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EMISSIONS COMPARISON OF ALTERNATIVE FUELS IN AN ADVANCED AUTOMOTIVE DIESEL ENGINE

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Background and Objectives –The Partnership for a New Generation of Vehicles (PNGV) has identified the compression-ignition, direct-injection (CIDI) diesel engine as a promising technology in meeting the PNGV goal of an 80-mpg, production-prototype, mid-sized sedan by 2004. Challenges remain in reducing emissions levels of the CIDI engine to meet future emissions standards. Techniques under consideration for emissions control include improved combustion processes, after-treatment devices, and alternative fuels. The objective of this program was to perform an initial screening of several reformulated and alternative diesel fuels to obtain information on their potential for emissions reduction in a CIDI engine.

Technical Approach –The Department of Energy initiated this testing to determine the emissions impact from various fuel blends in a CIDI engine. The emissions testing was performed utilizing a Daimler-Benz model OM 611 diesel engine. This engine is a 2.2L, direct-injection diesel equipped with a high-pressure, common-rail injection system. The OM 611 also has variable EGR, is turbocharged with intercooling, and has variable intake swirl capability. No adjustments were made to the engine operating parameters to account for variations in the fuel properties.

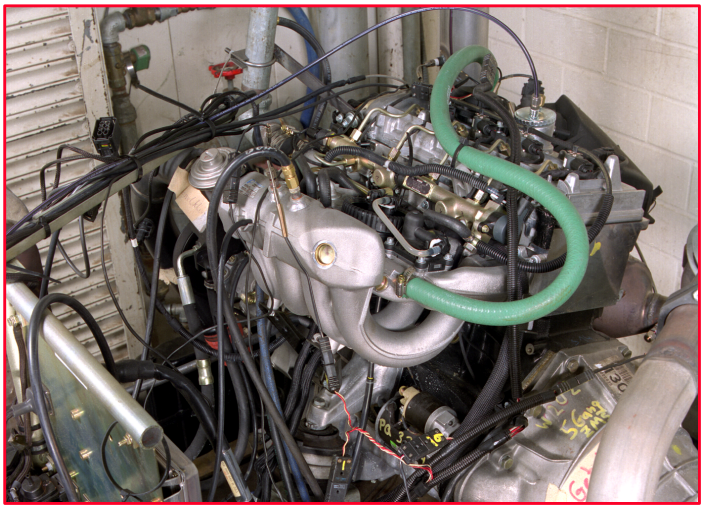
Seven fuels were included in the test program. A 2D EPA certification diesel served as the baseline for comparison of the remaining six fuels. The reformulated/alternative fuels included: "pseudo-California Certification fuel (CARB); Low-Sulfur Low-Aromatics diesel (LS); Neat Fischer-Tropsch synthetic diesel (FT100); Twenty-percent blend of biodiesel in fuel LS (B20); Twenty-percent blend of Fischer-Tropsch in fuel LS (FT20): Fifteen-percent blend of Methylal (DMM) in fuel LS (DMM15).

The test sequence consisted of 13 steady-state speed and load points. The 13 points are not related to the standard, EPA 13-mode test for heavy-duty engines. The test sequence was repeated three times for each fuel in a randomized test matrix. For each test mode, emissions of total particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO), total hydrocarbons (HC) and fuel consumption were measured. A particulate size distribution was determined for each fuel during one of the triplicate 13-mode tests. The data are engine-out emissions only, and the exhaust after-treatment system was disconnected.

Results –All six alternative fuels showed a reduction in PM emissions compared to 2D, with no statistically significant increases in NOx emissions. For an equally weighted average of the 13 test modes, the DMM15 blend produced a 52-percent reduction in particulates when compared to the 2D baseline fuel. Fuel FT100 reduced PM emissions by 37 percent, with B20 showing a 32-percent reduction. Several of the alternative fuels significantly reduced HC emissions at the low-speed, low-load operating modes. Average reduction in HC ranged from 24 to 50 percent of the 2D level. Carbon monoxide emissions were reduced across the entire operating range of the engine. For the 13-mode average, CO reductions ranged from 15 to 36 percent. The particulate size distribution measurements indicated no gross differences among the seven test fuels.

Conclusions and Recommendations –This test program has demonstrated that emissions levels can be reduced through the use of reformulated and alternative fuels in a CIDI diesel engine. Particulate matter emissions were reduced with no significant increase in emissions of NOx. The DMM15 blend showed the largest reduction in PM (52 percent) followed by the FT100 fuel (37 percent) and the B20 blend (32 percent). Because of the volatility of DMM, the DMM15 blend required changes to the fuel system to prevent the DMM from boiling out of solution. This may cause problems if this fuel is to be used on a wide-scale basis. The Fischer-Tropsch fuel, however, was substituted in the engine with no alterations and produced a good reduction in particulate emissions levels.

These results demonstrate that benefits can be achieved through the direct substitution of fuels in advanced diesel engines. Additional reductions in emissions may be possible if engine operating parameters such as injection timing and exhaust gas recirculation (EGR) levels can be adjusted for a specific fuel. Investigations of fuel system and materials compatibility will also be important along with the effects of alternative fuels on the performance of after-treatment devices.



OM 611 Engine