**Electric Power Research Institute
Environmental Control Technology Center
Report to the Steering Committee**

**Topical Report
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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. This program was continued in August at the ECTC, and the results will be compared to test data 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 entitled "Basic Ergonomics" was reviewed and discussed with the 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 1914 as of 8/31/97.

The monthly safety meeting with the NYSEG Kintigh Station and the EPRI ECTC was held on August 28, 1997 to exchange information and cover joint safety issues. The major points of discussion included the future plans for the ECTC SO₂ spiking system, and the Phase I environmental site assessment of the ECTC.

Pilot and Mini-Pilot Testing

The equivalent and actual availability for the ECTC Carbon Injection System was 81% during this period. The System was off-line during the following periods this month:

- August 11-12 for 19 hours to inspect the SDA flue gas heater.
- August 13-15 for 76 hours to repair air leaks in the ESP hotdeck.

The Dry Sorbent Injection (DSI) test block continued this month with tests DSI-4; DSI-4a; DSI-4b; DSI-4c; and DSI-5. The objective of this test block is to study the ECTC electrostatic precipitator (ESP) performance and removal efficiency for total mercury as activated carbon and other sorbents are injected across 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 flows through the Spray Dryer Absorber (SDA) for temperature control, and then through the ESP and the ECTC outlet ductwork.

During the test block, various sorbents are to be injected upstream of the ESP at several different loading rates as the flue gas is sampled for particulate (method 5), SO₂/O₂ (ECTC CEMs), and total mercury (method 101A). The mercury samples collected during the testing this period 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 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 concentration as received from the Kintigh Station; ESP outlet particulate loading of 0.1-0.2 lb./MBtu;

ESP inlet flue gas temperatures of 275 and 300°F; and activated carbon injection rates of 10 lb./Macf.

The following maintenance work was completed on the Carbon Injection System this performance period:

- The SDA flue gas heater was inspected.
- The ESP hotdeck/crock inspection revealed that a majority of the crock covers were leaking. These covers were resealed and the inleakage was resolved.
- Various adjustments were made to the ESP field settings to maintain the proper outlet particulate emissions for the test block.
- Various CEM inspection/calibrations were complete.
- The SDA atomizer was inspected and readied for operation.
- The ECTC sump pump drive motor was replaced.
- All normal and routine scheduled maintenance was completed on the ECTC facility equipment.
- The activated carbon feeder was inspected and calibrated.
- A power supply was replaced on OpCon 210 in the WDPF system.

Financial Report

The Financial Report for the four Operations and Maintenance contract tasks are summarized below for the month of August 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

	August	Year to Date	Contract Total
Task 100	\$ 53,164	\$ 200,745	\$ 14,679,754
Task 200	\$ 7,954	\$ 45,047	\$ 8,556,242
Task 300	\$ 18,598	\$ 81,776	\$ 1,276,364
Task 400	\$ -	\$ 63	\$ 53,298
DOE Grant	\$ -	\$ 132,616	\$ 248,792
TOTAL	\$ 79,716	\$ 460,247	\$ 24,814,450

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

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.

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 and continued through August. 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./MBtu. Upstream of the ESP, the flue gas mercury concentration was measured using EPA Method 101A. Several of the other inlet flue gas parameters/species (SO₂, O₂, 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.

During this month, testing at an ESP inlet flue gas temperature of 300°F was concluded as 4 more samples were collected at 10 lb./Macf. Also, during this period, it was determined that there were some installation problems with the mass particulate monitor (ESC P-5A) in service for ESP performance data. Adjustments were made to the unit installation, and it was calibrated and returned to service.

As testing continued in August, correlations were made between the output data from the ESC P-5A and the data from regular EPA Method 5 samples so that the P-5A unit could be used to evaluate the ESP outlet loading on a continuous basis. The ESP hot deck was also inspected this month due to high O₂ inleakage data across the ESP and the possibility of leaking crocks. After the inspection, the hot deck crocks were resealed and the high inleakage was resolved. As testing resumed, the test matrix continued at an ESP inlet flue gas temperature of 275°F and a carbon injection rate of 10 lb./Macf through the end of the month. A summary of the operating conditions in August is presented in Table 1.

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

Date	Test Description	Operating Summary
Fri. Aug. 1, 97	DSI-4: Carbon Injection (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	Carbon through the night ranged from 8 lb./hr to 10 lb./hr. Sampling console problems, with heated box heater, needed to be replaced. Started Methods 101A run #1 at 8:50 at a carbon rate of 9.04 lb/hr, run #2 was started at 10:00, and finished at 11:00 with a carbon rate of 9.10 lb/hr. At 11:25 carbon was turned off. The ESP was kept up to see how long it took to return to baseline after carbon was turned off. It took about 1 hour to return to baseline. ESP was started on purge air at 12:50, and isolated from NYSEG at 13:50. 3000 lb of carbon ordered, and won't be shipped until 8/9 or at the latest 8/14.
Mon. Aug. 4, 97	DSI-4a (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	I&C in at 04:00 to calibrate opacity monitor, CEMs, and P5-A. Waiting for NYSEG to level out and Electrician to check ESP readings. Started Method 5 at 8:50 at ESP outlet. Finished at 10:29 with the mass loading of 0.176 lb/MMBtu. This will be the setting that is used for next set of carbon injection test. Carbon was started up at 13:00 at 9.2 lb/hr to see ESP performance response with this loading and NYSEG at 700 MW, and carbon was turned off at 14:00. This test resulted in an increase in opacity and P5-A readings and a voltage on "A" field lowered. A contractors meeting was held at 14:00. Plans for next couple weeks were discussed for use of time and on-site carbon.
Tue. Aug. 5, 97	DSI-4a (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	Work out correlation between Method 5 stack sampling and P5-A reading. Obtain correction factor to put into WDPF. From existing data between P5-A and mass loading the correction factor range from 3 - 1. Will calibrate P5-A, run a Method 5 and record 5 min. average values during sampling. Hopefully get an accurate reading to correlate, and input a correction factor into the WDPF.

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

Date	Test Description	Operating Summary
Wed. Aug. 6, 97	DSI-4a (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The P-5A was calibrated at 07:30 by the I&C department. A method 5 was started at 9:00, along with recording 5 min. average readings for the sample period. The Method 5 was completed at 10:30. This mass loading resulted in a 0.188 lb/MMBtu value. After looking into the inconsistent P-5A values, it was determined that the unit was not installed properly. The P-5A requires 36 inches from the duct center to the back duct wall for the focal point to be at the center of the duct. These adjustments will be made on Friday when the facility is off line.
Thur. Aug. 7, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	With the P-5A not properly installed the day was used to see if the carbon had an effect on mass loading. The carbon injector was started at 6:00 at a rate of 9.2 lb/hr. The Method 5 was started at 7:30, allowing for the carbon to "season" the ESP. P-5A, NYSEG loading, and opacity were tracked during sampling. The Method 5 was completed at 9:00, resulting in a mass loading of 0.170 lb/MMBtu . A darker color was noticed on the filter from the carbon. The carbon did not seem to effect the mass loading, is comparable to the previous days loading. The facility was shut down to allow for changes to be made to duct work to install the P-5A tomorrow.
Fri. Aug. 8, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	Duct changes made. A 24 inch extension was added, to allow for proper focal length on the P-5A instrument. The blank flange was painted flat black and then insulated. Received some of the Hg analysis numbers from Radian. A conference meeting was held at 11:30 with R. Chang. Testing for the past and up coming week were discussed.

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

Date	Test Description	Operating Summary
Mon. Aug. 11, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	I&C came in at 4:00 to calibrate the CEMs, opacity monitor and the P-5A. Had some difficulty with the P-5A. A Method 5 was started at 8:30, along with recording 5 min. averages of opacity, NYSEG loading and P-5A. The mass loading was finished at 10:00 and the result showed a loading of 0.208 lb/MMBtu. This associated with a WDPF correction factor of 0.53. It was noticed that the fan output had increased, hot deck temperatures were lower, and purge air increased. A blockage is suspect on the SDA inlet heater. Something is causing the hot deck not to reach temperature, ambient air is being introduced. There seems to be an increasing noise at the inlet to the heater. The facility is shut down at 14:00 to cool off duct work, so that the heater can be opened in the morning. Received the rest of the mercury analysis numbers.
Tue. Aug. 12, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The SDA heater was opened first thing in the morning and no blockage was found. The noise was most likely from some broken heater framing and a few corroded elements. Also opened the man way between the DRG header and the heater, this was also clean. The SDA inlet was checked too, nothing found. The facility was brought up on gas, to do a pressure profile of the gas configuration. The pressure profile showed no drastic pressure drops in the system that would be caused by a plugged duct. The facility will be kept up over night to do a method 5 for P-5A calibration in the morning then be shut down. The facility will be allowed to cool, and then the hot deck will be inspected for leaks.
Wed. Aug. 13, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The P-5A and opacity monitor were calibrated at 7:00. A Method 5 was started at 9:00, along with recording 5 min. averages for opacity, NYSEG loading, and P-5A. This mass loading showed a 0.221 lb/MMBtu result, that gave a WDPF correction factor of .60 for the P-5A. At 11:00 the facility was purged. The ESP hot deck was opened up and will be allowed to cool overnight.
Thur. Aug. 14, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The facility is down for hot deck inspection. After entering the hot deck of the ESP, it was noticed that many of the silicone seals around the plates on the crocks had crack and were dried out. The plates were caulked 2 per crock and 40 crocks. The hot deck was closed up on afternoon shift and the silicone was aloud to set and dry overnight.

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

Date	Test Description	Operating Summary
Fri. Aug. 15, 97	DSI-4b (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The facility is down due to hot deck repairs. The ESP heaters were turned on allowing the ESP to warm and be ready to pull gas on Monday.
Mon. Aug. 18, 97	DSI-4c (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	I&C is in at 4:00 to calibrate opacity monitor, CEMs, and P-5A. There was a problem found on the opacity monitor when the unit would not cal. zero. The problem was resolved and the unit put back in service at 10:30. At 10:45 a Method 5 was started on the ESP-Outlet, along with recording 5 min. averages of opacity, P-5A, and NYSEG load. The Method 5 was finished at 12:20, and the results showed a mass loading of 0.178 lb/MMBtu and a correction factor of 0.42.
Tue. Aug. 19, 97	DSI-4c (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The load of the NYSEG station is low, and waiting for load to build and stabilize. A correction factor was put on the P-5A reading from the WDPF, using three previous correlation to get 0.52. Hoppers E-A were pulled at 9:00, then carbon was started at 9:17 at 9.2 lb/hr. A Method 5 was conducted on the ESP-Inlet along with using the P-5A at the ESP-Outlet. The Inlet was 4.867 lb/MMBtu and the Outlet was 0.204 lb/MMBtu. Carbon was shut off at 15:45, the ESP hoppers were emptied and timed.
Wed. Aug. 20, 97	DSI-4c (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	Carbon injection was started at 05:00 at a rate of 9.2 lb/hr. A solenoid valve needed to be fixed on one of the towers before sampling could begin. The carbon injection rate was at 10.5 lb/hr when the first run of Method 101A was started at 8:45. Run #2 was started at 10:00 and when concluded the carbon was at 8.95 lb/hr. Carbon injection was turned off at 11:30, and "A" field was pulled. A voltage drop was noticed when the carbon was turned off at a 11:30 (55V to 52V). This drop was not recovered after carbon had been off for a while. To try and clean "A" field, over night the ESP was switched to "B" field only and rapping was increased on "A", then returned at 05:00.

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

Date	Test Description	Operating Summary
Thur. Aug. 21, 97	DSI-4c (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	At 05:00 the ESP was switched back from "B" to "A" field, and the rappers were reset. The lower voltage was still present. The opacity monitor was cleaned, and no change was recorded. A few more things were tried on the ESP to clean the plates, no effect was seen. The inlet temperature was raised to 320°F, and increased the rappings on "A" field. Also switched to only "B" field. Opacity and the P-5A are also running high (8-11%, 230-280 mg/Am ³). At 10:00 the inlet was at 318°F, NYSEG at 700 MW and the voltage was at 54V. The inlet temperature was then lowered back down to 300°F. Voltage decreased with temperature decrease. Lowered to 52-53V at 300°F. At 12:00 carbon was started at 9.2 lb/hr. At 13:00 voltage recovered to 54V, opacity was at 5.6%, and P-5A was at 180 mg/Am ³ . Carbon was allowed to go until 20:00, then the ESP inlet temperature was lowered to 275°F (using dmp 2 and SDA heater). Once 275°F was reached and maintained carbon was turned on at 9.2 lb/hr. Carbon injection went for 4 hr., then shut off and the ESP inlet returned to 300°F.
Fri. Aug. 22, 97	DSI-4c (10,200 scfm, 300°F, 9.2 lb/hr) ESP A (10)	The ESP inlet was returned to 300°F and ESP settings and meter readings were recorded and checked. The 3000 lb. of Activated carbon ordered arrived. After the ESP was checked out and returned to baseline, the unit was shut down.
Mon. Aug. 25, 97	DSI-5, Carbon Injection (10,200 scfm, 275°F, 9.2 lb/hr) ESP A,B (5)	The facility was brought on line and set up to achieve 10,200 scfm, at 275 °F, using damper 2 and SDA heater. Once the inlet temperature was maintained at 275°F carbon was injected at 9.2 lb/hr from 11:00 - 14:00. After carbon was turned off, the ESP recovered to baseline readings.
Tue. Aug. 26, 97	DSI-5, Carbon Injection (10,200 scfm, 275°F, 9.2 lb/hr) ESP A,B (5)	At 8:58 a Method 5 was started on the ESP outlet, along with recording 5 minute averages of opacity, P-5A, and NYSEG load. The Method 5 was finished at 10:28, resulting in a loading of (P-018) 0.301 lb/MMBtu and the P-5A recorded a 0.295 lb/MMBtu (2% diff). Electrical made adjustments to the ESP to achieve 0.1 - 0.2 lb/MMBtu. He was not able to accomplish this with just a field, and still have it be stable during carbon injection. The ESP was set up with 5 on "A" and 5 on "B".
Wed. Aug. 27, 97	DSI-5, Carbon Injection (10,200 scfm, 275°F, 9.2 lb/hr) ESP A,B (5)	A Method 5 was started at 8:17 at the ESP outlet. The Method 5 was finished at 9:47 resulting in a mass loading (P-019) of 0.104 lb/MMBtu. Graphs were set up using lb/hr vs. % removal Hg. Ordered shipping containers to ship out Hg samples - dual paint can box. Carbon was started at 13:30 injecting 9.2 lb/hr.

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

Date	Test Description	Operating Summary
Thur. Aug. 28, 97	DSI-5, Carbon Injection (10,200 scfm, 275°F, 9.2 lb/hr) ESP A,B (5)	Carbon injection through the night ranged from 8.8 to 10.2 lb/hr. A Method 101A was started at the ESP Inlet and Outlet at 8:20 and concluded run #2 at 10:45. Carbon injection during sampling started at 10.24 and ended at 10.32 lb/hr. Carbon injected through the night at 9.2 lb/hr.
Fri. Aug. 29, 97	DSI-5, Carbon Injection (10,200 scfm, 275°F, 9.2 lb/hr) ESP A,B (5)	Carbon ran at 9.3 lb/hr to 10.79 lb/hr during the night shift. At 7:50 a Method 101A was started at both the inlet and outlet of the ESP. Run #2 of the method 101A was finished at 10:00, the carbon was also shut off then. The ESP recovered to baseline readings at 11:00 and was shut down for the weekend.

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 (45µm). The mean particle size for this FGD carbon material has been previously analyzed and reported to be approximately 15µm.

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 August test matrix and included an inlet ESP gas flow of 10,200 scfm at 300°F and 275°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) 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 continued this month, the data from the gas sampling periods and the lab analysis was collected and analyzed to plot the mercury removals associated with the various carbon injection rates. This data is presented below in Figure 2 for 300°F testing and Figure 3 for 275°F testing.

Figure 2. Total Mercury Removal vs. Carbon Injection, 300°F.

Figure 3. Total Mercury Removal vs. Carbon Injection, 275°F.

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	43
10 at 275°F	52

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 of 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, 4 more sample sets were collected during this test period. Based on the 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 43%. During this testing, the ESP inlet temperature was also allowed to fluctuate between 285°F to 315°F.

At the other test condition (DSI-5) this month, the ESP inlet temperature was held constant at 275°F ($\pm 5^\circ\text{F}$) using the SDA inlet heater. The carbon injection rate for this lower temperature test was 10 lb/Macf. At this injection rate, 4 sample sets were taken. When compared to the 300°F average removal efficiency at 10 lb/Macf, the data from the 275°F testing showed a higher average removal efficiency (52%). The other carbon injection rates (0, 2, 5 lb/Macf) at 275°F are planned for testing next month.

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 $300^\circ\text{F} \pm 15^\circ\text{F}$ and 275°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 was scheduled this test period to repair the ESP and reduce the amount of inleakage across the system.

Future Testing

Testing in September will continue with the Dry Sorbent Injection (DSI) investigation across the ECTC ESP. Based on the current test matrix, the September testing will investigate the effects of mercury removal and ESP performance at carbon injection rates of 0, 2, and 5 lb/Macf, at a 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)

4.0 MW Pilot FGD Unit	1 9 9 6											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	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	
	UNIT DOWN		DOE/PRDA Phase I - Multiple Pollutant Removal Using the Condensing Heat Exchanger (CHX)									
0.4 MW Mini-Pilot FGD Unit												

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		
	0.4 MW Mini- Pilot FGD Unit											
	EPRI / Third-Party Testing											

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 (%)
<i>Carbon Injection 10 lb/Macf (10200 scfm, 300 F, 9.2 lb/hr)</i>																			
DSI-4	8/1/97	M-041	ESP-In	8:50	4.19	58.9	-	59533	9.04	4.81	-	56	0.111	589	1292	1044	19	97	-
DSI-4	8/1/97	M-042	ESP-Out	8:50	1.72	-	-	59533	9.04	4.81	-	56	0.111	589	1292	1044	19	97	-
DSI-4	8/1/97	M-043	ESP-In	10:00	3.85	51.7	-	65220	9.10	4.23	-	55	0.109	571	1246	1013	19	97	-
DSI-4	8/1/97	M-044	ESP-Out	10:00	1.86	-	-	65220	9.10	4.23	-	55	0.109	571	1246	1013	19	97	-
DSI-4a	8/4/97	P-011	ESP-Out	849	-	-	-	0	0.00	2.34	0.176	47	0.059	708	1374	1172	15	96	-
DSI-4a	8/6/97	P-012	ESP-Out	9:00	-	-	-	0	0.00	2.65	0.188	81	0.100	575	1403	1162	17	95	-
DSI-4b	8/7/97	P-013	ESP-Out	10:00	-	-	-	64105	9.20	3.12	0.170	80	0.098	690	1474	1204	18	96	-
DSI-4b	8/11/97	P-014	ESP-Out	8:32	-	-	-	0	0.00	3.78	0.208	322	0.395	684	1495	1247	17	95	-
DSI-4b	8/13/97	P-015	ESP-Out	8:57	-	-	-	0	0.00	3.13	0.221	297	0.369	707	1425	1169	18	94	-
DSI-4c	8/18/97	P-016	ESP-Out	10:45	-	-	-	0	0.00	5.62	0.196	340	0.427	610	1289	1108	14	95	-
DSI-4c	8/19/97	P-017	ESP-In	10:13	-	-	-	64105	9.20	5.97	4.867	164	0.204	694	1483	1247	16	-	-
DSI-4c	8/20/97	M-045	ESP-In	8:42	3.54	43.5	-	81844	10.50	5.70	-	165	0.086	514	1237	1037	16	98	56
DSI-4c	8/20/97	M-046	ESP-Out	8:43	2	-	-	81844	10.50	5.70	-	165	0.086	514	1237	1037	16	98	56
DSI-4c	8/20/97	M-047	ESP-In	9:58	3.4	19.4	-	72635	8.95	5.94	-	170	0.089	478	1323	1112	16	98	55
DSI-4c	8/20/97	M-048	ESP-Out	10:00	2.74	-	-	72635	8.95	5.94	-	170	0.089	478	1323	1112	16	98	55
<i>Carbon Injection 10 lb/Macf (10200 scfm, 275 F, 9.2 lb./hr.)</i>																			
DSI-5	8/26/97	P-018	ESP-Out	8:58	-	-	-	0	0.00	3.44	0.301	244	0.295	690	1596	1333	16	92	-
DSI-5	8/27/97	P-019	ESP-Out	8:17	-	-	-	0	0.00	1.99	0.104	146	0.176	684	1591	1363	14	97	-
DSI-5	8/28/97	M-049	ESP-In	8:20	6.56	58.2	-	43072	10.24	1.44	-	108	0.077	667	1573	1343	15	98	26
DSI-5	8/28/97	M-050	ESP-Out	8:20	2.74	-	-	43072	10.24	1.44	-	108	0.077	667	1573	1343	15	98	26
DSI-5	8/28/97	M-051	ESP-In	9:35	6.3	59.5	-	45200	10.32	1.37	-	106	0.076	693	1603	1413	12	98	27
DSI-5	8/28/97	M-052	ESP-Out	9:36	2.55	-	-	45200	10.32	1.37	-	106	0.076	693	1603	1413	12	98	27
DSI-5	8/29/97	M-053	ESP-In	7:50	4.19	42.0	-	61245	9.30	1.52	-	112	0.080	477	1347	1136	16	98	23
DSI-5	8/29/97	M-054	ESP-Out	7:50	2.43	-	-	61245	9.30	1.52	-	112	0.080	477	1347	1136	16	98	23
DSI-5	8/29/97	M-055	ESP-In	9:02	3.88	49.7	-	61160	8.60	1.67	-	118	0.084	478	1351	1137	16	98	19
DSI-5	8/29/97	M-056	ESP-Out	9:02	1.95	-	-	61160	8.60	1.67	-	118	0.084	478	1351	1137	16	98	19

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