Status of APBF-DEC NOx Adsorber/DPF Projects

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APBF-DEC* is Managed and Directed by Technical Committees

DOE, EPA, additive companies, automobile manufacturers, engine manufacturers, energy companies, emission control mfrs., Calif. agencies

APBF-DEC Steering Committee

- Unregulated emissions
- Experimental design and data analysis
- Fuel and lubricant provision
- Communications

- Fuels, engines, NO\textsubscript{x} adsorbers, and diesel particle filters
- Fuels, engines, selective catalytic reduction and diesel particle filters
- Lubricants

*Advanced Petroleum-Based Fuels - Diesel Emission Control
APBF-DEC Activity is Supported by Industry and Government Partners and Subcontractors

- DOE
  - NREL
  - ORNL
- API - American Petroleum Institute
- EMA - Engine Manufacturers Association
- MECA - Manufacturers of Emission Controls Association
- ACC - American Chemistry Council
- NPRA - National Petrochemical and Refiners Association
- CARB - California Air Resources Board
- SCAQMD - South Coast Air Quality Management District
- EPA
- Battelle
- FEV
- SwRI
- Ricardo
- ATL
- DRI
5 Fuels Testing Projects Being Conducted at Contract Laboratories

- **NOx Adsorber/DPF**
  - Ricardo – Heavy-duty engine
  - SwRI – “Heavy-light duty” pickup truck
  - FEV – Light-duty passenger car

- **Urea SCR/DPF**
  - SwRI – Heavy-duty engine

- **Lubes**
  - ATL – Medium-duty engine
Objective: Examine fuel property effects on advanced diesel emission control systems.

Approach:

• Demonstrate low emissions potential of diesel engines equipped with advanced fuel, NOx adsorbers, DPFs, double-wall exhaust, etc
  - Three engine and/or vehicle platforms, two different exhaust system architectures on each platform
• Age systems with DECSE 8 and 15 ppm S fuel for up to 1500 hrs
  - Periodic emissions evaluations during aging
  - Periodic unregulated emissions measurement with 15 ppm S refinery product
• Examine other fuel properties
Each platform will determine effects of fuel properties on:

- NOx and PM reduction efficiency
- Fuel economy
- Other particle emissions
  - PM breakdown (SOF, sulfate, insolubles)
  - PAH and Nitro-PAH
  - Metals
- Other gas phase emissions
  - THC, NMHC, CO, CO₂
  - Gas phase PAH and nitro-PAH
  - Nitroxyalkanes
  - Benzene
  - 1,3 butadiene
  - Formaldehyde
  - Acetaldehyde
  - N₂O
  - SO₂
  - H₂S
Heavy-Duty Project Being Conducted at Ricardo

- 15 liter ISX engine supplied by Cummins
  - DOHC, 4 valves/cylinder, central unit injector
  - Rated at 475-500 hp, 1650 lb.ft torque
  - Fitted with EGR system, compliant with 2002/2004 standards
- Cummins is supporting control system interface
- HD FTP and 13-mode S.S.
Heavy-Duty Single Leg Adsorber System

- Catalysts supplied by MECA member
- Single leg NOx Adsorber system delivered
- Increased EGR, in-cylinder post-injection, and in-pipe fuel injection will be used for regeneration
Heavy-Duty Dual Leg Adsorber System

- Catalysts supplied by MECA member
- Dual leg NOx Adsorber system expected 8/2002
- Rich exhaust conditions will be achieved by in-pipe fuel injection
Heavy-Duty Status/Plans

- Currently tuning/optimizing ECS – A (single leg system). Continue through October ‘02
- Baseline engine-out testing: October 2002 (includes toxic/unregs with BP15)
- Delivery of ECS-B (dual leg system) expected this month. Will tune/optimize through December ‘02
- Aging and performance testing: Jan-Oct 2003
- Other fuel properties: Fall 2003
Pickup/SUV project being conducted at Southwest Research Institute

- 2002 Chevrolet Silverado 2500 HD pickup
- 6.6 liter Duramax Diesel
  - 300 hp @ 3100 rpm
  - Center-mounted Turbocharger
  - Charge Air Cooled
  - Bosch Common Rail Fuel Injection
  - 4V Aluminum Heads
  - 2002 CA Calibration
- FTP, US06, and HFET cycles
Pickup/SUV Project Single Leg Adsorber System (ECS-A)

Single In-Line Emissions Control System
Pickup/SUV Project Dual Leg Adsorber System (ECS-B)

Dual-Branch Emissions Control System
Exhaust Temperatures Over the Light-duty FTP present a significant challenge

- **Downpipe Location (Average = 162°C)**
- **"Catalyst" Inlet Location (Average = 153°C)**
Transient engine dyno test emulates the light-duty chassis dynamometer FTP
Engine dyno test produces nearly same NOx as chassis dynamometer test

Test Cell Cycle (Cold_Rev_8) Results in 7% Lower NOx Compared to Vehicle Test
Engine dyno exhaust temperature also agrees well with chassis test

- **Vehicle Test - No EGR**
- **Test Cell - No EGR (Cold_Rev_8)**
More aggressive EGR has yielded significant engine-out NO\textsubscript{x} reduction

Mass Reduction to Reduce Required NAC Efficiency to 95%

- No EGR
- EGR\_Cal2\_Revised
- Engine-Out Target

Accumulated Engine-Out NO\textsubscript{x} Mass (grams)

Time (seconds)
Pickup/SUV Project Status and Plans

- All catalysts on hand
- Currently tuning/optimizing systems (both single and dual leg systems). Continue through November ‘02
- Baseline engine-out testing: October 2002 (includes toxic/unregs with BP15)
- Aging and performance testing: Jan-Dec 2003
- Other fuel properties: Fall 2003
Passenger car project being conducted at FEV

- Audi A4 Avant platform
- 1.9 liter engine
  - Bosch common-rail fuel injection
  - Central vertical injector
  - 4 valves/cyl
  - 100 kW @ 4000 rpm
  - ASCET-SD controls
- FTP, US06, and HFET cycles
Both passenger car emission control systems are single leg configuration.

Pre-Cat \rightarrow
Different formulations for ECS-A and ECS-B

NAC

CDPF
In addition to vehicle, three additional engines and engine test cells dedicated to this project.

Test Cell 4

Test Cell 5
Passenger Car Project Status and Plans

- Completed prototype engine builds, vehicle set up
- First sets of catalysts on hand (both systems)
- Developing transient dynamometer test to emulate chassis tests
- Currently tuning/optimizing systems. Continue through December ‘02
- Baseline engine-out testing: October 2002 (includes toxic/unregs with BP15)
- Aging and performance testing: Jan-Nov 2003
- Other fuel properties: Spring 2004
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Questions?

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