Quarterly Update

**Advanced Petroleum-Based Fuels–
Diesel Emissions Control (APBF-DEC) Project**

#9, Spring 2003

BACKGROUND

The APBF-DEC is an industry/ government project to identify and evaluate (1) the optimal combinations of low-sulfur diesel fuels, lubricants, diesel engines, and emission control systems to meet projected emission standards for the 2000 to 2010 time period, while maintaining improvement in engine efficiency and durability and (2) properties of fuels and vehicle systems that could lead to even lower emissions beyond 2010.

Sulfur in the fuel is known to interfere with the functioning of most emission control technologies and has been implicated as a possible factor in the formation of ultrafine particulate matter (PM). A systems approach is being used, i.e., simultaneously investigating fuels, lubricants, engines, and emission control systems.

A government/industry steering committee and working groups are guiding the APBF-DEC project. Funding for the project has been budgeted at $33 million and is being provided by federal and state government agencies, trade associations, and private industry. Representatives from these and other agencies, trade and professional associations, national laboratories and private sector companies serve on the 20-member APBF-DEC Steering Committee and its working groups.

The project is managed by DOE's National Renewable Energy Laboratory (NREL). Information about the APBF-DEC project is posted at: http://www.ott.doe.-gov/apbf.shtml.

APBF-DEC is the successor to the Diesel Emissions Control-Sulfur Effects (DECSE) project. DECSE publications and technical reports are available at: http://www.ott.-doe.gov/decse/.

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APBF-DEC Amending Scopes of Several Projects To Achieve Results on Time, within Budget

The technical scopes of two of the five test projects in the Advanced Petroleum-Based Fuels—Diesel Emissions Control (APBF-DEC) Project are being modified and changed. They are the nitrogen oxides (NO_x) adsorber catalyst (NAC)/diesel particle filter (DPF) technology projects: the pick-up truck/SUV and the heavy-duty truck. The focus will be on testing one system in each project, instead of two systems. This change will not be applied to either the passenger car project/NO_x adsorber/DPF or the selective catalytic reduction (SCR)/DPF project. Meanwhile, important tests to answer the original study questions are being continued, e.g., the effects of various sulfur (S) levels in diesel fuel on regulated and unregulated emissions and durability tests of the emission control systems.

The working group is considering other changes to the passenger car project to ensure completion of its work within budget and by the end of the 2004 calendar year. For example, two key changes are being considered: to replace most of the chassis testing with engine testing in the passenger car project and to remove the task of testing other fuels and fuel properties. If these changes are approved by the APBF-DEC Steering Committee, the aging time for the passenger car project could be increased from 1,000 hours to 2,200 hours and duplicate and triplicate evaluation tests could be added.

The other two projects—the SCR/DPF technologies, fuels, and engines project and the lubricants project—will continue as originally planned. For background information about the projects, please see the previous Quarterly Updates and the recently published APBF-DEC Annual Progress Report, FY 2002, at http://www.ott.doe.gov/apbf.shtml. Following are summaries of each project's major tasks.

Three NO_x Adsorber/Diesel Particle Filter (DPF) Projects

Pick-up Truck/SUV NO_x Adsorber/DPF

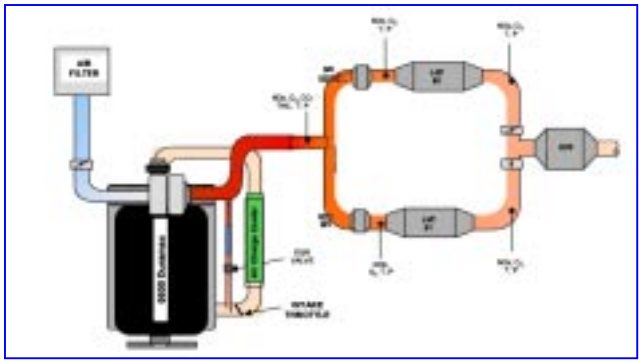
Test Bed: 2500 series Chevrolet Silverado, Duramax 6.6L diesel engine
Testing Laboratory: SwRI, San Antonio, TX

One emission control system (ECS)—the dual-leg system—is being used in Phase I testing, rather than two as originally planned. Emphasis is being placed on cold start strategies, supplemental fuel injection for NAC regeneration, NAC sulfur exposure tests, and desulfurization strategy development. New re-sized emission control components (NAC, DPF, and diesel oxidation catalysts [DOC]) are on hand or

NO_x Adsorber/DPF. The NO_x adsorber catalyst is a flow-through exhaust emissions control device with the potential to significantly reduce nitrogen oxides (NO_x), hydrocarbon (HC), and carbon monoxide (CO) emissions in the exhaust from diesel engines. When combined with a DPF, the system also can oxidize the diesel particulate matter (PM) and other unregulated emissions.

The purpose of the tests is to demonstrate the potential of low-sulfur fuel to enable achievement of stringent emission reductions from diesel engines using a system that includes the engine, fuel, NO_x adsorber, DPF, and thermal management technologies.

expected to be delivered in June. Then the optimization strategies will be tested and re-calibrated for the new components. A dynamic NAC regeneration strategy will be used based on a NO_x model control with a forced DPF regeneration. Once this is complete, the system aging and evaluation work will begin, probably in late June.

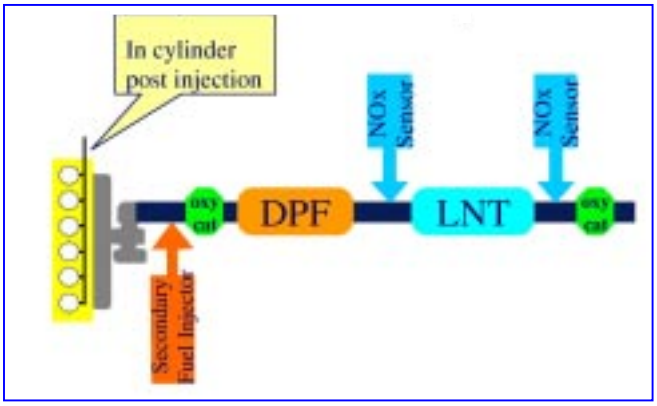


The dual-leg emission control system (ECS) is being aged in the engine test cell (above). The underbody of the pick-up truck/SUV (below) allows space for additional emission control components.

A Cummins ISX engine is shown in the test cell, where durability tests will be conducted.

Heavy-Duty NO_x Adsorber/DPF
Test Bed: 15L Cummins ISX, DOHC engine
Testing Laboratory: Ricardo, Inc., Burr Ridge, IL

Similar changes have been made to the test plan for the heavy-duty NO_x adsorber/DPF project. The project is using the single leg ECS rather than the dual-leg (see graphic). The ECS hardware was delivered to the testing laboratory in mid-April, enabling the development of regeneration and desulfurization strategies as well as beginning the durability tests in May. The first test will use 15-ppm S fuel for a 2,000-hour aging test and will be followed by a 300-hour test using 8-ppm S fuel. The durability tests are scheduled to be completed early in the 2004 calendar year.



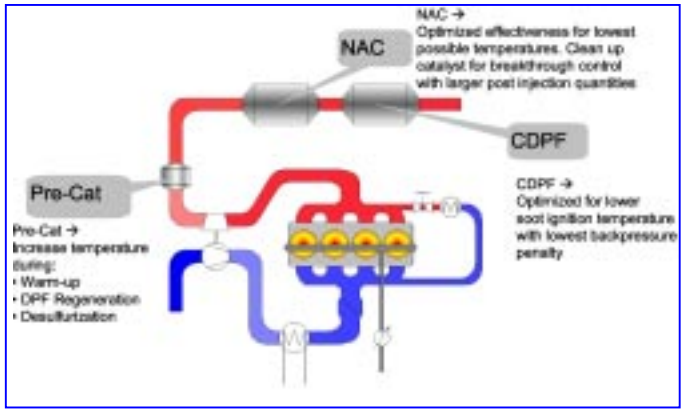
The schematic shows the single-leg ECS being used in the heavy-duty NAC project.

The passenger car underbody arrangement allows room for the ECS components.

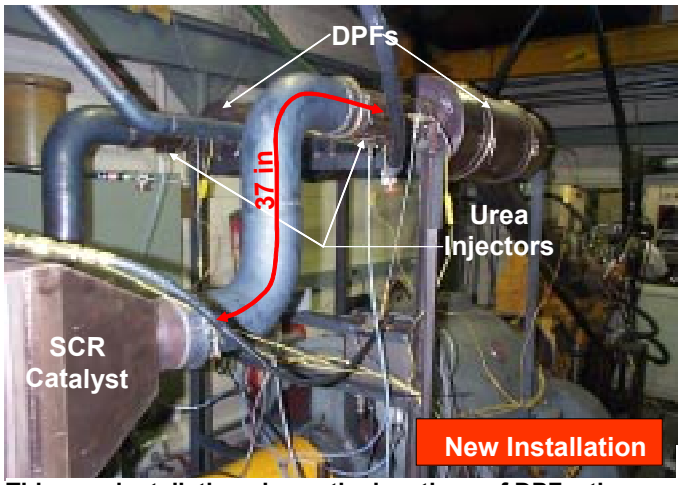
Passenger Car NO_x Adsorber/DPF

Test Bed: Audi A4 Avant with a 1.9 liter (L) TDI engine
Testing Laboratory: FEV Engine Technology, Inc., Auburn Hills, MI

This project is in the final stages of optimizing and calibrating the ECS. Final ECS strategies were set at the end of April. A dynamic NAC regeneration strategy is also being used, with NO_x sensors for feedback control and forced DPF regeneration. Baseline engine-out tests and an initial zero-hour tailpipe test will be conducted in May. Aging and evaluation testing will continue into 2004.



The underbody schematic illustrates the passenger car's ECS, with a pre-catalyst, a NO_x adsorber catalyst, and a catalytic diesel particle filter (CDPF).



This new installation shows the locations of DPFs, the SCR catalyst, and urea injectors. Urea is considered to be a stable, safe means of providing ammonia to SCR catalysts.

Selective Catalytic Reduction (SCR)/DPF Project

Test Bed: Caterpillar C-12 engine, a heavy-duty engine, model year 2000
Testing Laboratory: Southwest Research Institute (SwRI), San Antonio, TX

The SCR/DPF project calibrated its first combination test system (called System A), which demonstrated NO_x results just slightly above the 2010 federal emission standard and particulate matter (PM) results better than the standard. During the 200 hours of aging required before the comprehensive emission tests with different fuels, the SCR catalysts suffered slight degradation in performance. The desired maximum was exceeded during temperature "excursions" and the work on System A was suspended until replacement catalysts could be obtained.

SCR/DPF. The selective catalytic reduction technology (SCR) is an emissions reduction technology that—combined with a diesel particle filter (DPF), advanced fuel formulations and engine technologies—can reduce NO_x and PM emissions. Two different SCR/DPF systems are being evaluated.

The purposes of this test are to demonstrate the low diesel emissions possible by using advanced fuels, engines, and SCR/DPF technologies; evaluate the sensitivities of emission controls to fuel variables; determine regulated and unregulated emissions with and without emission controls; and examine the emission control system's durability.

Meanwhile, System B was installed in the emission test cell and calibrated for low emissions. The steady-state calibration produced results very similar to those from System A—NO_x results were very close to the 2010 federal emission standard, and PM was better than the standard. System B is being calibrated for work on the transient test cycle. When System B's calibration is complete, it will be subjected to 200 hours of aging, followed by emission tests with the different fuels. System B will then go to the durability test cell for 6,000 hours of aging. System A will be completed in a similar manner then moved to the durability test cell.

Additional hardware was installed in this engine to accommodate the exhaust gas recirculation system.

Lubricants

Test Bed: International T444E, 7.3L engine, with retrofits
Testing Laboratory: Automotive Testing Laboratories, East Liberty, OH
Technical Monitor: Shawn Whitacre, NREL

The APBF-DEC lubricants project will continue to be conducted in two phases in parallel with the four engine hardware technology projects. Phase I has completed its objective to characterize the effects of lubricant properties on engine out emissions. The data have been analyzed and the final report for Phase I is being prepared. The report is expected to be available on the Web site later this summer (see Internet address on page 1). The plan for Phase II testing will focus on the effects of lubricant formulation on the durability of NO_x adsorber catalysts. The results from Phase II, coupled with Phase I results, are expected to provide guidelines for (1) lubricant formulation (e.g., basestock selection and additive chemistry) and (2) guidelines for engine manufacturers and ECS suppliers.

Lubricants. Testing of lubricant formulations is being conducted to determine which, if any, lubricant-derived components in the emissions are detrimental to the performance or durability of the emission control systems (ECS). The test engine is installed on a dynamometer combining a double-ended GE DC-electric brake (200hp) with a Go-Power DT-2000 water brake (800hp), which provides precise control and high torque/power absorption capability on a single in-line assembly.

Acronyms used in this Quarterly Update

DOC – diesel oxidation catalyst
DPF – diesel particle filter
ECS – emission control system
EGR – exhaust gas recirculation system
hp – horsepower
LNT – lean NO_x trap
NAC – NO_x adsorber catalyst
NO_x – nitrogen oxides
PM – particulate matter
S – sulfur
SCR – selective catalytic reduction
SO_2 – sulfur dioxide