GASOLINE VEHICLE EXHAUST PARTICLE SAMPLING STUDY

David Kittelson, Winthrop Watts, and Jason Johnson

University of Minnesota

ABSTRACT

The University of Minnesota collaborated with the Paul Scherrer Institute, the University of Wisconsin (UWI), and Ricardo, Inc., to physically and chemically characterize the exhaust plume from recruited gasoline spark ignition (SI) vehicles. The project, supported by DOE's Office of FreedomCAR and Vehicle Technologies, had four primary objectives:

- Measure representative particle-size distributions from on-road SI vehicles and distinguish between SI and diesel emissions.
- Compare the information obtained from on-road tests to a small subset of light-duty gasoline vehicles tested on a chassis dynamometer under steady-state cruise conditions and using the Unified Cycle at both room temperature and 0°C.
- Characterize bulk and size-segregated chemical composition of the particulate matter (PM) emitted in the exhaust from the gasoline vehicles.
- If results from objectives 1 and 2 do not agree with regard to PM-size distribution, utilize the latest information on particle formation and dilution to explain the differences.

Particle number concentrations and size distributions are strongly influenced by dilution and sampling conditions. Laboratory methods were evaluated to dilute SI exhaust in a way that would produce size distributions that were similar to those measured during experiments. Size fractionated samples were collected for chemical analysis using a nano-microorifice uniform deposit impactor (nano-MOUDI). In addition, bulk samples using Teflon and quartz fiber filters followed by polyurethane foam were collected and analyzed by the UWI researchers.

Data were also collected during cold, cold start idle tests, laboratory tests to determine the impact of lube oil consumption on particulate matter emissions and during an on-road study to compare weekday with weekend air quality around the Twin Cities area. This portion of the study resulted in the development of a method to apportion the diesel and SI contribution to on-road aerosol.

A mixture of low-, mid-, and high-mileage vehicles was recruited for testing during the study. Under steady highway cruise conditions, a significant particle signature above background was not measured, but during hard accelerations number weighted size distributions for the test fleet were similar to modern heavy-duty diesel vehicles. Number emissions were much higher at high speed and during cold starts, and fuel-specific number emissions range from 10^{12} to 3 x 10^{16} particles/kg fuel. A simple relationship between number and mass emissions was not observed. Other results will be discussed.