DOE/PC/94251--T5

Advanced Emissions Control Development Program

Quarterly Technical Progress Report #6

for the period: January 1 to March 31, 1996

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Executive Summary

Babcock & Wilcox (B&W) is conducting a five-year project aimed at the development of practical, cost-effective strategies for reducing the emissions of hazardous air pollutants (commonly called air toxics) from coal-fired electric utility plants. The need for air toxic emissions controls will likely arise as the U. S. Environmental Protection Agency proceeds with implementation of Title III of the Clean Air Act Amendments of 1990. Data generated during the program will provide utilities with the technical and economic information necessary to reliably evaluate various air toxics emissions compliance options such as fuel switching, coal cleaning, and flue gas treatment. The development work is being carried out using B&W's new Clean Environment Development Facility (CEDF) wherein air toxics emissions control strategies can be developed under controlled conditions, and with proven predictability to commercial systems. Tests conducted in the CEDF will provide high quality, repeatable, comparable data over a wide range of coal properties, operating conditions, and emissions control systems. The specific objectives of the project are to: 1) measure and understand the production and partitioning of air toxics species for a variety of steam coals, 2) optimize the air toxics removal performance of conventional flue gas cleanup systems (ESPs, baghouses, scrubbers), 3) develop advanced air toxics emissions control concepts, 4) develop and validate air toxics emissions measurement and monitoring techniques, and 5) establish a comprehensive, self-consistent air toxics data library. Development work is currently concentrated on the capture of mercury, fine particulate, and a variety of inorganic species such as the acid gases (hydrogen chloride, hydrogen fluoride, etc.).

Background

The ultimate objective of this project is to develop practical, cost-effective strategies for reducing the emissions of hazardous air pollutants (commonly called air toxics) from coal-fired power plants. The need for such controls will likely arise as the U. S. Environmental Protection Agency (EPA) proceeds with implementation of requirements set forth in the Clean Air Act Amendments (CAAA's) of 1990. Promulgation of air toxics emissions regulations for electric utility plants could dramatically impact utilities burning coal, their industrial and residential customers, and the coal industry. Work during the project will supply the information needed by utilities to respond to potential air toxics regulations in a timely, cost-effective, environmentally-sound manner which supports the continued use of the Nation's abundant reserves of coal, such as those in the State of Ohio.

The Clean Air Act Amendments of 1990

Title III of the CAAA's established a list of 189 hazardous air pollutants and charged the EPA with the responsibility for regulating emissions of these substances into the atmosphere as required to protect public health and the environment. The first phase of compliance is to be based on available technology, and will require many industrial plants to install the "maximum achievable control technology". Electric utility plants are exempt from this requirement, however, pending the outcome of several risk assessment and emissions characterization studies. The EPA is scheduled to propose its plan for regulating electric utilities under Title III in a report to Congress in November, 1995.

The EPA is currently working with the U. S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and the Utility Air Regulatory Group (UARG) to characterize air toxics emissions from existing power plants. Both DOE and EPRI have put major field testing programs into place to accomplish this purpose. The results of these emissions characterization studies will be reviewed by the EPA in conjunction with the results of several on-going EPA risk assessment studies to determine the need for air toxics emissions regulations aimed at coal-fired utilities. These field testing programs will provide considerable insight into the quantities of air toxics being emitted by power plants. However, B&W believes that they are only a first step toward developing an understanding of the formation, partitioning, and capture of air toxics species, and how to effectively control their emissions.

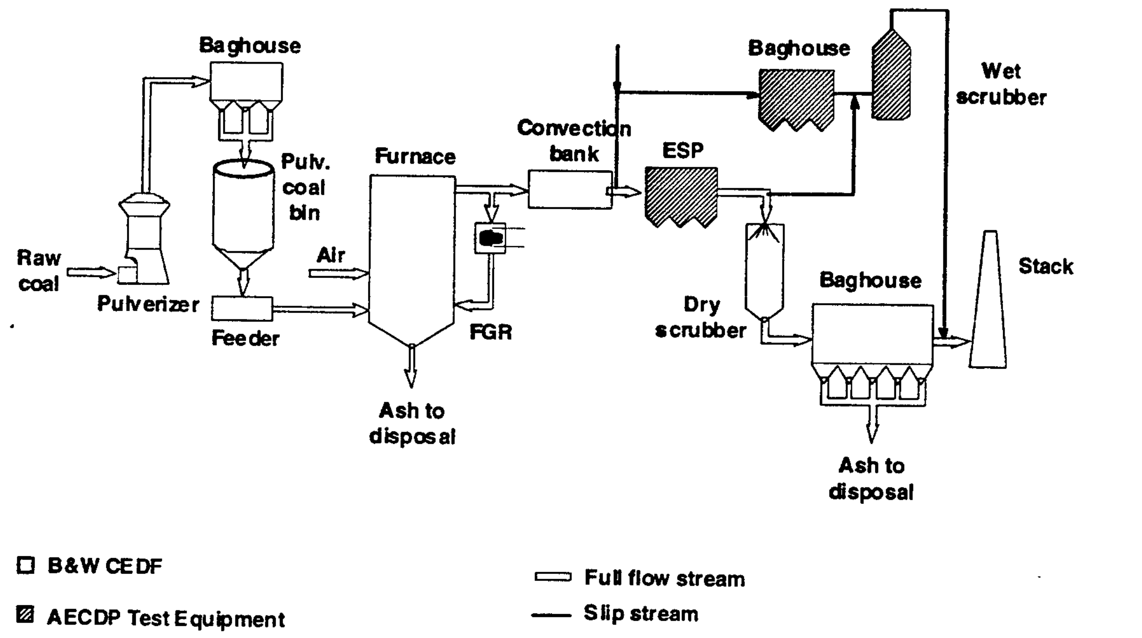
While the EPA's ultimate approach is uncertain, at least some air toxics species issuing from utility stacks may be regulated – especially some of the high-risk compounds such as arsenic, cadmium, chromium, and mercury, and/or compounds known to be emitted in relatively large quantities such as hydrogen chloride and hydrogen fluoride. Mercury, in particular, is the subject of intensive research due to its known build-up in the atmosphere, subsequent deposition in lakes, and potential human health and environmental impacts. B&W strongly believes that a proactive approach to the development of the technical and economic information utilities will need to assess air toxics control options is needed to keep pace with regulatory actions.

Overview of the Project

The objective of this project is to develop practical strategies and systems for the simultaneous control of SO_2, NO_x, particulate matter, and air toxics emissions from coal-fired boilers in such a way as to keep coal economically and environmentally competitive as a utility boiler fuel. Of particular interest is the control of air toxics emissions through the cost-effective use of conventional flue gas clean-up equipment. This objective will be achieved through extensive development testing in B&W's new $16.5 million, state-of-the-art Clean Environment Development Facility (CEDF) wherein air toxics emissions control strategies can be developed under controlled conditions and with proven predictability to commercial power plant systems. It is understood that the B&W CEDF is being funded entirely with B&W funds, and, hence, is not part of the scope of work of this project.

The CEDF has been designed for pulverized coal firing, and has a rated capacity of 100 million Btu/hr (thermal input). It is designed to simulate the furnace environment (temperatures, residence times, etc.) of a commercial boiler in order to yield representative results for combustion NO_x and air toxics emissions studies at the furnace exit. The convective pass simulates a commercial boiler convection bank from the furnace exit to the air heater exit.

The project will extend the capabilities of the CEDF to facilitate air toxics emissions control development work on "backend" flue gas cleanup equipment. Specifically, an ESP, a fabric filter (baghouse), and a wet scrubber for SO_2 (and air toxics) control will be added – all designed to yield air toxics emissions data under controlled conditions, and with proven predictability to commercial systems. A schematic of B&W's CEDF and the project test equipment to be added is shown in the figure.



Clean Environment Development Facility

The specific objectives of the project are to:

Provide a flexible, representative test bed for conducting air toxics emissions control development work.

Measure and understand production and partitioning of air toxics species for a variety of Ohio coals.

Optimize the air toxics removal performance of conventional flue gas cleanup systems.

Quantify the impacts of coal cleaning on air toxics emissions.

Develop advanced air toxics emissions control concepts.

Develop and validate air toxics emissions measurement and monitoring techniques.

Establish an air toxics data library to facilitate studies of the impacts of coal selection, coal cleaning, and emissions control strategies on the air toxics emissions of coal-fired power plants.

Description of Project Phases

The project is divided into three phases. Phase I (Facility Modification and Benchmarking) consists of installation, shakedown, validation, and benchmarking of the test equipment to be added (ESP, fabric filter, and wet SO_2 scrubber) to B&W's CEDF. Baseline air toxics emissions and capture efficiency will be established for each of the major flue gas cleanup devices: ESP, baghouse, and wet SO_2 scrubber. All tests will be conducted with a high sulfur Ohio steam coal. The work in this phase will culminate in the development of a data library, or database, for use by project participants.

Phase II (Optimization of Conventional Systems) testing will involve the development of air toxics control strategies based on conventional particulate and SO_2 control equipment. Development testing, engineering and evaluation will be done to optimize the performance of these devices for the capture of air toxic species. Phase II testing will also provide data on the impacts of coal properties on air toxics emissions for several steam coals. The impacts of coal cleaning on air toxics emissions will be investigated through the testing of two cleaned coals and their associated parent (uncleaned) coals. The development of new air toxics measurement techniques and monitoring instrumentation will also be investigated in this phase.

Phase III (Advanced Concepts and Comparison Coals) testing will be directed at the development of new air toxics emissions control strategies and devices, to further reduce the emissions of selected toxics. Testing will also be conducted to extend the air toxics data library to include a broader range of coal types. Finally, the development work on advanced air toxics emissions measurement and monitoring techniques begun in Phase II will continue in Phase III.

Work Performed During Reporting Period

PHASE I

The Phase I scope of work was conducted under five major tasks. Phase I work began on November 1, 1993.

Task 1 -- Project Planning and Management

Work during the reporting period primarily consisted of routine planning, tracking, and scheduling activities. Routine air toxics cognizance activities also continued. This work includes a literature survey, discussions with a variety of other air toxics investigators, and participation in various meetings, seminars and workshops. Two members of the project team attended the EPRI-DOE-EPA Joint Workshop on Mercury Measurement and Speciation Methods for Utility Flue Gas.

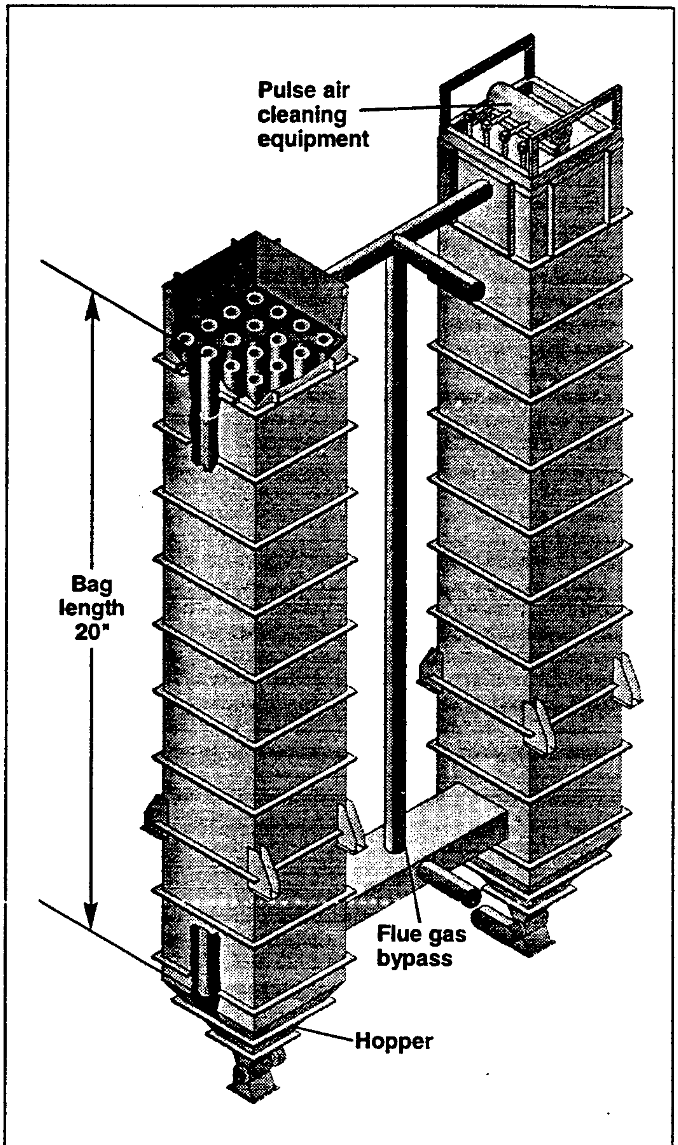
All Phase I activities were completed during the reporting period.

Task 2 – Test Equipment Modification and Shakedown

Work under this task was previously completed on schedule and within budget.

Fabric Filter

The fabric filter system consists of a pulse-jet baghouse and a fly ash disposal system. The fabric filter and the wet scrubber are designed for a partial flow flue gas slipstream from the CEDF of 5 million Btu/hr.



Pulse-Jet Baghouse. Particulate from the flue gas stream is collected on the outside surface of a porous filter bag in the baghouse. The pulse-jet baghouse is named for the manner in which the bags are cleaned. The filter cake is removed from the outer surface of the bag by a pulsed jet of compressed air which causes a sudden bag expansion. The dust is effectively removed by inertial forces as the bag reaches maximum expansion.

The baghouse initially contains commercial size conventional fabric filter bags to simulate air toxics capture in commercial baghouses. The control of these substances is determined by the baghouse operating parameters that affect particulate collection. The baghouse design permits baghouse operation over a wide range of air-to-cloth ratio (measure of the gas passing through each square foot of fabric in the baghouse), particulate loading, cleaning cycle frequency and cleaning pressure. The baghouse temperature can be varied to evaluate the effect of operating temperature on air toxics and particulate collection. Particulate collection efficiency can also be affected by the type of fuel combusted, the resulting particulate characteristics, and the particle size distribution in addition to baghouse operation.

The baghouse is designed to process 6,000 lb/hr of flue gas with a particulate loading of 94 lb/hr. The baghouse will reduce particulate emissions to less than the New Source Performance Standard of 0.03 lb/ 10^6 Btu. The primary design characteristics for the baghouse are summarized below:

AECDP Baghouse Design Summary

Compartments	two; 33 ft high x 4 ft square
Bags/Compartment	16
Bag Dimensions	6¼" diameter x 20 ft long
Air-to-Cloth ratio	3.2 to 5.2 ft/sec
Cleaning Method	Pulse-jet; on-line or off-line

Fly Ash Disposal System. The fly ash collected on the fabric filter bags will fall into the baghouse hopper and pass through a rotary valve into a vacuum ash handling system for transport to a disposal bin. The baghouse flyash will be mixed with wet scrubber by-product for landfill disposal.

Wet Scrubber

The wet scrubber subsystems include the absorber tower, reagent feed system, mist eliminator system, and slurry dewatering and disposal system. The absorber tower is designed as a vertical section of a commercial reactor to simulate the SO_2 and air toxics removal. Emphasis is placed on the duplication of gas/liquid interaction, minimization of wall impingement, and the proper simulation of operating parameters that affect particulate control in a wet scrubber. The wet scrubber is designed to treat the flue gas from the partial flow, pulse-jet baghouse or a flue gas slipstream from the full-flow electrostatic precipitator, and includes the equipment required to handle the associated reagent and waste streams.

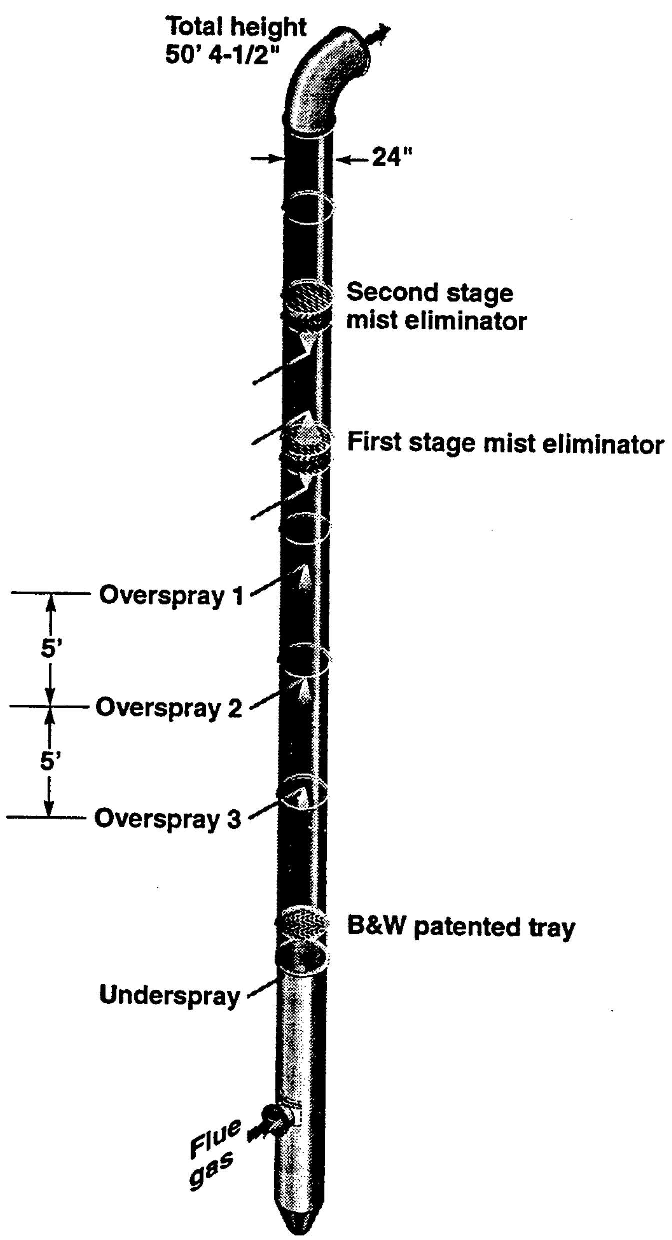
Absorber tower. The absorber tower consists of the absorber tower and a separate slurry recirculation tank. The particulate loading in the flue gas entering the absorber tower depends upon the operating efficiency of either the upstream ESP or pulse-jet baghouse, and will typically be in compliance with the New Source Performance Standard (NSPS) for coal-fired boilers. The absorber tower operating conditions will be influenced by the type of fuel. The design incorporates a perforated-plate tray to reduce flue gas flow maldistribution. The absorber tower comprises several interchangeable modules to vary the number of perforated trays and the tray height. The modular tower design permits testing with different spray and tray configurations to best simulate the operation of conventional wet scrubbers.

The wet scrubber is designed to process 5,062 lb/hr of flue gas with a SO_2 concentration of up to 6,000 ppm. The primary design characteristics for the wet scrubber system are summarized in the following table:

AECDP Wet Scrubber Design Summary

Design limestone stoichiometry	1.1 mole Ca/mole SO_2 absorbed
Nominal SO_2 removal	90%
Design L/G ratio	267 gpm/1000 acfm
Normal L/G ratio	120 gpm/1000 acfm
Tower velocity range	5.0 to 20 ft/sec

Absorber Recirculation Tank. The absorber recirculation tank is located below the absorber tower to facilitate the gravimetric flow of reaction products into the tank. The design of the recirculation tank allows the evaluation of the degree of forced oxidation on SO_2 removal and air toxics collection in the wet scrubber. The air sparger system provides clean, humidified air to obtain a wide range of oxidation levels. The absorber recirculation tank is equipped with an agitator to keep the solids from settling.



The pH of the slurry stream from the recirculation tank to the spray nozzles is monitored with an in-line pH sensor. The continuous pH measurement is used to control the slurry feed rate from the fresh slurry storage tank to the recirculation tank.

Reagent Feed System. This system comprises a slurry storage/preparation tank, agitator, and pump and will operate in a batch mode. The reagent (typically limestone) preparation system does not include a ball mill for grinding the limestone on-site. Pulverized limestone will be delivered to the facility. The reagent feed system is designed to handle a wide range of slurry feed rates and reagents to achieve specific levels of SO_2 control for the variety of coals.

Mist Eliminator System. Mist eliminators minimize carryover of slurry and liquid droplets generated in the absorber tower. To prevent buildup and plugging, the mist eliminators are periodically washed by way of water spray nozzles. The wet scrubber is designed to operate with vertical flow and/or horizontal flow mist eliminators. The system also includes a mist eliminator wash/recycle tank. To evaluate the contribution of the mist eliminators to particulate collection efficiency and air toxics capture, sampling ports are located at the inlet and outlet of the mist eliminator sections. The modular tower design permits simple removal of the mist eliminator sections for testing purposes.

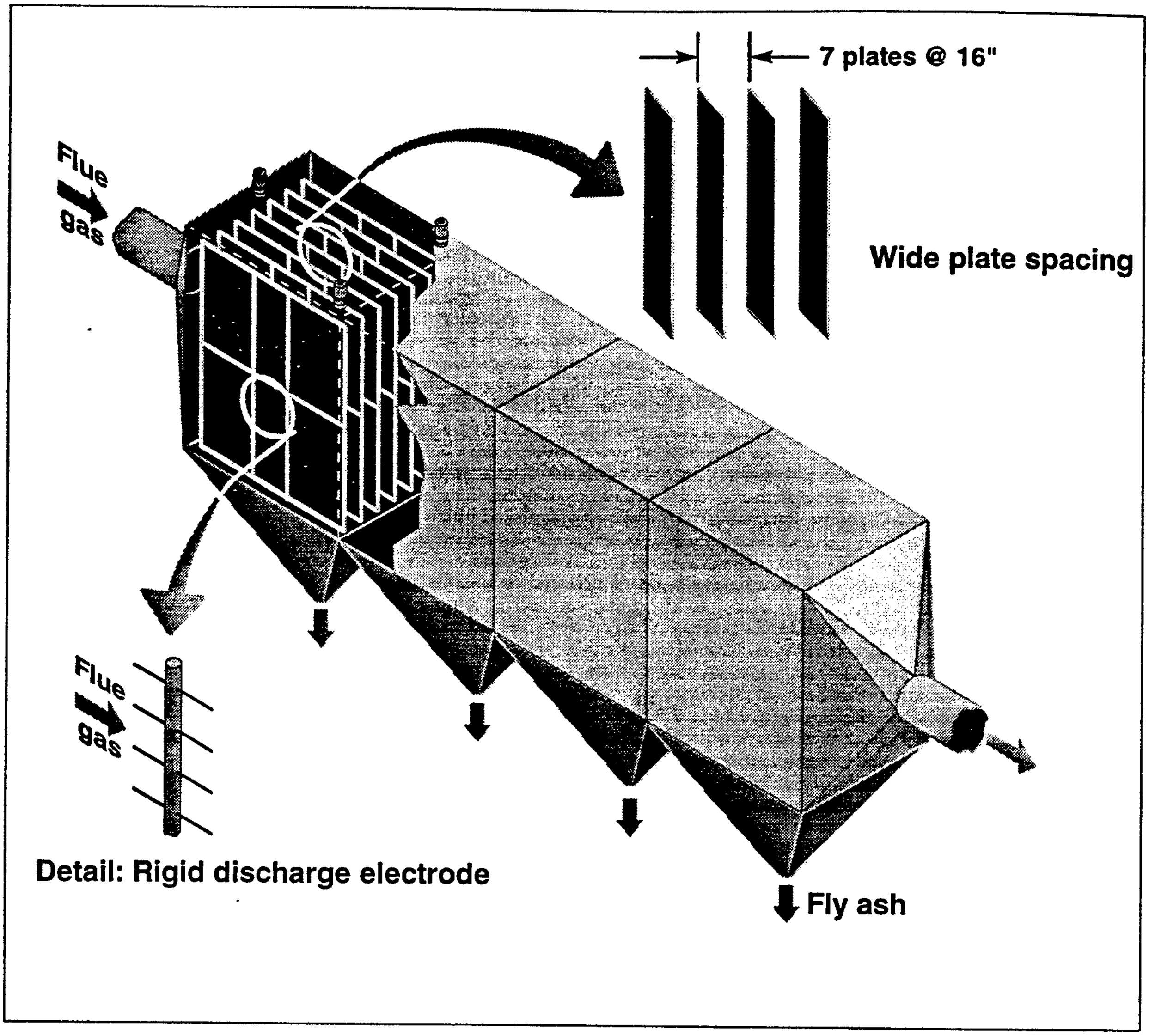
Slurry Dewatering and Disposal System. Slurry from the absorber recirculation tank is sent to the dewatering system for solids disposal and return of the clarified water. The waste slurry dewatering system consists of a hydroclone, several slurry settling tanks, a clarified recycle water storage tank, an agitator and a pump. The system is designed to be run on a batch basis. The reaction products from the slurry recirculation tank are sent to the hydroclone for primary dewatering. A density transmitter in the recirculation line is used to activate the pump to the hydroclone. The hydroclone overflow is returned to the slurry recirculation tank to duplicate the slurry chemistry in a commercial scrubber. Secondary dewatering occurs in settling bins prior to mixing with flyash or dry sorbent for landfill disposal. The clarified recycle water storage tank is equipped with a blowdown line to control the concentration of chlorides in the scrubber liquor. The blowdown on the clarified recycle water storage tank is adjustable to determine the effect of chloride level on SO_2 removal performance and the possible influence on air toxics capture.

Booster Fan. The booster fan located downstream of the wet scrubber is designed to overcome the pressure losses in the AECDP test equipment. The fan provides the turndown capacity to simulate a wide range of commercial flue gas cleanup equipment operation. A "wet", induced-draft fan was selected instead of a forced-draft fan to avoid wet scrubber operation at a positive pressure, and to prevent employee exposure to flue gas.

Electrostatic Precipitator

The ESP operates on the full flue gas flow (100 million Btu/hr) from the CEDF. The ESP is being supplied by B&W's commercial Environmental Equipment Division (EED). Design of the ESP follows conventional practice used commercially in power boiler emissions control. The ESP consists of discharge electrodes which impart an electric charge to ash particles in the flue gas as it passes through the ESP. The charged particles are attracted to charged collector plates and are removed from the gas stream. The plates are rapped periodically to remove the collected particles. The ash falls into hoppers below the plates and is removed from the ESP through rotary air locks.

The ESP design is sufficiently flexible to treat flue gas from a range of coals with variable ash and sulfur contents. The ESP is designed to process 102,893 lb/hr of flue gas with a particulate loading of 1883 lb/hr. The ESP is designed reduce particulate emissions to less than the New Source Performance Standard of 0.03 lb/10^6 Btu. The ESP will include wire discharge frames and rigid discharge electrodes. Both discharge systems are used in commercial ESPs. The primary design characteristics for the ESP are summarized in the following table.



AECDP ESP Design Summary

Electric fields	four; 6m high x 4m deep
Specific collection area (SCA)	330-370 ft^2/1000 ACFM
Flue gas velocity	3.6 to 4.0 ft/sec
Migration velocity	7.5 to 9.8 cm/sec
Residence time	13 to 14 sec
Transformer rectifier sets	four; 75 kV, 125 mA

Task 3 – Benchmarking and Verification Tests

Verification Tests

Verification testing of the wet scrubber, fabric filter, and ESP subsystems were previously completed. The objectives of these tests were to characterize the performance of the units, and to correlate that performance with commercial systems.

Air Toxics Benchmarking Tests

The objective of the air toxics benchmarking tests is to characterize the air toxics removal performance of the baghouse, ESP, and wet scrubber under conditions representative of current commercial practice. The benchmarking tests were successfully completed previously. Air toxics measurements were simultaneously made at the inlet and outlet of each of the three flue gas treatment devices while firing the CEDF at 100 MBtu/hr with a high sulfur Ohio bituminous coal. Measurements included mercury, trace metal, HCl, HF, and total particulate concentrations. A post-test review – "lessons learned" – was conducted with sampling and sample recovery personnel to identify areas where our procedures could be improved.

Task 4 – Data Analysis and Reporting

Chemical analysis and data reduction work were previously completed.

The required status reports, etc., were prepared and issued. Comments were received from both OCDO and DOE on the draft Phase I Final Report. A final version of the report was prepared and issued. The air toxics data library was also assembled.

Task 5 – Technology Transfer

The second project Advisory Committee meeting was held on January 31, 1996. Phase I test results and Phase II objectives were reviewed with the Committee. Several valuable comments and suggestions were received from the Committee.

PHASE II

The Phase II scope of work will be conducted under six major tasks. Phase II work began on February 29, 1996. Only work under Task 1, *Project Planning and Reporting,* was begun during the reporting period.

Task 1 -- Project Planning and Management

Work during the reporting period primarily consisted of planning and scheduling activities related to the preparation of the Phase II Management Plan (DOE) and Phase II Milestone Plan (OCDO). Routine air toxics cognizance activities, begun during the last phase, also continued. This work includes a literature survey, discussions with a variety of other air toxics investigators, and participation in various meetings, seminars and workshops.

Preparations were made for a Project Participants Committee meeting to be held at DOE-PETC's offices on April 3, 1996. The purpose of the meeting is to discuss Phase II testing priorities and objectives to aid in the preparation of the Phase II Management Plan.

Planned Work for Next Reporting Period

PHASE II

Task 1 -- Project Planning and Management

The Phase II Management Plan (DOE) and Phase II Milestone Plan (OCDO) will be issued.

Task 2 -- Capture of Air Toxics in Conventional Systems

Planning and preparation will begin for the first testing campaign.

Task 3 -- Impacts of Coal Properties on Air Toxics Emissions

Some initial planning will be done.

Task 4 -- Advanced Measurement Concepts

Identification of potential on-line monitoring techniques will begin.

Task 5 -- Data Analysis and Reporting

Required status reports will be issued.

Task 6 -- Technology Transfer

The Newsletter will be issued.

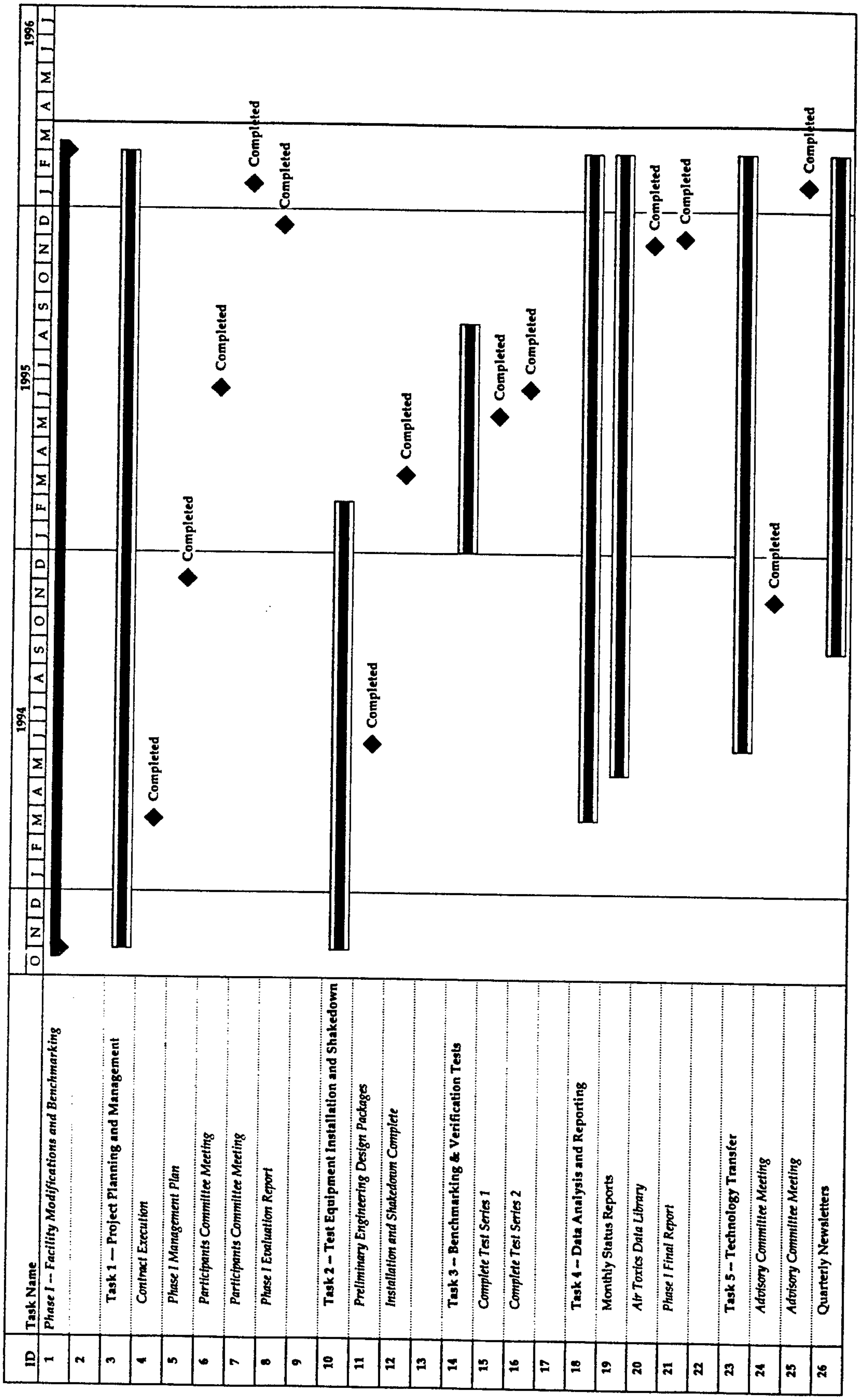
Phase I Milestones and Schedule

All Phase I tasks were completed. The Phase II milestone plan will be included in the next report (upon completion of the Phase II Management Plan).

Budget and Schedule Issues

Phase II activities began on February 29, 1996. A funding authorization was received from OCDO for the Phase II scope of work. Only a part of of the funding needed for Phase II was authorized by the DOE – the remainder being held up by the federal budget impasse. It is anticipated that the authorized DOE funding will take us through late May or early June of this year.

Advanced Emissions Control Development Program
Phase I Milestone Plan



Phase I Milestone Plan

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