MEASUREMENT OF ON-ROAD AND LAB DIESEL PARTICLE SIZE

Jason Johnson, David Kittelson, and Winthrop Watts
University of Minnesota

Particle-size distributions measured in the CRC/DOE E-43 project will be described. The project was designed to determine if modern diesel engines produce size distributions with a significant nuclei mode (particles with diameter less than about 30 nm) under real-world, on-road conditions; to establish laboratory dilution conditions that give size distributions similar to those measured on-road; and to compare the tendency to produce nanoparticles (a nuclei mode) of newer and older technology engines. Other objectives included determination of the chemical composition of these particles and their lifetime in the atmosphere. The first three of these goals are discussed in this presentation.

Field studies were carried out using four test trucks powered by Caterpillar and Cummins engines. On-road chase studies were carried out in Minnesota, and CVS performance cell and chassis dynamometer studies were carried out at Caterpillar and Cummins. A wind tunnel study was also carried out at the National Aeronautics and Space Administration's Langley Wind Tunnel. U.S. Environmental Protection Agency certification and a market-basket blend of California fuels were used.

On-road dilution is rapid (1,000:1 in 2 seconds), and the test vehicles produced bimodal distributions with nuclei mode and accumulation mode geometric number mean diameters ranging from 6 to11 nm and 52 to 62 nm, respectively. Number and volume fractions in the nuclei mode ranged from 37 to 87 percent and 0.3 to 2.1 percent, respectively. Nuclei mode particles were found to consist primarily of volatile material. Lower sulfur fuel produced a smaller nuclei mode under most conditions, but the accumulation modes produced by all fuels were similar. Cold temperatures favored nuclei mode formation. Both old and new technology engines produced nuclei modes of similar magnitude, but the older technology engines produced larger accumulation modes. Nuclei mode properties were highly variable due in part to changes in engine, fuel, and environmental conditions and in part due to on-road experimental uncertainties.

Laboratory exhaust samples were obtained using a mini two-stage ejector dilutor, a partial flow CVS system followed by an ejector dilutor, and a Sierra BG-1 dilutor followed by an ejector dilutor. Although it was not possible to duplicate all individual on-road size distributions in the laboratory, composite average on-road size distributions were similar to those obtained using the CVS or BG-1 systems. Our results suggest that rather than attempting to simulate on-road formation of nuclei mode particles, which takes place under highly variable ambient conditions, the best laboratory sampling strategy might be to adjust conditions to evaluate the tendency of an engine/fuel/operating condition to form nanoparticles.