty, non-high-NOx, 4-cylinder, model years 1999-2003, low-emission diesel engine</td>
<td>50%</td>
<td>90%</td>
<td>60%</td>
</tr>
</tbody>
</table>

### California Environmental Protection Agency

**AIR RESOURCES BOARD**

**VERIFICATION PROCEDURE - LEVEL 2**

This page last reviewed January 3, 2005

**Level 2**

LEVEL 2 verification is for those technologies achieving at least 50 percent or greater reduction in particular matter. If the technology also includes NOx reduction, it will be stated in the description. Please read the executive order(s) below which provide additional information on the applicability of the device for your particular engine. Click on the link below each system for a list of engine families for which devices have been approved (engine series names are provided for reference in most cases). For more detailed information on the device, please contact the device manufacturer directly. New information will be posted as additional systems are verified. Please check periodically for updates.

The ARB has verified the DuraTech Diesel Inc., DFM DUO multi-stage filter (DMF) system with/without the Donaldson Spracle closed crankcase filtration system for 1991 through 2002 diesel engines used in on-road applications operating on ultra low-sulfur diesel fuel. The DFM DMF system with/without the Donaldson Spracle closed crankcase filtration system uses a multi-stage flow-through filter with an optional closed crankcase filtration system to achieve a 90 percent reduction in particulate matter emissions qualified for a Level 2 verification. Specific engine families and conditions for which the DFM DMF system with/without the Donaldson Spracle closed crankcase filtration system has been approved may be found in the Executive Order and attachment below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Executive Order</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 16, 2005</td>
<td>DEO-06-012</td>
<td>Attachment</td>
</tr>
<tr>
<td>December 16, 2005</td>
<td>DEO-06-013</td>
<td>Attachment</td>
</tr>
</tbody>
</table>
### Tailpipe PM Levels

#### On-road

Older engines are higher polluters

<table>
<thead>
<tr>
<th>Model Year</th>
<th>PM Reg. (g/bhp-hr)</th>
<th>Retrofit Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-1988</td>
<td>Unregulated (~1.0)</td>
<td>Level 1?</td>
</tr>
<tr>
<td>1988-1990</td>
<td>0.60</td>
<td>Level 1</td>
</tr>
<tr>
<td>1991-1993</td>
<td>0.25</td>
<td>Level 1,2</td>
</tr>
<tr>
<td>1994-2006</td>
<td>0.10</td>
<td>Level 1,2,3</td>
</tr>
<tr>
<td>2007+</td>
<td>0.01</td>
<td>OE installed</td>
</tr>
</tbody>
</table>

#### Off-road 300-600 hp

Older engines are higher polluters

<table>
<thead>
<tr>
<th>Model Year</th>
<th>PM Reg. (g/bhp-hr)</th>
<th>Retrofit Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-1996</td>
<td>Unregulated (~1.0)</td>
<td>Level 1?</td>
</tr>
<tr>
<td>Tier 1 1996-2000</td>
<td>0.40</td>
<td>Level 1, (2,3?)</td>
</tr>
<tr>
<td>Tier 2 2001-2005</td>
<td>0.15</td>
<td>Level 1,2 (3?)</td>
</tr>
<tr>
<td>Tier 3 2006-2010</td>
<td>0.15</td>
<td>Level 1,2,3</td>
</tr>
<tr>
<td>Tier 4 2011</td>
<td>0.015</td>
<td>OE installed</td>
</tr>
</tbody>
</table>
Emissions Technology Assessment

• **Best Available Control Technology (BACT)**
  - Highest level PM reduction technology (Level 3, 2, or 1) which is verified for specific engine families and operating conditions

• **Must start with Level 3**
  - Default to Level 2 or 1 when needed

Temperature Profile

• **Exhaust temperature/duty cycle requirements**
  - Match technology level to engine/vehicle operation
    - Duty cycle dominant
    - Particular engine, ambient temps play smaller role
  - Determine data-logging need
    - Representative sample of engines
    - Coldest applications
    - I.E. short, slow, flat routes; high idle
Exhaust Temperature/Duty Cycle

- Temperature profile
  - Data-logger kit
    - Hardware
    - Installation/operations manual
    - Software
    - Instructions/data form
- Complete data-logging
  - Data taken and provided to control technology supplier

Exhaust Temperature/Duty Cycle

- Data Analysis
  - Data imported into supplier database for analysis and storage
  - Analysis/assessment for proper temperature criteria
- Feedback response documented to customer
Emissions Technology Application

- Product selection
  - Sales/application literature
  - Engine HP
  - Exhaust flow
  - Muffler configuration
  - Inlet/outlet size

### DPF Muffler Kits

<table>
<thead>
<tr>
<th>Style</th>
<th>Length</th>
<th>ID No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style 1</td>
<td>30.0”</td>
<td>10.0”</td>
</tr>
<tr>
<td>Style 2</td>
<td>30.0”</td>
<td>20.0”</td>
</tr>
<tr>
<td>Style 3</td>
<td>30.0”</td>
<td>20.0”</td>
</tr>
<tr>
<td>Style 4</td>
<td>30.0”</td>
<td>20.0”</td>
</tr>
<tr>
<td>Style 5</td>
<td>30.0”</td>
<td>20.0”</td>
</tr>
<tr>
<td>Style 6</td>
<td>30.0”</td>
<td>20.0”</td>
</tr>
</tbody>
</table>

### Muffler Styles

- Style 1
- Style 2
- Style 2A
- Style 3
- Style 4
- Style 4A
- Style 5
- Style 6
Installation Kit

Emissions Technology Operation

- Installation/maintenance
  - Owner’s manual
    Installation, warranty and maintenance procedures
  - Application documentation files
    - Specific control technology match to engine/vehicle application

Diesel Particulate Filters (DPF) Installation, Operation and Maintenance Manual

Guides the user through the installation of DPF technology, ensuring adherence to emissions standards.
Summary

• Complete fleet analysis
• Tailpipe emissions (MY) determine options
• Verified products for grant funded projects
• Exhaust temperature profile needed for Level 2&3
• Engine HP, flow needed for sizing
• Engine & exhaust configuration needed for parts selection