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Hu, Shaohua (PI); Herner, Jorn; Robertson, William; Chang, M.-C. Oliver; Huai, Tao; Collins, John; Dwyer, Harry and Ayala, Alberto
California Air Resources Board
Emission Control Technologies (NOx and PM Emission Control Technologies)

Effects of Catalysts on Emissions from Heavy-Duty Diesel Retrofits for PM and NO_X Control

The Air Resources Board (ARB), with co-funding from the South Coast Air Quality Management District and the California Energy Commission has initiated a large study in collaboration with a number of academic partners to characterize the emissions from HDDVs equipped with advanced retrofits. Some of these are of the type expected as original equipment in diesel engines meeting the 2007/2010 emission standards. In this study, PM emission controls include four types of diesel particulate filters (DPF): a bare DPF, a DOC + un-catalyzed DPF, a catalyzed DPF, and a DOC + catalyzed DPF. The DPFs regeneration process can also be classified as either passive or active. NO_X emission controls include two prototype systems: a vanadium-based SCR and a zeolite-based SCR. The prototype DPF+SCR technologies are of particular interest because they represent a window into the future aftertreatments expected for simultaneous control of PM and NO_X.

Vehicles were tested at ARB's Heavy-duty Diesel Emissions Test Laboratory (HDETL) in Los Angeles over three driving cycles: steady state cruise, transient urban dynamometer driving schedule (UDDS), and idle operation. PM tailpipe emission samples were collected for analysis of organic and elemental carbon, PAHs, water-soluble ions, and trace metals/elements. Samples were collected for toxicity analysis by means of chemical and biological assays to determine oxidative potential. Real time instrumentation was used for particle number counting and sizing, particle-bound PAHs, and particle surface area measurements. Gas phase emission measurements included CO, CO_2, total and speciated hydrocarbons, NOx and NO_2.

The DOC reduced HC and CO by more than 90%. The DOC also reduced air toxics such as BTEX and PAHs, by more than 70%. High concentrations of nucleation-mode particles emissions were seen for vehicles with well aged retrofits (>50,000miles) when exhaust temperatures rose slightly above 300 ^oC. The NO_2 fraction of NO_X was increased from 9% to 50% by a DOC, and further increased to 66% by addition of a catalyzed DPF to the DOC. The SCR systems demonstrated an 80% or better reduction of NO_X. However, real-time measurements indicate less control of NOx during stop-and-go vehicle activity. The aftertreatment devices were efficient at reducing PM emissions and the corresponding toxicity in terms of redox activity (cruise: 72-95%; UDDS: >87% on a per km driven basis) relative to the baseline vehicle. The semi-volatile fraction of particles showed higher redox potential than the solid particle fraction for most vehicle configurations.

In general, the after-treatment devices work as designed. Catalytic loadings and exhaust temperature are two key components for achieving emissions control targets. The individual control components work in combination and can not be tested in isolation. It important to evaluate overall systems.