DOE/PC/95256--T2

Investigation and Demonstration of Dry Carbon-Based Sorbent Injection for Mercury Control

Contract DE-AC22-95PC95256

Draft Quarterly Technical Report
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Executive Summary

The overall objective this two phase program is to investigate the use of dry carbon-based sorbents for mercury control. This information is important to the utility industry in anticipation of pending regulations. During Phase I, a bench-scale field test device that can be configured as an electrostatic precipitator, a pulse-jet baghouse, or a reverse-gas baghouse has been designed and will be integrated with an existing pilot-scale facility at PSCo's Comanche Station. Up to three candidate sorbents will then be injected into the flue gas stream upstream of the test device to determine the mercury removal efficiency for each sorbent. During the Phase II effort, component integration for the most promising dry sorbent technology (technically and economically feasible) shall be tested at the 5000 acfm pilot-scale.

An extensive work plan has been developed for the project. Three sorbents will be selected for evaluation at the facility through investigation, presentation, and discussion among team members: PSCO, EPRI, ADA, and DOE. The selected sorbents will be tested in the five primary bench-scale configurations: pulse-jet baghouse, TOXECON, reverse-gas baghouse, electrostatic precipitator, and an ESP or fabric filter with no Comanche ash in the flue gas stream. In the EPRI TOXECON system, mercury sorbents will be injected downstream of a primary particulate control device, and collected in a pulse-jet baghouse operated at air-to-cloth ratios of 12 to 16 ft/min, thus separating the mercury and sorbent from the captured flyash. In the no-ash

configuration, an external flyash sample will be injected into a clean gas stream to investigate possible variations in sorbent effectiveness in the presence of different ashes. The use of an existing test facility, a versatile design for the test fixture, and installation of a continuous mercury analyzer will allow for the completion of this ambitious test plan.

Darco FGD activated carbon, a sorbent evaluated during a previous pilot-scale mercury control test at Comanche Station, has been identified as one of the three candidate sorbents. Final selection of test sorbents will take place next quarter when more results from EPRI laboratory testing will be available. Initial results from EPRI laboratory flyash evaluations are also being reviewed to assist with the selection of flyashes for the no Comanche ash configuration.

The primary activity during the quarter was the design and fabrication of the facility. The main structure, which incorporates the particulate control module (PCM), sorbent injection section and in-duct heater was functionally complete at the end of March. Finish work on the structure will take place in April and arrangements are being made to erect the facility at the host site, Comanche Station, on April 29 and 30, 1996. The control panel is also currently being fabricated.

The project is on schedule to begin testing the first week of June, 1996 in the ESP configuration. Two week s of baseline testing are planned before the first sorbent, FGD activated carbon, is injected into the duct.

Activities During Reporting Period

Task 1. Sorbent Selection

The objective of this task is to identify and select the most promising sorbents to be tested. The team of PSCO, ADA, and EPRI in consultation with DOE shall provide input and recommendations as to the sorbents that are showing the most promise from on-going research programs. Final selection of sorbents has been postponed until late April when results from testing in EPRI laboratories should be available.

Darco FGD, an activated carbon derived from lignite, has been identified as one of the three candidate sorbents. FGD is used to remove mercury in municipal solid waste (MSW) combustors in Europe and the United States. It has also been used in several utility mercury removal tests including previous tests at Comanche Station. Unused FGD from the previous Comanche tests is available and will be used during the current program. The mass mean diameter of a sample of the FGD carbon from the Comanche tests, as measured by a sedigraph, was 24.5 microns. The BET surface area as measured by American Norit Company, the manufacturer of Darco FGD, is 600 m^2/g.

A conference call is scheduled for late April for the project team to review available sorbent data and finalize the list of sorbents to be tested during the first test configuration. If the status of laboratory tests prevent final selection of the test sorbents during this call, it may be necessary to acquire sufficient supplies of the most promising candidate sorbents to prevent delays in testing. It is estimated that less than 50 pounds of each sorbent will be required for each test configuration.

An Eastern and Midwestern ash will be selected based on results from EPRI and DOE laboratory tests. Samples of PSCo's Comanche and Arapahoe Generating Station flyashes will be included in the laboratory evaluations. Arapahoe Station also has one unit with low NO_x burners that has loss on ignition (LOI) in the range of 5 to 10% and low mercury levels. Other ash candidates included Texas Lignite, Eastern low sulfur coal with high LOI due to low NO_x burners and high sulfur Eastern bituminous coal ash.

Candidate flyash samples were analyzed for as-received mercury and LOI. These results are shown in Table 1. The mercury content of most flyash samples was below the detection limit (<0.1 ppm). Sample C1, flyash from Comanche Station, contained 2.2 ppm mercury. Previous testing at Comanche suggested that the flyash itself may adsorb mercury. The higher mercury content in the Comanche ash supports this possibility.

Initial tests are being conducted in the laboratory to determine the ability of the different flyashes to adsorb additional mercury at representative operating conditions. During the first series of tests, nitrogen was passed though a sample of the ash heated to 325°F. The mercury concentration in the gas stream downstream of the sample was monitored continuously. Each sample desorbed a slight amount, < 0.01 % mercury by weight, under these conditions.

A second series of tests is underway. During these tests, the flyash sample is heated to 500°F with a nitrogen purge to promote some thermal desorption of mercury. The samples are then evaluated for their ability to adsorb mercury at temperatures from 225°F to 325°F. Samples from Comanche and Arapahoe have been tested thus far. In both cases, minimal desorption or adsorption occurred.

Table 1.
Flyash Sample Analytical Results

ID	Coal (*Mine*)	Boiler	LOI (%)	Ash Hg (ppm)	Particle Size MMD (micron)
C2	Powder River Basin *Belle Ayre*	350 MW	0.79	2.2	11
A1	Western Subituminous *Cypress Amax 20 mile*	Top Fired	8.16	<0.1	40
A4	Western Subituminous *Cypress Amax 20 mile*	Top Fired Low NOx Burners 70% SO_2 removal with sodium sesquicarbonate	15.2	<0.1	21
M1	Texas Lignite *Monticello*	575 MW	0.15	<0.1	16
H1	Eastern Bituminous Low Sulfur *West Virginia*	600 MW Phoenix low NOx burners SO_3 conditioning	4.79	<0.1	
S1	Eastern bituminous high sulfur *Blacksville No2*	680 MW B&W opposed wall Low NOx burners	8.56	0.3	

A Bahco size distribution analysis was conducted on four ash samples. This information was collected to assess the characteristics which may affect mercury adsorption of the flyash. However, since quantitative adsorption and desorption results are not yet available, further size distribution tests have been postponed. The cumulative size distribution results for the four ashes tested are shown in Figure 1 below. The size of the ash can affect the collection efficiency of the electrostatic precipitator or fabric filter. Hopper ash typically has a larger size distribution than ash flowing in the duct. In some samples, such as appears to be the case in sample A1, large particles in the hopper catch may bias the overall size distribution.

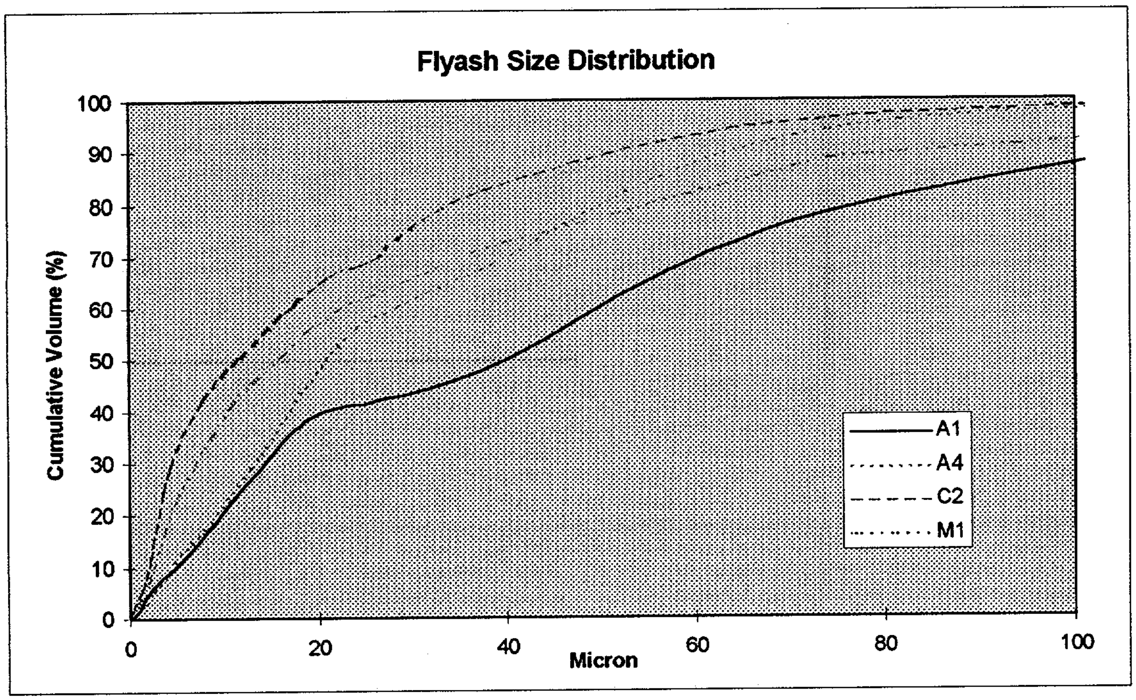

Figure 1. Size distribution of four flyash samples.

Task 2. Design, Fabrication and Installation of bench-scale pilot

The design of the bench-scale pilot, including a full package of fabrication drawings, was completed early in this quarter. A sketch of the structure is shown in Figure 2. The sketch shows three vertical sections within the structural tower. These are the injection section with several injection ports, shown on the left in the sketch, the larger particulate collection section in the center of the tower, and the outlet duct on the right. There are three platforms in the tower with integral stairs to access the sampling ports, injection ports, heater assembly, and the collection section. The in-duct heater is upstream of the injection section and can be accessed from the top platform.

Main Structure

Fabrication of the main structure of the pilot is expected to be completed in April. The pilot is scheduled to be erected on-site at Comanche April 29 and 30.

The main structure is incorporated into an 8-foot by 10-foot tower that is 30-feet high. The injection section and collection section are built within the tower and accessible from platforms at 10-feet, 20-feet and 30-feet. The injection section is a 12-inch diameter pipe with 4-inch ports at five locations along its 16-foot length. A photograph of this section taken during fabrication is shown in Figure 3. The five port locations are shown in the photograph.

The outer housing of the collection section consists of a 28-inch diameter, 20-foot long pipe. A photograph of this section taken during fabrication is shown in Figure 4. The hopper is shown in the foreground of the picture. Figure 5 is a photograph of the hopper assembly including the rotary valve and a "Y" with a valve at each flange. When the valve on the vertical leg of the "Y" is open, ash will drop into the pipe under the hopper. This pipe is a portion of the outlet duct (see Figure 2 for clarification). When the valve on the vertical leg of the "Y" is shut and the adjacent valve is open, the flyash can be collected in a batch mode.

An electrical resistance heater upstream of the injection section will be used to increase flue gas temperatures. Water cooled coils will be installed at this location to cool the gas when necessary. A photograph of the heater section taken during fabrication is shown in Figure 6.

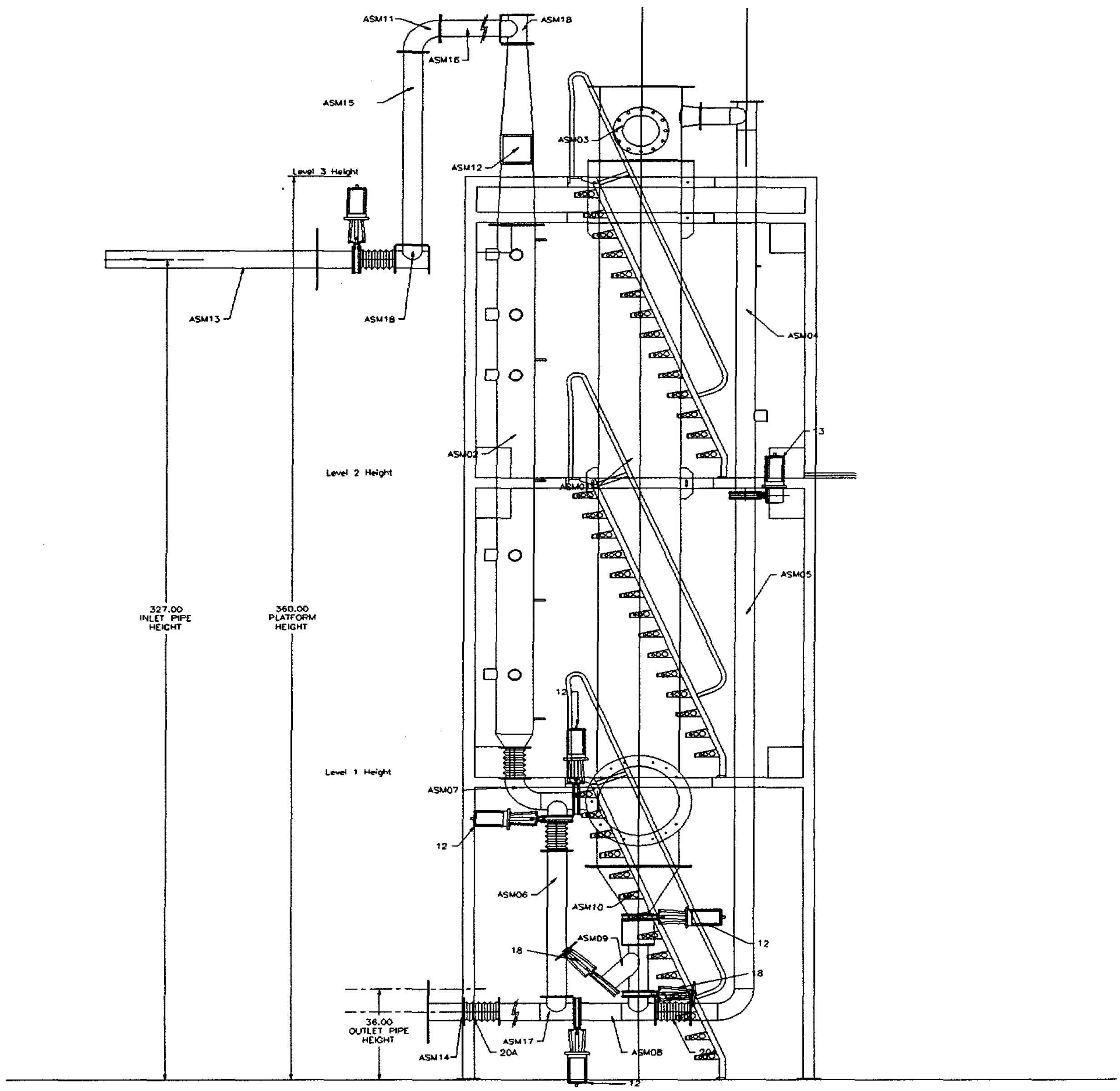

Figure 2. Sketch of particulate control module.

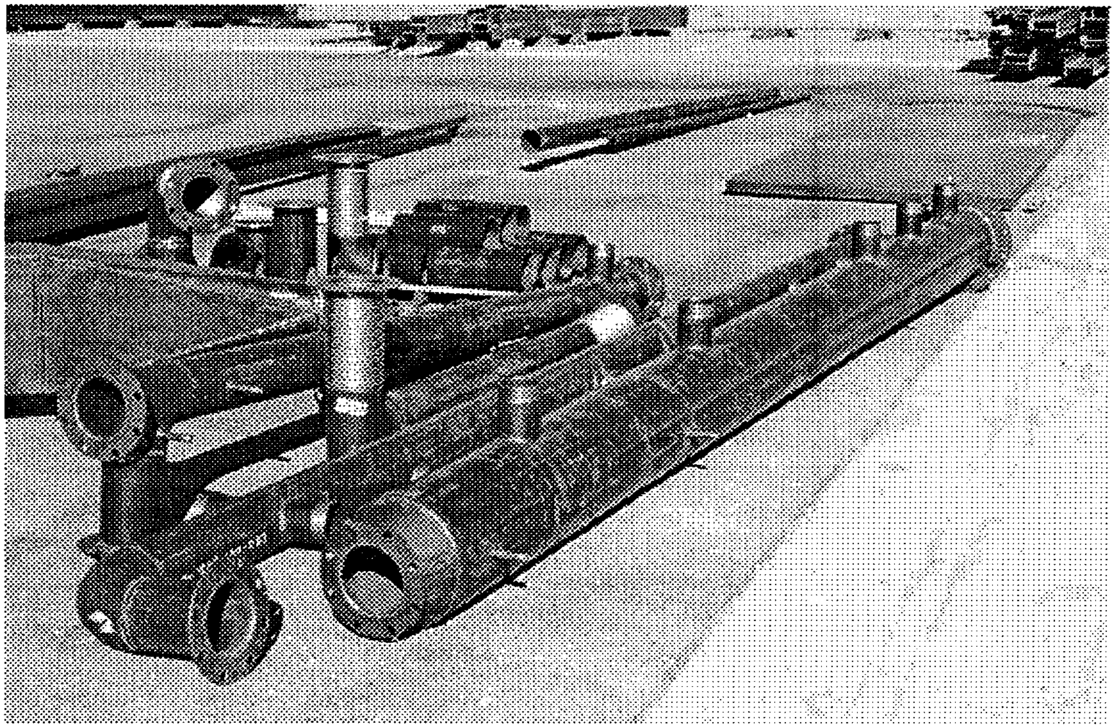

Figure 3. Photograph of injection section taken during fabrication.

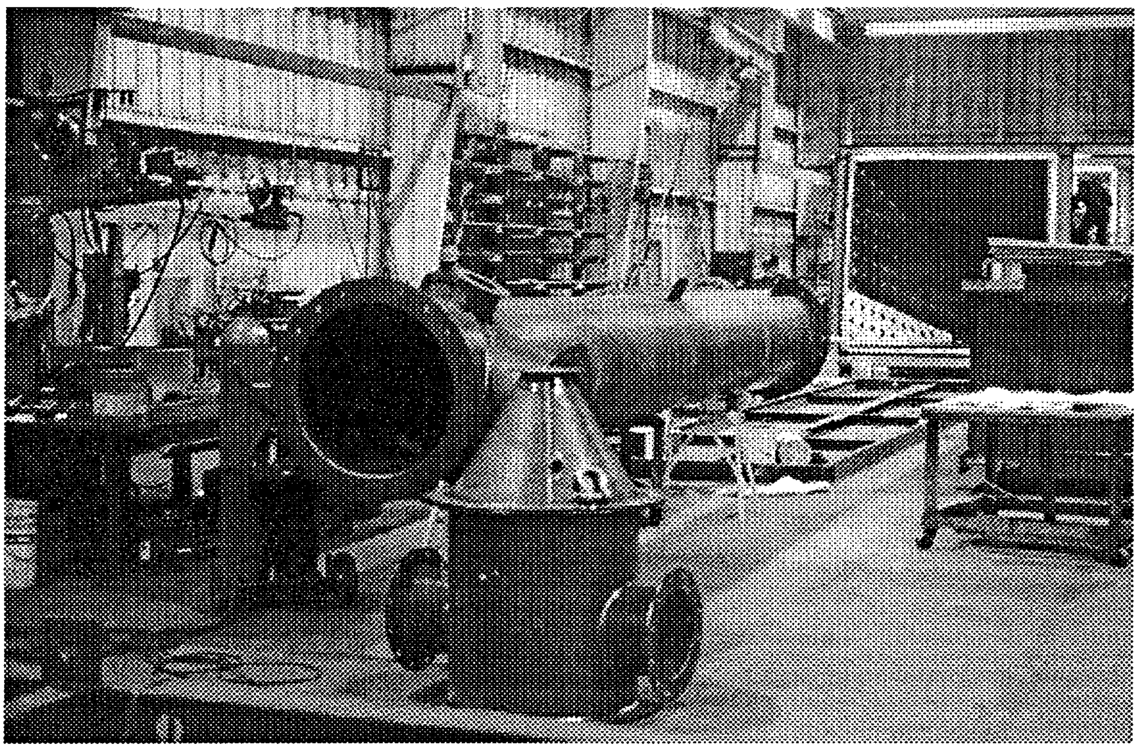

Figure 4. Photograph of collection section taken during fabrication.

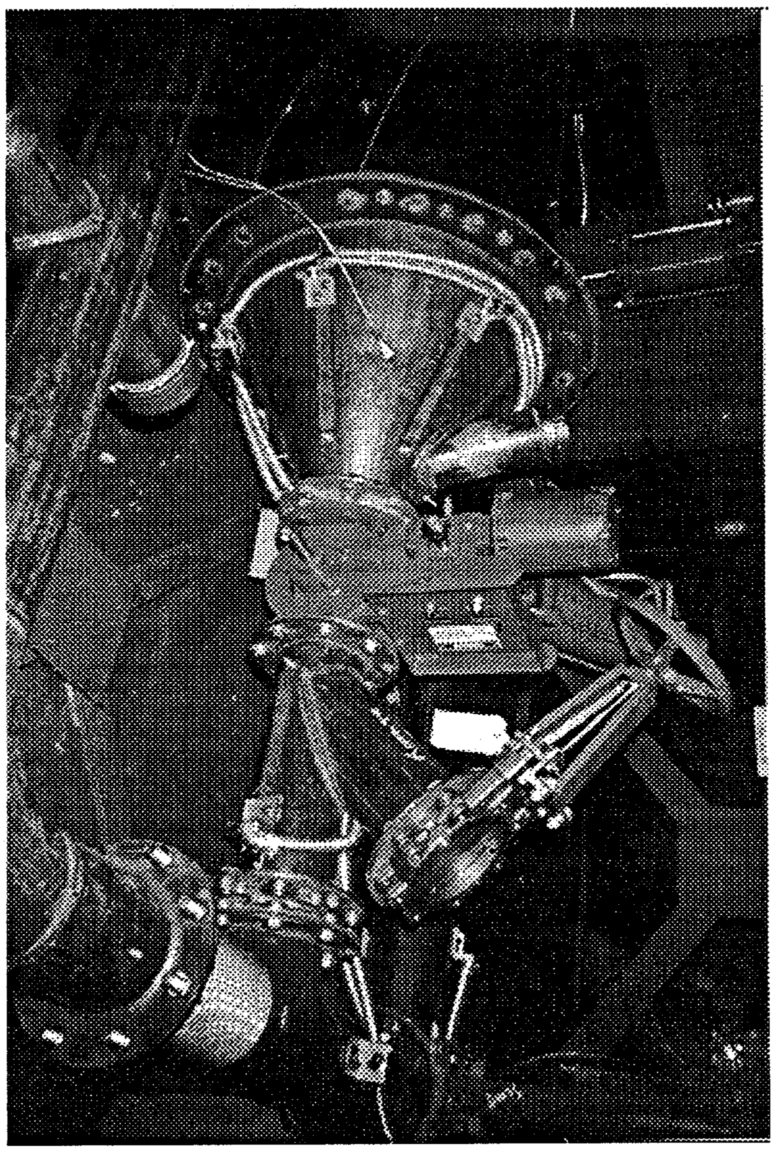

Figure 5. Photograph of hopper assembly taken during assembly.

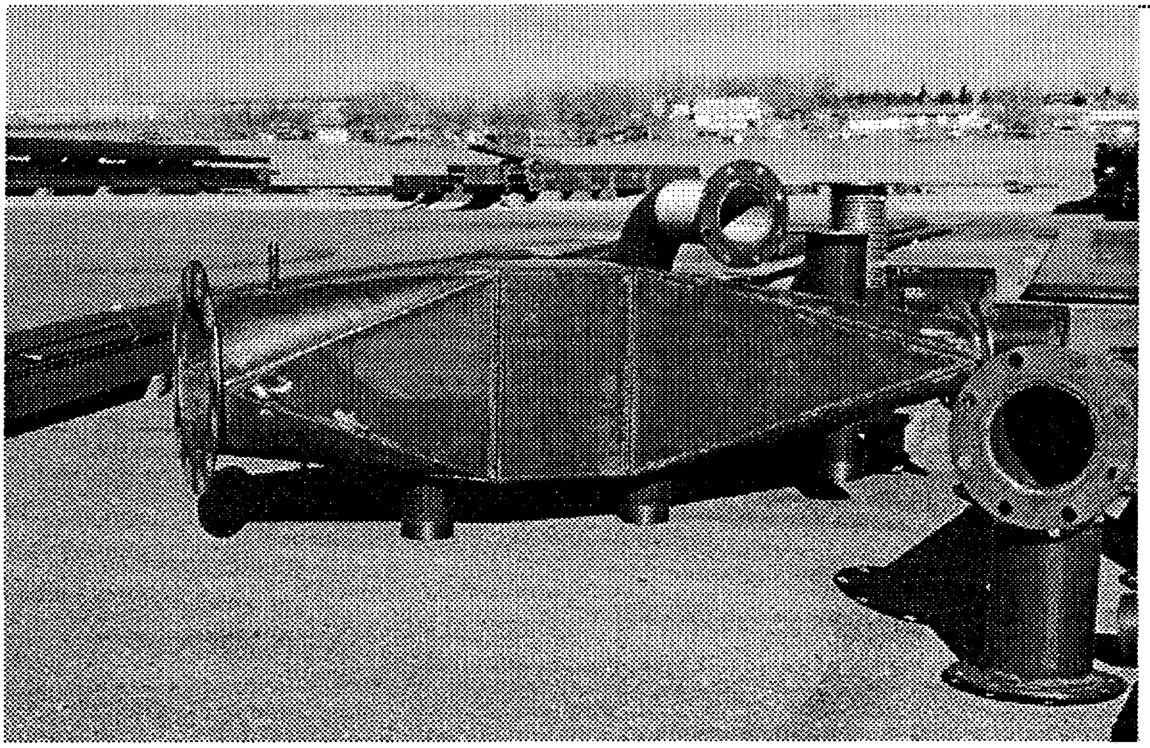

Figure 6. Photograph of heater section taken during fabrication.

A mast will be installed on the tower to allow configuration changes in the PCM without the assistance of a crane. The boom on the mast will extend 25 feet above the tower. It is estimated that three people will be required for major configuration changes, such as from the electrostatic precipitator to the pulse-jet baghouse. This change includes removing the four 10-inch diameter gas passages, each 20-feet long.

ESP Configuration

The PCM will be configured as an ESP for the first test series. Four 10-inch diameter pipes will be hung from a tubesheet at the top of the 28-inch diameter pipe. The 10-inch diameter pipes will serve as the gas passages for the ESP. Four electrodes, one for each gas passage, will be attached to a rigid frame and powered from a single T-R set. The T-R set will be located at ground level and power will be brought to the electrodes through a shielded bus.

Control System

Fabrication of the control panel was begun in April. The panel should be completed by mid-May and incorporated into the pilot assembly.

The control system is designed to allow manual or automatic operation of the pilot. The primary control elements for the pilot will be a Programmable Logic Controller (PLC) and an intelligent data-logger. Pneumatic actuators on several valves including the inlet, outlet, bypass, flow control, purge, and hopper isolation valves permit automatic flow control, off-line cleaning, and isolation of the pilot for shut-down. The control system will be programmed to bring the pilot off-line, clean the bags or rap the plates, and purge the system for alarm trip conditions. Trip conditions include low boiler load and low duct temperature for all configurations and high duct temperature and high tubesheet pressure drop during the fabric filter tests. Duct and wall heaters will be used to adjust and maintain temperatures. The bag cleaning or plate rapping sequence can be controlled automatically or manually at the control panel. Parameters which will be monitored and recorded include: gas temperatures, flowrate, pressures, boiler load, secondary voltage and current (ESP), cleaning/rapping frequency, pulse pressure or reverse gas flow (fabric filter), and mercury concentration.

Mercury Measurement

Results from laboratory testing indicate that gas sampling for mercury measurement in cases where the mercury concentrations are low, less than $10\mu g/m^3$ as experienced at coal-fired utilities, may pose unique problems caused by mercury adsorbing onto the sampling lines. It is recommended that the Project Team discuss options for the mercury sampling system. From the perspective of ease of installation, cost concerns, and compatibility with other continuous emissions monitor systems, it would be desirable if standard Teflon gas sampling lines proved effective. However, due to the state-of-the-art in mercury measurement and sampling, it is not clear that the standard Teflon lines will be acceptable. Several options, including Teflon, are currently being investigated in laboratory tests.

Task 3. Field Evaluations of Sorbents for Mercury Control

Actual sorbent testing at Comanche Station is scheduled to begin in early June, 1996. A preliminary one to two week data gathering visit to the plant discussed last quarter was not possible because a mercury analyzer was not available. Baseline mercury measurements will be collected during the first test configuration. These data will be compared to previous mercury samples taken at the Comanche pilot facility in past years.

The testing sequence proposed in the previous quarterly report will be followed. In this testing sequence, the ESP configuration would be tested first, the pulse-jet configuration would follow, and then the reverse-gas baghouse.

Task 6. Management and Reporting

The contract with ADA was signed this quarter. PSCo legal review of the revised EPRI contract was complete but a contract has not been signed.

ADA signed a subcontract with Mountain States Sheet Metal (MSSM) in Pueblo, Colorado on March 5, 1996 and approval was given for the shop to begin fabrication of the main structure. MSSM is also under contract to erect the pilot at Comanche. It is expected that MSSM will complete all work on the ADA subcontract by the first of May.

Activities Scheduled for Next Quarter (April 1 - June 30, 1996)

Task 1. Sorbent Selection

Laboratory evaluations of potential sorbents and flyash candidates will continue. This work is being conducted at ADA and other labs on separate DOE and EPRI programs, however, the results from these evaluations will be the basis for sorbent and flyash selection in this Phase I. It is expected that final sorbent selections for the ESP configuration will be made early this quarter.

Task 2. Design and Fabrication and Installation of bench-scale pilot

The bench-scale pilot will be erected on-site at Comanche Station and operations in the first test configuration will commence by the end of next quarter.

Task 3. Field Evaluations of Sorbents for Mercury Control

The project is still on target for a test start date of June 3. The PCM will be configured as an electrostatic precipitator for the first test series. It is expected that testing with the first sorbent, FGD activated carbon, will be nearing completion by the end of next quarter.

Task 6. Management and Reporting

A contract with EPRI is expected to be in place during the next quarter.

Contract Concerns

There are no concerns at this time.