DOE/PC/95256--T1

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

Contract DE-AC22-95PC95256

~~Draft~~ Quarterly Technical Report
November 1 - December 31, 1995

February 5, 1996

Public Service Company of Colorado: Terry Hunt
ADA Technologies: Sharon Sjostrom
DOE Program Manager: Tom Brown

Executive Summary

The overall objective this two phase program is to investigate 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 simulate an electrostatic precipitator, a pulse-jet baghouse, or a reverse-gas baghouse will be designed and integrated with an existing pilot-scale facility at Public Service Company of Colorado's (PSCo's) Comanche Station. Various sorbents will then be injected to determine the mercury removal efficiency for each. During the Phase II effort, component integration of the most promising technologies (technically and economically feasible) shall be tested at the 5000 acfm pilot-scale.

An extensive work plan has been developed for the project. A maximum of 4 sorbents will be selected through investigation, presentation, and discussion among team members: PSCO, Electric Power Research Institute (EPRI), ADA Technologies (ADA), and the U.S. Department of Energy (DOE). The sorbents will be tested in the five primary bench-scale configurations: pulse-jet baghouse, TOXICON, reverse-gas baghouse, electrostatic precipitator, and particulate control device with no ash. In the EPRI TOXICON system, mercury sorbents are injected downstream of a primary particulate control device, and collected in an 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 evaluate the ability of different ashes to remove mercury. The use of an

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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.

The final sorbent selection, originally scheduled to be completed in January 1996, has been postponed until late April. Mercury sorbent evaluations are being conducted at various EPRI and DOE laboratories under separate programs. The results of these evaluations will be reviewed in April to finalize the list of sorbents to be tested in this Phase I effort. It is expected that FGD activated carbon will be one of the sorbents tested due to the availability of test data and encouraging results. This delayed task does not affect the overall project schedule.

The primary task currently underway is the facility design. The design is expected to be finished in January, 1996. The facility, regardless of the particulate control module configuration, will be fitted with supply line injection ports, through which mercury sorbents and SO_2 control sorbents can be added to the flue gas stream. Several sorbent injection ports are included in the design to vary the in-duct residence time from 0.75 to 1.5 seconds. An in-duct heater will be installed to vary and control flue gas temperature. In-duct spray cooling for temperature reduction will be accomplished through the test ports. A heat exchanger can also be used to cool the gas without adding moisture. The particulate control module has a hopper on the bottom for storing the collected fly ash and sorbent products; the hopper design will accommodate returning the collected products to the flue gas stream, retaining them for separate disposal, or recycling them to increase the utilization rate.

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. Results from testing in EPRI laboratories should be available by April 1996. Based on this schedule, the final selection of sorbents has been postponed until late April.

To evaluate the ability of flyash to adsorb mercury from flue gas, 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 flyash will be included in the laboratory evaluations. Other ash candidates include an ash from an Eastern low sulfur coal with high unburned carbon measured using Loss On Ignition (LOI) due to low NO_x burners. Arapahoe Station also has low NO_x burners and has relatively high unburned carbon in the flyash due to its unique firing method. Previous mercury testing at Arapahoe has shown approximately 75% mercury removal. Other flyash candidates are being discussed.

A new sorbent selection matrix was developed based on a conference call between PSCo, DOE, EPRI and ADA. This proposed matrix is included in appendix A. The final matrix will not be finalized until early May, 1996.

Task 2. Design of bench-scale pilot

The initial design of the bench-scale pilot is expected to be finished by the end of January, 1996. Drawings of the facility will be submitted to PSCo engineers for approval. Vendor bids for materials will be included with the drawings. An overall arrangement schematic is presented in Figure 1. The existing ductwork and fan are shown in dashed lines in the sketch. The bench-scale facility is indicated by solid lines and includes details such as the duct heater, injection ports, flow sensors, and dampers.

Final approval of the design by PSCo and release to purchase equipment is expected by the middle of February, which will also mark the beginning of the fabrication stage. It is anticipated that the bench-scale facility will be installation at Comanche Station in May, 1996.

Task 3. Field Evaluations of Sorbents for Mercury Control

Actual testing at Comanche Station is not scheduled to begin until June, 1996. However, a preliminary one to two week data gathering visit to the plant is currently being discussed. This trip would include measuring baseline mercury concentrations in the Comanche pilot facility slipstream. Measurements would be made on gas drawn from both upstream and downstream of the existing full-scale reverse gas baghouse. Although this activity was not planned in the original test program, it is believed that the data will provide valuable information for test planning. The information collected would include data to quantify the variability with time of the baseline mercury concentration in Comanche's flue gas and any unexpected issues associated with

INSTRUMATION AND CONTROL LEGEND

L1 HOST LOAD SIGNAL

TC1 HOST GAS TEMP
TC2 INLET GAS TEMP
TC3 HEATER CORE TEMP
TC4 HEATER OUTLET TEMPERATURE
TC5 INJECTION SECTION INLET TEMP
TC6 INJECTION SECTION UPPER TEMP
TC7 INJECTION SECTION MIDDLE TEMP
TC8 INJECTION SECTION BOTTOM TEMP
TC9 INJECTIOIN SECTION OUTLET TEMP
TC10 PCM INLET GAS TEMP (BOTTOM)
TC11 PCM OUTLET GAS TEMP (TOP)
TC12 REVERSE GAS AIR TEMP
TC13 FLOWMETER GAS TEMP
TC14 DISCHARGE GAS TEMP
TC15 BYPASS GAS TEMP

TS1 INJECTION SECTION UPPER SKIN TEMP
TS2 INJECTION SECTION MIDDLE SKIN TEMP
TS3 INJECTION SECTION LOWER SKIN TEMP
TS4 PCM LOWER SKIN TEMP
TS5 PCM UPPER SKIN TEMP
TS6 OUTLET DUCT SKIN TEMP
TS7 HOPPER SKIN TEMP
TS8 DISCHARGE SKIN TEMP

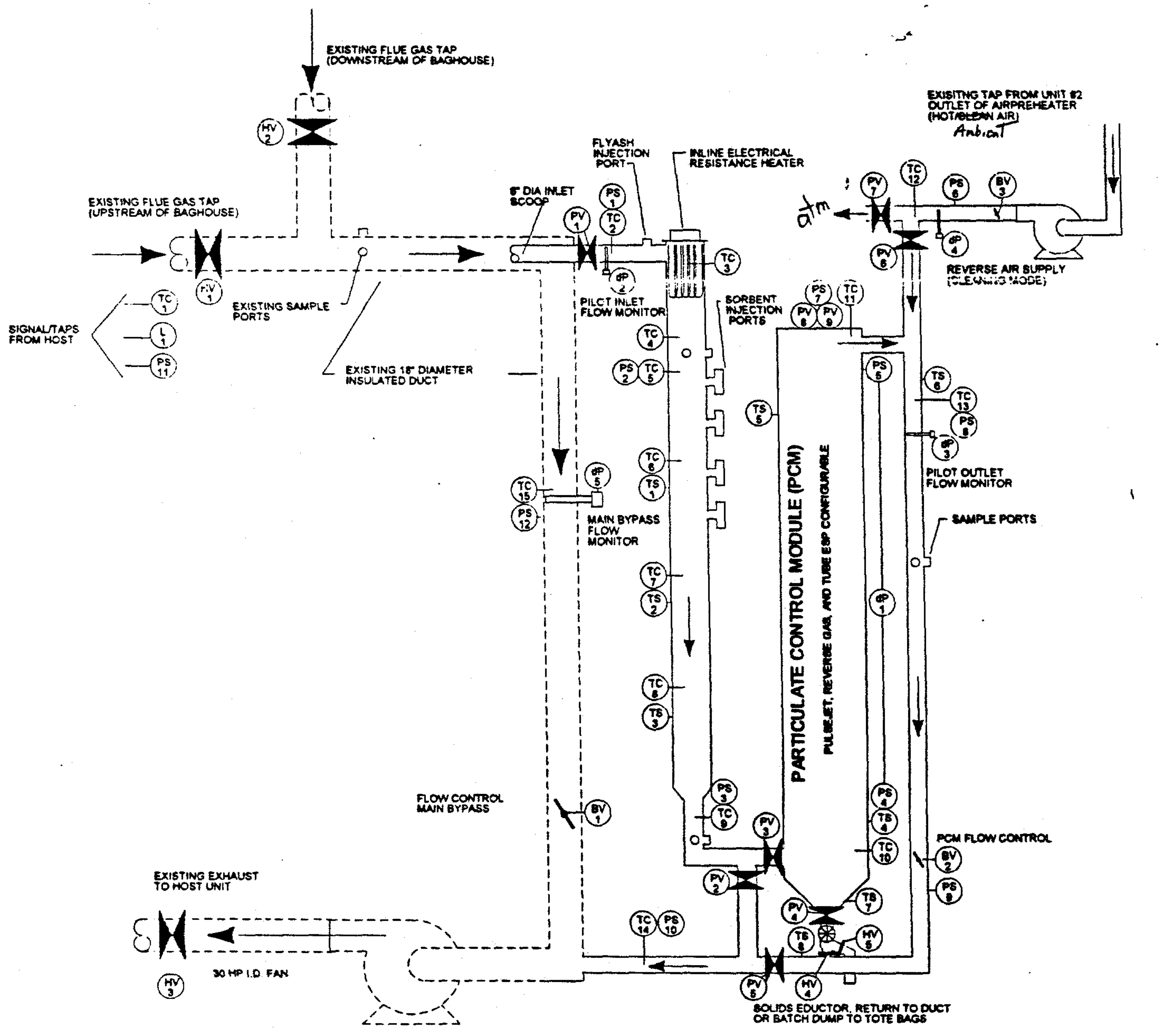
PS1 INLET STATIC PRESSURE
PS2 INJECTION SECTION INLET PRESSURE
PS3 INJECTION SECTION OUTLET PRESSURE
PS4 PCM DIRTY SIDE PRESSURE
PS5 PCM CLEAN SIDE PRESSURE
PS6 REVERSE GAS AIR STATIC PRESSURE
PS7 PULSE AIR REVBERVOIR PRESSURE (PSIG)
PS8 FLOW MONITOR STATIC PRESSURE
PS9 OUTLET DUCT PRESSURE (CONTROL VALVE)
PS10 DISCHARGE OUTLET PRESSURE
PS11 INSTRUMENT/CONTROL AIR SUPPLY (PSIG)
PS12 MAIN BYPASS STATIC PRESSURE

dP 1 TUBESHEET DIFFERENTIAL PRESSURE
dP2 PILOT INLET FLOW MONITOR
dP3 PILOT OUTLET FLOW MONITOR
dP4 REVERSE GAS FLOW MONITOR
dP5 MAIN BYPASS FLOW MONITOR

HV1 FLUE GAS SUPPLY (HAND VALVE)
HV2 CLEAN FLUE GAS SUPPLY (HAND VALVE)
HV3 FLUE GAS RETURN (HAND VALVE)
HV4 SOLIDS RETURN (HAND VALVE)
HV5 SOLIDS BATCH DUMP (HAND VALVE)

PV1 INLET ISOLATION (PNEUMATIC VALVE)
PV2 BYPASS (PNEUMATIC VALVE)
PV3 PCM INLET (PNEUMATIC VALVE)
PV4 PCM HOPPER (PNEUMATIC VALVE)
PV5 OUTLET ISOLATION (PNEUMATIC VALVE)
PV6 REVERSE AIR ISOLATION (PNEUMATIC VALVE)
PV7 REVERSE AIR BYPASS (PNEUMATIC VALVE)
PV8 PULSE CLEANING ARM 1 (GOYEN VALVE)
PV9 PULSE CLEANING ARM 2 (GOYEN VALVE)

BV1 FLOW CONTROL, MAIN BYPASS (HAND BUTTERFLY VALVE)
BV2 PCM FLOW CONTROL, (PNEUMATIC BUTTERFLY VALVE)
BV3 REVERSE AIR FLOW CONTROL, (HAND BUTTERFLY VALVE)



FACILITY SCHEMATIC		
SCALE NONE		DRAWN BY T.E.
DATE 2/7/96		
COMANCHE TEST FACILITY		
ADA TECHNOLOGIES, INC.		DRAWING NUMBER 4420-201-000 Rev 0

sampling. The baseline mercury measurements would be compared to previous mercury samples taken at the Comanche pilot facility.

The testing sequence is also currently being reviewed. During a conference call between PSCo, DOE, EPRI and ADA in December 1995, Ramsay Chang of EPRI suggested testing in an order of increasing total residence time. With the revised testing sequence, the ESP configuration would be tested first. In an ESP, there is little opportunity for the carbon sorbent, once collected on the plates, to continue removing mercury. In a fabric filter, flue gas continually passes through the dustcake of collected particulate matter. This represents additional opportunity for the carbon to adsorb mercury. In addition, the time the sorbent remains on the filter (time between cleans) is typically shorter in a pulse-jet than a reverse-gas baghouse. Therefore, the pulse-jet configuration would be tested second. The reverse-gas would be the final test configuration. This change in testing sequence has not been finalized and would not affect the projected start date or duration of testing.

Task 6. Management and Reporting

The Management Plan was presented to DOE during a project kickoff meeting at PETC on November 13, 1995. The Final Management Plan was reissued during December to incorporate comments from DOE.

The contract with ADA is being negotiated. It is expected that the contract will be reviewed and approved in January, 1996. The EPRI contract is also being reviewed.

Activities Scheduled for Next Quarter (January 1 - March 31, 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 for the basis for sorbent and flyash selection in this Phase I. PSCo and ADA are assisting EPRI in identifying and collecting candidate flyash samples.

Task 2. Design and Fabrication of bench-scale pilot

It is expected that the bench-scale design will be completed, approved and fabrication will be at least 50% complete by the end of next quarter.

Task 3. Field Evaluations of Sorbents for Mercury Control

Arrangements are being made for a data gathering visit to the host site during March or April 1996. This site visit is tentative due to demand for the continuous mercury analyzer on several DOE and EPRI programs.

Task 6. Management and Reporting

Contracts with ADA and EPRI are expected to be in place during the next quarter.

Contract Concerns

There are no concerns at this time.

ADA Technologies, Inc.

An Environmental Science and Engineering Company *Memorandum*

February 6, 1996

TO: Terry Hunt

CC: Tom Brown, Ramsay Chang, Mike Durham, Jean Bustard

FROM: Sharon Sjostrom

RE: Dry Sorbent Evaluation: Revised Test Matrix

This is a proposed test matrix incorporates those items identified during our December 11, 1995 conference call. It is expected that each test condition will require 1 to 3 days of testing. The process conditions, flyash and sorbent characteristics to be evaluated include:

1. Duct temperature ranges
   A) 190-210 °F (expected cold weather baseline)
   B) 225-275 °F (expected warm weather baseline)
   C) 300-325 °F
2. Duct residence time
   A) 1 second
   B) Design allows for 0.75 to 1.5 seconds
3. Mercury concentrations
   Baseline (nominally $7 \mu g/m^3$ expected)
   Doped (TBD based on site characterization test and issues with doping)
4. Methods to lower temperature
   Cooling with water (increased moisture content)
   Cooling with heat exchanger
5. Carbon particle size
   5-7 μm
   20-40 μm
6. Carbon sorbents (B and C may be different for each configuration)
   A) FGD Activated Carbon
   B) Sorbent B (small particle size - TBD based on laboratory results)
   C) Sorbent C (TBD based on laboratory results)
7. Flyash (TBD based on laboratory results)
   High LOI due to low NOx burners
   High LOI due to coal characteristics
   Eastern flyash
   Midwestern Flyash

Appendix A--Test Matrix

A summary of the testing is shown below and detailed on pages 3 through 7. Sorbent A has been identified as FGD carbon. Sorbents B, C, and D may be different for different configurations and will be determined based on results from laboratory testing on other DOE and EPRI programs.

1. Electrostatic Precipitator
    - 1.1 Baseline
    - 1.2 Sorbent A (FGD)
    - 1.3 Sorbent B
    - 1.4 Sorbent C
    - 1.5 ESP Additive

    (1.2–1.4: Vary **temperature, residence time** and **Hg concentration**.)
2. Pulse-Jet (upstream of reverse-gas baghouse)
    - 2.1 Baseline
    - 2.2 Sorbent A (FGD)
    - 2.3 Sorbent B
    - 2.4 Sorbent C

    Pulse-Jet (downstream of reverse-gas baghouse with sodium injection for SO_2 control)
    - 2.5 Baseline
    - 2.6 Sorbent D

    (2.2–2.4, 2.6: Vary **temperature**, and **Hg concentration**.)
3. Toxicon
    - 3.1 Baseline
    - 3.2 Sorbent D

    (3.2: Vary **temperature**, **sorbent injection**, and **Hg concentration**.)
4. Reverse-Gas Configuration (upstream of existing reverse-gas baghouse)
    - 4.1 Baseline
    - 4.2 Sorbent A (F GD)
    - 4.3 Sorbent B
    - 4.4 Sorbent C

    Reverse-Gas (downstream of reverse-gas baghouse with sodium injection for SO_2 control)
    - 4.5 Baseline
    - 4.6 Sorbent D

    (4.2–4.4, 4.6: Vary **temperature**, and **Hg concentration**.)
5. Alternative Ash Tests
    - 5.1 High LOI ash as sorbent
    - 5.2 Midwestern and Eastern flyash evaluations
    - 5.3 Water Spray

1. Electrostatic Precipitator

Test ID	Hg Sorbent	Hg Concentration	Temperature	Res. Time
1.1 Baseline	None	Baseline	225-275 °F	1 sec.
1.2a Sorbent A	FGD	Baseline	225-275 °F	1 sec.
1.2b	FGD	Doped	225-275 °F	1 sec.
1.2c	FGD	Baseline	225-275 °F	B
1.2d	FGD	Baseline	300-325 °F	1 sec.
1.2e	FGD	Baseline	190-210 °F	1 sec.
1.3a Sorbent B	B	Baseline	225-275 °F	1 sec.
1.3b	B	Doped	225-275 °F	1 sec.
1.3c	B	Baseline	225-275 °F	B
1.3d	B	Baseline	300-325 °F	1 sec.
1.4a Sorbent C	C	Baseline	225-275 °F	1 sec.
1.4b	C	Doped	225-275 °F	1 sec.
1.4c	C	Baseline	225-275 °F	B
1.4d	C	Baseline	300-325 °F	1 sec.
1.5a ESP Additive	FGD	Baseline	225-275 °F	1 sec.
1.5b	B or C	Baseline	225-275 °F	1 sec.
1.5c	FGD	Baseline	300-325 °F	1 sec.

2. Pulse-Jet Configuration: Inlet upstream of Comanche R-G baghouse

Test ID	Hg Sorbent	Hg Concentration	Temperature
2.1 Baseline	None	Baseline	225-275 °F
2.2a Sorbent A	FGD	Baseline	225-275 °F
2.2b	FGD	Doped	225-275 °F
2.2c	FGD	Baseline	300-325 °F
2.2d	FGD	Baseline	190-210 °F
2.3a Sorbent B	B	Baseline	225-275 °F
2.3b	B	Doped	225-275 °F
2.3c	B	Baseline	300-325 °F
2.4a Sorbent C	C	Baseline	225-275 °F
2.4b	C	Doped	225-275 °F
2.4c	C	Baseline	300-325 °F

2.5 - 2.6 Pulse-Jet Configuration with Sodium Injection: Inlet downstream of R-G baghouse

Test ID	Hg Sorbent	Hg Concentration	Temperature
2.5	None	Baseline	225-275 °F
2.6a	D*	Baseline	225-275 °F
2.6b	D*	Doped	225-275 °F
2.6c	D*	Baseline	300-325 °F

* Sorbent D may be A, B, C or alternate sorbent chosen for sodium testing

3. Toxicon

Test ID	Hg Sorbent	Temperature	Residence Time
3.1 Baseline	Baseline	225-275 °F	1 Sec
3.2a	D*	225-275 °F	1 Sec.
3.2b	D* int. injection	225-275 °F	1 Sec.
3.2c	D*	300-325 °F	1 Sec.
3.2d	D*	225-275 °F	B

* Sorbent identified based on previous tests

4. Reverse-Gas Configuration: Inlet upstream of Comanche R-G baghouse

Test ID	Hg Sorbent	Hg Concentration	Temperature
4.1 Baseline	Basleine	Baseline	225-275 °F
4.2a	A:	Baseline	225-275 °F
4.2b	A:	Doped	225-275 °F
4.2c	A:	Baseline	300-325 °F
4.3a	B:	Baseline	225-275 °F
4.3b	B:	Doped	225-275 °F
4.3c	B:	Baseline	300-325 °F
4.4a	C:	Baseline	225-275 °F
4.4b	C:	Doped	225-275 °F
4.4c	C:	Baseline	300-325 °F

4.5 - 4.6 Reverse-Gas Configuration with Sodium Injection: Inlet downstream of R-G baghouse

Test ID	Hg Sorbent	Hg Concentration	Temperature
4.5	None	Baseline	225-275 °F
4.6a	D*	Baseline	225-275 °F
4.6b	D*	Doped	225-275 °F
4.6c	D*	Baseline	300-325 °F

* Sorbent D may be A, B, C or alternate sorbent chosen for sodium testing

5. No Comanche Ash: Particle Control Device: ________________

Test ID	Hg Sorbent	Flyash	Temperature
5.1a	None (ash)	LOI 1:	225-325 °F
5.1b	None (ash)	LOI 2:	225-325 °F
5.2a	FGD	Midwestern:	225-275 °F
5.2b	FGD	Eastern:	300-325 °F
5.3 Water Spray	FGD	None	225-275 °F