Characterizing Vehicular Contributions to PM2.5 in Fairbanks, Alaska:

On-Road Emission Testing – Plume Following Study

In order to better understand emissions from on-road diesel and medium to heavy duty vehicles of all types in Fairbanks winters under ambient temperature of -24 ^{0}F, on-road plume study was conducted by Sierra Research. The on-road plume testing method was designed to complement the dynamometer –based laboratory testing of light duty vehicles. This work was sponsored by Alaska Department of Environmental Conservation with in-kind support from Fairbanks North Star Borough.

Vehicles that could not be readily tested on a chassis dynamometer or on which little information existed regarding $PM_{2.5}$ emissions were followed on road with a vehicle equipped with bumper and roof-mounted cyclones to sample on road plumes. Real time analyzers were used to measure $PM_{2.5}$ and CO_2 concentrations. The vehicle was operated for on-road plume following over a period of 15 days in February and March of 2010. The plume following vehicle was deployed on-road in Fairbanks to follow and measure emissions from seven gasoline-powered vehicles that had just been dynamometer tested, a selection of light, medium and heavy duty diesel vehicles, and a pseudo-random sample of nearly 1,000 on-road vehicles.

The objective of the plume-following project was to collect on-road data for dynamometer-tested gasoline-powered vehicles to validate a plume-following methodology and to establish dynamometer to on-road calibrations, including consideration of cold start effects, to measure on-road emissions, potentially including plug-in, cold start effects for a sample of light, medium and heavy duty on-road diesel powered vehicles and to evaluate the fraction of high $PM_{2.5}$ emitting vehicles in the on-road fleet.

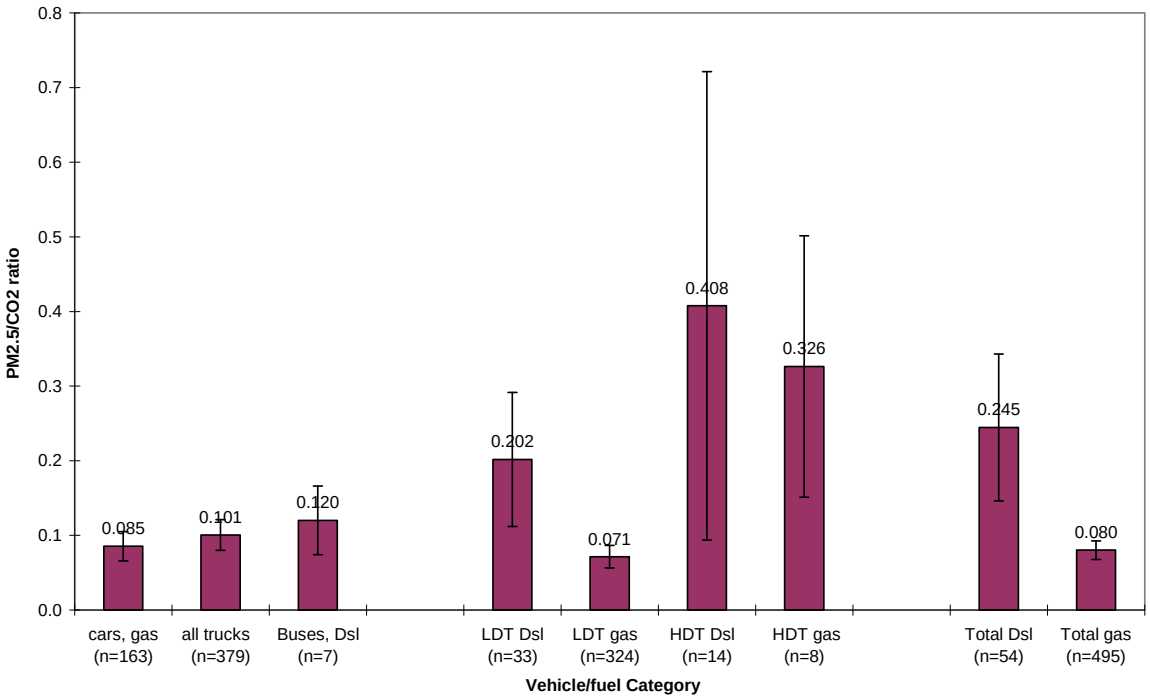
Prior to actual following of randomly selected vehicles with the plume following vehicle, dynamometer –tested gasoline vehicles, light to medium duty diesel vehicles from a used car lot, a Borough transit bus and a number of heavy-duty vehicles operated by Lynden Transport of Fairbanks were tested for data collection technique. The on-road plume following evaluated the fraction of high $PM_{2.5}$ emitters from the on-road vehicle fleet. All potential factors that could have influenced the data, such as identifying the cold start vs. plug in vehicles, quality of plume capture, possible interference from other stationary and mobile sources and determination of background concentrations were addressed during the process.

Data analysis from on-road plume following study showed plume ratio of 0.215 µg/m^3 $PM_{2.5}$ per ppm of CO_2 during accelerations. This allowed for distinguishing the two “high emitters” from the four “normal emitters” seen in the previously dynamometer-tested sample of light duty gasoline-powered vehicles. Based on the plume ratio and from the pseudo-randomly selected

sample of 630 on-road vehicle plumes, 7.5 % of the on-road fleet in Fairbanks could be classified as high $PM_{2.5}$ emitters.

Figure 1 shows the types of vehicles and the average PM2.5/CO2 ratio for 549 vehicles from the on-road plume sample.

Figure 1
Avg. $PM_{2.5}/CO_2$ In-plume Ratios for On-Road Vehicle Accelerations
(n = 549 identified unique vehicles, by category, error bands show ±2 std devs)



Note: n = 549 identified vehicles with known characteristics, no repeats; error bands show +2 standard deviations

The highest average emission ratio was for heavy duty Diesel trucks (0.408) closely followed by heavy duty gas trucks (0.326); these two categories were statistically indistinguishable from each other. The next highest average emission was for Diesel-powered vehicles (0.245), which was about 3 times that for gasoline powered emission vehicles. So in overall, the diesel (light or heavy duty) vehicles were emitting 3 or 4 times greater than the gasoline vehicles. The average emission ratio of light-duty gas powered trucks was comparable to that for gas-powered cars and Diesel buses.