IMPACT OF LUBE OIL ON ADVANCED LIGHT-DUTY CIDI ENGINE EMISSIONS

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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-size sedan by 2004. Challenges remain in reducing emissions levels of the CIDI engine to meet future emissions standards. Techniques under consideration for this project include the use of an alternative fuel (ADMM15) and the use of different lubricants. The objective of this program was to perform an initial screening of three different lubricants to obtain information on their potential for emission reduction in a CIDI-engine.

Technical Approach: The Department Of Energy (DOE) and CRC initiated this testing to determine the emissions contribution of various oil formulations in a CIDI engine. The emissions testing was performed using a DaimlerChrysler OM 611 diesel engine. This engine is a 2.2L, turbo-charged with inter-cooling, direct-injection, diesel equipped with a high-pressure, common-rail fuel injection system. It also has variable-EGR and variable intake swirl capacity. No adjustments were made to the engine operating parameters to account for various fuel and lubricant properties. The test conditions were thus run with constant-torque settings.

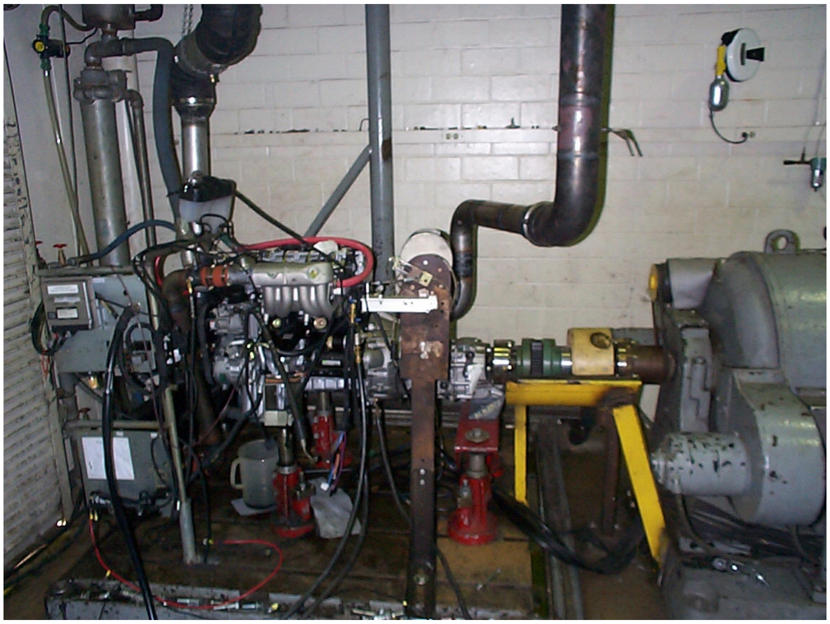
Three lubricants were used for the evaluation: a mineral based SAE 5W-30; a synthetic SAE 5W-30 with similar viscosity characteristics but lower volatility; and a synthetic SAE 15W-50, which has volatility similar to the synthetic 5W-30, but higher viscosity throughout the temperature range. Two test fuels were used: a California certification fuel (CARB) and a low-sulfur low-aromatic fuel containing 15% dimethoxymethane (ADMM15). This latter oxygenated fuel has been shown to be a low particulate forming fuel in other studies [2].

The test sequence consisted of five steady-state speed and load points and one FTP heavy-duty transient test. The steady-state conditions were selected to span a wide range of engine operations, and are consistent with the steady-state conditions selected for previous programs. The transient test, although a heavy-duty test with a predominance of high-power conditions, was selected since it is a widely recognized dynamometer-based transient cycle. The test sequence was repeated three times for each fuel and oil in a randomized test matrix. For each test mode, regulated emissions of total particulate matter (PM), nitrogen oxides (NO_x), carbon monoxide (CO), and total hydrocarbons (HC) were measured. To investigate the composition of the particulate in further depth, the total particulate was fractionated into the fuel volatile organic fraction (Fuel-VOF), oil volatile organic fraction (Oil-VOF), and the residual non-volatile organic fraction (Non-VOF).

Results: At most modes, the interaction between oil and fuel variables on emissions was not significant, thus allowing independent consideration of the fuel and oil effects.

Conclusions: Lubricant formulation makes a significant contribution to engine particulate emissions, which increases in importance as fuel-derived emissions are reduced. At low-power, light-duty cycle operations, the lubricant contribution to PM is predominately in the volatile fraction. The data developed here suggests that at high-power, heavy-duty cycle operations, the lubricant may have a significant contribution to the non-volatile portion of the PM.

Lubricant formulation changes can reduce the oil-VOF portion of the PM, and through changing the engine frictional losses also have a significant impact on NO_x and CO_2 emissions.



Side View of Mercedes Benz OM611 Exhaust System