ELECTRIC POWER RESEARCH INSTITUTE
ENVIRONMENTAL CONTROL TECHNOLOGY CENTER

REPORT TO THE STEERING COMMITTEE

Monthly Technical Progress Report

**US/DOE Patent Clearance is not Required
Prior to the Publication of this Document**

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Prepared by:

**EPRI/ECTC
Parsons Power**

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EXECUTIVE SUMMARY

General Operations

Operations and maintenance continued this month at the Electric Power Research Institute's (EPRI's) Environmental Control Technology Center (ECTC). Testing for the month involved the Dry Sorbent Injection (DSI) test block with the Carbon Injection System.

The 1.0 MW Cold-Side Selective Catalytic Reduction (SCR) unit, the 0.4 MW Mini-Pilot Wet Scrubber, and the 4.0 MW Pilot Wet Scrubber remained idle this month in a cold-standby mode and were inspected regularly. These units remain available for testing as future project work is identified.

Pilot Testing Highlights

The 1990 Clean Air Act Amendments have required that the Environmental Protection Agency (EPA) assess the health risks and environmental effects associated with air toxic emissions (primarily mercury) from fossil-fuel fired utility boilers. EPRI has sponsored research on environmental mercury since 1983 to determine the factors that may influence human health, and to determine the role of electric power generating stations in contributing to those factors. Over the last four years, EPRI's Environmental Control Technology Center (ECTC) has conducted EPRI and DOE sponsored testing to develop and demonstrate appropriate measurement methods and control technologies for power plant atmospheric mercury emissions.

Building upon the experience and expertise of the EPRI ECTC, a test program was initiated at the Center in July to further evaluate dry sorbent-based injection technologies upstream of a cold-side ESP for mercury control, and to determine the effects of such sorbents on ESP performance. The results from this program will be compared to the results from previous DOE/EPRI demonstrations, and to other ongoing programs.

The primary objectives of this test program are to:

- Determine the levels of mercury removal achievable by dry sorbent injection upstream of an electrostatic precipitator (ESP). The process parameters to be investigated include sorbent residence time, sorbent type, sorbent size, sorbent loading, and flue gas temperature.
- Determine the impact of sorbent injection on ESP performance.

FACILITY STATUS

General

The NYSEG Kintigh Station provided flue gas to the Center 100% of the time during this performance period. As the Kintigh Station operated with a variety of coals, fluctuations in the Center's inlet SO₂ concentrations were experienced.

Safety training for the month was conducted by the Operations Manager. A safety video discussing the hazards of working in hot temperatures was viewed by the O&M staff. Inspections of the ECTC Facility and safety equipment (SCR air-packs, fire extinguishers, etc.) were completed and recorded this month. All systems were found to be in good condition. By continuing to emphasize safe work habits at the Center, we have raised the total number of days without a lost time injury to 1883 as of 7/31/97.

The monthly safety meeting with the NYSEG Kintigh Station and the EPRI ECTC was held on July 15, 1997 to exchange information and cover joint safety issues. From this meeting, several staff from the ECTC maintenance group were scheduled for a Kintigh Station training and review course on lifting and rigging.

Pilot and Mini-Pilot Testing

The equivalent and actual availability for the ECTC Carbon Injection System was 100% during this period.

The Dry Sorbent Injection (DSI) test block was initiated this month with tests DSI-0; DSI-1; DSI-2; DSI-3; and DSI-4. The objectives of the testing this month were to study the ECTC electrostatic precipitator (ESP) performance and removal efficiency for total vapor-phase mercury as activated carbon and other sorbents were injected upstream of the ESP. For this testing, the ECTC flue gas path was configured so that the particulate and acid-gas rich dirty raw gas (DRG) from the facility inlet would flow through the Spray Dryer Absorber (SDA) for temperature control, and then through the ESP and the ECTC treated gas return (TGR) outlet ductwork. During the test block, activated carbon was injected upstream of the ESP at several different loading rates as the flue gas was sampled for particulate (Method 5), SO₂/SO₃/O₂ (ECTC CEMs and cold condensation sampling), and mercury concentration (Method 101A).

The mercury samples collected from the testing were forwarded to Radian International for off-site analysis; ash samples from the ESP and the ECTC ash silo, and coal samples from the Kintigh Station were also collected weekly for archiving and analysis at a later date. The operational parameters for the DSI testing with the Carbon Injection System this period included: gas flow of 10,200 scfm; inlet SO₂ concentrations as received from the Kintigh Station; ESP outlet particulate loading of 0.1-0.2 lb/MBTU; an inlet flue gas temperature of 300°F; and activated carbon injection rates of 0-10 lb/Macf.

The following maintenance work was completed on the Carbon Injection System, and across the ECTC facility during this performance period:

- The Acrison weigh loss feeder was inspected and calibrated for the various injection rates.
- The P-5A was installed in the TGR duct to measure the ESP outlet mass particulate emission along with opacity. Several calibrations were made across the unit this period and its installation was modified for better measurement of the flue gas in relation to duct diameter.
- Various ESP field adjustments were made to maintain the desired ESP outlet mass emission limit.
- Various CEM inspection and calibrations were performed.
- A failure in the control board of the Acrison weigh loss feeder occurred this period. This control board was bypassed with a manual control circuit to allow the sorbent injection to be maintained during the testing. A new control board for the unit was purchased and has since been installed.
- CEM cabinet #10 was inspected, repaired and calibrated.
- The stator and rotor was replaced in pump 17.
- The annual inspection of the facility overhead hoists was completed. A few minor problems were found and corrected.

Financial Report

The Financial Report for the four Operations and Maintenance contract tasks are summarized below for the month of July 1997, the year to date, and the contract total.

Task Definitions:

Task 100: Operations and Maintenance Labor

Task 200: Purchased Materials

Task 300: Engineering Support

Task 400: Training

Table i.
Monthly Operating Costs by Task

	July	Year to Date	Contract Total
Task 100	\$ 44,327	\$ 147,581	\$ 14,626,590
Task 200	\$ 7,634	\$ 37,093	\$ 8,548,288
Task 300	\$ 12,256	\$ 63,178	\$ 1,257,766
Task 400	\$ -	\$ 63	\$ 53,298
DOE Grant	\$ -	\$ 132,616	\$ 248,792
TOTAL	\$ 64,217	\$ 380,531	\$ 24,734,734

The attached graph illustrates the budgeted and actual expenses for ECTC O&M activities through July 1997.

Figure i.
1997 Operation & Maintenance Costs

PILOT AND MINI-PILOT TEST ACTIVITY

Testing Overview

The 1990 Clean Air Act Amendments have required that the Environmental Protection Agency (EPA) assess the health risks and environmental effects associated with air toxic emissions (primarily mercury) from fossil-fuel fired utility boilers. EPRI has sponsored research on environmental mercury since 1983 to determine the factors that may influence human health, and to determine the role of electric power generating stations in contributing to those factors. Over the last four years, EPRI's Environmental Control Technology Center (ECTC) has conducted EPRI and DOE sponsored testing to develop and demonstrate appropriate measurement methods and control technologies for power plant atmospheric mercury emissions.

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The primary objectives of this test program are to:

- Determine the levels of mercury removal achievable by dry sorbent injection upstream of an electrostatic precipitator (ESP). The process parameters to be investigated include sorbent residence time, sorbent type, sorbent size, sorbent loading, and flue gas temperature.
- Determine the impact of sorbent injection on ESP performance.

Summary of Operations

The Dry Sorbent Injection (DSI) test block with the Pilot Spray Dryer Absorber (SDA) and electrostatic precipitator (ESP) began during the first week of July. The process configuration for this testing (with sampling and injection points) is shown below in Figure 1.

Figure 1. Process Flow Diagram for Dry Sorbent Injection (DSI) Test Block

During this test program, a commercial carbon based sorbent (activated FGD carbon from American Norit) was studied for injection into the ECTC flue gas stream for mercury control. At the Center, testing was conducted primarily across the cold-side ESP (5.0 MW equivalent gas flow). For this testing, the ECTC ESP was configured to simulate a retrofit application utilizing a small (1-2 field) unit; the ESP was also calibrated and detuned to produce a baseline outlet mass particulate emission of 0.1-0.2 lb/MMBtu. Upstream of the ESP, the flue gas mercury concentration was measured using EPA Method 101A. Several of the other inlet flue gas parameters/species (SO_2 , O_2 , HCl , etc.) were also continuously monitored and adjusted to meet testing requirements and determine their effects on mercury removal.

Downstream from the ESP inlet sampling point, the activated carbon was injected into the ESP with mercury sampling at the ESP outlet to determine removal efficiency. Periodic sampling of the collected flyash/carbon solids was also conducted to help determine particulate removal efficiencies across the ESP, and to determine the impact of carbon injection on flyash loss on ignition (LOI). Also, with the characterization data on the inlet flue gas composition and monitoring of the ESP operation, the particulate collection efficiency of the ESP was recorded to determine any degradation effects as the activated carbon was injected into the system.

A summary of the operating conditions in June is presented in Table 1.

Table 1. July 1997 Dry Sorbent Injection (DSI) Operating Summary

Date	Test Description	Operating Summary
Mon. July 7, 97	DSI-0: Baseline conditions (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	Gas flow was started at 00:00 at 10,200 scfm, and allowed duct work to begin heating up. The opacity monitor and CEMs were brought on-line and calibrated in the morning. Log sheets and parameter sheets were prepared for the control room. Schedules were put together for collecting ash samples and pulling ash daily. Equipment was heated up and calibrated by 11:00. At 13:00 a VT was conducted on the ESP outlet, the actual flow rate measured at the outlet was 12,200 scfm (-16%). The SDA inlet venturi was used in this duct configuration. I&C calibrated the SDA inlet venturi (off by 100 scfm). The increased flow rate at the ESP outlet was from in leakage across the ESP and the ESP fan. The CEM O ₂ readings confirmed this. Method 5 sampling was postponed until 7/8. Nozzle probes were ordered from Joe West Glass, 0.210" and 0.290".
Tue. July 8, 97	DSI-0: Baseline conditions (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	At 08:30 a VT was conducted on the ESP outlet, the measured flow rate was 12,200 scfm. This was the flow rate used for isokinetic sampling with Method 5. Method 5 samples were taken at the outlet to the ESP at 09:30 and 12:47. These samples resulted in a mass loading of 0.090 lb./MMBtu and 0.093 lb./MMBtu.
Wed. July 9, 97	DSI-0: Baseline conditions (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	Conducted baseline Method 101A sampling at the inlet and outlet of the ESP. Two samples were taken at each location. The inlet sample was getting too much ash collected on the filter, so filters were switched out between tests. The screw feeder was calibrated for 1.8 lb/hr.

Table 1. July 1997 Dry Sorbent Injection (DSI) Operating Summary (cont.)

Date	Test Description	Operating Summary
Thur. July 10, 97	DSI-0: Baseline conditions (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	The CR called at 05:00, had problems with screw feeder. The CR got the feeder in range, then 45 minutes later the hopper was empty. I&C checked out the problem and found that the board was bad, sending false signals. Without sorbent injection another set of baseline Method 101As samples were taken. A replacement board was ordered; the bad board was bypassed with a variac control for motor speed until new part arrived.
Fri. July 11, 97	DSI-0: Baseline conditions (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	Screw feeder still out of service (working on bypass without control board). A Method 5 sample was taken on the inlet and outlet of the ESP. The VT sample at the inlet measured 10,290 scfm (-0.9% difference), and the outlet measured 12,196 scfm. The mass loading results were: ESP inlet 3.137 and 3.762 lb/MMBtu, ESP outlet 0.092 lb/MMBtu. NYSEG off-line at 23:30
Mon. July 14, 97	DSI-1: Carbon Injection (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	NYSEG was down Saturday and Sunday, and was still coming up at 6:00 (230 MW). 6:45 NYSEG at 466 MW, ESP inlet 292°F, opacity 1.55%, 10,200 scfm. Method 5 sample conducted on ESP outlet, resulted in 0.072 lb/MMBtu. CEM #10 probe pulled, cleaned, and placed back in service. A calibration was done on screw feeder for 1.8 lb/hr, using the veriac (set pt. 12, 120 V).
Tue. July 15, 97	DSI-1: Carbon Injection (10,200 scfm, 300°F, 1.8 lb/hr)	Sorbent injection at 1.8 lb/hr started at 05:00. At 07:30 the carbon injection rate was at 1.82 lb/hr, no adjustment. Started the Method 101A samples at the ESP inlet and outlet, first set at 08:00, second set at 09:50. At 11:00 the injection rate was 1.61 lb/hr, adjusted up to 1.85 lb/hr. Injected 1.8 lb/hr through the night.
Wed. July 16, 97	DSI-1: Carbon Injection (10,200 scfm, 300°F, 1.8 lb/hr) ESP A&B (5,10)	Sorbent injection rates ran at 1.65 - 1.90 lb/hr over night. At 07:30 the screw feeder was adjusted up to 1.76 lb/hr. Started Method 101A sampling at 08:10, sample #2 at 09:25. The screw feeder was at 1.81 lb/hr when sampling was finished. The last bag of carbon was started at 22:00. Injected 1.8 lb/hr through the night.
Thur. July 17, 97	DSI-1: Carbon Injection (10,200 scfm, 300°F, 1.8 lb/hr) ESP A&B (5,10)	Operations called and the carbon order left Buffalo today, should be here today or tomorrow. Over night carbon ranged from 2.28 - 1.82 lb/hr. Before sampling the injection rate was at 1.90 lb/hr. Began Method 101 sample run #1 at 8:10, and #2 at 9:25. The P-5A was put back into the duct and is being worked on by I&C. A point was created for the P-5A on the WDPF (PAI050). Injected 1.8 lb/hr through the night.

Table 1. July 1997 Dry Sorbent Injection (DSI) Operating Summary (cont.)

Date	Test Description	Operating Summary
Fri. July 18, 97	DSI-1: Carbon Injection (10,200 scfm, 300°F, 1.8 lb/hr) ESP A&B (5,10)	At 07:45 the carbon feed rate was at 1.63 lb/hr. Started Method 101A sampling at 08:00, and at 09:15. The carbon rate when finished was at 1.60 lb/hr. After the last Method 101A test a carbon sample was taken and the sorbent injection was shut down at 11:00. The reading for the P-5A was placed on the HSSD overview graphic. At 13:00 the waste silo was emptied and a sample was taken (will be done every Friday).
Mon. July 21, 97	DSI-2: Carbon Injection (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,10)	At 04:00 the carbon was mistakenly turned on, was noticed at 07:20 and turned off. CEM #10 not calibrated, will be done tomorrow. Waited two hours before sampling, for ESP to clean itself. At 09:45 a Method 5 sample was started at the ESP-outlet. A VT was not conducted. Rather, the data from the three previous VTs (H=1.9) at the same conditions and location was used. The Method 5 sample resulted in a mass loading of 0.072 lb/MMBtu. It was decided to stay at this loading (since this is also where the 1.8 lb/hr injection was tested). Also these results would be closer to what we could achieve at the lower flow rate loading. At 11:30 the screw feeder was calibrated for 4.8 lb/hr. Electrical worked on the ESP parameters for the low flow rate configuration. At 15:00 CEM #10 went to bad values.
Tue. July 22, 97	DSI-2: Carbon Injection (10,200 scfm, 300°F, 4.6 lb/hr) ESP A&B (5,10)	Carbon injection was to begin at 05:00 at a rate of 4.6 lb/hr, but the shaft on the screw feeder would not turn. I&C worked on it and got it started at 12:00, no samples were taken. Worked on data reduction and put together data summary. At 17:00 the screw feeder stopped working. I&C notified and will look at it in the morning.
Wed. July 23, 97	DSI-2: Carbon Injection (10,200 scfm, 300°F, 4.6 lb/hr) ESP A&B (5,10)	The CR tried the screw feeder at 02:20 and it worked. The injection rate through the night was between 3.99 - 4.7 lb/hr. At 07:15 carbon was sampled at 4.58 lb/hr. Started Method 101A sampling at 8:00, and at 09:17. The injection rate at 10:45 was 4.42 lb/hr. Planned to inject at 4.8 lb/hr through the night.
Thur. July 24, 97	DSI-2: Carbon Injection (10,200 scfm, 300°F, 4.6 lb/hr) ESP A&B (5,10)	Carbon rates ranged from 4.7 - 4.1 lb/hr through the afternoon and evening shifts. At 07:30 a problem with the screw feeder was noticed. Could not get a high enough rate even with a higher veriac setting. By 09:00 the problem was corrected by aerating the hopper. The carbon was allowed to go for 1 hour, then a method 101A sample was started at 10:15. Carbon rate was started at 4.9 lb/hr, and finished with 5.0 lb/hr at 13:30. Will run 4.6 lb/hr through the night and switch to 9.2 lb/hr at 05:00. The ash collected in the ESP hopper samples show that the first ESP fields "A & B" have more carbon present. This is indicated by a darker color compared to fly ash alone. "A" field is the darkest and gets lighter with each field after. Also noticed a strong sulfur smell in both "A & B" hoppers.

Table 1. July 1997 Dry Sorbent Injection (DSI) Operating Summary (cont.)

Date	Test Description	Operating Summary																								
Fri. July 25, 97	DSI-3: Carbon Injection (10,200 scfm, 300°F, 9.2 lb/hr) ESP A&B (5,10)	The carbon rate was switched to 9.2 lb/hr at 05:00. Method 101A sampling began at 8:00 with a carbon rate of 9.2 lb/hr and the second sample set finished at 10:45 with a carbon rate 9.64 lb/hr. At 11:00 the facility was shut down. The controller was replaced on the screw feeder by I&C. Held a meeting at 13:00 with R. Chang. Discussed the results thus far and gave a brief operating summary. Also talked about taking the pH of hopper samples, LOI and C:Hg ratio. Will continue testing at 10,200 scfm, with a carbon rate of 10 lb/Macf, and with loading of 0.1-0.2 lb/MMBtu. Will wait for Hg results for next conference meeting.																								
Mon. July 28, 97	DSI-4: Carbon Injection (10,200 scfm, 300°F, 0 lb/hr) ESP A&B (5,5)	I&C came in at 04:00 to calibrate the opacity monitor, CEMs, and P-5A. On the P-5A,an extension was installed to get the proper readings at the duct diameter that the unit was installed in. Now the unit is reading ~66 mg/Am³ compared to 1,300 mg/Am³. NYSEG was at a low load in the morning, so waited until 10:00 to start Method 5 sampling at the ESP outlet. Finished at 11:30. The result was a 0.099 lb/MMBtu. The ESP will be detuned further to get in the range of .1-.2 lb/MMBtu. The C:Hg ratios were calculated for 10 lb/hr assuming 10 µg/Nm³ Hg. It was 28,000:1 (need at least 7.4 lb/hr to get 20,000:1).																								
Tue. July 29, 97	DSI-4: Carbon Injection (10,200 scfm, 300°F, 0 lb/hr) ESP A (3)	At 07:00 NYSEG was at 300 MW, waited for load to increase. Started Method 5 sampling at 09:37 and finished at 11:10. The results showed a mass loading of 0.395 lb/MMBtu. ESP at to high of loading will be tuned up and another mass loading will be taken in the morning. Shipping material for mercury samples arrived, and ordered sampling filters. Ran pH on hopper samples. Put 0.5 g of ash in 20 ml of DI water. Results below: <table><tr><td>date</td><td>field</td><td>pH</td><td>carbon</td></tr><tr><td>7/25</td><td>A</td><td>9.08</td><td>9.2</td></tr><tr><td>7/23</td><td>A</td><td>10.15</td><td>4.6</td></tr><tr><td>7/17</td><td>A</td><td>10.68</td><td>1.9</td></tr><tr><td>7/10</td><td>A</td><td>10.99</td><td>0</td></tr><tr><td>7/25</td><td>-</td><td>11.49</td><td>carbon only</td></tr></table>	date	field	pH	carbon	7/25	A	9.08	9.2	7/23	A	10.15	4.6	7/17	A	10.68	1.9	7/10	A	10.99	0	7/25	-	11.49	carbon only
date	field	pH	carbon																							
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7/17	A	10.68	1.9																							
7/10	A	10.99	0																							
7/25	-	11.49	carbon only																							
Wed. July 30, 97	DSI-4: Carbon Injection (10,200 scfm, 300°F, 0 lb/hr) ESP A (5)	Started Method 5 sampling at 07:23 and finished at 08:53. The resulting mass loading was 0.281 lb/MMBtu																								
Thur. July 31, 97	DSI-4: Carbon Injection (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (5)	Started carbon at 9.2 lb/hr. Method 101A sampling started at 09:10 at a carbon rate of 9.54 lb/hr. Set #2 started at 10:30 and finished at 11:30 with a carbon rate of 9.77 lb/hr. At 12:00, 36L of KMnO ₄ were sent to Radian for Hg analysis. At 13:50 “A” field tripped off-line due to high hopper alarm. Carbon will be injected over night at 9.2 lb/hr.																								

Summary of Results

The Dry Sorbent Injection (DSI) testing this month investigated the effects of activated carbon injection (Norit FGD carbon) upstream of an ESP to determine total mercury removal efficiencies and performance effects with regard to particulate removal efficiency. Recall that FGD carbon is a lignite-based carbon material and is primarily sold as a sorbent for removal of heavy metals species in incinerator flue gas streams. The average grind size for this dry carbon powder is approximately 95% minus 325 mesh screen (45 μ). The mean particle size for this FGD carbon material has been previously analyzed and reported to be approximately 15 μ .

To simulate full-scale operating conditions for this test block, an appropriate inlet ESP gas flow, temperature, and outlet opacity range was selected and maintained to:

- provide a representative gas/carbon residence time through the ESP;
- prevent the formation of acid gas condensation in the ESP; and,
- simulate current/future outlet opacity performance limits.

The operating conditions required to meet these objectives were specified in the July test matrix and included an inlet ESP gas flow of 10,200 scfm at 300°F with an ESP outlet particulate emission limit (pre-carbon injection) of 0.1 - 0.2 lb/MBtu. These test conditions were continuously monitored through the ECTC DRG flow venturi and the outlet opacity and P-5A particulate monitors, and were regularly checked through EPA Method 2 (velocity traverse) sampling and EPA Method 5 (outlet opacity) measurements. This gas flow was selected to maintain a representative gas flow residence time of 2-3 seconds through the first ESP field ("A" field), and a carbon residence time of 5 seconds from the point of injection to the exit of the first ESP field. The data used to determine the appropriate residence times for full-scale simulation testing are shown below in Table 2.

ESP INLET GAS FLOW (scfm)	TEMP. (deg F)	PRESSURE (in. w.c.)	ESP INLET GAS FLOW (acfm)	INLET DUCT VEL (ft/min)	ESP VEL (ft/min)	ESP GAS RESIDENCE TIME (sec)	GAS RESIDENCE TIME/FIELD (sec)
4000	220	-10	5281	1682	88	47	9
4000	250	-10	5514	1756	92	45	9
10200	220	-20	13815	4400	230	18	4
10200	250	-20	14425	4594	240	17	3
10200	300	-20	15441	4917	257	16	3
8000	275	-10	11417	3636	190	22	4
8000	300	-10	11805	3760	197	21	4
8000	320	-10	12116	3859	202	21	4
6000	300	-20	9083	2893	151	27	5
11000	300	-20	16652	5303	278	15	3

Table 2. ESP Gas Flow Residence Time

Flue gas sampling during this testing was conducted at the ESP inlet and outlet locations using EPA Method 101A for total vapor-phase mercury measurement in the ECTC flue gas stream. During this test period, all flue gas sampling was conducted at vapor-phase mercury levels as received from the NYSEG Kintigh Station flue gas (i.e., the flue gas was not spiked/doped with any additional mercury species - elemental or ionic). During this period, measurements of the vapor-phase concentrations for total mercury at the ESP inlet (without carbon injection) indicated baseline Hg levels of 2-6 $\mu\text{g}/\text{Nm}^3$. With this data, the various representative carbon injection rates for the test matrix were calculated as shown in Table 3.

Carbon Injection Rate (lb/Macf)	Carbon : Mercury Ratio (lb/lb)	Carbon Injection Rate (lb/hr)
2	15,000:1	1.8
5	24,000:1	4.6
10	55,000:1	9.2

Table 3. Calculated carbon injection rates

Mercury Removal

As testing was initiated, it was determined that the task of sample analysis for total vapor-phase mercury would be contracted to Radian International with off-site analysis. With each sampling period (with and without carbon injection), regular Method 101A samples were collected for total vapor-phase mercury and were sent off-site for analysis. In analyzing the data from the gas sampling periods and the lab analysis this month, a plot of the mercury removals associated with the various carbon injection rates was prepared and is presented below in Figure 2.

Figure 2. Total Mercury Removal vs. Carbon Injection.

From the data analysis, it was determined that some early samples produced negative removal values. These were found at the 0 and 2 lb/Macf injection rates. The cause of such low/negative removals at the low carbon injection levels was determined to be attributable to the low baseline levels of total mercury in the flue gas, which in turn approached the limits of detection when these samples were analyzed. Also, in the early part of the program, there were delays in the analysis of samples which may have approached the shelf-life period of the mercury samples. In plotting the data from this test period, such negative removals were omitted.

As the carbon injection rates were increased in the test matrix, higher removals for total vapor-phase mercury were obtained. From a review of the data plot and the raw data, an average removal efficiency was determined for each carbon injection rate. These efficiencies are shown in Table 4 below.

Carbon Injection Rate (lb/Macf)	Average Mercury Removal Efficiency (%)
0	9
2	12
5	47
10	46

Table 4. Carbon Injection Rate vs. Average Mercury Removal

At the 5 lb/Macf carbon injection range, an appreciable increase in total vapor-phase mercury removal was determined across the ESP, and the average removal efficiency was calculated at 47%. However, there were only four data points taken at this point in the test matrix, and the analytical data from the samples collected during this injection rate was scattered and showed a wide range mercury removal (24% to 70%). Also, in reviewing the operating conditions period, it should be reported that the inlet flue gas temperature was allowed to fluctuate between a range of 285°F to 315°F. As this may be a variable causing the scatter in the mercury removal data, additional samples will be taken during the test program with a more constant ESP inlet temperature of $300 \pm 5^\circ\text{F}$.

At the 10 lb/Macf carbon injection range, only 2 sample sets were collected during this test period. Based on this limited data, there did not appear to be an increase in total vapor-phase mercury removal, as the average removal efficiency for this period was calculated at 46%. During this testing, the ESP inlet temperature was also allowed to fluctuate between 285°F to 315°F. However, additional data points at this carbon injection rate will be collected and analyzed during the next report period.

ESP Performance

During the testing of activated carbon injection for total vapor-phase mercury removal this month, the effects of carbon injection on ESP performance were also measured. This effort was conducted during the baseline operating conditions during the period (10,200 scfm inlet ESP gas flow and an inlet ESP gas temperature of $300^\circ\text{F} \pm 15^\circ\text{F}$). To study ESP performance, the ESP outlet opacity was continuously

monitored (with and without carbon injection) through the use of several methods:

- Environmental Systems Corp. (ESC) P-5A mass concentration particulate monitor;
- regular EPA Method 5 gas samples, and;
- continuous % opacity readings.

Daily voltage/current (V/I) readings were also taken across each transformer rectifier (TR) set energized in the ESP, and weekly air load readings taken before each weekly start-up of the ESP. This data, when considered with the measurements taken on the flyash collected from the ESP ash hoppers (ash loss-on-ignition (LOI) content and pH), allowed the impact of sorbent (carbon) injection to be characterized with respect to ESP performance.

The test data collected this month for ESP performance (at carbon injection rates of 0 - 10 lb./Macf and inlet gas temperatures of $300^{\circ}\text{F} \pm 15^{\circ}\text{F}$) showed minimal effects on ESP outlet opacity. The results from the weekly air load readings on the ESP prior to each ESP start-up indicated no degradation or change in baseline settings, and the baseline V/I data for the ESP did not change. While it was noticed that there were some increases in the secondary voltages across the energized ESP fields during the high injection rates of carbon injection this period (resulting in improved ESP efficiency/decreased opacity), this data is scattered and needs additional review. Also, during this period, it was noticed that an significant amount of air inleakage across the ESP unit itself was occurring. An ESP outage will be scheduled during the August test period to repair the ESP and reduce the amount of inleakage across the system.

Future Testing

Testing in August will continue with the Dry Sorbent Injection (DSI) investigation across the ECTC ESP. Based on the current test matrix, the August testing will investigate the effects of mercury removal and ESP performance at the same carbon injection rates tested this period, but at a lower and controlled inlet ESP gas temperature of $275^{\circ}\text{F} \pm 5^{\circ}\text{F}$. Also, the number of data points/sample points per each injection rate will be increased next month. As this test series is completed, some data points in the 300°F test matrix will be repeated with more attention placed on controlling inlet ESP gas temperature.

APPENDIX A

TEST SCHEDULE(S)

	1 9 9 6											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4.0 MW Pilot FGD Unit	EPRI Wet FGD Toxics Testing		DOE/PRDA Phase I - Mercury and HAPs Control with Wet FGD			EPRI Wet FGD Toxics Testing		Third party Testing - Rotorfilter Technology	EPRI Toxics Removal Testing	EPRI SOx/NOx Process Testing	ECTC Fall Outage	
0.4 MW Mini-Pilot FGD Unit	UNIT DOWN		DOE/PRDA Phase I - Multiple Pollutant Removal Using the Condensing Heat Exchanger (CHX)									

1 9 9 7											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4.0 MW Pilot FGD Unit	DOE/PRDA Phase I - Clear Liquor Scrubbing (CLS) with Anhydrite Production			NYSEG Spring Outage	CLS Anhydrite extension testing	Dry Sorbent Injection for Hg Removal and ESP performance studies			EPRI ECTC Testing		ECTC Fall Outage
	ECTC Bench-scale FGD Unit (proposed)								DuPont FGD Additives Study		API Process Additives Study
0.4 MW Mini-Pilot FGD Unit	DOE/PRDA Phase I - Condensing Heat Exchanger (CHX) Testing		Reconfigure Mini-Pilot Scrubber		Unit Available for EPRI / Third-Party Testing						

4.0 MW Pilot Wet FGD Unit	1 9 9 8 (proposed)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	DOE/PRDA Phase II Clear Liquor Scrubbing with Anhydrite						DOE/PRDA Phase II Condensing Heat Exchanger (CHX) Testing			EPRI / Third-Party Testing		
	EPRI / Third-Party Testing											
0.4 MW Mini- Pilot FGD Unit												

ECTC Test Schedule ('96 - '98)

APPENDIX B

PROCESS/ANALYTICAL DATA SUMMARY

EPRI/EPDC
Dry Sorbent Injection across the ESP
Data Summary

Test	Date	Sample ID	Sampling Location	Time	Hg (ug/Nm ³)	Removal (%)	Hg in Ash	C:Hg* (#:1)	Carbon (lb/hr)	Opacity (%)	Mass Loading (lb/MMBtu)	P-5A (mg/m3)	P-5A (lb/MMBtu)	NYSEG (MW)	SO2 Inlet (ppm)	SO2 Outlet (ppm)	Difference (%)	ESP Efficiency ** (%)	Inj. Efficiency (%)
Baseline Conditions (10200 scfm, 300 F, 0 lb/hr)																			
DSI-0	7/7/97	P-000	ESP-Out	-	-	-	-	0	0.00	-	-	-	-	444	-	-	-	-	-
DSI-0	7/8/97	P-001	ESP-Out	9:29	-	-	-	0	0.00	3.22	0.090	-	-	349	-	-	-	98	-
DSI-0	7/8/97	P-002	ESP-Out	12:47	-	-	-	0	0.00	2.81	0.093	-	-	409	1189	1062	11	-	-
DSI-0	7/9/97	M-001	ESP-In	9:05	4.63	7.1	-	0	0.00	2.77	-	-	-	580	1214	1086	11	-	-
DSI-0	7/9/97	M-002	ESP-Out	9:07	4.3	-	-	0	0.00	2.77	-	-	-	580	1214	1086	11	-	-
DSI-0	7/9/97	M-003	ESP-In	10:20	4.09	-44.0	-	0	0.00	3.61	-	-	-	390	1081	917	15	-	-
DSI-0	7/9/97	M-004	ESP-Out	10:20	5.89	-	-	0	0.00	3.61	-	-	-	390	1081	917	15	-	-
DSI-0	7/10/97	M-005	ESP-In	8:34	3.81	2.6	-	0	0.00	2.95	-	-	-	366	1143	985	14	-	-
DSI-0	7/10/97	M-006	ESP-Out	8:34	3.71	-	-	0	0.00	2.95	-	-	-	366	1143	985	14	-	-
DSI-0	7/10/97	M-007	ESP-In	10:02	3.3	7.9	-	0	0.00	3.18	-	-	-	439	1225	1062	13	-	-
DSI-0	7/10/97	M-008	ESP-Out	10:02	3.04	-	-	0	0.00	3.18	-	-	-	439	1225	1062	13	-	-
DSI-0	7/11/97	P-003	ESP-In	9:42	-	-	-	0	0.00	3.87	3.137	-	-	554	1299	1164	10	-	-
DSI-0	7/11/97	P-004	ESP-Out	9:38	-	-	-	0	0.00	3.92	0.092	-	-	567	1348	1210	10	-	-
DSI-0	7/11/97	P-005	ESP-In	10:37	-	-	-	0	0.00	4.22	3.762	-	-	629	1458	1323	9	-	-
Carbon Injection 2 lb/Macf (10200 scfm, 300 F, 1.8 lb/hr)																			
DSI-0	7/14/97	P-006	ESP-Out	9:03	-	-	-	0	0.00	1.76	0.072	-	-	700	1339	1206	10	98	-
DSI-0	7/15/97	M-009	ESP-In	8:35	3.49	-2.6	-	14390	1.82	2.52	-	-	-	704	1000	1010	-1	-	-
DSI-1	7/15/97	M-010	ESP-Out	8:35	3.58	-	-	14390	1.82	2.52	-	-	-	704	1000	1010	-1	-	-
DSI-1	7/15/97	M-011	ESP-In	9:50	3.78	10.3	-	11753	1.61	2.65	-	-	-	709	1116	1100	1	-	-
DSI-1	7/15/97	M-012	ESP-Out	9:50	3.39	-	-	11753	1.61	2.65	-	-	-	709	1116	1100	1	-	-
DSI-1	7/16/97	M-013	ESP-In	8:10	2.46	-27.6	-	19741	1.76	2.34	-	-	-	708	1224	1190	3	-	-
DSI-1	7/16/97	M-014	ESP-Out	8:10	3.14	-	-	19741	1.76	2.34	-	-	-	708	1224	1190	3	-	-
DSI-1	7/16/97	M-015	ESP-In	9:25	3.22	-23.0	-	15510	1.81	2.55	-	-	-	709	1210	1153	5	-	-
DSI-1	7/16/97	M-016	ESP-Out	9:25	3.96	-	-	15510	1.81	2.55	-	-	-	709	1210	1153	5	-	-
DSI-1	7/17/97	M-017	ESP-In	8:09	2.92	-30.8	-	17954	1.9	3.72	-	1300	-	696	1276	1239	3	-	-
DSI-1	7/17/97	M-018	ESP-Out	8:09	3.82	-	-	17954	1.9	3.72	-	1300	-	696	1276	1239	3	-	-
DSI-1	7/17/97	M-019	ESP-In	9:25	4.56	50.9	-	11921	1.97	3.35	-	1300	-	719	1259	1231	2	-	-
DSI-1	7/17/97	M-020	ESP-Out	9:25	2.24	-	-	11921	1.97	3.35	-	1300	-	719	1259	1231	2	-	-
DSI-1	7/18/97	M-021	ESP-In	8:00	4.07	14.0	-	11051	1.63	3.21	-	1346	-	701	1217	1171	4	-	-
DSI-1	7/18/97	M-022	ESP-Out	8:00	3.5	-	-	11051	1.63	3.21	-	1346	-	701	1217	1171	4	-	-
DSI-1	7/18/97	M-023	ESP-In	9:13	2.18	-11.0	-	20252	1.60	2.83	-	1337	-	715	1229	1172	5	-	-
DSI-1	7/18/97	M-024	ESP-Out	9:13	2.42	-	-	20252	1.60	2.83	-	1337	-	715	1229	1172	5	-	-
Carbon Injection 5 lb/Macf (10200 scfm, 300 F, 4.6 lb/hr)																			
DSI-2	7/21/97	P-007	ESP-Out	9:44	-	-	-	0	0.00	1.7	0.072	1209	1.497	711	1748	-	-	98	-
DSI-2	7/23/97	M-025	ESP-In	8:05	4.72	24.2	-	26775	4.58	2.64	-	1373	-	424	1413	1069	24	-	-
DSI-2	7/23/97	M-026	ESP-Out	8:05	3.58	-	-	26775	4.58	2.64	-	1373	-	424	1413	1069	24	-	-
DSI-2	7/23/97	M-027	ESP-In	9:17	4.43	41.3	-	27531	4.42	2.87	-	1274	-	440	1423	1075	24	-	-
DSI-2	7/23/97	M-028	ESP-Out	9:17	2.6	-	-	27531	4.42	2.87	-	1274	-	440	1423	1075	24	-	-
DSI-2	7/24/97	M-029	ESP-In	10:20	7.33	69.2	-	18408	4.89	2.67	-	1238	-	592	1606	1312	18	-	-
DSI-2	7/24/97	M-030	ESP-Out	10:20	2.26	-	-	18408	4.89	2.67	-	1238	-	592	1606	1312	18	-	-
DSI-2	7/24/97	M-031	ESP-In	11:34	5.79	54.4	-	23828	5.00	2.69	-	1229	-	677	1718	1408	18	-	-
DSI-2	7/24/97	M-032	ESP-Out	11:35	2.64	-	-	23828	5.00	2.69	-	1229	-	677	1718	1408	18	-	-
Carbon Injection 10 lb/Macf (10200 scfm, 300 F, 9.2 lb/hr)																			
DSI-3	7/25/97	M-033	ESP-In	7:58	3.95	27.1	-	64268	9.20	2.67	-	991	-	552	1454	1217	16	-	-
DSI-3	7/25/97	M-034	ESP-Out	7:58	2.88	-	-	64268	9.20	2.67	-	991	-	552	1454	1217	16	-	-
DSI-3	7/25/97	M-035	ESP-In	9:11	5.02	48.4	-	52988	9.64	3.09	-	1011	-	517	1476	1210	18	-	-
DSI-3	7/25/97	M-036	ESP-Out	9:12	2.59	-	-	52988	9.64	3.09	-	1011	-	517	1476	1210	18	-	-
Carbon Injection 10 lb/Macf (10200 scfm, 300 F, 9.2 lb/hr)																			
DSI-4	7/28/97	P-008	ESP-Out	10:00	-	-	-	0	0.00	1.5	0.099	77	0.096	678	1470	1276	13	97	-
DSI-4	7/29/97	P-009	ESP-Out	9:37	-	-	-	0	0.00	5.29	0.395	159	0.198	390	1167	950	19	90	-
DSI-4	7/30/97	P-010	ESP-Out	7:23	-	-	-	0	0.00	4.45	0.281	140	0.174	435	1135	926	18	93	-
DSI-4	7/31/97	M-037	ESP-In	9:10	5.11	38.7	-	51514	9.54	4.13	-	59	0.117	558	1345	1100	18	97	-
DSI-4	7/31/97	M-038	ESP-Out	9:10	3.13	-	-	51514	9.54	4.13	-	59	0.117	558	1345	1100	18	97	-
DSI-4	7/31/97	M-039	ESP-In	10:30	5.12	52.7	-	52653	9.77	4.18	-	60	0.119	642	1410	1144	19	97	-
DSI-4	7/31/97	M-040	ESP-Out	10:30	2.42	-	-	52653	9.77	4.18	-	60	0.119	642	1410	1144	19	97	-

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