United States
Environmental Protection
Agency

Environmental Sciences
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S3-83-109 Jan. 1984

EPA

Project Summary

Emission Characterization of Major Fossil Fuel Power Plants in the Ohio River Valley

Gary Baker, Paul Clarke, Richard Gerstle, Wade Mason, and Mark Phillips

This study characterizes the atmospheric emissions from five major coal-fired power plant units in the Ohio River Valley between Portsmouth, Ohio, and Louisville, Kentucky. This characterization provides data that are representative of the boiler fuel emission control combinations of the current power plant population as well as those scheduled to go on line before the end of 1983. The Environmental Protection Agency will use these data to determine the impact of existing and planned power plants on air quality in this river valley.

This Project Summary was developed by EPA's Environmental 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

To better understand the relative contribution to the ambient air quality attributable to emissions from coal-fired power plants, the Environmental Protection Agency (EPA) is conducting a two-phase concurrent study in the Ohio River Valley. The first phase involves the selection of representative coal-fired boilers that typify emissions from units currently in use and those to be brought on line prior to the end of 1983. This phase will provide source emission data for the second phase of the project: an ambient monitoring placement study to be conducted over a 3- to 5-year period. This particular study presents the results of the first phase.

The information presented in this report is representative of emissions from power plants operating in the Ohio River Valley. The results of this report should not be used to estimate emissions for power plants located outside the Ohio River Valley Region.

In the source emission study, five representative units were selected for testing. The constituents measured were total filterable particulates, particulate sulfate, sulfuric acid mist (H_2SO_4), sulfur dioxide (SO_2) particulate and gaseous chlorides, and particulate and gaseous fluorides (sampled by manual methods); and sulfur dioxide (SO_2), carbon dioxide (CO_2), nitrogen oxides (NO and NO_X), and oxygen (O_2) (sampled by continuous monitors). Particulate fractions were calculated by particulate sizing and elemental analysis was conducted for particle size fractions.

This report presents the selection strategy utilized to choose the five test sites, a description of the plants tested, the sampling and analytical techniques employed, and a summary of the data obtained. In addition, the pollutant emissions for the study region were projected for those power plants presently operating and those which will come on line by the end of 1983.

Site Selection

The EPA had determined that the study area would consist of the stretch of the Ohio River from Portsmouth, Ohio, to Louisville, Kentucky. This area was chosen because it probably represents the most active region of coal-fired power plants in the country. This region has 45 coal-fired power plant boilers in operation

and another 17 units either under construction or planned. Several common characteristics were found when boilers were grouped according to the following age categories:

Group I:	25 years or older
Group II:	10 to 25 years old
Group III:	less than 10 years old

Further, the relative size of the units in these age categories was similar. Group I ranged from 69 to 215 MW (113 MW average); Group II from 150 to 225 MW (192 MW average); and Group III from 277 to 610 MW (469 MW average).

Five potential test sites were identified. One unit was selected from Group I and two units each were selected from Groups II and III. The unit selected from Group I typifies boilers of that era, and the four units selected as representative of Groups II and III are typical of those size categories. One unit from Group II and one from Group III are equipped with control devices for controlling particulate emissions only. The other two units in Groups II and III are equipped with full particulate and SO_2 control devices. The lettering system used to designate each plant that participated in the project indicates the order in which the plants were tested.

Plant A, which was selected from Group III, has a rated nameplate generating capacity of 560 MW and was placed into service in 1970. This Babcock and Wilcox unit has an opposed-fired burner configuration and is equipped with a Buell weighted wire electrostatic precipitator (ESP) to control particulate emissions.

Plant B, which was selected from Group I, has a rated nameplate generating capacity of 125 MW and was placed into service in 1954. This Babcock and Wilcox unit has a front-fired burner configuration and is equipped with a retrofit Research Cottrell ESP installed in 1973 to control particulate emissions.

Plant C, which was selected from Group II, has a rated nameplate generating capacity of 163 MW and was placed into service in 1958. This Combustion Engineering unit has a tangential-fired burner configuration. The particulate emission control system consists of two ESP's in series. The newer retrofit Research Cottrell ESP was installed in 1975.

Plant D, from Group III, has a rated nameplate generating capacity of 411 MW and was placed into service in 1962. This Babcock and Wilcox unit has an opposed-fired burner configuration. The air pollution control equipment consists of an American Air Filter (AAF) rigid frame ESP that was installed in 1978. After passing through the ESP, the flue gas enters a carbide lime mobile bed flue gas desulfurization (FGD) system, which was also installed in 1978 by AAF.

Plant E, from Group II, has a rated nameplate generating capacity of 156 MW and was placed into sevice in 1962. This Combustion Engineering unit has a horizontal-fired burner configuration. The air pollution control equipment consists of a Research Cottrell weighted wire ESP installed in 1962. After passing through the ESP, the flue gas enters an AAF lime slurry FGD system, which was installed in 1976.

Sampling Methods

Both manual and continuous sampling methods were used to obtain emission data for the various pollutants. During on-site testing, the power plants operated in a normal manner with the loads changing according to demand. Tests were conducted over at least a 5-day sampling period in an effort to obtain emission data under a number of operating conditions. Manual sampling was performed at the outlets of the air pollution control devices only.

Particulate emissions were determined by EPA Method 5. Samples were collected at a filter and probe temperature of approximately 120°C. Filterable particulates consist of the material caught in the probe and filter portion of the EPA Method 5 sampling train. The material (condensibles) captured in the impinger section of the sampling train was not included. Stack gas flow rates determined during the Method 5 tests were used to calculate the mass emission rates of all the pollutants sampled.

Particle size distributions were determined with an Andersen 2000 Mark III in-stack cascade impactor. This impactor has eight stages and a backup filter, with particle size cutoffs ranging from 0.5 to 15 μm. A standard EPA Method 5 control module was used to maintain isokinetic sampling conditions. The Andersen impactor was also used to obtain particulate samples in various particle size fractions suitable for elemental analysis by X-ray fluorescence (XRF). To determine the particle size distributions, the impactor was run with all eight stages plus a glass fiber backup filter. To obtain samples for elemental analysis, the impactor was assembled with a Zefluor filter and a sample on a substrate suitable for XRF analysis. All particle size samples were obtained at a single sampling point located in the stack at a point of average gas velocity.

The Controlled Condensation System (CCS) was utilized to simultaneously collect and differentiate particulate sulfate, chloride, fluoride, sulfur trioxide (SO_3 as H_2SO_4), sulfur dioxide (SO_2), gaseous hydrogen chloride (HCl), and hydrogen fluoride (HF). The CCS sampling train consists of a heated Vycor probe, a heated quartz filter that collects the particulate matter, a modified Graham condenser that cools the gas below the acid dewpoint to collect the SO_3 (H_2SO_4) vapor, and impingers that scrub the SO_2, HCl, and HF from the flue gas sample. Samples were obtained at a single point located approximately one meter from the stack wall.

Summary of Results

The primary purpose of this study is to provide a comprehensive characterization of source emissions for power plants presently operating in the Ohio River Valley and for those that will come on line by the end of 1983. The task was accomplished by testing a selected group of plants and developing emission factors for specific particulate (Table 1) and gaseous (Table 2) pollutants.

Particle size distribution (PSD) samples were taken with an Andersen Mark III in-stack cascade impactor. All particle size samples were obtained at a single sampling point located in the stack at a point of average velocity. Particle size distribution samples were run simultaneously with the EPA Method 5 tests. The impactor was not heated during the tests at Plants A, B, and C; it was heated at Plants D and E to prevent moisture from condensing in the impactor. The flow rate through the impactor was maintained in the optimum range for all the sample runs.

The particle size distributions were examined for each plant tested to determine what percentage of particulate emissions fell into the range of inhalable and fine particulates. The inhalable particulate (IP) range includes those particles less than 15 μm in diameter. The fine particulate (FP) range includes particles less than 2.5 μm in diameter. Because the cut-points of the different stages of an Andersen Mark III impactor do not include 15 μm and 2.5 μm, a computer program was used to calculate and extrapolate these values. The different loads at which

Table 1 Particulate Emission Factors

Group	Plant	Type of control	Total particulate (mg/MJ)	Inhalable particulate range*	Fine particulate range†	Particulate chlorides (mg/MJ)	Particulate fluorides (mg/MJ)	Particulate sulfates (mg/MJ)
I	B	ESP	33.2	76.0	34.2	0.04	0.04	0.09
II	C	ESP	490.0	49.2	13.7	0.04	0.04	0.08
II	E	ESP and SO_2 scrubber	25.8	71.4	39.8	0.04	0.04	0.13
III	A	ESP	85.0	70.9	18.5	0.03	0.06	0.07
III	D	ESP and SO_2 scrubber	40.7	71.9	40.7	0.04	0.04	0.61

* Percentage of the particulate emissions less than 15 μm in diameter.
† Percentage of the particulate emissions less than 2.5 μm in diameter.

Table 2. Gaseous Emission Factors (mg/MJ)

Group	Plant	Type of control	SO_2*	H_2SO_4	NO_2	NO_x	HCl†	HF
I	B	ESP	892	4.8	9.2	278	32.3	3.0
II	C	ESP	735	4.8	10.0	214	41.2	3.3
II	E	ESP and SO_2 scrubber	576	16.1	5.4	355	0.20	0.10
III	A	ESP	683	2.4	11.8	508	43.7	3.8
III	D	ESP and SO_2 scrubber	905	19.3	5.3	802	0.82	0.09

* SO_2 emission factors dependent on sulfur content of coal.
† HCl emission factors dependent on chlorine content of coal and type of emission controls.

Table 3. Percentage of Inhalable and Fine Particulate

Plant	Inhalable particulates (<15 μm), percent	Fine particulate (<2.5 μm), percent
A	70.9	18.5
B	76.0	34.2
C	49.2	13.7
D	71.9	40.7
E	71.4	39.8

the plants operated during testing did not significantly affect the particle size distributions. All PSD runs for each separate plant were grouped together and the average mean cumulative mass concentration was determined for each unit. The computer program extrapolates the best-fit curve for the data supplied and removes outliers. Table 3 presents a comparison of the amount of particulate being emitted in the inhalable and fine particulate ranges at each plant.

At each plant tested particle size samples were run with the Andersen Mark III impactor by varying the number of filter stages directly in front of the Zefluor backup filter. Four different impactor sampling configurations were used during the sampling period, with two, four, six, or eight impactor stages placed before the Zefluor backup filter.

The Zefluor backup filters used for the different particle sizing runs were submitted to NEA Laboratories for elemental analysis. The filters for Plants A, B, and C were analyzed for 22 elements by neutron activation analysis (NAA) and X-ray fluorescence (XRF). The filters for Plants D and E were analyzed for these 22 elements and 4 additional elements, P, Ga, Rb, and Sr. Only two elements, Cd and Ba, were not detectable at any concentration in the samples analyzed.

The percentage of the total concentration for each element was determined. For Plants A, B, and C, the matrix elements Si, Al, Mg, Fe, and K comprised between 90 and 95 percent of the total elemental concentrations in most cases. For Plants D and E, the primary elements detected were Al, Si, P, S, Ca, and Fe, which comprised between 93 and 97 percent of the total elemental concentration.

Gary Baker, Paul Clarke, Richard Gerstle, Wade Mason, and Mark Phillips are with PEDCo Environmental, Inc., Cincinnati, OH 45246.
***Kenneth Knapp** is the EPA Project Officer (see below).*
The complete report, entitled "Emission Characterization of Major Fossil Fuel Power Plants in the Ohio River Valley," (Order No. PB 84-120 328; Cost: $22.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆U S GOVERNMENT PRINTING OFFICE 1984—759-015/7266