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Project Summary

Measurement of Sulfur and Carbon Species Emissions from Oil-Fired Commercial and Institutional Boilers

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This project was conducted to provide improved emission data that are used to support urban particulate models. The objectives of the study were twofold: to determine emission factors for primary sulfate and carbon from a variety of commercial and industrial heating units burning fuel-oil, and to evaluate and compare the performance of the miniature acid condensation system (MACS) and the acid condensation system (ACS) methods for determining free sulfuric acid (H_2SO_4).

The emission data summarized in the report are the result of two field studies in Philadelphia, PA, the first during March-April 1982 and the second during the Philadelphia Aerosol Study in August 1982. Five boilers were monitored in the studies. Two were utility boilers, and the remainder were small process steam or heating boilers ranging in size from 23,500 to 50,000 lb/h. Emission data for sulfur species, carbon species, and trace elements are presented in the report.

This Project Summary was developed by EPA's Atmospheric Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

During the past decade, receptor-oriented models have evolved rapidly and are now recognized as distinct disciplines. The models have been widely accepted and are currently one of the primary tools employed by control agencies to estimate the impact of sources at receptor sites. As is often the case, the rapid evolvement of models for particulate matter has resulted in certain inadequacies. Although large volumes of data have been accumulated on the chemical and physical characteristics of particulate matter, little is known about its sources and subsequent contribution to levels at specific receptor sites. The source impact on ambient loadings at these sites is recognized as an approximation at best. This approximation is due largely to many variables (primarily meteorological) that are random in nature, change with space and time, and may combine with other variables in a nonlinear manner. If modeling of particulate emissions is to acquire its anticipated prominence in air particulate control programs, additional research is needed to more adequately define the boundaries of the models and to rectify some of the inherent weaknesses, such as those described above. Additional work is also needed to improve the sampling and analytical techniques used in assessing the effect of individual sources.

This research program was initiated in support of a program to provide improved source emission data for urban particulate models. The objectives of the study were twofold: to determine emission factors for primary sulfate and carbon from a variety of commercial and industrial heating units burning fuel-oil, and to evaluate and

compare the performance of the miniature acid condensation system (MACS) and the acid condensation system (ACS) methods for determining free sulfuric acid (H_2SO_4).

The data summarized in this report are the results of two individual work assignments (WA-6 and WA-12) emanating from EPA Contract No. 68-02-3487. The field portion of WA-6 was conducted in Philadelphia, PA, from March 22 to April 6, 1982 (winter study). Work assignment 12 was conducted in Philadelphia from August 4 to August 14, 1982 (summer study). Five boilers were monitored in the study. Two of the units tested were utility boilers. The remaining three units were small process steam or heating boilers ranging in size from 23,500 to 50,000 lb/h.

Procedure and Results

Particulate Matter

Particulate matter was collected by using EPA Method 5 for the determination of mass loading, sulfate and carbon content, and trace element analysis. Mass loading was determined from the front half rinse of the Method 5 train (i.e., probe nozzle, probe, and front half of the filter holder, and the filter catch). Following mass loading determinations, the filters were divided into three sections. One half of each filter was used for elemental composition analysis via a Siemens Model MRS wavelength dispersive X-ray spectrometer. One quarter of each filter was used to determine carbon forms (organic carbon, elemental carbon, total carbon, and $CO_3^=$) by using an automated thermal-optical method. The final quarter of each filter was analyzed for particulate sulfate by ion chromatography.

The average particulate emission rate for the three heating boilers was 0.67 kg/h, with a range of 0.18 to 1.73 kg/h. The average emission rate for the two utility boilers was 11.53 kg/h, with a range of 4.78 to 20.40 kg/h.

The average particulate sulfate emission rate for the three heating boilers was 0.24 kg/h, with a range of 0.06 to 0.39 kg/h. The two utility boilers averaged 2.63 kg/h, with a range of 0.56 to 5.63 kg/h.

Total carbon emissions for the three heating boilers averaged 18.44 g/h, with a spread of 3.42 to 48.56 g/h. The average total carbon emissions from the two utility boilers was 1471.21 g/h, with a spread of 74.86 to 4171.33 g/h.

Trace elemental emission data and the full complement of analytical results, including blanks and duplicate runs, are appended in the report.

Primary Sulfates

Sulfur dioxide (SO_2) and H_2SO_4 emission data were obtained at each boiler by two methods: the Acid Condensation System (ACS) and the Miniature Acid Condensation System (MACS). The two systems are very similar except for the H_2SO_4 collector. The ACS train condenses the H_2SO_4 in a temperature-controlled (60°C, 140°F) condensation coil, and the MACS train uses a temperature-controlled (60°C, 140°F) glass wool plug. For comparison purposes, both trains were run concurrently from the same sampling port. The tests were conducted as single point samples, with average ΔP values determined from Method 5 particulate runs.

During the initial study, flow problems were encountered in the MACS system. With repeated use, the glass wool was redistributed and collected at one end of the holder, restricting the gas flow and resulting in a high pressure drop across the system. The change in pressure made it extremely difficult to maintain a consistent and repeatable sampling rate. This problem was alleviated during the second half of the study by enlarging the bore size of the glass wool holder and packing the wool in a more serviceable manner.

During the initial study (winter study), when flow problems were encountered, plotted data for the MACS method versus the ACS method showed a substantial variability between the two systems, with the MACS system producing much lower readings. When the flow problem was alleviated (summer study), good agreement between the two methods was achieved, with little constant or proportional bias in the MACS method relative to the ACS method.

The H_2SO_4 data collected by the MACS and ACS systems during the summer study are summarized in Table 1. The full complement of SO_2 and H_2SO_4 analytical results is presented in the report.

Conclusions

The results of this study provide evidence that the MACS can serve as a primary sulfate characterization method for combustion-source measurements. Within experimental error, the glass wool plug will collect H_2SO_4 as well as the Goksoyr-Ross-type condenser. The study also shows, as was evident in the winter study (initial study), that both metho (MACS and ACS) must be used w caution. Both methods of evaluation a subject to certain critical sampling para eters (filtration temperature and sampli flow rate) which, if varied for any reasc will result in incomparable and erroneo data.

Total carbon and trace element emi sion data are presented in the report, b conclusions are left to the reader.

Table 1. Summary of H_2SO_4 Data, A Versus MACS, Summer Study

Test Number	ACS (ppm)	MACS (ppm)
PES-1	4.35	5.35
PES-2	2.29	1.86
PES-3	2.45	1.60
PES-4	2.20	2.00
PES-5	4.49	1.00
SBS-1	0.83	0.23*
SBS-2	0.74	0.76
SBS-3	0.77	0.81
SBS-4	0.79	0.77
SBS-5	0.84	0.74
SBS-6	0.74	0.74
SBS-7	0.81	0.78
SBS-8	0.77	0.80

**Data not included in statistical analysis due anomalous value for MACS technique.*

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The complete report, entitled "Measurement of Sulfur and Carbon Species Emissions from Oil-Fired Commercial and Institutional Boilers," (Order No. PB 85-207 520/AS; Cost: $10.00, subject to change) will be available only from:
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