TITLE:	SAMPLING, ANALYSIS, AND PROPERTIES OF PRIMARY PM-2.5: APPLICATION TO COAL-FIRED UTILITY BOILERS

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ABSTRACT

OBJECTIVES

This project involves the design and construction of a state-of-the-art dilution sampler to investigate $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 μm) emissions from a pilot scale pulverized coal combustor. The sampler simulates the dilution and cooling processes that occur after the hot combustion products leave the stack. The goal is to provide a more basic understanding of the emissions of $PM_{2.5}$ from coal-based power generation systems.

ACCOMPLISHMENTS TO DATE

Work during the third year of the project has focused on the evaluation of the effects of dilution sampling on PM emissions from a pilot-scale coal combustor. The sampler was installed on a slipstream from the Combustion and Environmental Research Facility (CERF), a pilot scale pulverized coal combustor at the National Energy Technology Laboratory (NETL). For these experiments the CERF fired three different types of coal: a low sulfur, low ash Eastern Kentucky bituminous coal; a high sulfur, Pittsburgh seam bituminous coal, and a Powder River Basin subbituminous coal. Experiments were also performed using a coal-biomass blend. Measurements were made both before and after the baghouse. Experiments were performed to investigate the effect of dilution sampling on the particle size distribution. Measurements of the particle number size distribution between 3 nm and 10 μm were made as a function of dilution ratio and residence time. These measurements show a multimodal aerosol size distribution with a peaks at approximately 10 nm, 100 nm, and > 2 microns (the system is operated with a $PM_{2.5}$ cyclone on the inlet line).

The residence time and dilution ratio do not influence the particle mass emission rate, but before the baghouse these parameters have a significant effect on the size distribution and total number emission rate. Increasing the residence time dramatically decreases the total particle number concentration, and shifts the particle mass to larger sizes. Increasing the dilution ratio increases the concentration of ultrafine particles. The effects of residence time can be explained quantitatively by the coagulation of the emitted particles; however the effects of dilution ratio are more complex because dilution ratio influences both the coagulation rate and gas-to-particle conversion. The effects of dilution ratio on nucleation are consistent with theory. Little change is observed in the size distributions after the baghouse because coagulation rates after the baghouse are too slow to significantly alter the size distribution over the time scales of these experiments. Nucleation was only intermittently observed after the baghouse; this was somewhat surprising because theory indicates that nucleation should be favored under conditions with lower particle concentrations. We suspect that the filters in the baghouse remove the SO_3 from the flue gas, which, in turn, prevents nucleation.

Experiments were also performed to examine the effect of dilution sampling on $PM_{2.5}$ mass emission rates and $PM_{2.5}$ composition. For these experiments filter samples were taken over a range of dilution ratios and residence time. Hot filter samples were also collected simultaneously in order to compare the dilution sampler measurement with those of EPA method 5. The results indicate dilution ratio and residence time do not significantly alter the mass emission rates. The mass emission rates measured by the dilution sampler were comparable to those measured with the hot filters. The filter samples are being analyzed for water-soluble ions, metals, and organic and elemental carbon. Additional analysis has been performed using a scanning electron microscope to determine the emission rate of spherical aluminosilicate particles that are used as a tracer primary PM emissions from coal-fired boilers. We plan to present the results from the analysis of the filter sample at the UCR program review meeting in June.

During the remaining project period, effort will focus on the analysis of the composition data and the write up of guidelines for use of dilution sampling to characterize PM emissions from coal boilers. We anticipate submitting for publication one more journal paper describing the work.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAMS

In July 1997, the EPA issued new particulate matter standards that targeted the mass of particles smaller than 2.5 micrometers ($PM_{2.5}$). Emissions from coal-fired power plants and other combustion sources are significant contributors to ambient $PM_{2.5}$. Coal-fired power plants emit little primary PM, but are the dominant source of SO_2 and a major source of NO_x -- both important precursors of secondary fine particulate matter. EPA estimated annual identifiable control costs corresponding to the partial attainment of the selected PM standard to be $8.6 billion per year, based on the analysis of five major emitting sectors, one of which is coal-based power plants. Design of cost-effective PM control strategies is limited by the lack of understanding of the difficulty of establishing the PM source-receptor relationships. This project aims to improve our basic knowledge of $PM_{2.5}$ emissions from coal-based power systems. This information will allow us to better identify the contribution of coal-boilers to ambient PM.

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Journal Articles (peer reviewed)

E. Lipsky, C.O. Stanier, S.N. Pandis, and A.L. Robinson, "Effects of Sampling Conditions on the Size Distribution of Fine Particulate Matter Emitted From a Pilot-scale Pulverized-Coal Combustor," *Energy & Fuels*, **16(2)**, 302-310, 2002.

Conference Presentations

Lipsky, E.; Stanier, C.O.; Pandis, S. N.; Robinson; A.L. "Sampling $PM_{2.5}$ emissions from coal combustion: Effects of dilution ratio and residence time." Presented at $PM_{2.5}$ and Electric Power Generation: Recent Findings and Implications, Pittsburgh, PA, April 2002.

Lipsky, E.; Pandis, S. N.; Robinson; A.L.; Freeman, M. "Effect Of Sampling Conditions On Primary Particulate Matter Emissions From A Pilot-Scale Coal Combustor." Presented at American Association of Aerosol Reseach Annual Meeting, St. Louis, MO, November 2000.

Students Supported under this Grant

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