Amended Silicates™ for Mercury Control

Project Final Report

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Disclaimer

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Abstract

Amended Silicates™, a powdered, noncarbon mercury-control sorbent, was tested at Duke Energy's Miami Fort Station, Unit 6 during the first quarter of 2006. Unit 6 is a 175-MW boiler with a cold-side electrostatic precipitator (ESP). The plant burns run-of-the-river eastern bituminous coal with typical ash contents ranging from 8-15% and sulfur contents from 1.6-2.6% on an as-received basis. The performance of the Amended Silicates sorbent was compared with that for powdered activated carbon (PAC).

The trial began with a period of baseline monitoring during which no sorbent was injected. Sampling during this and subsequent periods indicated mercury capture by the native fly ash was less than 10%. After the baseline period, Amended Silicates sorbent was injected at several different ratios, followed by a 30-day trial at a fixed injection ratio of 5-6 lb/MMACF. After this period, PAC was injected to provide a comparison. Approximately 40% mercury control was achieved for both the Amended Silicates sorbent and PAC at injection ratios of 5-6 lbs/MMACF. Higher injection ratios did not achieve significantly increased removal. Similar removal efficiencies have been reported for PAC injection trials at other plants with cold-side ESPs, most notably for plants using medium to high sulfur coal.

Sorbent injection did not detrimentally impact plant operations and testing confirmed that the use of Amended Silicates sorbent does not degrade fly ash quality (unlike PAC). The cost for mercury control using either PAC or Amended Silicates sorbent was estimated to be equivalent if fly ash sales are not a consideration. However, if the plant did sell fly ash, the effective cost for mercury control could more than double if those sales were no longer possible, due to lost by-product sales and additional cost for waste disposal. Accordingly, the use of Amended Silicates sorbent could reduce the overall cost of mercury control by 50% or more versus PAC for locations where fly ash is sold as a by-product.

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Executive Summary

Amended Silicates™ is a patented sorbent designed to be injected into the flue gas stream at coal-fired power plants for capture of vapor-phase mercury. Mercury-laden sorbent is collected along with fly ash in the plant's existing particulate control equipment. In this application, Amended Silicates sorbent is used in a fashion identical to that for powdered activated carbon (PAC). A distinguishing feature of Amended Silicates is that use of the sorbent allows the continued sale of fly ash as a pozzolan additive in concrete. PAC has been shown in numerous utility trials to contaminate fly ash such that it is not suitable for use in concrete.

The Amended Silicates technology was developed with funding from the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE), and has been successfully tested on a slipstream from an Xcel Energy power plant in Colorado and full-scale in a short-term trial at another Xcel Energy plant burning Powder River Basin coal. The trial reported here evaluated the use of injected particulate sorbents to control mercury emissions from Duke Energy's Miami Fort Unit 6 for a period of six weeks under various conditions. Unit 6 is a 175-MW boiler with a cold-side electrostatic precipitator (ESP). Load on Unit 6 is adjusted to accommodate daily demand. The plant burns run-of-the-river coal originating from Kentucky, West Virginia, Ohio, Pennsylvania, and Illinois. Typical coal is a bituminous rank with ash contents ranging from 8-15% and sulfur contents of 1.6-2.6% on an as-received basis.

The project team included the host utility, Duke Energy, mercury control technology supplier Amended Silicates LLC and its parent companies; sorbent manufacturer BASF (formerly Engelhard Corporation); analytical support teams from the University of North Dakota Energy and Environmental Research Center and Western Kentucky University; fly ash reseller Boral Material Technologies; and various other supporter organizations.

The trial at Miami Fort Station began in late 2005 with the installation of a sorbent injection system designed by the team. The injection system was employed for both sorbents used during the trial – Amended Silicates and NORIT's DARCO® HG – and operated consistently for both. Over seventy-five tons of the Amended Silicates material was made by BASF specifically for the trial. The trial began with a period of baseline monitoring during which no sorbent was injected. Sampling during this and subsequent periods indicated only zero to ten percent mercury capture by the native fly ash. The fraction of elemental mercury in the flue gas ranged from 1/3 to 2/3 of the total mercury during the tests, as determined by Ontario-Hydro mercury measurements.

After the baseline period, Amended Silicates sorbent was injected at several different ratios, followed by a 30-day trial at a target injection ratio of 5-6 lb/MMACF. The Amended Silicates sorbent was manufactured in multiple lots, with some refinement of the process that resulted in lot-to-lot performance variations. After the 30-day trial, PAC was injected at several different ratios to provide a comparison. Approximately 40% mercury control was achieved with the best lots of Amended Silicates sorbent and with PAC at injection ratios of 5-6 lbs/MMACF. Higher injection ratios did not achieve significantly increased removal. Similar removal efficiencies have been reported for PAC injection trials at some other plants with cold-side ESPs, most notably for plants using medium to high sulfur coal.

Sorbent injection did not detrimentally impact plant operations. ESP operating parameters and stack opacity were not affected by sorbent injection. An inspection of the Unit 6

ESPs following the sorbent injection trial showed sorbents had no effects on the ESP internal components. Samples of fly ash and sorbent/fly ash mixes were tested by Boral and Separation Technologies for their suitability for use in concrete. The presence of PAC in fly ash from Miami Fort rendered the ash unusable as a concrete additive. The presence of Amended Silicates sorbent did not degrade fly ash quality. Samples of concrete made with the fly ash / Amended Silicates sorbent blend had compressive strength values matching that for samples made without Amended Silicates sorbent.

Economic analysis for mercury control on Unit 6 concluded that the cost for mercury control using either PAC or Amended Silicates sorbent was approximately equal if fly ash sales were not a consideration. If the plant did sell its fly ash, the effective cost for mercury control could more than double if those sales were no longer possible, due to the combination of lost by-product sales and additional cost for waste disposal. Accordingly, the use of Amended Silicates sorbent could reduce the overall cost of mercury control by 50% or more versus PAC for locations where fly ash is sold as a by-product.

Introduction

In 2006, Amended Silicates LLC (ASL) completed a cost-shared demonstration of its proprietary Amended Silicates™ mercury removal sorbent technology in a full-scale trial at a coal fired power plant. The trial was hosted by Cinergy (now part of Duke Energy) at Miami Fort Station in southwest Ohio and funded in part by US Department of Energy's National Energy Technology Laboratory (NETL).

The Amended Silicates sorbent technology comprises a powdered sorbent designed to be injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. The application is identical to that for powdered activated carbon, so Amended Silicates sorbent can be considered a drop-in substitute for more common mercury control media. This technology has been under development with funding from the EPA and DOE, and was previously demonstrated at a pilot scale on a slipstream from a Colorado power plant and in a short-term utility trial at a coal-fired unit of Xcel Energy. In the spring of 2004, ASL with partial funding from the Electric Power Research Institute (EPRI), conducted a full-scale sorbent injection project at an Xcel Energy power plant in the Denver, CO area.

The Amended Silicates sorbents use silicate minerals as substrate particles into which a chemical reagent with a strong affinity for mercury and mercury compounds is impregnated. The silicates provide a low-cost substrate material with average particle size of a few microns and extended surface area for the amendment process. This combination promotes maximum exposure of the chemical amendment to the mercury vapor present in the coal-fired flue gas stream. The base silicate materials typically sell for *4-8¢ per pound*, so they represent a very cost-effective sorbent substrate material. In addition, because of their silicate content, they have been shown to allow the continued sale of fly ash as a pozzolan material. Tests completed by Boral Material Technologies have indicated that there is no effect on fly ash use in concrete due to the addition of Amended Silicates sorbents, in dramatic contrast to the effect of even minute amounts of powdered activated carbon. This compatibility with continued fly ash sales is a major feature of Amended Silicates sorbent.

In 2003 NETL solicited proposals for commercial trials to support EPA's announced emissions regulations for mercury from coal-fired power plants. The objective of the program was to gather data to document the performance of mercury control technology alternatives when installed and operated at full-scale (100-MW or greater) power generating units. The Amended Silicates team was selected as one of eight cost-shared projects to evaluate mercury control technologies on a commercial scale.

Amended Silicates LLC is a joint venture of ADA Technologies, Inc. and CH2M HILL to commercialize Amended Silicates sorbents for mercury control. ASL arranged with BASF to manufacture the large quantity of sorbent needed for the demonstration, which was provided as a cost-share contribution. ASL was the prime contractor, working through technical personnel from its parent firms (ADA and CH2M HILL) to provide the technical direction and labor for the project. Duke Energy offered its Miami Fort Unit 6 as a host site, and provided on-site technical support during injection of the sorbent material as a cost-share contribution. ASL contracted for mercury semi-continuous emissions monitors (SCEMs) provided by the University of North Dakota's Energy and Environmental Research Center (UNDEERC), and for Ontario-Hydro wet chemistry testing conducted by Western Kentucky University (WKU). Boral Material Technologies participated by evaluating fly ash plus sorbent samples taken during sorbent injection activities to assess the impact of the added sorbent on the use of fly ash as a cement replacement in concrete. Compatibility with the sale of fly ash as a cement replacement is one of the significant advantages of Amended Silicates sorbents in comparison to activated carbon. Separation Technologies, LLC (STL) processed fly ash materials through its proprietary separate process to determine its compatibility with the separation process and to evaluate the impact of Amended Silicates sorbent on removal of Loss-on-Ignition (LOI) carbon from the fly ash. Powdered activated carbon and sorbent feeder equipment was provided by NORIT Americas at a discount price for use on the project.

Project Description

Objectives and Approach

This trial demonstration project was intended to show the effectiveness of Amended Silicates sorbent as a mercury control technology in coal-fired flue gas streams, including the ability to maintain fly ash sales at plants implementing its use. Overall project objectives included the following:

- Demonstrate the ability of Amended Silicates sorbent to control emissions of mercury from a commercial coal-fired power plant over a typical range of operating conditions for an extended period of time (30 days).
- Show that fly ash mixed with Amended Silicates sorbent is compatible with its use as a pozzolan replacement in concrete.
- Confirm that the use of Amended Silicates sorbents has no detrimental impacts on balance of plant operations.
- Estimate the cost to implement Amended Silicates mercury control at full-scale specific to the Miami Fort Unit 6 power generating station.

The project incorporated three sorbent injection campaigns: one where Amended Silicates sorbent was injected over a range of ratios (lb/MMACF) to establish process parameters required to meet mercury control targets, a second campaign where Amended Silicates sorbent was injected for a continuous period of 30 days to validate long-term consistent performance and to discover any impact on balance of plant operation, and a final period where powdered activated carbon was injected for performance comparison. Results from these trial periods were analyzed by the team to quantify system performance with respect to the objectives outlined above.

The project was defined in three stages: **preparation**, which incorporated all activities to prepare the host site for the demonstration, as well as the manufacture of at least 75 tons of Amended Silicates sorbent; **demonstration**, where a matrix of sorbent injection cases was conducted; and **analysis**, during which all the collected data was correlated, analyzed, and interpreted to provide quantitative information regarding the performance of the Amended Silicates sorbent at a commercial scale. The following sections describe the activities and results from each on these project stages.

Project Milestones

The milestones listed below outline the overall project schedule. Team member BASF was added after award of the cooperative agreement, so that the overall project timeline was extended to incorporate the addition of this key member as the manufacturer and supplier of the Amended Silicates sorbent.

- **April, 2004:** Cooperative agreement signed by Amended Silicates LLC and project initiated.
- **August, 2004:** Subcontracts were put in place, project team coordinated schedule, site characterization and planning efforts.
- **March, 2005:** Joint Development Agreement negotiated with BASF to become strategic manufacturing partner to Amended Silicates LLC.
- **April 2005:** BASF began scale-up assessment for preparation for sorbent manufacturing. Short-term cooperative effort between ADA and BASF technical staffs initiated.
- **July 2005:** Production process modifications identified for preparation of 75 tons of Amended Silicates sorbent to be used at Miami Fort.
- **October 2005:** Established conditions for commercial quantity production of Amended Silicates sorbent.
- **January 2006:** Initial delivery of Amended Silicates sorbent to Miami Fort Station.
- **January 2006:** Injection trial at host site started.
- **March 2006:** Injection trial at host site completed.
- **May 2006:** Ash samples received for leachate and stability testing.
- **June 2006:** Submitted samples of fly ash plus sorbent to Boral for analysis of compatibility with use as a cement replacement in concrete.
- **Fall 2006:** Data analyses completed.
- **Summer and Fall 2006:** Presented demonstration results at technical conferences.
- **March 2007:** Final Report submitted.

Preparation Stage

Team Members & Roles

A consortium of team members was assembled to support the technical and financial requirements necessary for an extended, full-scale test of this technology. The prime contractor, **Amended Silicates LLC**, maintained overall responsibility for the planning and implementation of the work. Amended Silicates LLC is a joint venture of ADA Technologies (ADA) and CH2M HILL that is focused on the commercialization of Amended Silicates sorbent.

ADA staff assumed the task of technical direction for the execution of the sorbent injection trial at the host site. Prior to the trial at Miami Fort, ADA personnel had completed smaller Amended Silicates studies at two Xcel Energy power plants in Colorado, which brought experience and expertise to this role. ADA staff conducted much of the planning, as well as provided on-site management throughout the sorbent injection periods, and carried out the analyses of the experimental data.

ASL negotiated an arrangement with **BASF** (Iselin, NJ) to manufacture the Amended Silicates sorbent needed for the demonstration under a joint development agreement. This approach leveraged the mercury-specific expertise of Amended Silicates with the broad sorbent and catalyst manufacturing and sales experience of BASF. BASF is capable of providing the logistics and infrastructure to produce and supply mercury control sorbents to the utility industry. BASF provided 75 tons of Amended Silicates sorbent to the project as a cost-share contribution.

The proposal to DOE listed Cinergy Corp. as the utility partner and host. During the project period, Cinergy merged with **Duke Energy** (Charlotte, NC), and subsequent references in this report are to Duke Energy. The host site was Unit 6 at Miami Fort Station, described below. Miami Fort staff assisted with the installation of the injection and monitoring equipment and supported the sorbent injection trials. Duke Energy was responsible for coal and fly ash analyses and provided access to plant CEM and operational data for use in analyzing trial results. The host site paid for and installed the injection and sorbent feeder systems. Plant-level planning and preparation work were performed as cost-share contributions to the project.

Boral Material Technologies (San Antonio, TX) tested the collected sorbent plus fly ash to assess the impact of the presence of sorbent on the use of fly ash as a concrete additive. The ability to continue to sell fly ash is one of the significant advantages of Amended Silicates sorbents in comparison to activated carbon and can be the deciding economic factor when utilities evaluate mercury control options. Boral is a regional marketer of fly ash as a pozzolan material.

Separations Technology, LLC (STL) is another organization that sells fly ash to concrete producers. STL also markets a proprietary technology to separate unburned carbon from fly ash to allow plants with elevated LOI levels to market their fly ash. Samples of the Miami Fort 6 fly ash were sent to STL for processing to determine its compatibility with the separation process and to evaluate the impact of Amended Silicates sorbent on removal of LOI carbon from the fly ash. STL completed this analysis at no cost to the project.

Western Kentucky University (WKU) was contracted to provide Ontario-Hydro sampling over four intervals during the demonstration period. This wet-chemistry mercury measurement technique is labor-intensive, and relatively expensive, and was scheduled only at specific periods during the trial to minimize costs. Ontario-Hydro sampling is considered the "gold standard" for mercury measurements in flue gas, particularly with respect to speciation between elemental and oxidized mercury in the vapor phase.

University of North Dakota Energy & Environmental Research Center (UNDEERC) personnel were on-site at Miami Fort throughout the test campaign operating two mercury SCEMs; one installed upstream of the sorbent injection ports and a second unit installed downstream of the Unit 6 particulate control device. The analyzers employed for the testing utilized commercial cold vapor atomic fluorescence spectrometers (CVAFS) coupled with a gold amalgamation system. The upstream installation featured an inertial separator to remove particulate matter from the sample gas stream in a way that does not affect the vapor-phase mercury measurement. Both locations used wet-chemistry conversion systems to speciate the mercury measurements for quantifying elemental and total vapor-phase mercury concentrations in the flue gas.

Host Plant Description

Miami Fort Station is located on the Ohio River in southwestern Ohio, about 30 minutes from Cincinnati. The plant operates four coal-fired units generating 1,300-MW of electricity. Unit 6 was chosen for this trial because it fires medium- to high-sulfur eastern bituminous coals and has cold-side electrostatic precipitators (ESPs) installed for control of particulate emissions. This configuration is representative of a large portion of the U.S. coal-fired power plant fleet. Construction started on Unit 6 in 1958 and went operational in November of 1960. The unit features a 185MW General Electric turbine-generator and a Combustion Engineering tangentially-fired boiler. It is equipped with three ESP particulate control units which were commissioned and put into service at different times over the life of the unit. The three precipitators are arranged in series, and are designated (moving in the direction of gas flow) as "old-new", "new-new", and "old", which reflect the order in which the ESP boxes were installed. The old-new and new-new ESPs are situated back-to-back and are fully integrated, with the same cross-sectional dimensions such that there is no transition ductwork between the two. For this trial, all outlet sampling was performed at the exit of the "new-new" precipitator, as there was no space to install sampling equipment between the old-new and new-new boxes. The plant burns run-of-the-river coal originating from Kentucky, West Virginia, Ohio, Pennsylvania, and Illinois. Typical coal is a bituminous rank with ash contents ranging from 8-15% and sulfur contents of 1.6-2.6% on an as-received basis. As discussed later in this report, coal burned in Unit 6 during the trial contained more than 2% sulfur.

Sorbent Selection & Manufacturing

Amended Silicates sorbents were developed by ADA Technologies through funding from DOE and US EPA. Specific formulations were created and evaluated in a series of extensive laboratory and pilot test programs. This research led to several patents and patent pending innovations. The commercial potential of this new sorbent material led to the formation of the Amended Silicates LLC joint venture described earlier. In 2005, ASL entered into negotiations with BASF to manufacture Amended Silicates for the Miami Fort trial. BASF's expertise in full-scale manufacturing of catalysts and adsorbents has been applied to the Amended Silicates composition to ensure that the sorbent can be made uniformly with consistent quality and at the lowest possible cost.

A total of nine lots of sorbent were manufactured by BASF for the testing at Miami Fort. BASF modified the production conditions during manufacturing of some of the lots to refine the production process. It was noted during the trial that certain lots provided better overall performance (better flowability and capture efficiency) than others.

The Amended Silicates sorbent (Figure 1) uses silicate minerals as substrate particles on which a chemical reagent with a strong affinity for mercury and mercury compounds is impregnated. Because of their physical construction, these silicates present extended surface area on each particle combined with an easily-generated particle size of a few microns. This configuration promotes maximum exposure of the chemical amendment to the dilute mercury vapor present in the coal-fired flue gas stream. In addition, because of their high silicate content, they have been proven compatible with the continued sale of fly ash as a pozzolan material.

Tests by Boral Material Technologies have shown that the addition of Amended Silicates sorbent does not affect the requirements for air-entraining agent in a fly ash sample suitable for use in concrete, in contrast to the effect of powdered activated carbon.

Conventional powdered activated carbon (PAC) was injected into the host unit for a one week period to acquire data for comparison with the Amended Silicates trial. The carbon sorbent was NORIT's DARCO® HG, formerly known as DARCO® FGD, a sorbent used in a number of previous trials at coal-fired utilities. NORIT provided the PAC and rental of the sorbent feeder at a 30% discount as a cost share contribution to advance the state of knowledge of mercury control using injected sorbent materials.

Figure 1. Amended Silicates is a non-carbon, mercury-specific adsorbent.

Modeling, Selection and Installation of Injection System

One of the project's first activities was the design of the sorbent injection system. To facilitate this effort, Amended Silicates LLC contracted with CH2M HILL to carry out computational fluid dynamics (CFD) modeling of the proposed sorbent injection ports on the host unit at Miami Fort Station to determine the number and locations of injection port required to achieve a uniform distribution of sorbent in the Unit 6 ductwork. Duke Energy supplied a description of the unit as well as drawings of the exhaust ductwork between the combustion air preheater and the ESP for use in the modeling activity. The project plan called for the rental of a NORIT Americas Porta-PAC™ unit, so an initial layout of the injection system utilized specifications from that unit. Parameters such as carrier air flow, sorbent delivery rates, and sorbent particle size distributions were included so that a complex CFD model could be employed to predict the mass loading distribution of sorbent particles in the duct cross-section of the host unit. A baseline array of injection lances was defined for initial model runs, shown schematically in Figure 2. Each of the four injection lances were designed with opposing ports, and used carrier air to introduce sorbent particles into the flue gas orthogonal to the direction of its flow (gas flow is out of the page in Figure 2). In this configuration, the injection lances were about ten feet apart. To achieve rapid dispersion of the sorbent particles into the flue gas, the carrier air jets from the lance ports must penetrate about five feet into the flue gas.

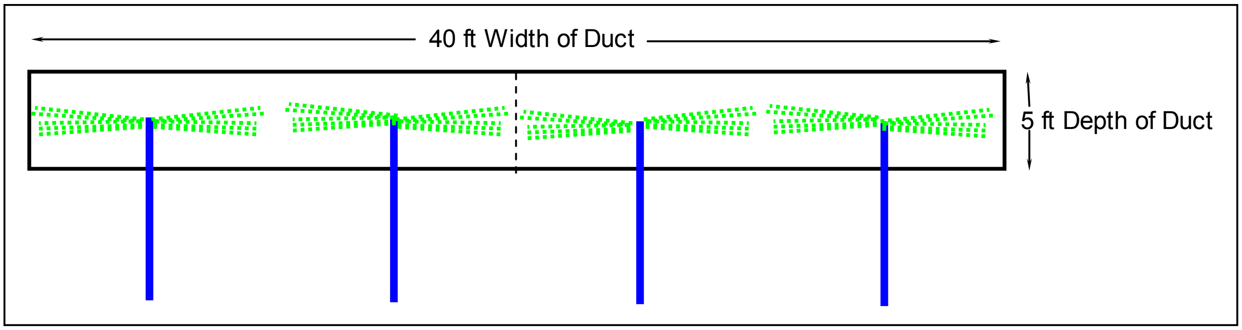


Figure 2. Layout for Sorbent Injection Lances for Miami Fort Unit 6 Ductwork.

A three-dimensional rendering of the Miami Fort Unit 6 ductwork as defined in the model is presented in Figure 3. The light blue coloring marks the ductwork path within the larger, dark gray rectangular solid that marks the model boundary. The bright blue elements are turning vanes within the ductwork. The red section lines labeled A-A, B-B, and C-C mark the cross-sections at which particle distributions were computed by the CFD model, using the sorbent injection system parameters. Sections are shown on the rendering: Section A-A is located ten feet above the sorbent injection location, and section B-B is 40 feet above injection. The flow path in the ductwork is upward, from the outlet of the air preheater at the bottom right to the ductwork feeding the first ESP on Unit 6 at the top rear. There are several directional changes in the flow path, in addition to the turning vanes; each of these elements was seen in the modeling results to promote dispersion of the injected sorbent particles throughout the flowing flue gas.

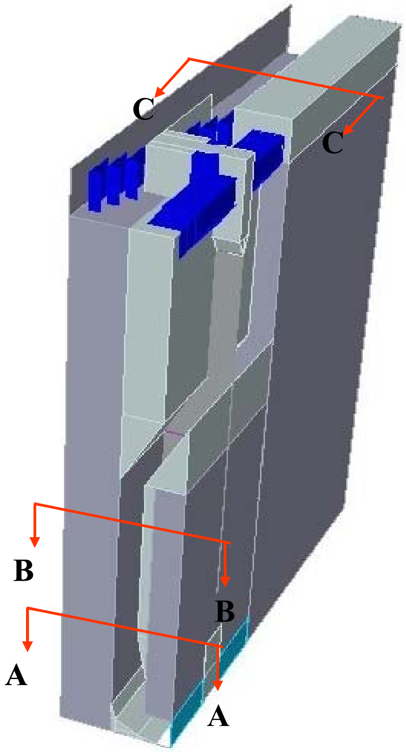


Figure 3. Computer generated image of the Unit 6 ductwork between the air preheater and ESP.

The initial modeling showed that four sorbent injection ports did not distribute the sorbent adequately in the ductwork. Consequently, additional model runs were made with eight injection lances. Results of this additional modeling are compared to the earlier 4-lance configuration in Figure 4 below, showing sorbent particle concentrations and gradients at the 40-foot elevation above the injection level. The multicolor gradients show that there is significant non-homogeneity in the four-lance configuration. In contrast, the eight-lance configuration indicates a more uniform distribution of sorbent in the duct.

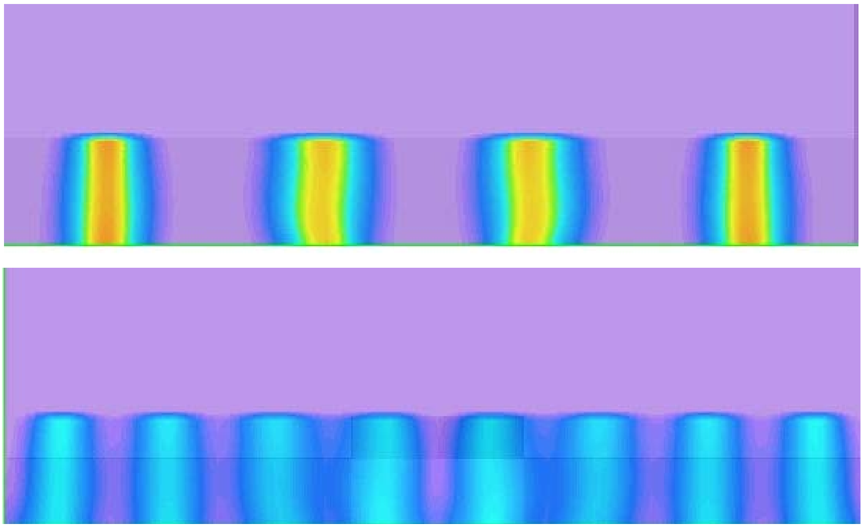


Figure 4. Sorbent particle dispersion gradients from CFD Model 40 ft above the proposed injection location. Top image shows dispersion with four lances, bottom image with eight lances.

During a February, 2005 site visit an array of four ports was noted just downstream of the air heater outlet on Unit 6. These ports were judged to be viable candidates for use as sorbent injection locations. Given that only four ports existed, ASL conducted additional CFD modeling to evaluate use of these ports on sorbent distribution in the duct cross-section. The model was configured with four lances spaced on 10-foot centers across the split duct just downstream of the outlets from the twin air pre-heaters. Sorbent dispersion in the flue gas as a function of distance downstream of the injection ports was predicted in model runs.

At the location of the existing ports, the outlet duct is split into two sections, which are joined just downstream, see Figure 3. The two parallel duct sections exiting the air pre-heaters are seen adjacent to the right-most "A" identifying the cross-section line in the rendering. Sorbent dispersion was calculated downstream the sorbent injection ports by the CFD model; plots are shown in Figure 5: section A-A (10 feet), section B-B (40 feet) and section C-C (after second set of turning vanes).

This additional CFD modeling showed that there is a high degree of mixing 40 feet above the sorbent injection point, as reflected in the relatively uniform shading in the cross-section plots. These results compared favorably with earlier model projections for an eight-lance array situated at a location about 40 feet downstream of the current location. Furthermore, after the second set of turning vanes, (image C-C), the sorbent is completely distributed throughout the duct. Based on these results it was recommended that the existing ports be used for installation of the sorbent injection lances. When the actual installation was undertaken, the existing ports were used for gas sampling lances to supply gas to the mercury SCEM and for Ontario-Hydro sampling for mercury measurements. New ports were installed a few feet above (downstream of) the existing ports for the sorbent injection lances.

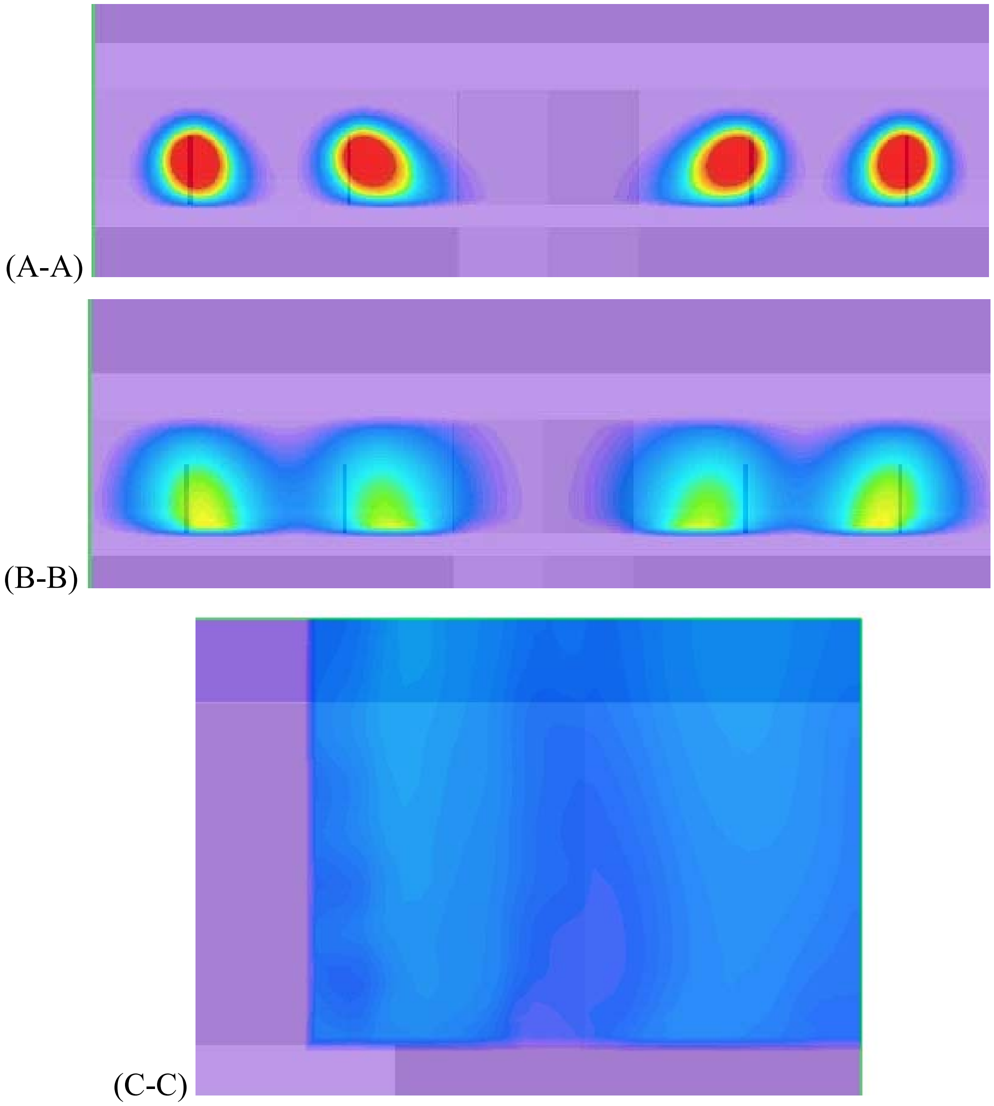


Figure 5. Sorbent distribution as a function of distance from injection ports: (A-A) 10-ft downstream, (B-B) 40 ft downstream, (C-C) after second turning vanes.

The team built a prototype injection lance to evaluate the performance of the proposed injection nozzle. The prototype lance was tested with three different nozzle configurations: (1) simple holes, (2) extensions ground to match the interior curvature of the lance piping, and (3) extensions where the nozzle stub extended into the curvature of the lance piping. A smoke flare was used to visualize the discharge flow from the opposing injection ports in the different lance configurations, see Figure 6. The carrier air rate was that specified for the CFD modeling – a nominal discharge velocity of about 60 feet per second. Photos of the discharge were taken with a digital camera.

The testing indicated that the addition of short injection nozzle extensions that were ground to match the interior curvature of the piping provided more uniform plume dispersion in the direction normal to the lance and such a configuration was used in the final design of the injection lances installed at Miami Fort Unit 6.

Figure 6. Evaluation of injection lance port designs, simple hole design (left) and nozzle extensions (right). The nozzle extensions provided a more uniform distribution pattern.

In the final configuration, four lances were positioned at one-third the depth of duct, based on results from the CFD modeling exercise. Compressed air transported the dry sorbent to the injection lances at a maximum delivery rate of about 400 lb per hour, or about 10 lb/MMACF. The lances were located just downstream of the air pre-heaters where the flow path turned from horizontal to vertical in the ductwork, which offered a residence time for sorbent injected into the flue gas flow on the order of three to four seconds before entering the ESPs.

The lances were supplied sorbent from a NORIT Porta-PAC sorbent feeder system leased for the test period. The system was installed on Unit 6 in early January 2006. Sorbent was supplied from a Super Sack® mounted on a frame in the Porta-PAC unit. A feed hopper with a positive displacement screw fed sorbent into the throat of an eductor. Motive air carried the sorbent materials to the four injection lances. Feed rate of sorbent was determined by the rotational speed of the feed screw. The mass rate of sorbent was correlated to feed screw speed through a series of calibration runs. Calibration data was used to determine proportionality constants that were programmed into the feeder controller.

The feeder screw speed was manually controlled during the parametric studies using an onboard programmable controller. During the extended injection periods, a steam rate signal from the control room was wired into the feeder controller such that the feed rate was proportional to unit load to give a consistent sorbent injection ratio (lb/MMACF). The system was used to feed both the Amended Silicates and PAC sorbents, and was able to handle both sorbent types without modifications. Amended Silicates sorbent and PAC materials were packaged in 1 cubic yard Super Sacks. A Super Sack of Amended Silicates sorbent weighed ~1250 lb/sack; while a Super Sack of activated carbon weighed ~1000 lb/sack. The difference in sack weights is due to the difference in bulk densities for the two materials.

Mercury Sampling – Ontario-Hydro

Western Kentucky University was contracted to provide Ontario-Hydro (O-H) sampling on several dates during the trial period. This wet-chemistry mercury measurement technique is labor-intensive, and therefore relatively expensive, and was scheduled at specific periods during the trial. During the O-H tests, triplicate measurement runs were made at the inlet and outlet sample ports simultaneously. O-H sampling runs typically last about 90 minutes, during which the load and firing conditions of the host boiler were maintained as constant as possible. The first O-H sampling period was during the baseline phase of the project to assess mercury removal by native flyash. The WKU team returned twice in February and once in March to complete three more O-H sampling sessions during the parametric and 30-day Amended Silicates sorbent injection periods. No O-H sampling was performed during the PAC injection period.

Mercury Sampling – SCEM

University of North Dakota Energy & Environmental Research Center personnel were on-site at Miami Fort throughout the test campaign operating two PS Analytical mercury SCEMs: one installed upstream of the sorbent injection ports and a second unit installed at the outlet of the second of three ESP boxes. The analyzers employed for the testing utilized commercial cold vapor atomic fluorescence spectrometers (CVAFS) coupled with a gold amalgamation system. The gold traps were protected by passing the sample gas through a sodium hydroxide solution to remove SO_2 and HCl gases. The CVAFS detection system of the analyzer measures elemental mercury. For total mercury measurements, oxidized mercury in the gas sample was converted to elemental mercury by passing the gas through a reducing solution of stannous chloride in a sodium hydroxide matrix. Hence, total and elemental vapor-phase mercury was measured respectively by sampling gas from the pretreatment/converter system or sampling gas from the pretreatment system with no chemical conversion. Typical integration times for the samples were five to nine minutes, depending on operating conditions of the host unit and location of the SCEM instrument. The operating mode was one where a gas sample was extracted to a gold amalgamation trap for a predetermined period of time, and then the trap was heated to desorb mercury from the trap into a gas flow routed to the CVAFS instrument. In the interim, sample gas flow was routed to a second gold trap, and the cycle was subsequently completed for the second trap. The SCEMS were calibrated daily, typically in the morning. The SCEMS were operated in a mode where total mercury was measured for 8 sampling intervals, then switched to monitor elemental mercury for 3 sampling intervals.

Mercury Sampling – Iodated Carbon Traps

During a portion of the test period the team sampled the effluent gas composition for mercury using iodated carbon (IC) traps, mimicking EPA Method 324. EPA Method 324 was developed as a simpler means to track mercury emissions and provide a cross-check on SCEM data. Method 324 collects mercury in combustion flue gas streams using dry sorbent traps, followed by analysis of each trap by cold vapor atomic fluorescence spectrometry (CVAFS). The analyte measured by this method is total vapor-phase mercury, which represents the sum of elemental and oxidized forms of mercury. Mercury concentrations are determined on a mass basis (µg/m^3) and then combined with flue gas flow data to calculate the continuous mass emission rate of total vapor phase mercury. IC traps were purchased from Frontier Geosciences (Seattle, WA). The sampling procedure with the IC traps was performed at times matching the O-H sampling. Measures were taken to prevent water from condensing in the trap by maintaining the IC trap at a temperature above the dew point temperature. Sample gas flow was isokinetic with a flow through the trap set at 500 cubic centimeters per minute.

QA/QC Plan and Demonstration Plan

The ASL team prepared a Quality Assurance / Quality Control (QA/QC) plan to define the sampling collection and handling protocols for the testing, specifically for the Ontario-Hydro and mercury SCEM measurements. A draft QA/QC Plan for the SCEM was completed by UNDEERC and reviewed by the other team members. Comments were incorporated into the plan, which was then used during the trial to guide QA/QC activities. A copy of the finalized plan is provided in the Appendix A.

In late 2005 the team wrote a comprehensive Demonstration Plan describing the trial objectives, format, protocols, schedule, and the responsibilities of the parties involved. The complete Demonstration Plan is included in the Appendix B; its contents are described in the preceding and following sections.

Project Data Website

The project plan originally called for creation of a secure website to provide the various project members access to the extensive data sets from the demonstration work. However, establishing access protocols and data uploads proved more cumbersome than anticipated and maintenance of the website did not keep pace with the rapidly expanding data files from the test. Ultimately the concept was abandoned and data analyses were centralized at ADA's offices with file distribution via email.

Demonstration Stage

The demonstration stage encompassed a series of measurement and injection campaigns at Miami Fort Station, starting in January of 2006 (see Table 1). Mercury SCEMs were operated throughout the demonstration phase to collect data on mercury concentrations upstream of sorbent injection ports and at the outlet of the ESP of the host unit. At four discrete times during the demonstration, O-H wet chemistry sampling was performed to collect data for comparison to the mercury SCEMs data.

ADA coordinated the staffing in support of the trial operations at Miami Fort. This included periods for Ontario-Hydro sampling conducted by personnel from WKU, SCEM operation by staff from UNDEERC, and the collection of fly ash samples for evaluation by team members Boral Material Technologies and STL. These fly ash samples were extracted from the ESP hoppers by plant personnel and were subsequently sent for testing to evaluate the impact of sorbent injection on use of the fly ash as a cement replacement.

Table 1. Test period dates at Miami Fort.

Test Period	Dates	Sorbent injection ratios
Baseline	Jan 14 – Jan 25	None
AS Parametric tests	Jan 26 – Feb 12	2-8 lbs/MMACF
AS 30-day trial	Feb 13 – Mar 14	4-7 lbs/MMACF*
PAC comparison tests	Mar 15 – Mar 21	2-10 lbs/MMACF

* Target injection ratio was 5-6 lbs/MMACF. Data falling within the range of 4-7 lbs/MMACF was accepted for analysis.

The staffing plan allowed ADA to rotate personnel in order to provide technical support at an appropriate level throughout the trial period. Four different engineers and technicians from ADA were on-site at different times during the testing. At times, such as at the start of injection period, multiple ADA personnel were present to provide around-the-clock coverage. ADA also coordinated the efforts of Duke Energy plant personnel in support of the trial, and oversaw the activities associated with O-H sampling and SCEM operation.

Coal Sampling

Throughout the trial period composite coal samples from each of the coal circuits on Unit 6 were collected for chemical analyses. Miami Fort Station burns run-of-the-river coal, which can vary widely. Typically, the coal has a mercury content ranging from 0.5 to 1.0 ppb (by weight) depending on the source of the coal. Because of the expected variability in the feed coal, coal samples were taken daily throughout the demonstration period and analyzed for heat value (BTU/lb), mercury, sulfur and ash content. Samples were labeled and delivered to a contract analytical laboratory for analysis. Coal sampling was performed Monday through Friday by plant technicians or co-op workers. ADA representatives collected composite coal samples during the weekends.

Unit 6 has five coal circuits that supply coal to the boiler. Each circuit has a bunker to store roughly sized coal, a feeder to control coal flow in the circuit, a pulverizer to grind the coal to a fine powder, and multiple distribution lines to feed the pulverized coal to the burners. Each feeder has a 12” X 6” sampling port that can be used to extract coal as it is fed to the pulverizer. The sample port has a dead volume that gradually fills with coal over time. In order to get a representative sample of the coal being fed to pulverizers, coal in the dead volume was removed and placed in a bucket. Once the sample port has been purged of old coal, a representative coal sample was taken. Approximately one (1) pound coal samples were taken from each of the operating feeders. These individual coal samples were combined in a 5-gallon bucket and mixed. Approximately one (1) pound of the composite coal was then placed in a plastic bag and labeled as follows:

Study: Cinergy Sorbent Injection Demonstration
Sample Type: Coal
Date: mm/dd/yy
Time: hh:mm (24-hr format)
Unit: 6
Feeders: 1-6

Data Collection during the Sorbent Trial

The sampling regime for the baseline, parametric and 30-day tests is summarized in Table 2. Composite coal samples and ash samples from specific ESP hoppers were collected daily throughout the test period. Coal samples were analyzed for mercury, ash, sulfur and heating value and the fly ash samples were analyzed for LOI, mercury and tracer chemical contents. Tracer chemical analysis of the fly ash samples provided insight into the uniformity of the injection system and the amount of captured mercury. The distribution of Amended Silicates sorbent throughout the ESP was quantified by measuring the concentration of tracer chemical found in each hopper fly ash sample. Distribution of carbon in the ESP with PAC injection is not practical since the PAC concentration is indistinguishable from the unburned carbon on the fly ash. ADA also compared the mercury content on the incoming coal and that found in the captured fly ash which provided another means of estimating the mercury concentration in the flue gas during baseline activities.

Table 2. Data collected during trial periods.

Sample/Signal/ Evaluation	Baseline Evaluation	Parametric Evaluation	30-day Evaluation
Host unit operating parameters	hourly avgs	hourly avgs	hourly avgs
ESP Operation (voltage & current)	3x daily	3x daily	3x daily
Mercury SCEM	every ~15 min	every ~15 min	every ~15 min
Mercury Ontario-Hydro	3 days	3 days	4 days
Coal Samples	daily	daily	daily
Hopper Ash Samples	daily	daily	daily
Flyash Pond Water Samples	weekly	weekly	weekly

Baseline Mercury Measurements

Baseline measurement of the mercury concentration in coal, fly ash, and flue gas began on January 14th and ran through January 25th. During this period operational parameters of the ESP and the host unit boiler were recorded so that later impact of sorbent injection on balance-of-plant operations could be assessed. Staff from WKU conducted Ontario-Hydro sampling during the baseline period on January 17th through 19th. UNDEERC personnel were on-site at Miami Fort throughout the test campaign operating the two mercury SCEMs used for inlet and outlet gas sampling. Routine operation of the SCEMs began during the baseline period.

Early in the sampling campaign it became apparent that the SCEM vapor-phase mercury data exhibited greater variability than typical in UNDEERC's experience at most utility sites. While the inlet samples appeared to be relatively consistent, the outlet samples displayed frequent spikes of inordinately high mercury readings. The team met to discuss this issue and attention quickly focused on the sampling probe configuration used at the outlet port. Modifications were made to improve the insulation and temperature control of the sampling probe and gas transfer lines. Also, the particle traps in the sampling trains were monitored more closely and cleaned or replaced more often to prevent excessive accumulation of ash, which can act as a mercury sink or source depending on temperature changes in the flue gas stream. These changes improved signal stability, but the outlet SCEM mercury data continued to show significant perturbations. To handle these perturbations appropriately, ADA developed a data reduction protocol which utilized statistical methods to assess the relevancy of each datum point so that values outside of a defined variance could be eliminated from the data set. Results from the O-H sampling were more consistent, but by the nature of this method the data cover only a limited extent of the total test period. O-H data represents an integrated value of mercury content of the flue gas stream over a sample time interval of about 90 minutes.

Parametric Tests with Amended Silicates Sorbent

The objective of the parametric test series was to characterize the performance of Amended Silicates sorbent over a series of increasing sorbent injection rates for short periods of time (a few hours at each condition). This was done to collect performance data to be used in selecting the injection ratio at which the long-term (30-day) trial would be conducted. Parametric tests began January 26th and continued through February 12th, with a time gap to modify the injection system for improved operation. Injection ratios of 1, 2, 3, 5, 8, and 9 lbs/MMACF were examined during the parametric trial period.

Issues were encountered early in the injection trials when operating at injection ratios greater than 5 lbs/MMACF. Sorbent accumulated in the smallest-diameter sections of pipe in the supply lines where piping branched to feed sorbent to each of the four injection lances. Plugs were initiated by small sorbent nodules in the supply, which would bridge and partially block the smallest-diameter openings, leading to further agglomeration and deposition of sorbent material and eventual clogging. This problem was addressed by a modification to the piping network to increase the size of the smallest-diameter pipe sections and by the installation of a wire mesh screen at the feeder to collect any sorbent nodules before they entered the sorbent distribution network. In addition, the sorbent manufacturing process was improved to minimize the nodule content in Super Sacks of sorbent. Because of this problem the actual injection rate for parametric runs targeting injection ratios higher than 5 lbs/MMACF likely did not reach the target rate and the actual rates of sorbent injected into the flue gas stream at the highest injection mass ratios are uncertain. Consequently, the parametric data obtained at ratios nominally higher than 5 lbs/MMACF are suspect.

Once the plugging problem was diagnosed, changes were made to the distribution piping network and to the sorbent manufacturing process. When fully implemented, a trial was run to prove that the injection system could be run for 24 hours at a nominal sorbent injection ratio of 6 lb/MMACF without clogging. With success in this trial, the injection system was deemed ready for the long-term trial.

Unit 6 was then returned to normal operations (no sorbent injection) for a period of one week to re-establish a baseline condition prior to the start of the 30-day trial with Amended Silicates sorbent.

30-Day Injection Trial with Amended Silicates Sorbent

The 30-day trial period began February 13th and continued through March 14th. During this period the Amended Silicates sorbent was continuously injected at a nominal ratio of 5-6 lbs/MMACF. Injection was suspended for a period of 24 hours on March 3rd while the host site conducted an annual emissions test on the stack shared by Units 5 and 6. The plant manager requested that sorbent injection be halted for this period to eliminate any possible effect that could impact stack test results.

Actual injection ratio of the sorbent varied somewhat throughout the day as Unit 6 load was adjusted to accommodate daily demand on the Duke Energy system grid. The injection system was set up in a load-following mode, but the response by the injection system was not able to maintain the target 5-6 lbs/MMACF range during low-load periods. Figure 7 plots sorbent injection ratio over the entire 30-day trial period. Some diurnal variation following unit load is easily seen. Most of the variation was due to these unit load changes, as well as the shutdown during the March 3rd stack testing of Unit 5. Briefly on February 18th and again during the final two days of the 30-day period, some intentional deviations from the 5-6 lbs/MMACF set point were run to gather additional parametric data on the sorbent. These adjustments were not believed to impact the primary purposes for the 30-day trial, that is, to evaluate performance consistency of the Amended Silicates sorbent, capture samples of fly ash mixed with sorbent for evaluation, and assess the impact of sorbent injection on balance-of-plant equipment.

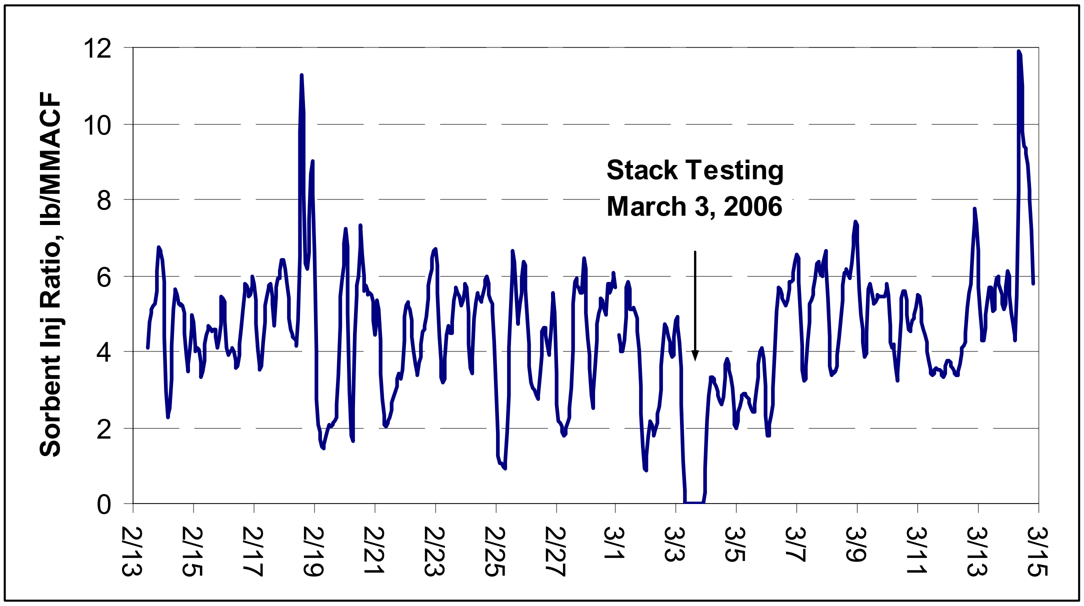


Figure 7. Amended Silicates sorbent injection ratio during the 30-day trial. Most of the variation in absolute injection rate is due to the daily load changes on Unit 6.

Carbon Injection

For the final week of injection testing powdered activated carbon (PAC) was injected to obtain mercury removal data for comparison with the Amended Silicates sorbent results. PAC injection began on March 15th and continued through March 21st. The same feed and injection system used for the Amended Silicates sorbent was employed for the injection of PAC. The week dedicated to PAC injection included changes in injection rates to obtain data on mercury removal as a function of sorbent injection ratio. As shown in Figure 8, the diurnal variation in Unit 6 load also generated fluctuation in injection ratio (lbs/MMACF) for PAC.

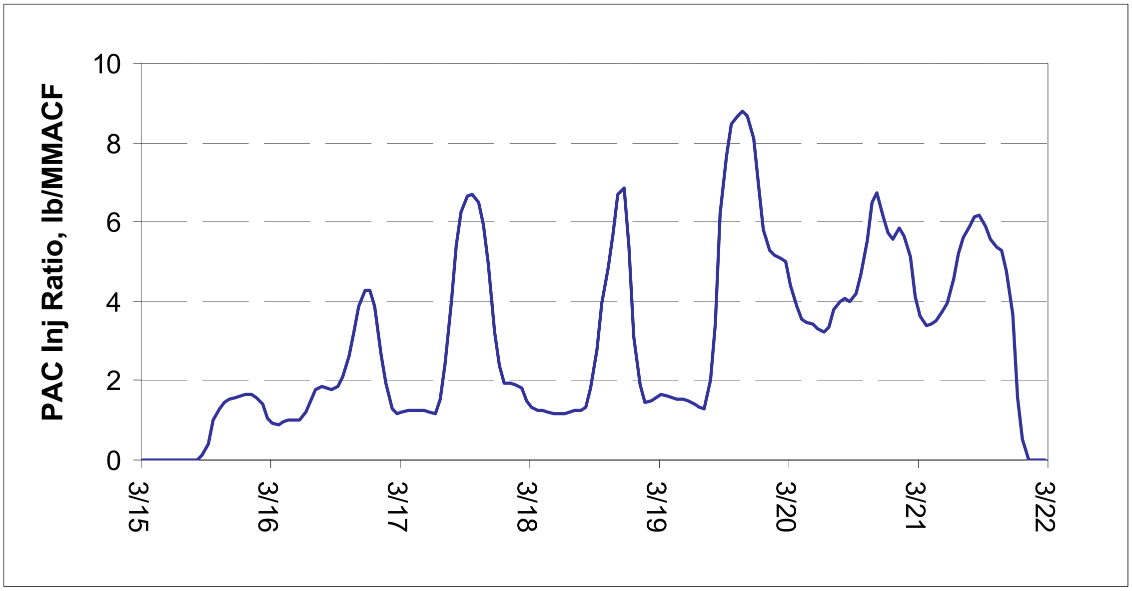


Figure 8. PAC injection ratio. The variation in absolute injection rate is due to diurnal load changes on Unit 6 as well as intentional adjustment of injection ratio.

Ash Pond Water Sampling

Following the site visit to Miami Fort in February 2005, four 1-liter water samples from the fly ash sluice on Unit 6 were collected by site personnel and sent to ADA Technologies for Settleable Solids and Total Suspended Solids determinations. Protocols used for the analyses were taken from the Standard Methods for Examination of Water and Waste Water reference (Clesceri, 1998), using Method 2540F for Settleable Solids analysis and Method 2540D for Total Suspended Solids.

The host unit employs a wet ash-pull system for transferring ash to one of two ash ponds at the plant. Water from these ash ponds drains into the Ohio River adjacent to Miami Fort Station. The host site was required to secure a permit from the local environmental control agency for the trial of mercury sorbents at Miami Fort station. The local authority required that Duke Energy obtain water samples from the fly ash pond used to collect the fly ash from the Unit 6 ESPs. Duke contracted URS to collect weekly ash pond water samples during the trial. The water samples were taken in accordance with US EPA Method 1669 "Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels" also known as the "Clean Hands" / "Dirty Hands" method. Water samples were analyzed for mercury using US EPA Method 1631 for low-level mercury determination by a certified analytical laboratory.

Fly Ash Sampling

Fly ash at Unit 6 is captured from the flue gas in a series of three ESPs installed at different times over the life of Unit 6. The ESPs are designated by plant personnel as "old-new", "new-new", and "old". Precipitators have specific collection areas (SCA) of 190, 163 and 175, respectively. The old-new and new-new ESPs are installed back-to-back so that there is no transitional ductwork between them. Ash is transferred out of the hoppers using a wet ash-pull system to one of two ash ponds on the site. The hoppers are dumped sequentially with a cycle time of about one hour. In all, there are 30 fly ash hoppers associated with the old-new/new-new ESPs. A schematic of the ESP configuration is shown in Figure 9.

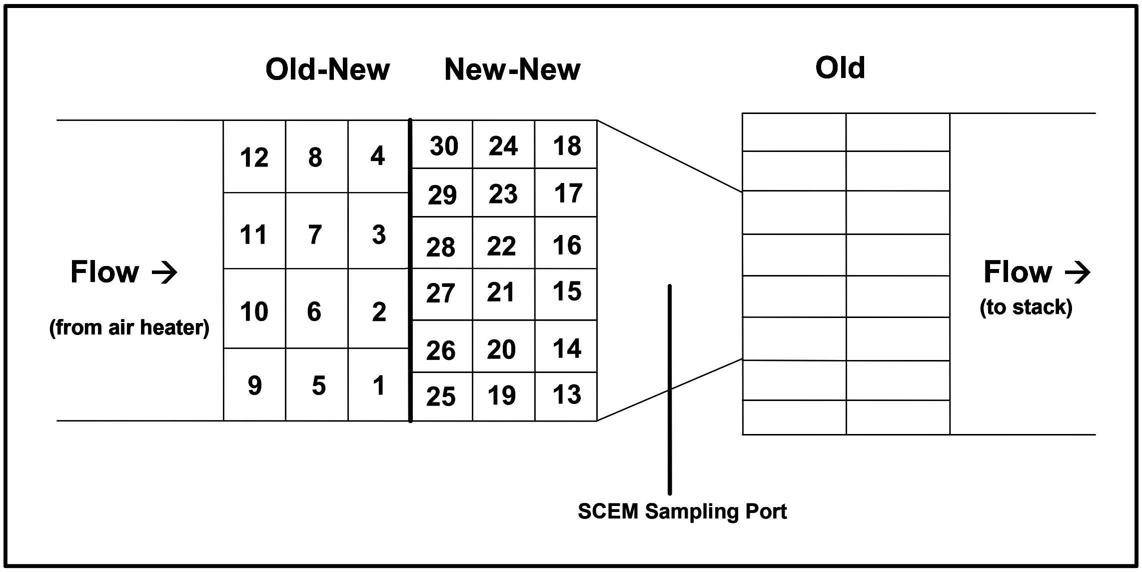


Figure 9. Schematic of Miami Fort Unit 6 ESP layout.

Three times during the program all thirty ash hoppers were sampled; once during baseline tests to determine which hoppers could be routinely sampled to collect representative fly ash material; once during the Amended Silicates parametric tests to assess the uniformity of Amended Silicates sorbent injection; and a final time during the 30-day Amended Silicates injection trial. An on-site ADA engineer directed the collection of these complete hopper sample sets.

Separate ash samples from the center hoppers in the first two rows (hoppers 6, 7, 10, and 11 per the layout in Figure 9) were retrieved on a daily basis during the trial. Fly ash sampling was performed Monday through Friday by plant technicians or co-op workers. ADA staff sampled the fly ash hoppers on weekend days. Ash samples were collected through a 3” ball valve on the side of the ash hoppers. The procedure for obtaining a fly ash sample required the operator to: (1) open the 3” ball valve, (2) insert an extraction rod with sample bottle connected to the end through the valve and scoop ash into the bottle, (3) withdraw the extraction rod and (4) close the 3” valve. The daily ash samples were taken from the four designated hoppers and combined for a daily composite sample. Approximately one (1) pound of fly ash material was obtained each day. The composite sample was placed in a plastic bag and sealed. Each sample was labeled as follows:

Study: Cinergy Sorbent Injection Demonstration
Sample Type: Fly ash
Date: mm/dd/yy
Time: hh:mm (24-hr format)
Unit: 6
Hopper # (1-30): (For example: 6,7,10,11)

Fly ash samples were then delivered to a contract analytical lab for analysis. Sample analysis included percent LOI, tracer chemical content, and mercury concentration.

Twice during the trial large-scale samples of fly ash were obtained. At these times, three 55-gallon drums were filled with fly ash from ash hoppers 6, 7, 10, and 11; the same hoppers sampled on a daily basis. Large-scale samples were collected during the baseline and 30-day trial phases of the demonstration and sent to STL to be used in their carbon separation equipment. In addition, four 5-gallon buckets were filled with fly ash for DOE and Boral during the baseline period, 30-day Amended Silicates injection trial and activated carbon injection trial. Samples sent to Boral were tested using the foam index protocol and used in concrete mixes. Compressive strength data for cement slab made with baseline flyash material were compared to data from slab prepared with flyash containing Amended Silicates sorbent.

Results & Analyses Stage

The use of SCEMs, as well as the other mercury, ash, and coal sampling protocols, resulted in the acquisition of a substantial quantity of data over the demonstration phase of the project. This information was reviewed for QA/QC, and then archived to ADA's internal computer network for safe storage and analysis. Mr. Tom Broderick of ADA served as the lead engineer for the project team at the host site during the trial and undertook the majority of the data analysis. Further analysis and data review was provided by Principal Investigator Mr. Jim Butz, with oversight and guidance from staff at CH2M HILL and Duke Energy. Preliminary and final analyses were reviewed by members of the project consortium prior to publication or presentation. This section details the collection and processing of raw data, the subsequent analytical methods, and discussion of findings from the trial.

Data Reduction and Smoothing

For multiple reasons discussed in the UNDEERC report (Appendix C), the mercury readings recorded by the SCEMs at both the upstream and ESP outlet locations exhibited extraordinary variability with frequent measurements that appeared inordinately high or low. Consequently a systematic, statistical data processing methodology was developed to reduce the raw data into a form that could be used for calculations. The goal of the methodology was to devise a protocol for processing the data that was objective and unbiased, without preferentially eliminating low or high mercury measurements, but instead identified the underlying trends in the data that were being masked by the variability in the raw measurements. Such a data routine was developed and applied to the raw data sets.

The primary assumptions for the development of a data reduction algorithm are that (1) the mercury measurements are truly well behaved, (2) the variation between sequential data points is within statistical variance, and (3) allowable variance between sequential data points does not change substantially over short periods of time. On the basis of these assumptions, a data reduction routine was developed and is described in detail in Appendix D. The objective function for the statistical analysis was derived as a "linear distance variable," with an acceptance criterion that the distance between any two datum points is within a mean distance plus three standard deviations. Application of this constraint allowed the retention of 95% of the total dataset. The data plots presented in this report are comprised of data that has been subjected to this analysis.

The diurnal variation in load for Unit 6 created fluctuations in operating conditions throughout the testing. Unit 6 is typically operated at full-load from early morning to late evening, and then lowered to 60% load overnight. During the parametric trials it was desired to achieve comparable operating conditions for the multiple runs, with only the sorbent injection ratio as a variable. This was accommodated in the analysis by considering only the data obtained during a time interval when Unit 6 was operating at steady high-load conditions. In general, these conditions were achieved daily between 12:00 to 20:00 hours (noon to 8 pm). A review of plant data showed that after ramping up to full-load in the morning, the flue gas temperature reached a steady-state condition in three to four hours. An additional constraint applied to the parametric results required a minimum of three continuous hours at steady-state conditions before applying SCEM mercury data for mercury removal calculations. This additional three hours of steady-state operation allowed the flue gas system time to equilibrate in terms of mercury partitioning within the ductwork.

Host Unit Operation

Duke Energy's Unit 6 is an on-demand boiler with a 175-Megawatt rating. During weekdays, Unit 6 was typically operated at nominal full-load (greater than 160 MW) from 5:00 in the morning until midnight. Overnight and on weekends, the boiler operated at a nominal 60% full-load (90 MW). Operating conditions for the boiler can change on a moment's notice by a request from Duke Energy dispatchers who monitor power grid demand and manage generating units to match that demand. During the 30-day continuous trial of Amended Silicates sorbent injection, Unit 6 operated at full-load 56% of the time. During the final week of the trial when activated carbon was injected, the host unit operated at full-load 52% of the time.

Miami Fort Station purchases "run-of-the-river" coal delivered from several mines in surrounding states via barges operating on the Ohio River. The coal is classified as a bituminous coal with medium sulfur content. Daily coal samples were taken during the entire trial period, including baseline, parametric evaluation, the 30-day Amended Silicates sorbent injection trial, and the activated carbon injection trial. Coal samples were submitted to a contract laboratory for analysis of key properties, including those shown in Table 3 below. Properties of the coal burned in Unit 6 during the demonstration based on 61 daily samples are listed in Table 3.

Table 3. Properties of Coal Burned at Miami Fort Station

Coal Properties	Average Value (moisture-free basis)	Range of Values (moisture-free basis)
Ash Content	11.07 %	8.79 – 15.70 %
Sulfur Content	2.28 %	1.78 – 2.88 %
BTU Content	13,186 BTU/lb coal	12,561 – 13,654 BTU/lb coal
Hg Content	0.11 micrograms/gram coal	0.07 – 0.39 micrograms/gram coal

In addition to the daily coal samples, daily fly ash samples were also taken by Duke and ADA Technologies personnel to track the amount of mercury captured by the native fly ash and as a result of injected sorbent materials. Twice during the demonstration, fly ash was sampled from all thirty ESP ash hoppers and analyzed for mercury content, elemental content, and LOI. The data provided a means for assessing the distribution of ash materials within the various ESP hoppers and whether there were preferential locations where mercury or sorbent materials disengaged from the flue gas. During the baseline and the 30-day sorbent injection phases of the project, several 55-gallon drums and multiple 5-gallon buckets of fly ash were extracted for further investigative work.

Currently Duke Energy does not sell the fly ash collected from Unit 6 at Miami Fort, although it does sell fly ash from other units at the plant and from other generating stations in the system. The plant operates under a permit issued by the local environmental regulatory authority and was required to inform the authority of the planned sorbent injection trial. The governing authority required Duke Energy to take weekly water samples from the ash ponds to monitor mercury content during the trial. Water samples were analyzed for total mercury to determine if sorbent injection had an impact on the mercury concentration in the pond water. Analytical results are presented in the Ash Pond Water Analysis section of this report.

Throughout the trial, the plant captured operational data for the host unit, including unit load, air pre-heater temperatures, barometric pressure, percentage of oxygen in the combustion gas, steam flow, and concentrations of sulfur dioxide, nitrogen oxides, and carbon dioxide in the flue gas. Periodically, the data from their automated data acquisition system (Pi system) and from the UNDEERC SCEMs were downloaded for ASL to review and use in characterizing the impact of plant operating conditions on mercury removal.

Unit 6 ESP operating parameters were not wired into the automated data acquisition system for the host unit. Project personnel recorded the secondary voltage and current readings for each of the 12 transformer/rectifier (T/R) sets installed in the Unit 6 ESPs. These data were recorded by hand and manually entered into a spreadsheet to accumulate the data for later statistical analysis. Typically, ESP readings were taken two to three times during the day.

Coal Mercury Content

Mercury levels in the coals changed significantly during the trial. Early in the baseline phase, mercury levels in the coal ranged from 0.07 to 0.39 micrograms/gram of moisture-free coal with corresponding vapor-phase mercury concentrations 20 to 60 micrograms Hg/Nm^3 (corrected to 3% oxygen). Two weeks into the trial, the average mercury levels in the coal dropped into a range of 0.07 to 0.17 micrograms/ gram of moisture-free coal. From that time on, the mercury levels in the coal were more consistent with upstream mercury concentrations ranging between 4 and 20 micrograms Hg/Nm^3 (corrected to 3% oxygen). Variation in the mercury content of the daily composite coal sample is shown in Figure 10 below.

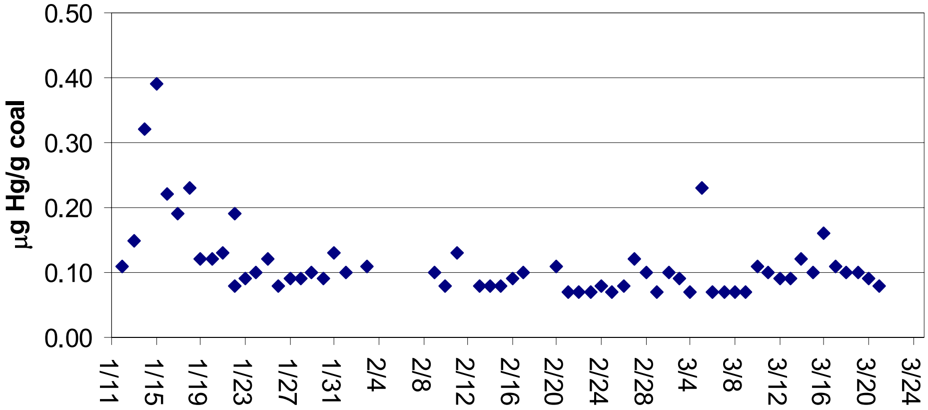


Figure 10. Mercury content in coal burned in Miami Fort Unit 6 during the trial period.

Baseline Measurements

For the baseline period, SCEM and O-H methods were used to make mercury measurements upstream of the sorbent injection location (although there was no sorbent injection during baseline) and at the outlet of the ESP. Data taken during the Baseline period are shown in Figure 11. Upstream and outlet SCEM data integrated over the baseline period from January 18th to January 24th indicated mercury removal by native fly ash was about 19%. Ontario-Hydro tests conducted January 17th, 18th and 19th showed that the baseline mercury removal by flyash was lower, on the order of 10%. Similar mercury removal results were obtained from a mercury balance using mercury content data from coal and fly ash samples taken on those same days (Figure 12). Mercury removal by the native fly ash determined via a mercury mass balance was found to be 8%. These multiple approaches to quantification of fly ash mercury capture strongly indicated that there was very little mercury removed (typically less than 10%) by the fly ash present in the flue gas on Unit 6.

The oxidized and elemental mercury concentrations in the flue gas were determined with measurements by the SCEMs and O-H methods. Analysis of the baseline upstream SCEM data indicated that 56% of the vapor-phase mercury was present in the elemental state at the location just downstream of the air preheater. The elemental mercury fraction at the same location as measured by the O-H method was around 62%. Thus the fractions of elemental mercury in the flue gas at the upstream sampling location as determined by the two methods are comparable. At the outlet of the ESP, however, there was a significant difference in the mercury speciation results for the two measurement techniques. SCEMs data indicated that 66% of the vapor-phase mercury was elemental mercury, compared to the O-H result of 37% elemental mercury.

The difference between the reported SCEM and O-H outlet mercury speciation data may have been due to issues with the SCEM sampling equipment. Heaters on the outlet sample probe and the hotline had difficulties keeping the sample gas at a temperature equal to or greater than the temperature of the flue gas. Mercury in the hot sample gas in contact with cooler surfaces of the sampling equipment will establish new equilibrium gas-phase mercury concentrations at the cooler gas temperature. Elemental mercury is easier to transport from the sample location to the SCEM, however, it is appreciably more difficult to transport oxidized forms of mercury. The inability to keep the sample gas at a high temperature has the potential to deposit oxidized mercury on the walls of the cooler probe and hotline. The mercury drop-out hypothesis supports the higher mercury removals seen for native fly ash as reported by the SCEM and also explains the higher percentage of elemental mercury in the ESP outlet gas. The good agreement between the O-H mercury results and the mercury material balance on the fly ash leads us to believe that the baseline mercury removals should be calculated based on the O-H measurements which indicate that mercury removed from the flue gas by fly ash is less than 10%. Table 4 summarizes the baseline total mercury concentrations reported by the SCEMs and the O-H method.

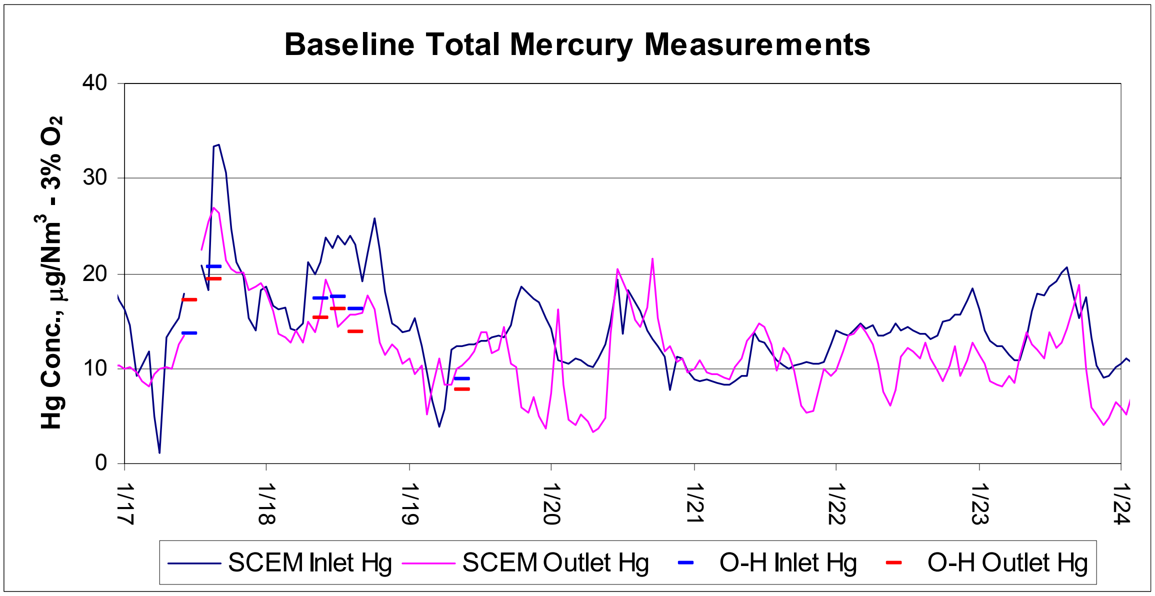


Figure 11. Baseline mercury measurements. Data from continuous mercury monitors and Ontario-Hydro sampling is shown.

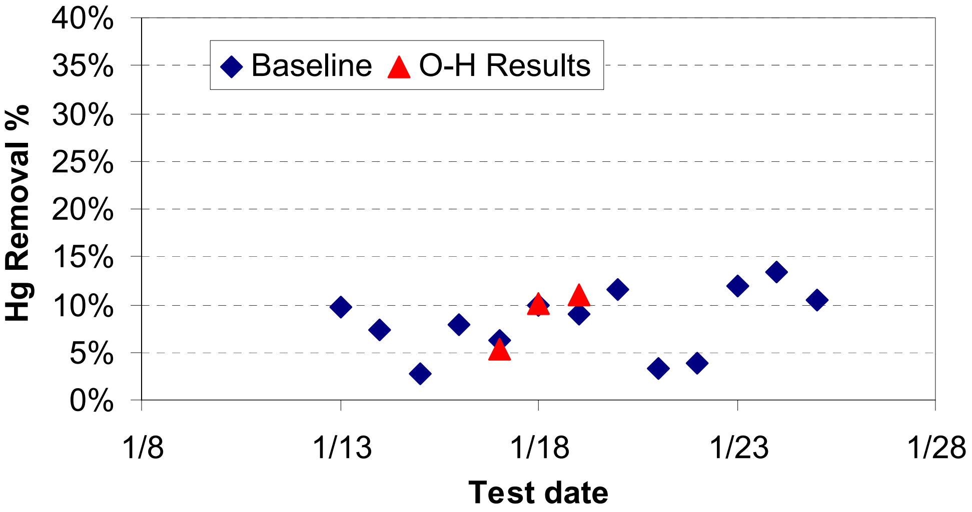


Figure 12. Material balance for baseline mercury capture by native fly ash as a percentage of the mercury present in the incoming coal. Results are based on particle-bound mercury measured by the Ontario-Hydro sampling is also shown.

Table 4. Summary of Baseline Total Hg Measurements for SCEMs and O-H methods

	Inlet Hg*		Outlet Hg*	
Date/Time	SCEM Data	O-H Data	SCEM Data	O-H Data
1/17/06 1100	20.0	13.6	13.4	17.2
1/17/06 1500	32.6	20.7	25.7	19.2
1/18/06 930	22.8	17.3	17.7	15.2
1/18/06 1230	23.5	17.5	14.4	16.4
1/18/06 1500	22.5	16.2	16.0	13.9
1/19/06 9:00	12.3	8.8	11.6	7.8

**Mercury concentrations are reported as μg Hg/Nm^3 corrected to 3% oxygen*

Parametric Tests with Amended Silicates Sorbent

Parametric tests were conducted from January 25th through February 12th. The parametric tests investigated incremental mercury removal from the host unit flue gas as a function of sorbent injection ratio. Only Amended Silicates sorbent was injected during this phase of the project. Sorbent was injected into flue gas for a period of 5 to 6 hours at a fixed injection ratio, an adequate time period for mercury capture process to reach a steady-state condition. During the parametric trials, upstream and ESP outlet mercury concentrations were measured with UNDEERC's semi-continuous emission monitors and by the Ontario-Hydro wet chemistry method as conducted by WKU. Ontario-Hydro mercury measurements were made over a three-day period during the parametric tests: February 1st, 2nd, and 3rd.

During the first week of parametric trials sorbent was injected into the flue gas at low injection ratios ranging from 1 to 5 lb/MMACF. Within this range of sorbent injection ratios, the sorbent distribution piping and injection lances performed well for the four- to six-hour injection trials. During the second week of the parametric trials the feed system was operated at higher injection ratios of 6 to 9 lb/MMACF. As noted previously, plugging at transition pieces in the distribution piping network and inside the sorbent injection lances occurred after a few hours of operation at the higher injection rates. Several modifications were made to the feed system and distribution network to facilitate continuous operation. Once the modifications were made, the injection system was operated for a 24-hour period to assess the viability of the modifications. Checks after the 24-hour run verified that there was no build-up of deposits in the piping network or feeder.

An example of the data from the SCEMs during the parametric trials is shown in Figure 13, which illustrates several issues experienced during the trials. During periods of no sorbent injection, there was little difference between the inlet and outlet mercury signals; as seen in the SCEM data for January 29th through January 30th, or on February 1st. This suggests that the baseline mercury capture by native fly ash during the parametric tests is even less than the 8 to 10% levels determined in the baseline phase of the project. Another issue that was frequently encountered during the parametric and 30-day trials was a decrease in the upstream mercury concentration; sometimes dropping to almost zero. Data for February 2nd, 3rd and 4th are times when the problem was more evident. The low upstream measurement issue was due to the inability to pull sample gas through the SCEM. A choked flow condition resulted from the formation of sodium hydroxide crystals in the chemical conversion tubing. Sodium hydroxide is one of the constituents used in the pretreatment/chemical converter solutions. This problem usually occurred in the overnight hours. Gas flow to the SCEM was subsequently reestablished in the morning by disassembling and cleaning the chemical conversion glassware.

The data in Figure 13 also illustrates the problem with clogging in the injection piping. For a vivid example, see the period during the day of February 2nd. The green line indicates the sorbent injection ratio, and is seen to drop to zero after an hour as the piping plugged and flow from the feeder stopped. Once the plug was removed, the feeder was re-started at a lower rate, where it was maintained for a few hours before shutting down the feed system at the end of the day. The upstream and outlet mercury SCEMs data shows a substantial removal of vapor-phase mercury from the gas stream during sorbent injection for this period, even though the sorbent injection ratio was variable.

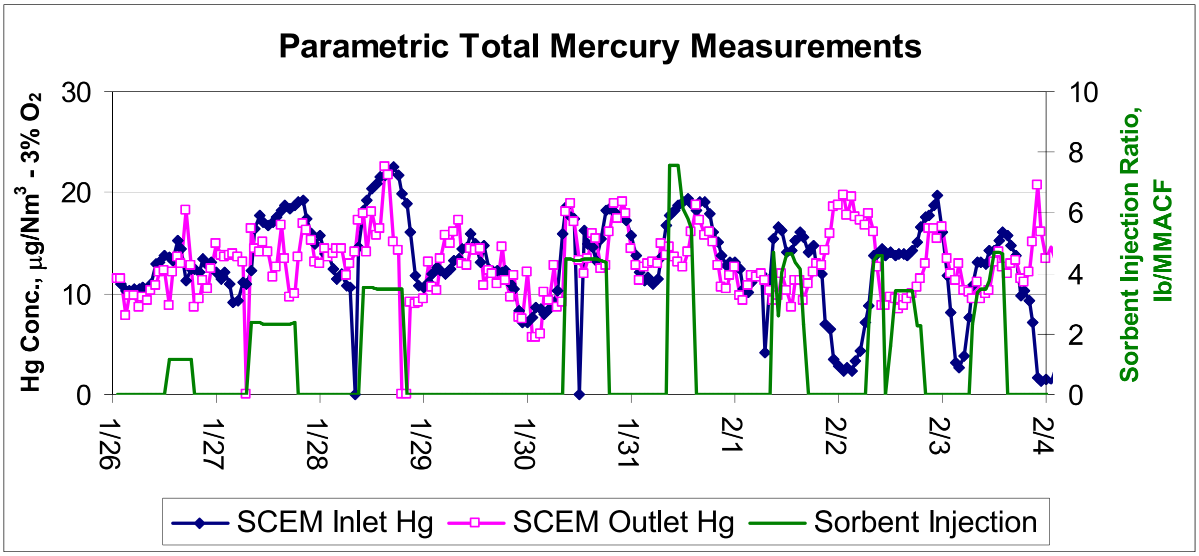


Figure 13. Mercury measurements during the parametric test period.

Vapor-phase mercury capture results from the SCEMs data and the Ontario-Hydro data taken during the parametric trials are summarized in Figure 14. For two of the three data points there was fair agreement between the two methods. One of the O-H data points is substantially above the apparent trend. Scatter in the data was attributed to the difficulties feeding the sorbent material consistently, especially at higher injection rates. It was observed that sorbent feed at times was interrupted or was delivered by the feed system at an uncharacteristic high ratio when a plug of sorbent was freed. The data displays a trend of increasing mercury removal as a function of increasing sorbent injection ratio up to a value of 5 lb/MMACF, at which point the mercury removals leveled off between 35 to 42%. Sorbent injection ratios greater than 5 lb/MMACF did not yield higher mercury removal, although the data at higher injection ratios was extremely limited due to the plugging issue noted earlier.

As shown in Figure 13 and Figure 14, there was no appreciable mercury removed by native fly ash during the parametric trials. A trend line for mercury removal as a function of sorbent injection ratio would not intercept the y-axis, thus indicating that mercury removal by fly ash alone is minimal. Data also suggests that a minimum sorbent injection ratio is needed to impact flue gas mercury concentrations. The parametric trials with powdered activated carbon (PAC) showed similar trends in both respects.

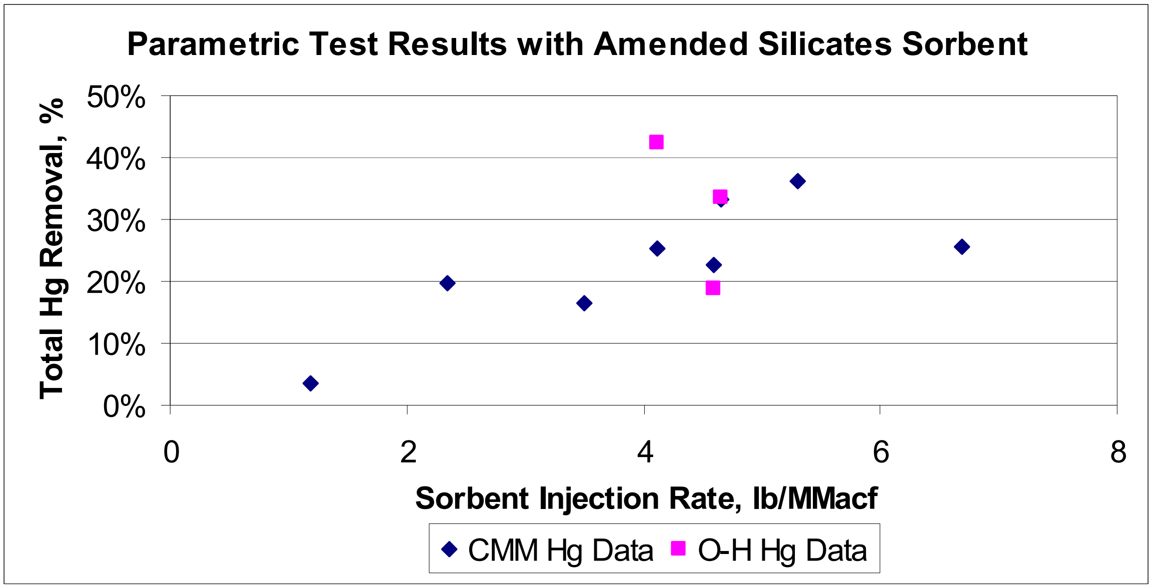


Figure 14. Mercury removal comparison for SCEM and Ontario-Hydro results

30-Day Injection Trial with Amended Silicates Sorbent

The 30-day Amended Silicates sorbent injection trial started February 13th and ran through March 14th. During that time, three mercury measurement methods were used to assess upstream and outlet mercury levels; SCEM, Ontario-Hydro, and Iodated Carbon (IC) traps. Since Unit 6 operates in an on-demand mode, unit load can change at anytime throughout the day. Typically, Unit 6 load was increased around 5 to 7 AM to nominal full-load and was decreased to an overnight level of about 50 to 60% of nameplate rating around midnight. After a load change, flue gas temperatures tend to fluctuate but stabilize within 3 to 4 hours, based on data taken from the host unit data acquisition system. In turn, vapor-phase mercury concentrations were seen to correlate with flue gas temperature; mercury concentrations increased with rising gas temperatures and decreased as gas temperatures cooled. The reason for the mercury concentration versus flue gas temperature trend is the combustion air per unit mass of coal used as a function of unit load. At reduced-load operation, there is an increase in combustion air per unit mass of coal, resulting in cooler gas temperatures into the ducting to the ESPs. The lower total mass flow also means that heat loss from the combustion gas to the ductwork is greater as well, resulting in flue gas temperatures under reduced-load operation that are 10° to 20°F lower than during full-load periods.

The 30-day trial period encompassed 710 hours of run time. However, fluctuations in Unit 6 load and the associated sorbent feed rate, and continued difficulties with the SCEMs led to lack of confidence in data obtained during significant portions of the 710-hour period. Accordingly, the following acceptance criteria were applied to data collected during the 30-trial: (1) inlet and outlet SCEMS are fully operational (not offline for repair or maintenance, or experiencing data issues); (2) inlet SCEM Hg readings must be greater than outlet SCEM Hg readings, and (3) sorbent injection ratio must lie within the range of 4-7 lbs/MMACF (see Figure 7). These criteria eliminated 18%, 22%, and 26% of the 710 operating hours, respectively. The first two criteria are indicative of the problems experienced with SCEMS at this site. For the data which passed these criteria the average removal efficiency for all lots of sorbent was slightly over 30%. The best two lots of sorbent provided an average removal efficiency of 40%, indicating that manufacturing conditions can be optimized to improve sorbent effectiveness.

Figure 15 shows the daily mercury removal results during full-load operations, that is, the most stable operating conditions. Most typically this represent the period between noon and 8 pm. Upper and lower red dashed lines in Figure 15 represent the plus and minus one standard deviations about the average mercury removal. The sorbent injection ratio is presented as a green line, with variations due to load changes and their corresponding gas flow changes. The daily mercury removals calculated from continuous mercury data taken during high-load operation are shown as the blue diamond symbols. The same data are presented in tabular form in Table 5.

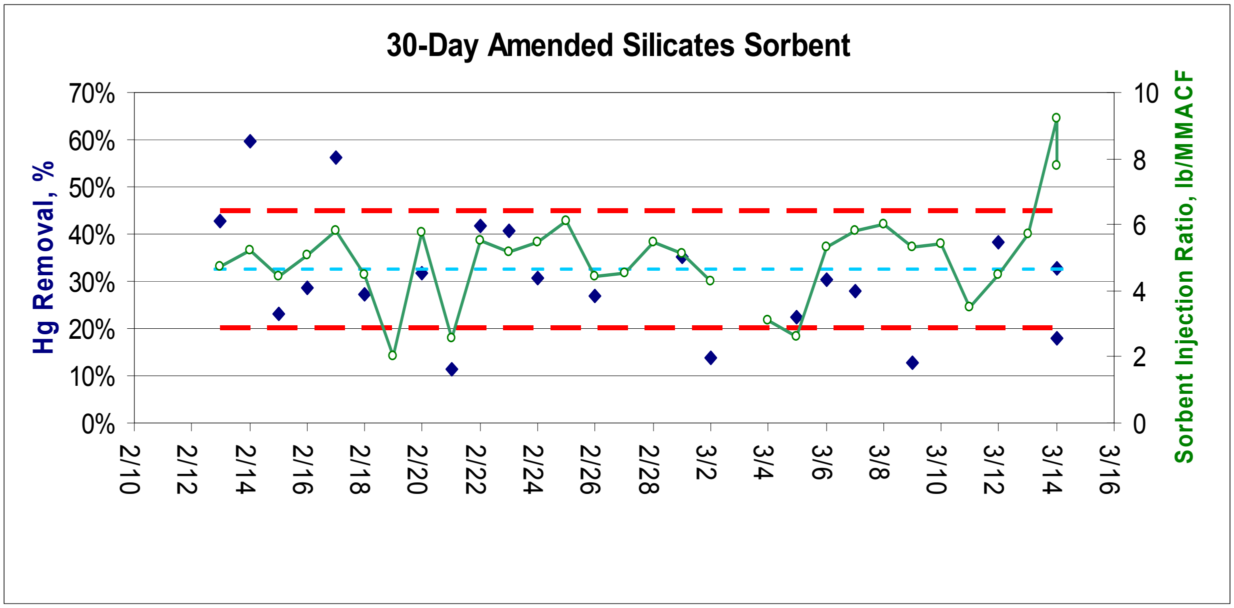


Figure 15. Daily mercury removal and sorbent injection ratio during the 30-day trial. The center dashed blue line is the average daily mercury removal and the red lines are the one standard deviation variation about the average.

Table 5. Daily Mercury Removals for Amended Silicates Sorbent as Measured by SCEMs

Date	Injection Ratio (lb/MMACF)	Inlet Hg (μg/Nm^3)	Outlet Hg (μg/Nm^3)	Removal Efficiency (%)
13-Feb	4.8	11.9	6.8	43
14-Feb	5.2	13.5	5.4	60
15-Feb	4.5	12.5	9.6	23
16-Feb	5.1	22.9	16.3	29
17-Feb	5.8	11.0	4.8	56
18-Feb	4.5	16.0	11.6	28
19-Feb	2.0	13.5	SCEM offline	
20-Feb	5.8	11.8	8.1	31
21-Feb	2.5	8.3	7.4	11
22-Feb	5.5	9.1	5.3	42
23-Feb	5.2	8.9	5.3	40
24-Feb	5.5	7.9	5.5	30
25-Feb	6.1	4.8	5.5	Low-Load
26-Feb	4.4	10.6	7.7	27
27-Feb	4.5	12.5	13.3	0
28-Feb	5.5	7.5	SCEM offline	
1-Mar	5.1	9.2	5.9	36
2-Mar	4.3	10.0	8.7	13
3-Mar		11.9	SCEM offline	Stack Testing
4-Mar	3.1	7.9	7.2	Low-Load
5-Mar	2.6	8.3	6.4	23
6-Mar	5.3	9.6	6.8	29
7-Mar	5.8	7.7	5.5	29
8-Mar	6.0	7.9	8.1	0
9-Mar	5.3	7.9	7.0	11
10-Mar	5.4	12.9	SCEM offline	
11-Mar	3.5	10.2	7.9	Low-Load
12-Mar	4.5	12.9	8.0	38
13-Mar	5.7	10.4	10.6	0
14-Mar	7.8	13.5	9.1	33

During the Parametric phase of the project, sorbent feed rates were quite erratic. Modifications to the sorbent feed system were completed prior to the start of the 30-day trial to eliminate problems with clogging in the sorbent distribution piping network. On three days during the 30-day trial, sorbent material was injected at higher and lower rates to gather additional data on incremental mercury removal as a function of sorbent injection ratio. Figure 16 plots the mercury removal data, collected during the period of full load, as a function of sorbent injection ratio. Mercury removal data were separated into 1 lb/MMACF sorbent injection increments (2-3, 3-4, 4-5 lb/MMACF, etc.) and the average, standard deviation and relative standard deviation were calculated for mercury removal efficiency data in each of the injection ratio increments. Average mercury removal for each injection ratio category is shown with plus and minus relative standard deviation error bars. The green boxes in Figure 16 indicate the spread of the data used in the calculations. Data show that mercury removal increased with sorbent injection ratio but leveled off at slightly over 30%. The best two lots of sorbent averaged 40% removal efficiency. Sorbent injection ratios above 5.5 lb/MMACF did not significantly increase mercury removal. This is the same trend noted in the Parametric Phase of the project.

Triplicate Ontario-Hydro measurements were made upstream of sorbent injection and at the outlet of the Unit 6 ESP twice during the 30-day trial. In Figure 16, the mercury removals based on the Ontario-Hydro results are shown along with removals calculated from the SCEM results. Ontario-Hydro results are seen to be within the scatter boxes of the SCEM results suggesting that the removals from the two mercury measurement methods are comparable.

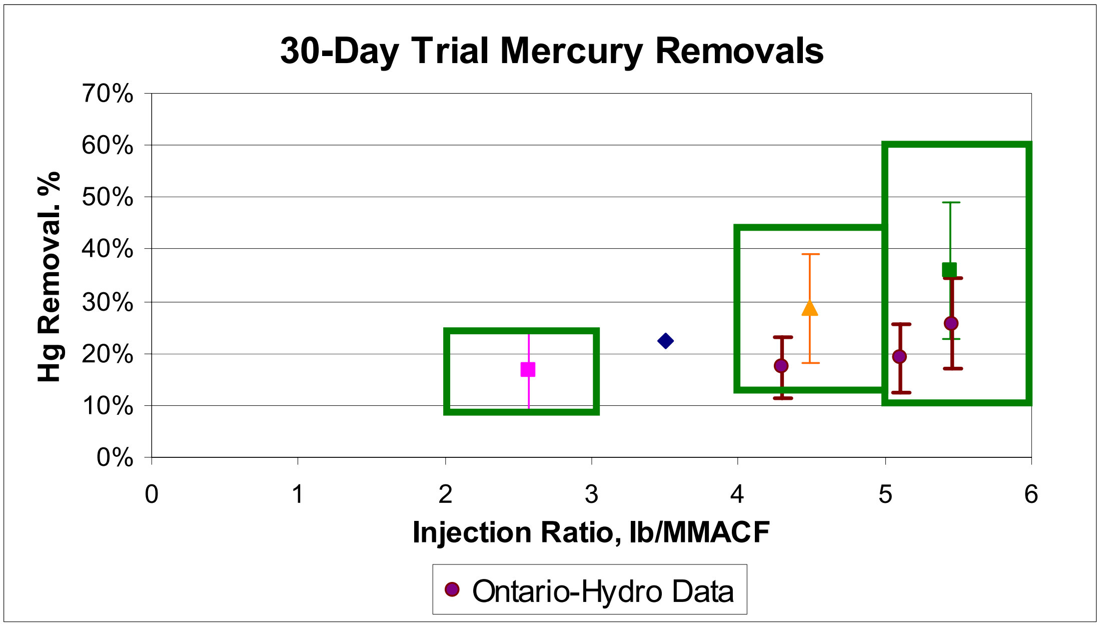


Figure 16. Mercury removal efficiency as a function of Amended Silicates injection ratio for data acquired during the 30-day trial. The green boxes represent the data variation.

A comparison of all three mercury measurement methods is presented in Table 6. Here, the ESP outlet vapor-phase mercury measurements are reported for the SCEM, Ontario-Hydro and IC trap methods. In general, the IC trap data was within 1 µg Hg/Nm^3 of the reported Ontario-Hydro data with the exception of two samples that were less by 3 to 4 µg Hg/Nm^3. On average, the SCEM mercury measurements are 10% higher than those reported by the Ontario-

Hydro method. Variation in the results shows the difficulty in obtaining consistent mercury data with the different measurement methods.

Table 6. Comparison of mercury measurements at ESP outlet

Test Date	SCEM Value (µg/nm^3)	Ontario-Hydro Value (µg/nm^3)	IC Trap Value (µg/nm^3)
2/28 Set 1	3.44	5.87	No data
3/1 Set 1	5.14	6.62	No data
3/1 Set 2	5.78	6.12	6.88
3/1 Set 3	5.68	6.22	6.33
3/2 Set 1	8.62	6.12	5.41
3/2 Set 2	9.54	6.94	No data
3/2 Set 3	9.98	7.31	4.51
3/14 Set 1	10.04	6.56	No data
3/14 Set 2	8.55	8.28	4.51
3/14 Set 3	9.87	7.84	8.80
3/14 Set 4	9.29	9.50	10.59

Hg measurements are reported as µg Hg/Nm^3 corrected to 3% O_2

Project scope called for plots of mercury emissions expressed in pounds mercury per trillion BTU (lb/trillion BTU) for the duration of the 30-day trial. The plots for mercury emissions are shown in Figures 17-20. Carbon dioxide level (orange line) is included on plots to indicate boiler load rate in the same time period. The sorbent injection ratio (green line) is included as a reference. The Emission calculations were made according to 40 CFR, Chapter 1 (7/1/04 edition), Appendix F to Part 75 supplement. Heat input was determined from the equation (1) using the F_c factor of 1,800 for bituminous coal. The carbon dioxide levels in the flue gas were taken from the plant emissions monitor recording system for use in the calculations.

$$HI = Qw \frac{1}{Fc} \frac{\%CO2}{100} \tag{1}$$

In Equation (1), HI is the hourly heat input rate during unit operation in MMBTU, Q_w is the hourly average volumetric flow rate during unit operations in standard cubic feet per hour (scfh), F_c is the combustion factor for bituminous coal in scf/MMBTU, and $\%CO_2$ is the hourly concentration of carbon dioxide in the flue gas during operations reported on a wet gas basis.

Mercury emissions in lb/trillion BTU was calculated based on the ESP outlet mercury concentration reported in micrograms Hg per normal cubic meter corrected to 3% oxygen (µg Hg/Nm^3 corrected to 3% O_2). The equation used to calculate mercury emissions in lb/trillion BTU is shown below as Equation (2).

$$lbHg / TrillionBTU = \frac{(Hgconc)(Qw)(K)}{HI} \tag{2}$$

Here, Hgconc is the hourly average of the outlet mercury concentration expressed in µg Hg/Nm^3 corrected to 3% O_2, Q_w is the hourly average volumetric flow rate during unit operations, scfh and K is a constant to account for unit conversion factors. Combining equations (1) and (2) gives the final form of Equation (3) used to calculate mercury emissions. The value for K' is 0.1123.

$$lbHg/TrillionBTU = \frac{(Hgconc)K'}{\left(\frac{\%CO2}{100}\right)} \qquad (3)$$

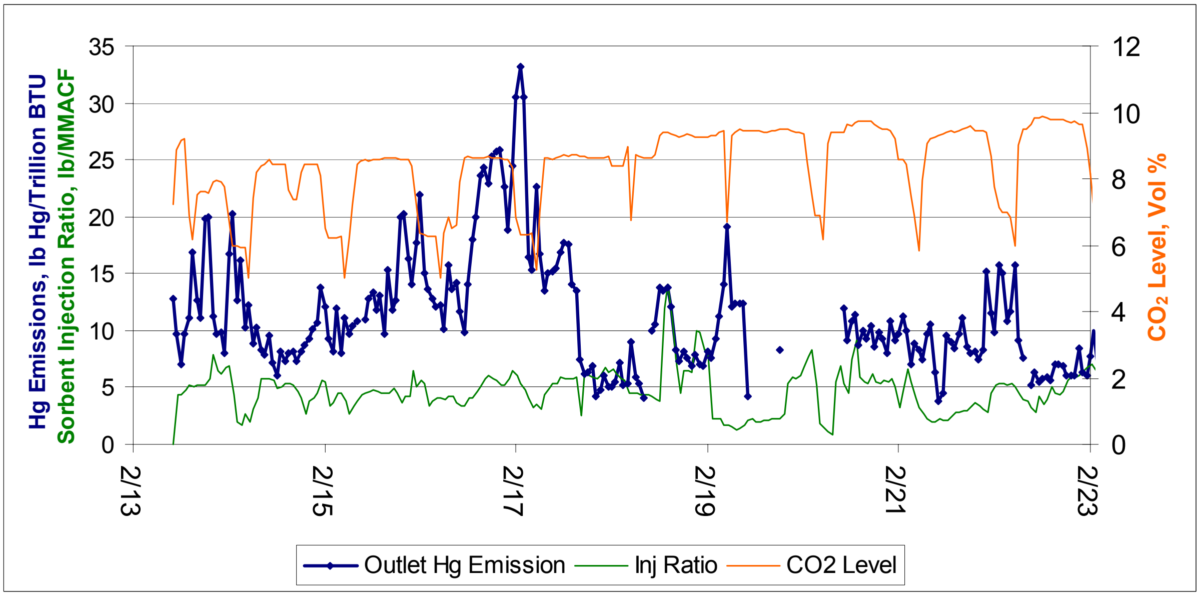


Figure 17. Hourly outlet mercury emissions in pounds Hg/trillion BTUs.

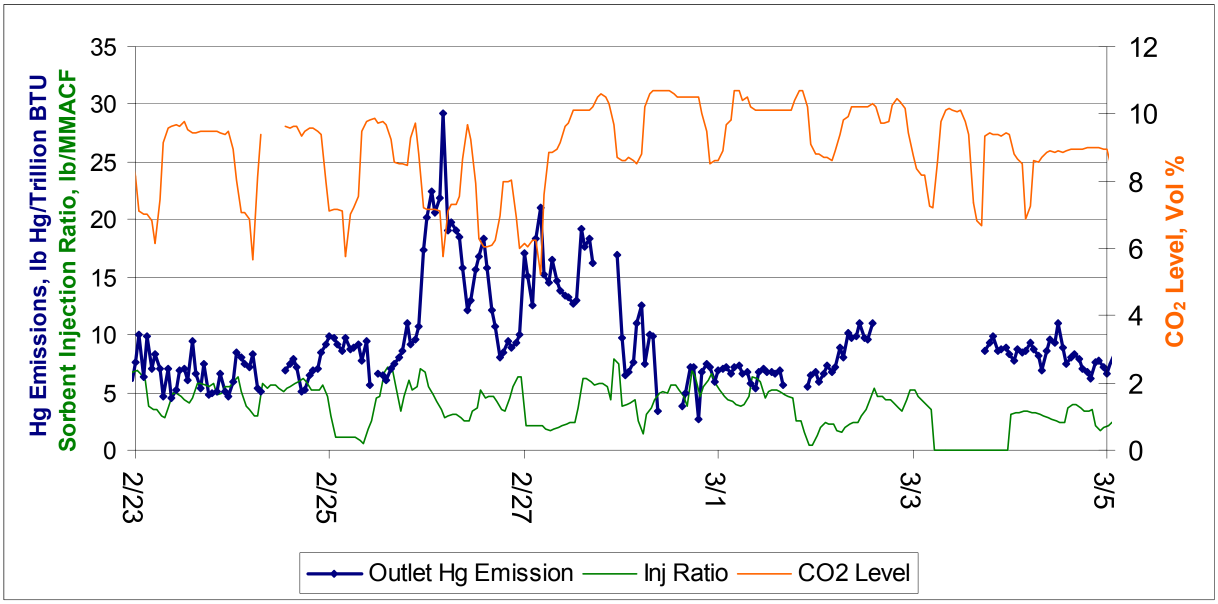


Figure 18. Hourly outlet mercury emissions in pounds Hg/trillion BTUs.

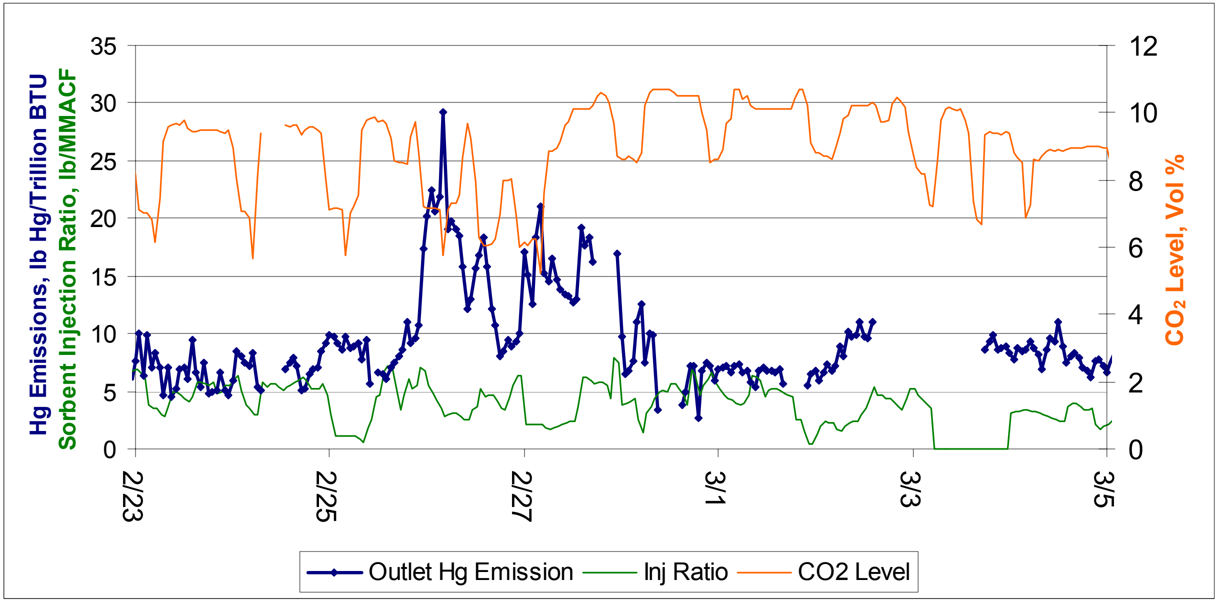


Figure 19. Hourly outlet mercury emissions in pounds Hg/trillion BTUs.

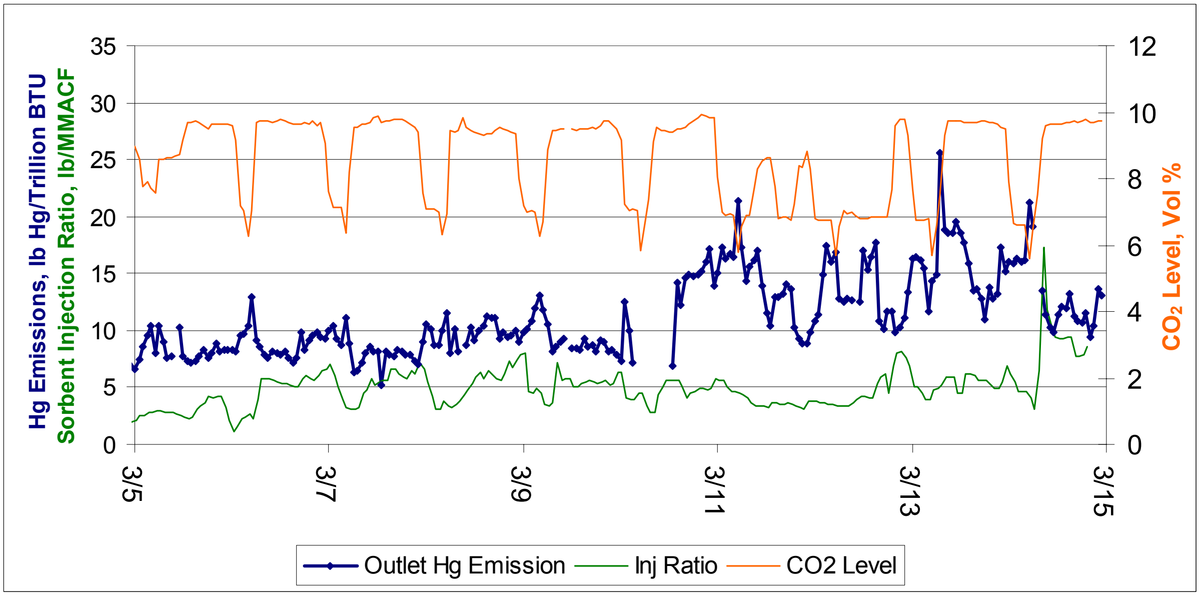


Figure 20. Hourly outlet mercury emissions in pounds Hg/trillion BTUs.

Carbon Injection

The powdered activated carbon sorbent injection trial started March 15th and ran through March 21st. Mercury measurements upstream of sorbent injection and at the outlet of the ESP were made with UNDEERC's SCEM equipment. Parametric tests at a series of increasing sorbent injection ratios were conducted for the first four days to investigate incremental mercury removal for activated carbon as a function of injection ratio. Figure 21 plots the measured vapor-phase mercury concentrations and sorbent injection ratios during the injection trial. The performance curve for activated carbon is presented in Figure 22. The data followed the same trend as the Amended Silicates sorbent data in which mercury removals plateau at sorbent injection ratios above 5 lb/MMACF. The highest mercury removal with PAC was about 49%.

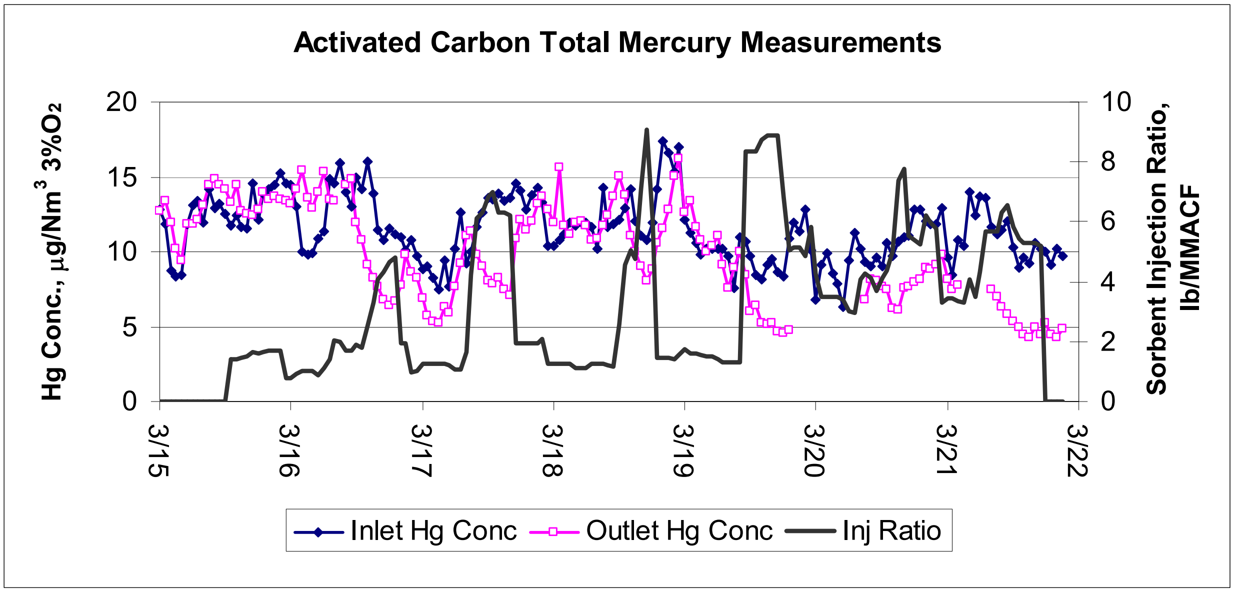


Figure 21. Mercury measurement during activated carbon injection test period.

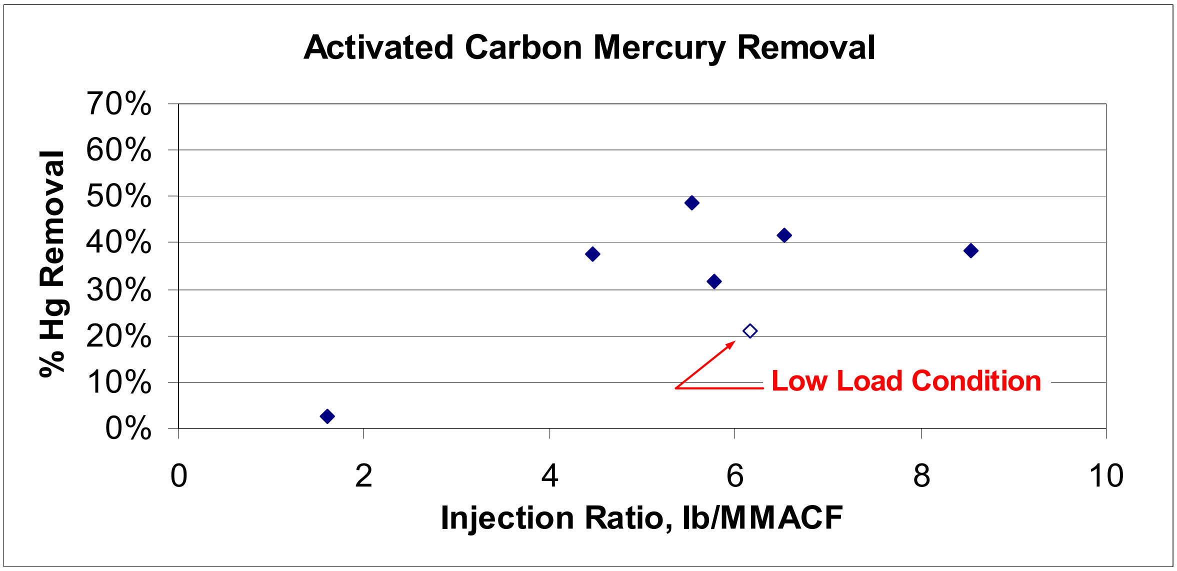


Figure 22. Mercury removal efficiency as a function of PAC injection ratio.

Outlet vapor-phase mercury concentrations expressed in pounds per trillion BTU (lb/trillion BTU) are plotted in Figure 23 for the period when powdered activated carbon was injected. Carbon dioxide level (upper, orange line) is included on plots to indicate boiler load rate in the same time period. The sorbent injection ratio (lower, grey line) is included as a reference. The Emission calculations were made in accordance with 40 CFR, Chapter 1 (7/1/04 edition), Appendix F to Part 75 supplement.

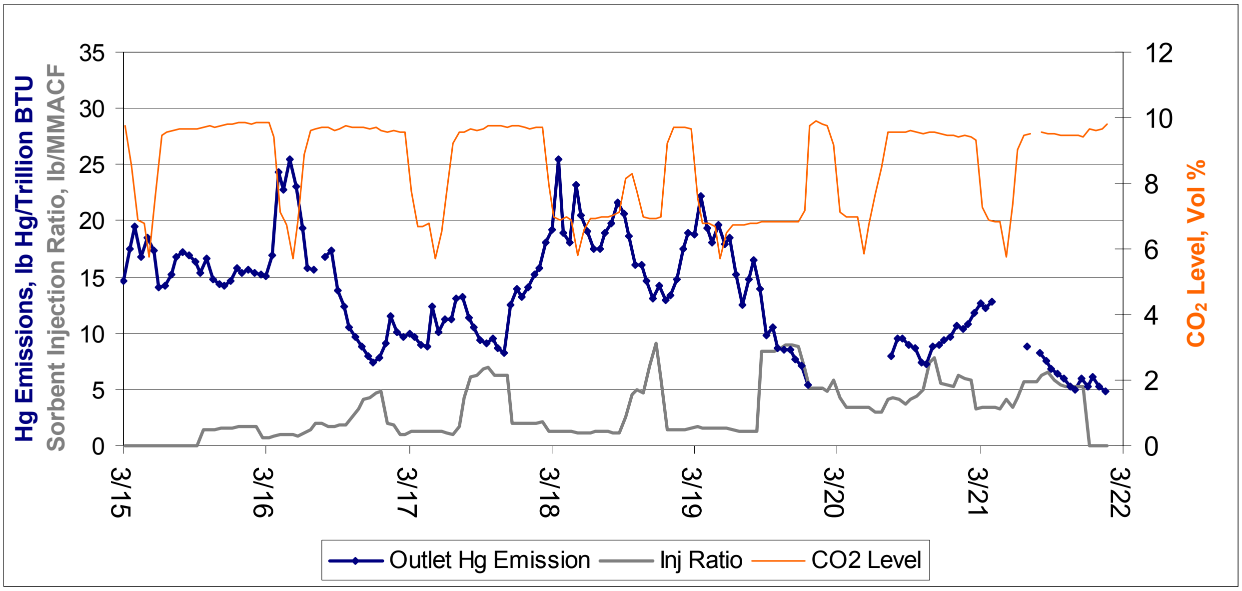


Figure 23. Hourly outlet mercury emissions in pounds Hg/trillion BTUs.

Performance Comparison for Amended Silicates Sorbent and Activated Carbon

Comparison of the data from the Amended Silicates sorbent extended injection trial and the powdered activated carbon showed that both sorbents controlled mercury emissions to the same extent. The average removal of mercury for the best Amended Silicates sorbent lots and PAC sorbents tested at Miami Fort was about 40% at an injection ratio of 5-6 lb/MMACF. Figure 24 plots the incremental mercury removal for the two sorbents as a function of injection ratio. It is also apparent that injection ratios greater than 5-6 lb/MMACF did not result in substantially higher mercury removals for either sorbent material.

In a broader context, the data from the Miami Fort injection tests were compared with PAC data taken from several other coal-fired units equipped with ESPs. Data used for comparison were derived from activated carbon injection trials funded by DOE NETL cooperative agreements, and conducted between 2001 and 2004 (Feeley, et al., 2005). Data from six plants were used in the comparison; three of the plants (Brayton Point, Yates (Unit 1) and Salem Harbor) burn bituminous coal, the remaining plants (Meramec, Leland Olds and Pleasant Prairie) burn subbituminous coal. All host units incorporated cold-side ESPs for particulate control with SCAs comparable to the first two ESPs on Miami Fort Unit 6. Mercury capture by the native fly ash at some of these plants was substantial ranging up to 60% compared to baseline removal of less than 10% at Miami Fort. Data from these other plants were corrected for baseline removal to yield the incremental mercury removal as a result of activated carbon injection.

The Miami Fort results are plotted alongside the above-noted sites in Figure 25. It is significant to note that the mercury removal with Amended Silicates sorbent and activated carbon at Miami Fort fall well within the range of PAC injection at other coal-fired power plants with similar air pollution control equipment. The diminishing effect on mercury removal of increasing sorbent injection is also easily seen. Removal trend lines for PAC injection at

Meramec, Pleasant Prairie, and Leland Olds are all observed to level off between 40 and 50% incremental mercury capture above an injection ratio of 5 to 6 lb/MMACF; the same effect is noted for the Miami Fort sorbent injection data. The plants burning bituminous coal – Brayton Point, Yates, and Salem Harbor – also exhibited lower overall capture efficiency, possibly indicating a detrimental effect of SO_2 on mercury capture.

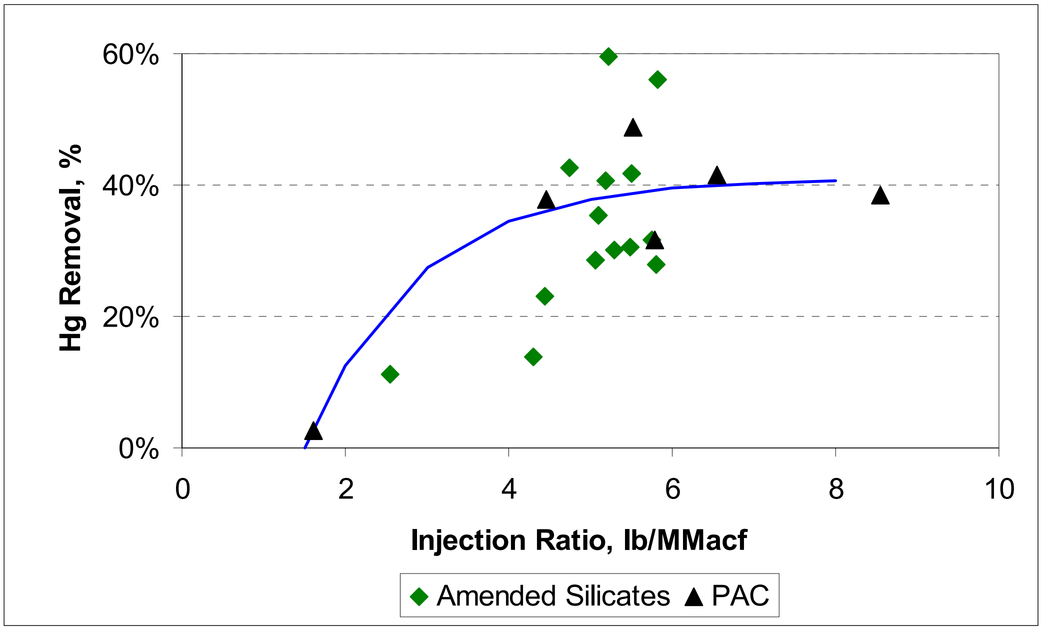


Figure 24. Comparative performance for Amended Silicates and activated carbon.

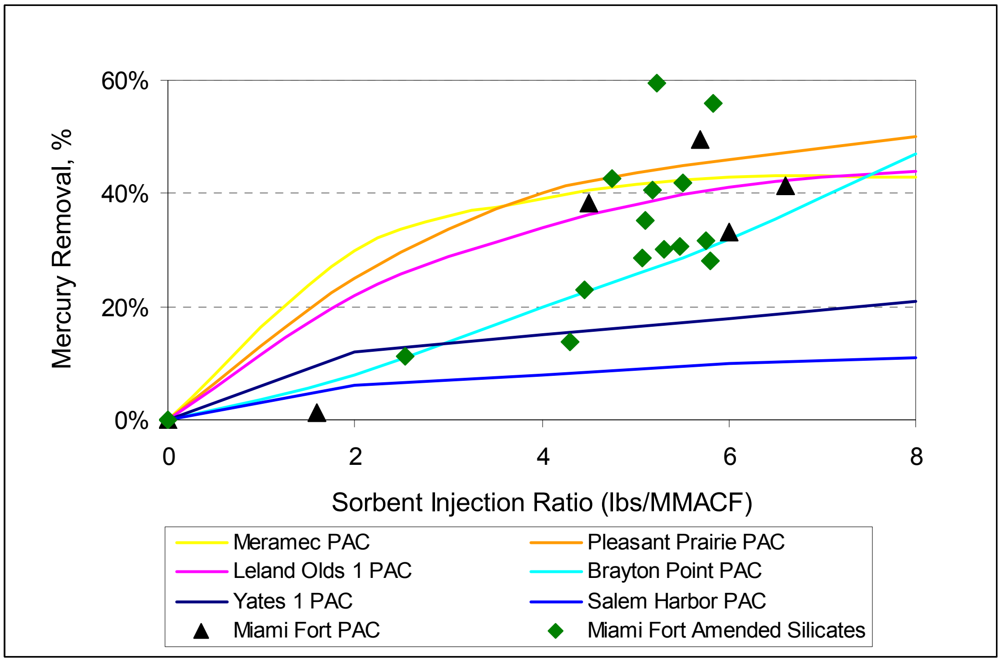


Figure 25. Sorbent Injection on Units with ESPs. Data normalized for baseline removal by fly ash. PAC data taken from Feeley, et al. May 2005.

Sulfur content of coal has been observed to bear a relationship to the mercury removal efficiency of sorbents at a number of power plants tested in the DOE NETL mercury test program. Data taken from AEP's Conesville plant, with coal sulfur in the range of 3.5-4% showed mercury removal no greater than 20% at injection ratios up to 18 lb/MMACF, as reported by Sjostrom, 2006a. Figure 26 shows results of untreated PAC sorbent at 6 different power plants using coal ranging from 0.7 to 4% sulfur, including PAC data from Miami Fort Unit 6.

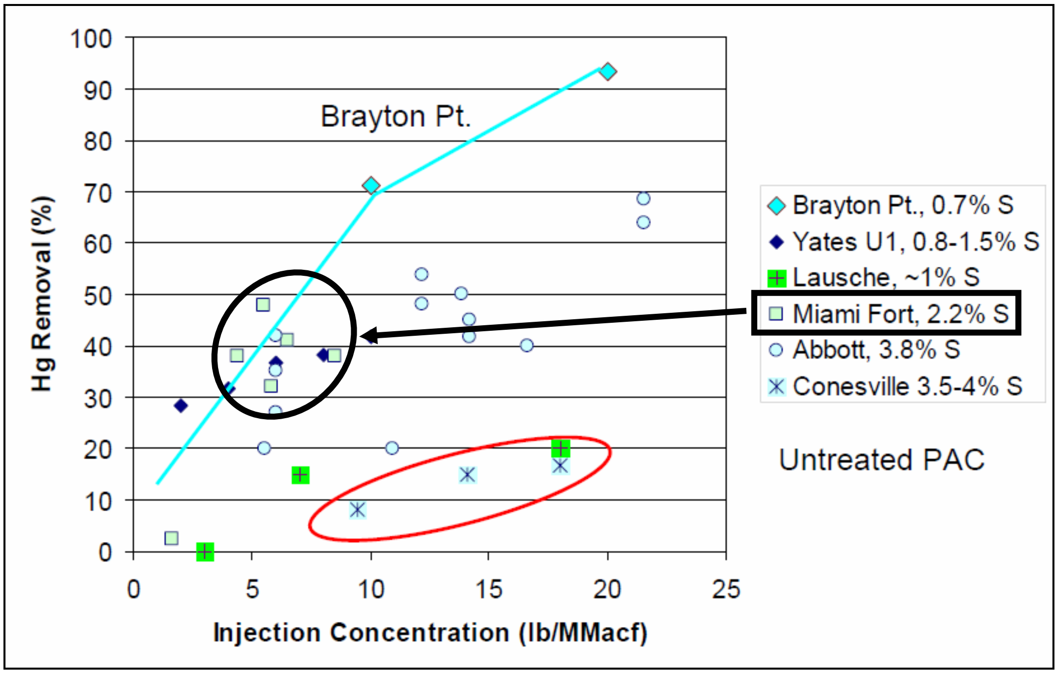


Figure 26. Comparison of mercury removal efficiency at 6 power plants with coal sulfur ranging from 0.7 to 4%. Figure adapted from Sjostrom, 2006b.

Ash Pond Water Analysis

As part of our evaluation to study the impact injected sorbents have on balance of plant equipment and operations, the project team completed sampling and analysis of the fly ash pond water. Two different tasks were conducted: one where the impact of sorbent addition on the solids content of the pond water was assessed, and a second where the mercury concentration in the pond water was measured before the start of the sorbent trial and during sorbent injection.

The first study was conducted six-months prior to the sorbent injection work. Four 1-liter samples of the fly ash pond water from Unit 6 were sent to ADA to determine solids content of the ash pond water as well as Settleable Solids (SS) and Total Suspended Solids (TSS). Solids in the samples were quite variable in terms of the amount and size distribution of material in the liquids. Contents of the bottles were combined in a single container to homogenize the sample for the analysis. The combined sample was then filtered through a series of sieve trays ranging in size from 3/8" to 35 mesh (nominal 500 micrometer diameter) to generate a size distribution for the solids. The weight of solids collected on each tray was measured and reported as oversized solids, with results shown in Table 7. The liquids and solids passing through the 35-mesh screen were collected and equally divided into four 1-liter samples for subsequent tests.

Table 7. Summary of Oversized Solids from Unit 6 Flyash Sluice Water

Sieve Size (inch or mesh)	Grams	wt %
+3/8”	59.4	13.2%
-3/8” / +1/4”	77.8	17.3%
-1/4” / +4 mesh	88.5	19.7%
-4 / +6	84.4	18.8%
-6 / +10	66.7	14.8%
-10 / +12	14.6	3.2%
-12 / +14	13.4	3.0%
-14 /+20	22.2	4.9%
-20 / +25	3.8	0.8%
-25 / +30	3.9	0.9%
-30 / +35	3.1	0.7%
-35	12.3	2.7%
Total	**450.1**	**100%**

One of these “minus-35 mesh” samples was used to quantify baseline amounts of SS and TSS in the fly ash pond water. The sample was poured into an Imhoff cone, agitated and allowed to settle for one hour. The volume of SS was determined by reading the marking on the side of the cone. TSS in the liquid was then measured by siphoning off 250 ml of liquid from the Imhoff cone and filtered it through a glass-fiber filter. The filter and residue retained on the filter were then dried to constant weight at 103 to 105ºC. The baseline sample was found to contain 76 mg of TSS per liter.

With the other three minus-35 mesh samples, activated carbon and Amended Silicates sorbent materials were added to the pond water samples to determine if the addition of these sorbents affected the amount of suspended solids in the samples. To each of the 1-liter bottles 0.15 grams of the appropriate sorbent material was added. This amount of sorbent is equivalent to a 5% weight loading of sorbent in the flyash material. The sorbent was dispersed in the liquid using vigorous shaking and analyzed for SS and TSS. Results are shown in Table 8.

Table 8. Analyses of Settleable and Suspended Solids in Flyash Sluice Water

Sample Description	Settleable Solids (SS)	Total Suspended Solids (TSS)
	mL/liter	mg/liter
Baseline (No additive)	4.8	76
0.15 g Activated Carbon added	4.8	97
0.15 g Amended Silicates Sorbent added	6.7	100

Bottom ash and fly ash from the four power generating units at Miami Fort Station are discharged to the same fly ash ponds, with Unit 6 contributing between 25% and 30% of the total flow to the pond. Historical TSS measurements for the discharge from the fly ash pond are in the single digit mg/L (ppm) levels. The Station’s National Pollution Discharge Elimination System (NPDES) limit on TSS for pond water discharged to the Ohio River is 30 ppm. Considering an incoming TSS of 76 ppm for the flyash sluice water and a 30% contribution to the overall flow to the ponds this indicates that significant settling occurs in the pond. Water samples spiked with activated carbon and Amended Silicates sorbent had about 30% more TSS over baseline measurements. Even with a 30% percent increase in TSS caused by the presence of a sorbent material, it does not appear that the TSS in the pond water discharge will exceed the NPDES permit limit.

As part of the data collected for the local environmental permitting authority, during the sorbent injection phase of the project weekly ash pond water samples were taken and analyzed for mercury content. This work was contracted to URS by Duke as a cost share contribution. Figure 27 presents the mercury data for the ash pond water samples. An increase in mercury levels was observed during periods of Amended Silicates and activated carbon sorbent injection phases of the project compared to baseline levels, although there was considerable scatter in both datasets. Mercury levels in ash pond water during the baseline and periods of sorbent injection were nominally 7 ppt and 11 ppt, respectively. No attempts were made to correlate the ash pond mercury levels with other water quality parameters such as pH or temperature. It should be noted that data on ash pond mercury measurements is the first of its kind. Without similar data from other plant sites it is difficult to gauge whether the reported mercury levels are significant. This issue will become more important as discharge standards are implemented. Further investigation needs to be directed in this area to understand the variation in water mercury levels as a function of seasonal water temperature and other water parameters. Water quality criteria for biological and chemical constituents in water streams discharged to the Ohio River have been proposed by the Ohio River Valley Water Sanitation Commission (ORSANCO). The Commission has proposed a total mercury concentration of 12 parts per trillion (ppt) as the mercury standard for discharged waters [Ohio River Valley Sanitation Commission, 2006]. Timeline for implementing the proposed water quality standards has not been specified but could be in the 2010 to 2012 time frame.

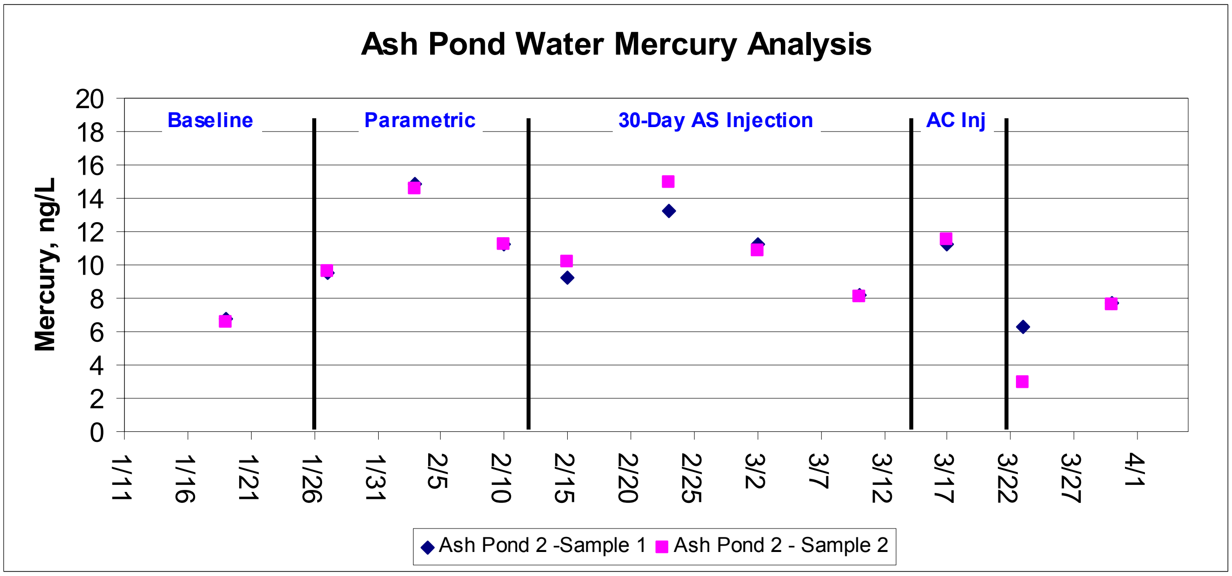


Figure 27. Reported mercury levels in ash pond water during demonstration.

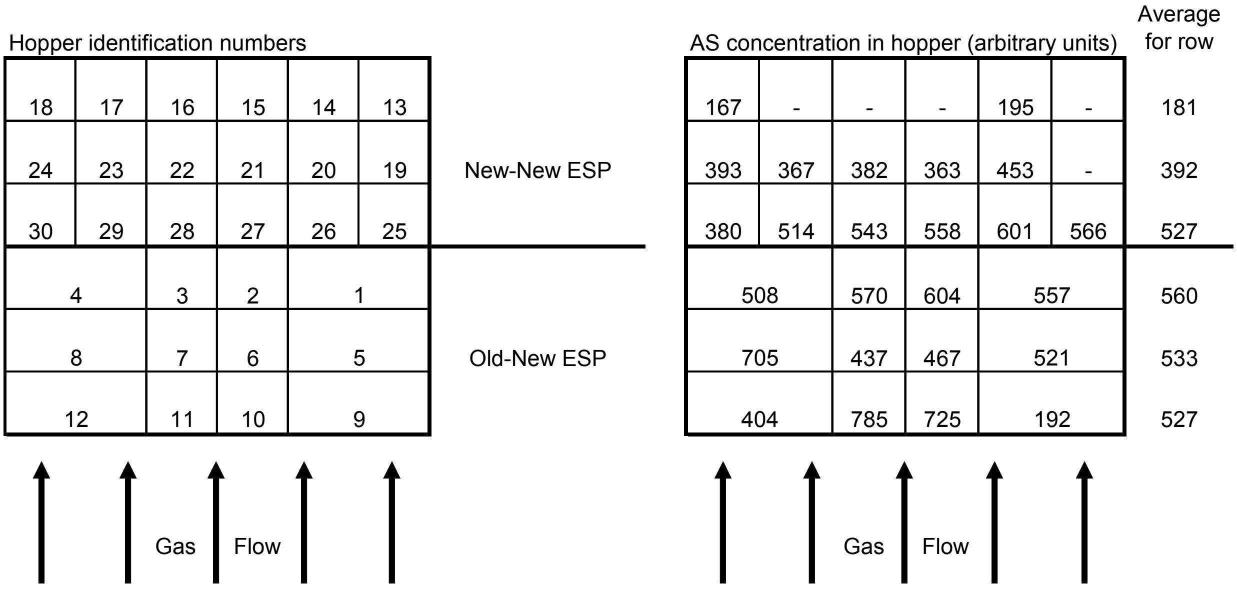
Fly Ash

Samples were extracted from the Unit 6 ESP hoppers for three purposes: first, to evaluate the distribution of sorbent in the exhaust duct cross-section; second, for submittal to a specified DOE contractor for analysis, and third, for use in evaluation of the impact of Amended Silicates sorbent on the use of fly ash as a cement replacement in concrete.

The ESP hopper layout schematic for Unit 6 is shown in Figure 28. The ash-laden flue gas enters the row of the combined "old-new" and "new-new" ESPs at the bottom of the schematic, where the hoppers are numbered 9 through 12. Most of the ash collected in the first few rows of hoppers in these units. Currently, Duke Energy does not sell the fly ash generated in Unit 6, although ash from other units at the plant is sold.

Twice during the demonstration fly ash samples from the entire set of hoppers were collected: during the baseline period and during the 30-day sorbent injection period. Ash samples were analyzed for mercury, tracer chemical content and LOI. The data provided a means for assessing the distribution of ash materials within the various ESP hoppers and whether there were preferential locations where mercury or sorbent materials disengaged from the flue gas.

The schematic on the right-hand side of Figure 28 presents data on concentrations of a tracer chemical found in the Amended Silicates sorbent at high concentrations, but in the neat fly ash at very low concentrations. Thus, the tracer chemical can be used as an indicator of sorbent distribution across the exhaust duct, as it is collected along with fly ash in the Unit 6 ESPs. The relatively similar values for concentration of the tracer chemical in the various ESP hoppers indicates that the sorbent is being uniformly distributed by the injection system (see Figure 28, right panel). The first four rows within the ESP provide strong evidence of a consistent collection of Amended Silicates sorbent and the sorbent concentration from left to right across duct also appears uniform. The data also show that Amended Silicates sorbent concentration drops in the rear hopper rows, a clear indication that the ESP is effectively collecting the injected sorbent.



Hopper identification numbers

18	17	16	15	14	13	
24	23	22	21	20	19	New-New ESP
30	29	28	27	26	25	
4		3	2	1		
8		7	6	5		Old-New ESP
12		11	10	9		

AS concentration in hopper (arbitrary units)

						Average for row
167	-	-	-	195	-	181
393	367	382	363	453	-	392
380	514	543	558	601	566	527
508		570	604	557		560
705		437	467	521		533
404		785	725	192		527

Figure 28. Miami Fort Unit 6 ESP hopper configuration and identification numbers (left) and the relative amounts of AS sorbent collected in each hopper (right) during sorbent injection tests on February 1st.

Additional samples from the ESP hoppers were recovered and sent to Boral Material Technologies for assessment of the suitability of the fly ash and sorbent / fly ash mixture for use as a pozzolan additive in concrete; these results are reported in the following section. Other fly ash samples were analyzed by ADA to quantify mercury leachability from the fly ash collected in the ESP hoppers during baseline as well as during sorbent injection.

Ash samples collected from Hopper 11 of the ESP on January 18, February 20, March 14, and March 21 were analyzed for total mercury concentration and mercury leachability via the EPA's Toxicity Characteristic Leaching Protocol (TCLP). Total mercury concentration was determined using EPA Method 7471B-4. The three fly ash samples were collected during baseline (no sorbent injection; January 18), Amended Silicates injection (February 20 and March 14), and PAC injection periods (March 21), respectively.

It is significant to note that the concentration of mercury in the fly ash samples were significantly higher for the samples containing both the Amended Silicates and powdered activated carbon sorbents. This is a strong indication that the sorbents were capturing additional vapor-phase mercury from the flue gas. It should be noted that fly ash samples taken during Amended Silicates sorbent injection were on days when calculated mercury removals suggested that the fly ash should have higher mercury content and subjecting these samples to the TCLP presents a greater challenge to sequester the mercury. Further, the data presented in Table 9 indicate that the leachable mercury levels for all three samples with a sorbent material present were very low. The leachability limit for mercury in the TCLP is 200 parts per billion, or 0.200 mg/L. These results show that the sorbents injected for mercury capture from the flue gas stream on Miami Fort Unit 6 strongly bound the mercury, and would be suitable for disposal in a designated landfill under current regulations.

Table 9. Total mercury and leachable mercury from fly ash samples.

Date and Sample Description	Sample wt. (g)	Total Hg Conc. (ppm)	Leachate Conc. (mg/L)	Percent leached
1/18/06 (baseline – no sorbent injected)	0.5340	0.23	0.006	2.6%
2/20/06 (Amended Silicates)	0.5020	0.55	0.002	0.4%
3/01/06 (Amended Silicates)	0.5093	0.59	0.002	0.3%
3/21/06 (PAC)	0.5278	0.47	0.007	1.5%

Fly Ash By-Product Assessment

Data from a number of sites where powdered activated carbon (PAC) has been injected for mercury capture has shown that the presence of PAC in fly ash can render that fly ash unusable as a pozzolan additive in concrete [Bustard et al., 2002]. This loss of fly ash sale as a by-product can have a significant impact on the economics of power plant operation, effectively multiplying the cost of mercury control by several-fold [Hoffmann & Ratafia-Brown, 2003]. A driving factor behind the development of the Amended Silicates sorbent is the fact that it allows utilities to maintain the ability to sell fly ash as a cement replacement in concrete. The reason that powdered activated carbon renders the fly ash un-sellable is because it tends to absorb air entraining agent added to concrete to allow the finished concrete to sustain changes in dimensions due to freeze-thaw cycles. The absence of air bubbles in concrete fosters cracking in pavements and foundations that are subject to freezing and subsequent thawing weather.

To verify the compatibility of the fly ash/Amended Silicates sorbent mixture with use as a cement replacement, the ASL team collected samples of fly ash for submittal to two team members for testing on three different dates in the trial. These team members were Boral Material Technologies, Inc., a major reseller of coal combustion fly ash, and Separation Technologies, LLC, a supplier of a technology for separating unburned carbon from fly ash to permit its sale as a cement replacement. Boral maintains a laboratory in its San Antonio, TX headquarters to conduct a variety of tests of fly ash and concrete properties. Separation Technologies' laboratory is in Massachusetts, and is capable of conducting similar tests to those in the Boral laboratory; STL also has equipment to conduct small-scale separations using their process to reduce the unburned carbon content (LOI) on samples as well.

Fly ash samples were collected for analysis on the dates noted earlier: January 18 as a baseline sample (no sorbent injection), March 14 during the injection of Amended Silicates sorbent, and on March 21 during the injection of powdered activated carbon. Injection ratios for the Amended Silicates sorbent and powdered activated carbon were very similar, around 5 lb/MMACF.

Four types of tests were run by Boral: LOI (unburned carbon content), mortar air ratio, concrete air, and concrete strength tests. Data from LOI and mortar air tests are presented in Table 10 below. The increase in LOI for the March 21st sample compared to the January 18th and March 14th samples reflects the injection of powdered activated carbon for mercury control at that time. More importantly, the mortar air results show a very similar mortar air ratio for the baseline (no sorbent) sample on January 18th and the Amended Silicates sorbent sample on March 14th. The significant reduction in mortar air for the powdered activated carbon sample from March 21st is due to the previously noted affinity of activated carbon for the air entraining agent used in the mixtures.

Table 10. Boral Test Report on LOI and Mortar Air*

Description	LOI (%)	Control Mortar Air (%)	Mortar Air (%)	MAR (%)
Baseline Fly Ash	4.14	17.63	14.12	80.09
Fly Ash with AS	3.65	17.63	13.31	75.50
Fly Ash with PAC	5.32	17.63	5.70	32.33

[Materials: Capitol Type I Cement, Air 40 (1 oz/cwt)]
**Boral Material Technologies Test Report, 2006)*

In another test of the Miami Fort fly ash samples, Boral prepared a total of 11 concrete mixes using material from the three sample dates (Boral Material Technologies Test Report, 2006). Three mixes were made from the baseline fly ash, with air entraining agent (AEA) concentrations of 1, 2, and 3 ounces per hundredweight of concrete. Three more mixes were made with the fly ash plus Amended Silicates sample, at the same AEA concentrations. And finally, five mixes were made with the fly ash plus powdered activated carbon sample at five

AEA concentrations: 3, 5, 8, 10, and 12 ounces per hundredweight. Entrained air measurements were made on all mixes, and are plotted in Figure 29 below. The almost-overlapping traces for the baseline and fly ash plus Amended Silicates samples clearly show that the injection of Amended Silicates sorbent does not affect the properties of concrete mixes with respect to entrained air. On the other hand, there is a very significant effect of the powdered activated carbon on the concrete, seen in the blue trace.

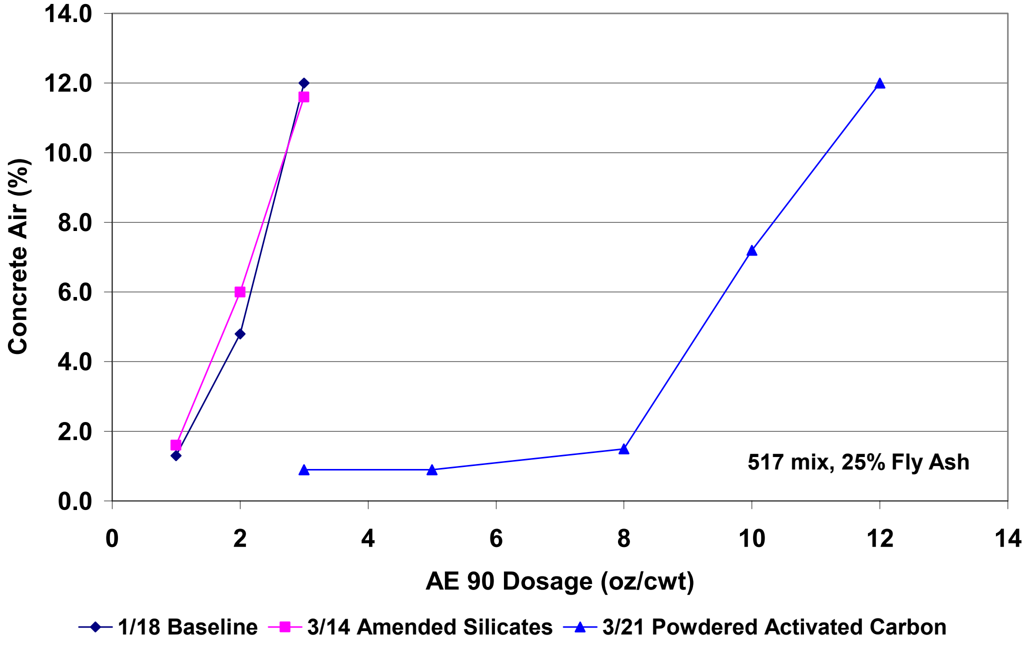


Figure 29. Effect of AEA dosage on entrained air for concrete mixes [Boral Materials Technologies Test Report, 2006].

Concrete suppliers usually target an entrained air level of 5 to 8% of the volume of the concrete. From the data presented in Table 11, it is seen that the concrete made with fly ash mixed with powdered activated carbon would require over four times the air entraining agent of the baseline fly ash or fly ash mixed with Amended Silicates sorbent.

Boral also ran strength tests on concrete samples made with fly ash samples from the three dates noted earlier. Results of these tests are shown in Table 11 below. Again, the data from the baseline neat fly ash and the fly ash plus Amended Silicates sorbent are virtually identical.

Table 11. Concrete Sample Strength Results*

Sample ID	Compressive Strength		
	7-day aging	28-day aging	56-day aging
Baseline Neat Fly Ash	2,487 psi	3,554 psi	4,365 psi
Fly Ash plus Amended Silicates	2,491 psi	3,581 psi	4,334 psi
Fly Ash plus Activated Carbon	2,190 psi	3,374 psi	3,955 psi

*(*Boral Material Technologies Test Report, 2007)*

Fly ash samples from the baseline period and the trial were also sent to STL for analysis. STL subjected some of the material they received to their unburned carbon separation process, producing a number of samples with different fractions of unburned carbon, measured as LOI. These multiple samples were then subjected to a Foam Index Test, a standardized method of determining the amount of air-entraining agent required to mix concrete with acceptable properties. Figure 30 plots the results from Foam Index testing of multiple samples of Miami Fort fly ash and fly ash plus Amended Silicates sorbent. These samples were subjected to the STL process to reduce LOI in the fly ash, and then run through the Foam Index test. The data strongly indicate once again that the foam index values for neat fly ash and fly ash mixed with Amended Silicates sorbent are quite similar over the entire range of LOI included in this test set.

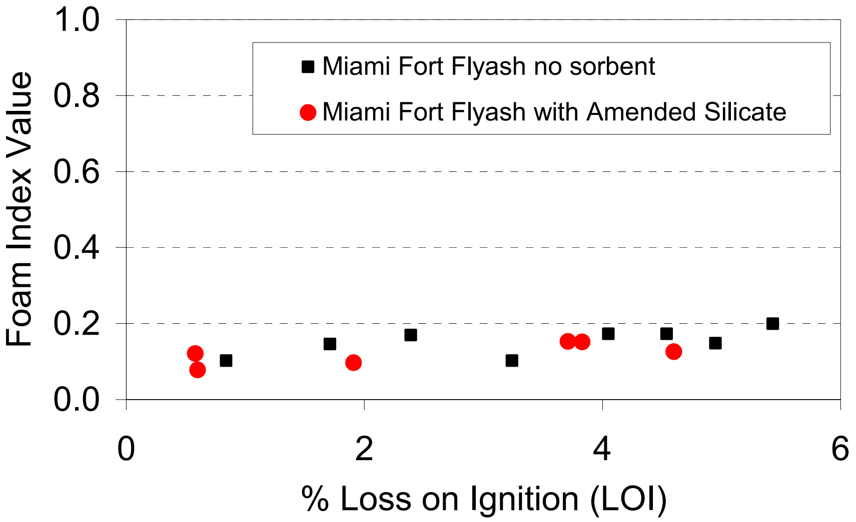


Figure 30. The presence of Amended Silicates sorbent in the fly ash has no effect on Foam Index test. [Separations Technology, LLC Test Report, 2006].

SCEM Operation Assessment

The SCEMS used for mercury measurements during the project were installed immediately downstream of the Unit 6 air pre-heater and at the outlet of the combined supplemental ESP box (upstream of the original ESP). Portable shelters were erected by UNDEERC at each location to maintain the analyzers in a temperature-controlled environment and to contain chemicals used in the chemical converter system. Temperatures inside the buildings were controlled through a combination of air conditioning and heating to sustain a 70 +/- 5ºF environment for the analyzers. The ambient environmental conditions were harsh at the shelter locations. The inlet SCEM was located on the air pre-heater deck, next to the Unit 6 boiler. Air temperature at this location varied with the outdoor temperature but was typically in the range of 100 to 115ºF. The outlet SCEM shelter was located outdoors atop the ESP roof. Although the weather conditions during the sorbent tests were mild by Midwest winter standards with average daytime temperatures in the mid- to upper- 40's and nighttime temperatures near freezing, there were occasions when temperatures dipped down to single digit levels. Given the harsh environmental conditions the mercury analyzers operated well at both locations; however, issues were encountered with the sampling equipment at both locations that affected the total time that reliable data was available from the instruments as well as the variability in the mercury readings as described below.

Issues with the Inlet SCEM – The chemical converter used for the inlet SCEM was originally located outside the temperature-controlled shelter on the air pre-heater deck. As noted, the air temperatures in the area were stifling and had an adverse effect on the operation of the chemical converter system. Excessively high temperatures on the pre-heater deck made it difficult to maintain consistent gas flow through the chemical converter. On several occasions, gas flow to the SCEM was interrupted by the formation of crystals inside the converter glassware, due to the evaporation of liquid from the impingers. The glassware for the oxidized mercury side of the chemical converter had to be disassembled and cleaned to remove the crystalline material. The issue was resolved by moving the chemical converter inside the SCEM building where the temperature of the converter chemicals could be more carefully controlled.

Issues with the Outlet SCEM - The location of the outlet sample port was on the outlet ducting of the combined ESP box, which was situated on the roof of the building in which Unit 6 is located. Duct work from the outlet of the ESP box is routed over the top of the combined ESP and then connected to the original ESP for Unit 6. The sample port was atop the outlet ductwork. There was insufficient space to erect the SCEM shelter on the ductwork platform, so it was erected on the roof of the combined ESP, approximately 40 feet below the sample port location. The sample probe consisted of a modified Method 17 probe fitted with a quartz glass filter to remove particulate from the sample gas stream. A 75-foot hotline was installed to transport the gas sample from the probe to the chemical converters and analyzer in the SCEM shelter.

The variability in the mercury data reported by the outlet SCEM during the baseline and parametric tests was substantial, especially in the oxidized mercury readings. During the tests attempts were made to keep the probe and heat trace line as hot as possible to prevent acid condensation from occurring in the sampling system, Small acid condensate droplets can absorb mercury forms in the sample lines. As these droplets grow, they are carried into the chemical converter solution, resulting in high mercury spikes for one or two readings. This was evident by very high short-term mercury values often exceeding 50 $\mu g/m^3$ in the outlet SCEMS data stream. The existing heating elements on the sample probe were believed to be undersized and were unable to maintain higher temperatures for substantial periods of time. Additional insulation and heating elements were added to the sample probe to maintain temperatures above 325ºF. The controlling temperature for the sample hotline was also increased to consistently bring the temperature above 300ºF. These modifications to the sampling system reduced the severity of the mercury reading excursions, although they didn’t totally eliminate the problem.

Miami Fort plant personnel worked closely with the ASL technical team to support the trial of Amended Silicates sorbent on Unit 6. In their observation of the operation of the SCEMS units, plant personnel voiced concern over the time devoted to maintaining the instruments, and the down-time encountered, even with a full-time operator (single-shift) dedicated to the two SCEMS units (Geers, 2006). Plant personnel have become comfortable with stack monitoring systems that acquire a continuous stream of data; these systems typically require maintenance on a much less frequent basis. When mercury regulations are implemented in future years it will be necessary to monitor mercury emissions by methods yet to be specified. If SCEMS are used for this application, the systems deployed for the trial at Miami Fort 6 would represent a substantial cost because of their frequency of maintenance and significant down time.

ESP Performance Assessment

One of the objectives for the trial of Amended Silicates sorbent at Miami Fort station was to assess the impact of sorbent injection on the balance of plant systems. One topic of concern was the performance of the particulate control equipment on Unit 6. To evaluate this aspect, the voltage / current behavior of twelve transformer rectifier sets of the Unit 6 ESPs was monitored during the sorbent injection trials. Unfortunately the T/R sets for the ESPs are not monitored by the automated plant data acquisition system. Data was obtained by hand, reading the instrumentation for each T/R set at periodic intervals each day. Information from all data sheets was then transferred to a master spreadsheet for analysis.

The spreadsheet data was used to generate mean values for output voltage and current for each of the T/R sets for three periods: baseline, Amended Silicates sorbent injection, and injection of powdered activated carbon. Assuming a random variation of 3% to be within the setpoint range, there was no observed difference between the mean readings within a 95% confidence level. Comparisons of ESP performance during baseline, Amended Silicates sorbent and activated carbon injection periods are shown in Figure 31 and Figure 32. An inspection during an outage about four weeks following the sorbent injection trial indicated no discernable deposition or corrosion attributable to the sorbent injection on the Unit 6 ESPs. Early in the sorbent injection effort, T/R set 3 dropped off line. The reason for the failure was due to an electrical connection issue and was found not to be attributed to sorbent injection.

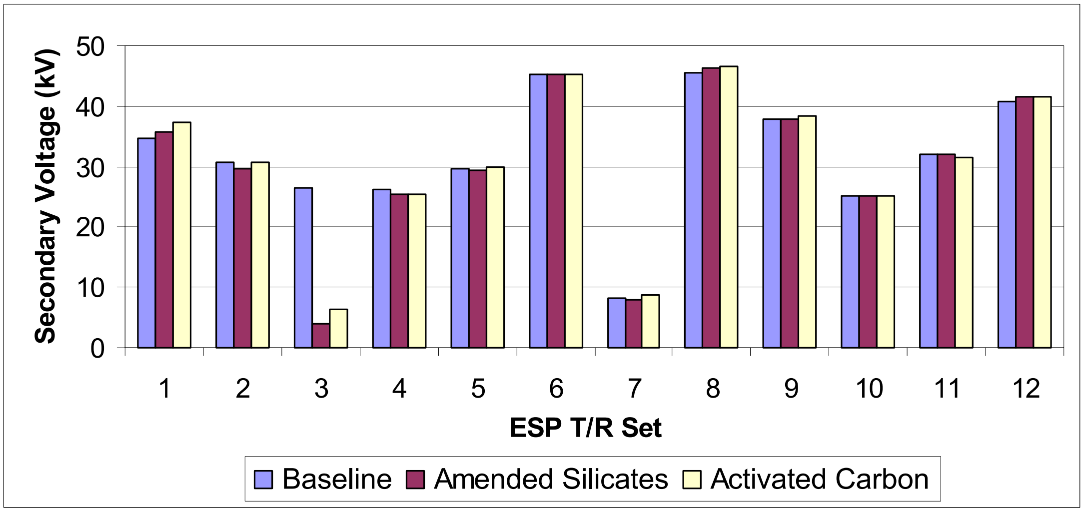


Figure 31. Average ESP secondary voltages during the sorbent injection project.

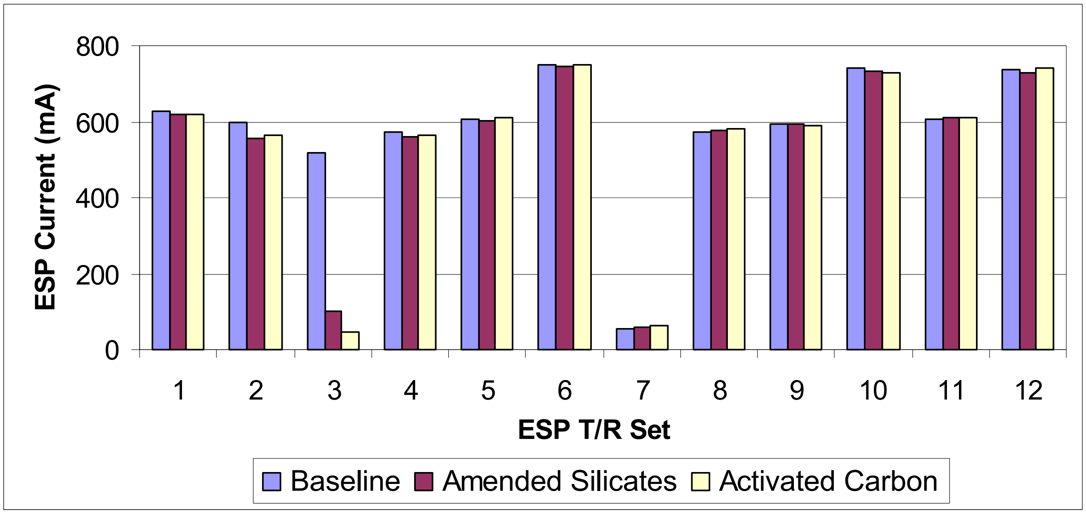


Figure 32. Average ESP current during the sorbent injection project.

Opacity Assessment

Figure 33 displays the opacity data as measured by installed stack opacity monitor. The opacity data is for the stack shared by Miami Fort's Units 5 and 6. Unit 5 is an older unit which was only operated for a few days during the sorbent injection trials. Analysis showed that the injection of Amended Silicates sorbent had no observed effect on stack opacity at the injection ratios used during the trial. Opacity data taken during the period of PAC injection also showed PAC had no effect on stack opacity. The only time opacity changed by a significant amount was during the brief operation of Unit 5, from February 27th through March 3rd. That increase is attributed to the contribution from Unit 5 to the common stack, and is unrelated to the sorbent injection testing at Unit 6.

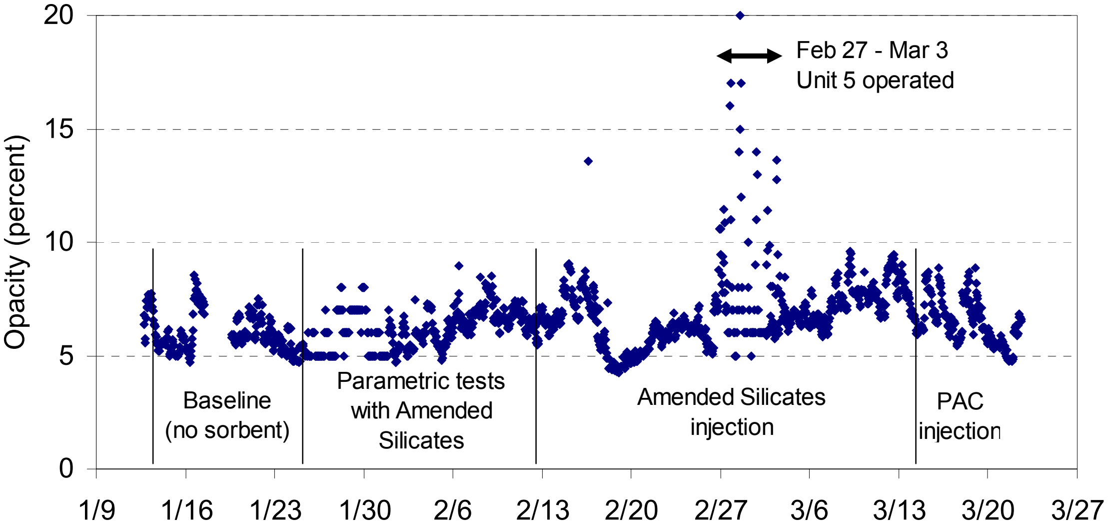


Figure 33. Stack opacity data for Miami Fort Units 5 and 6. Sorbent injection had no discernable effect on opacity.

Economics

While mercury capture from coal fired utility flue gas has been well documented through the injection of powdered activated carbon (PAC), the application of PAC for this purpose has been problematic to potential beneficial use of the collected particulate material. Since the resultant fly ash/PAC mixture may not be suitable for use as a pozzolanic additive (cement replacement) in concrete, sale of this waste material may be realized and waste disposal costs would be incurred. As a mineral-based sorbent, Amended Silicates provides an option for mercury removal that maintains the opportunity to sell the collected fly ash material and avoid paying disposal costs.

As part of the analysis of the trial of Amended Silicates sorbent at Miami Fort station, ASL has completed an economic analysis of mercury control at the host site using both the Amended Silicates sorbent and powdered activated carbon. This economic analysis incorporates the mercury removal results for the trial of both sorbent materials at Miami Fort Unit 6. During the trial, injection of DARCO® HG activated carbon provided by NORIT Americas was conducted for a short period of time precisely to collect data for comparison with the Amended Silicates sorbent that was the subject of the extended-term (30-day) segment of the trial. A summary of this economic analysis is presented herein.

The model applied to this analysis was one created earlier by the ASL team, which closely followed the approach outlined in two published studies: the *EPA Mercury Report to Congress* (1997), and *DOE/NETL's Phase II Mercury Control Technology Field Testing Program--Preliminary Economic Analysis of Activated Carbon Injection*, published in April 2006. Table 12 below provides plant information and assumptions which were used as a basis for the economic analysis.

The powdered activated carbon and Amended Silicates sorbent materials were injected upstream of the electrostatic precipitator at ratios ranging from 2 lb/MMACF up to levels in excess of 8 lb/MMACF. For the purposes of this economic analysis, mercury removals at injection ratios of 2, 4, and 6 lb/MMACF were included. Mercury removal did not increase at sorbent injection ratios greater than 6 lb/MMACF. The mercury removal performance for the Amended Silicates sorbent and activated carbon were very similar. A single regression equation was developed for both sorbent materials to give mercury removal efficiencies of 10%, 35%, and 40% for the injection ratios of 2, 4, and 6 lb/MMACF, respectively.

Capital costs were estimated from the report *DOE/NETL's Phase II Mercury Control Technology Field Testing Program--Preliminary Economic Analysis of Activated Carbon Injection* (Jones, et al., 2006). This report reviewed mercury removal results from multiple units of varying size and coal characteristics, and subjected the data from these units to a cost model analysis. The report noted that capital costs were somewhat insensitive to size of the unit over the range evaluated (100 MW to 360 MW), with the total capital requirement (TCR) in 2005 dollars being approximately $1.3 million. For the Miami Fort testing a TCR of $1.37 million was used. Since a sorbent injection system would be designed to handle a generic injectable sorbent, either Amended Silicates or powdered activated carbon could be used interchangeably. Thus it was assumed that there is no difference in capital cost for the two sorbent options.

Table 12. Plant information and Assumptions Used in Economic Analysis

Net Plant Output (MW)	175
Plant Capacity Factor	80.0%
Boiler Heat Input (MMBtu/Hr)	1,803
Air Quality Control Equipment	Cold-side Electrostatic Precipitator
Coal Type	Medium to High Sulfur Eastern Bituminous
Design Flue Gas Flow @ 300 degrees F (Acfm)	630,000
Net Heat Rate (Btu/Kw-hr)	10,300
Average Coal Heating Value (Btu/Lb)	12,060*
Average Coal Sulfur Content (wt. %)	2.02*
Average Coal Mercury Content (ppm)	0.12*
Average Coal Mercury Concentration (ug/NM3)	5.57*
Average Coal Ash Content (wt. %)	10.02*
Assumed Fly Ash/Total Ash Ratio	80.0%
Discount Rate	9.2%
Economic Life	20 years
Activated Carbon Sorbent Cost, delivered ($/lb)	0.67**
Amended Silicates Sorbent Cost, delivered ($/lb)	0.60, 0.70, 0.80***

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* Coal values on an as received basis

** A quotation for DARCO FGD activated carbon was received from NORIT Americas, Inc. at approximately $ 0.67 per pound delivered ($ 0.56/lb material and $ 0.11/lb delivery charge), which was for bulk trailers delivered to Cleveland, OH.

*** Since the manufacture of Amended Silicates sorbent is still being optimized, a range of cost values was used in the economic analysis.

In addition, the amortization for capital costs were included in the economic model which incorporated annual operating costs as well, including operating and maintenance labor, sorbent costs, waste disposal (if applicable), credit for fly ash sales (if applicable), and associated indirect costs. Ash impacts were calculated consistent with the DOE study utilizing a cost of $17/Ton for disposal and a sales credit of $18/Ton.

Based on the cost estimate performed by CH2M HILL (CH2M HILL, 2006), the annual cost of mercury control in millions of dollars, and as bus-bar costs in dollars per megawatt-hour were determined and are presented in Table 13 at each of the injection rates noted above for each of the two sorbents: powdered activated carbon and Amended Silicates sorbent. Because the mercury capture performances for Amended Silicates and activated carbon were the same, the costs when fly ash sales are not included are also very similar, as seen in the first two rows of the table. When the effect of fly ash sale is included, there is a dramatic advantage for the Amended Silicates sorbent, which is less than 43% of the cost of powdered activated carbon for all scenarios included. For example, at an injection ratio of 4 lb/MMACF, the cost per MW-hr for sorbent injection would be $2.18 for activated carbon compared to $0.98 for Amended Silicates sorbent at a sorbent cost of $0.7 per pound.

Table 13. Sorbent Injection Cost Comparison

	PAC- 2 Lb/MMACF	PAC - 4 Lb/MMACF	PAC -6 Lb/MMACF	AS - 2 Lb/MMACF	AS - 4 Lb/MMACF	AS - 6 Lb/MMACF
1st Year Cost-No Ash Impacts ($Million)	0.81	1.17	1.52	0.78^a 0.83^b 0.88^c	1.09^a 1.20^b 1.31^c	1.41^a 1.57^b 1.73^c
Bus-Bar Costs - No Ash Impact Cost ($/MW-hr)	0.66	0.95	1.24	0.63^a $0..67^b$ 0.71^c	0.89^a 0.98^b 1.06^c	1.15^a 1.28^b 1.41^c
Ash Impacts ($Million)	1.50	1.50	1.50	0	0	0
Total 1st Year Impact ($Million)	2.32	2.67	3.03	0.78^a 0.83^b 0.88^c	1.09^a 1.20^b 1.31^c	1.41^a 1.57^b 1.73^c
Bus-Bar Cost with Ash Impact Cost ($/MW-hr)	1.89	2.18	2.47	0.63^a 0.67^b 0.71^c	0.89^a 0.98^b 1.06^c	1.15^a 1.28^b 1.41^c

Notes:

[a] $.60 per pound
[b] $.70 per pound
[c] $.80 per pound

Fully loaded, amortized capital

Conclusions

During the first quarter of 2006, Amended Silicates LLC and consortium of partners completed approximately 60 days of sorbent injection testing for mercury control at Duke Energy's Miami Fort Unit 6. The testing included baseline measurements with no sorbent injection, followed by a parametric phase and an extended trial phase with injection of Amended Silicates sorbent, and finally injection of PAC. Operating parameters were monitored to assess impact of sorbent injection on plant operations. Samples of collected fly ash were tested to determine if fly ash quality was impacted by the presence of sorbent. The major conclusions are summarized as follows:

- A temporary sorbent injection system was installed to feed Amended Silicates sorbent and activated carbon over the range of 2 to 9 lb/MMACF. The installed equipment functioned well for both sorbent materials with no changes to the system.
- The native fly ash had very little capacity for mercury. Measurements and analysis indicated typical mercury capture from zero to ten percent by the native fly ash.
- Changes in the process conditions during manufacturing of the Amended Silicates sorbent yielded sorbent lots with better flowability and mercury capture performance than others. Further optimization of the full-scale manufacturing process is possible.
- Approximately 40% mercury control was achieved with the best Amended Silicates sorbent lots at injection ratios of 5-6 lbs/MMACF. Comparable results were achieved with PAC injection. Higher injection ratios did not significantly increase removal. These results mimic those seen at other plants with cold-side ESPs and coals with similar sulfur content.
- Mercury measurements with SCEM systems proved to be challenging. Erratic performance of the SCEMs was attributed to problems with the sample transfer lines and ash accumulation within the sampling probes. The SCEMs required maintenance and calibration checks on a daily basis. These issues raised concerns among plant personnel about the readiness of this SCEM configuration for industrial monitoring.
- ESP operating parameters and stack opacity were not affected by sorbent injection. Subsequent inspection of the ESP did not show any effects of the sorbent on the ESP internal components.
- The presence of PAC in fly ash from Miami Fort rendered the ash unusable as a concrete additive. The presence of Amended Silicates sorbent had no affect on fly ash quality based on tests run by fly ash resellers.
- When the value of fly ash sales is included in an economic analysis, the bus-bar cost of mercury capture with activated carbon costs twice that of Amended Silicates sorbent.

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List of Acronyms and Abbreviations

ADA	ADA Technologies, Inc.
AS	Amended Silicates Sorbent
ASL	Amended Silicates LLC
ASTM	American Society for Testing and Materials
AASHTO	American Association of State Highway and Transportation Officials
BTU	British Thermal Units
CMM	Continuous Mercury Monitor (used in Appendix C – UNDEERC Report)
CFD	Computational Fluid Dynamics
CH2	CH2M HILL
CVAFS	Cold Vapor Atomic Fluorescence Spectroscopy
CWT	Hundred Weight of Concrete
DOE	Department of Energy
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	Electrostatic Precipitator
IC	Iodated-Carbon
JDA	Joint Development Agreement
LLC	Limited Liability Company
LOI	Loss on Ignition
MMACF	Million Actual Cubic Feet
NETL	National Energy Technology Laboratory
NPDES	National Pollution Discharge Elimination System
ORSANCO	Ohio River Valley Water Sanitation Commission
OZ	Ounce
PAC	Powdered Activated Carbon
PPM	Parts Per Million
PPT	Parts Per Trillion
QA/QC	Quality Assurance/Quality Control
SCA	Specific Collection Area
SCEM	Semi-Continuous Emissions Monitor
SS	Settleable Solids
STL	Separations Technology, LLC
TCLP	Toxicity Characteristic Leaching Procedure
TCR	Total Capital Requirement
TSS	Total Suspended Solids
UNDEERC	University of North Dakota's Energy and Environmental Research Center
US	United States
WKU	Western Kentucky University

Appendices A through G

Table of Appendices

A. QA/QC Plan

QUALITY ASSURANCE PROJECT PLAN
FOR

Longer-Term Evaluation of ADA Amended Silicates at a Coal-fired Power Plant

September 15, 2004

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TABLES:

Appendix A

1.0 INTRODUCTION

Amended Silicates LLC has been awarded a project to demonstrate its Amended Silicates™ mercury removal sorbent technology in a full-scale trial at a coal fired power plant. The trial is to be hosted by Cinergy at a site in Ohio and funded in part by US Department of Energy's National Energy Technology Lab (NETL).

The Amended Silicate sorbent technology, a direct replacement for activated carbon, is a powdered sorbent injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. This technology has been under development for the past two years with funding from the EPA and DOE, and has achieved success in demonstrating the sorbent at a pilot scale on a slipstream from a Colorado power plant.

To support EPA's announced intent to regulate the emissions of mercury from coal-fired power plants, NETL solicited proposals and recently selected eight of those proposals for cost-shared projects to demonstrate mercury control concepts at a commercial scale. The objective of the program is to gather data to document the performance of mercury control technology alternatives when installed and operated at full-scale (100-MW) generating units. One of the selected proposals is for the demonstration of Amended Silicates sorbent technology.

This demonstration of Amended Silicate sorbents will evaluate the control of mercury emissions from Cinergy's Miami Fort Unit 6 for a period of six weeks under various conditions. A consortium is being established to support the technical and financial requirements imposed by a long-term test of this technology. The consortium will include utilities with an interest in cost-effective mercury control technologies, especially those that permit continued sale of fly ash as a pozzolan material; mercury control technology suppliers (i.e., Amended Silicates LLC and its parent companies); an organization to lead the mercury measurement effort; a modeler to provide insight into the fluid mechanics of sorbent injection; and other interested parties. There is strong interest on the part of EPRI and the American Public Power Association in participating in the planned demonstration project.

Amended Silicates LLC is a joint venture company formed by ADA Technologies and CH2M HILL that is focused on the manufacture and sale of Amended Silicate sorbent. The Amended Silicates team is leading the technical effort of the demonstration project. Cinergy has offered its Miami Fort Unit 6 as a host site, and will provide on-site technical support during injection of the sorbent material. The mercury semi-continuous emissions monitors (SCEMS) will be provided by the University of North Dakota's Energy and Environmental Research Center (UNDEERC), and the Ontario-Hydro wet chemistry testing will be conducted by the University of Western Kentucky. Boral Material Technologies will perform tests of the collected sorbent plus fly ash to assess the impact of the added sorbent on the use of fly ash as a concrete additive. The ability to continue to sell fly ash is believed to be one of the significant advantages of Amended Silicate sorbents in comparison to activated carbon.

The project team of Amended Silicates LLC, ADA Technologies (ADA), CH2M HILL (CH2), Western Kentucky University (WKU), and the Energy & Environmental Research Center

(EERC) is committed to delivering consistent, high-quality research that meets our clients' needs and expectations. In order to ensure that the goals of this project are realized, an organization-wide quality management system (QMS), authorized and supported by ADA, CH2, WKU, and EERC managers, is in effect and governs all programs. As the QA/QC team leader, the EERC has an independent QA manager who oversees all aspects of QA/QC for projects involving the EERC. ADA, WKU, and the EERC project managers are responsible for ensuring that project-specific QA/QC protocols are followed.

2.0 QUALITY OBJECTIVES AND CRITERIA

The purpose of the project is to determine the effectiveness of the Amended Silicates sorbent technology for removing mercury from coal-fired flue gas at Cinergy's Miami Fort Power Plant. Therefore, the important data are the measurements of mercury concentration in the flue gas upstream of sorbent injection and downstream of the electrostatic precipitator (ESP) at the host site.

To measure mercury concentrations at the designated sampling locations two methods will be used, the first is mercury sampling by WKU involving using the Ontario Hydro Mercury speciation Method (ASTM D6784-02). This method is the generally accepted method for measuring speciated mercury in combustion flue gases. This method was selected by the U.S. EPA for the 1998 Information Collection Request and is considered a reference method for the EPA rule making process. The second method is the use of continuous mercury monitors (CMMs). This portion of the project will be conducted by the EERC. The most important QA/QC approach that the project team can implement is that personnel doing the sampling and analytical methods are highly trained in the procedures. All responsible organizations have done substantial testing using these methods.

2.1 Ontario Hydro Mercury Speciation Method

Table 1 presents data quality objectives for accuracy, precision, and completeness using the Ontario Hydro Method. As shown in Table 1, to help ensure the accuracy of the measurement, one field blank and one field spike will be collected at each sample location for each test condition. The field blank and spikes consist of a sample train that is assembled, and taken to the same location as a test sample, leak-checked, and recovered. The quality objective for a field blank is less than 15% of the typical sample values and 15% of the true spiked value for the field spike. If the field blank does not meet this criteria, the data must be flagged and corrective action be taken to discover the source of the contamination. (Note: This becomes possible because WKU will be doing the analyses of the samples on site. Therefore, the results will be obtained within 24 hours of receiving the samples.)

Table 1: Data Quality Objectives for Flue Gas Mercury Analysis

Measure	Objective	Approach
Accuracy	<10% of sample value or <10 × instrument detection limit	Reagent blanks – analyze one blank per batch of each reagent.
Accuracy	Field blank <15% of sample value	Collect and analyze one field blank at inlet and one at outlet per test condition
Accuracy	Field and Laboratory Spikes <15% of true value.	Collect and analyze one field spiked sample at inlet per test condition.
Precision	<10%	All laboratory samples analyzed in duplicate; every 10th sample analyzed in triplicate.
Completeness	100%	Any failed or incomplete test will be reviewed and, if necessary, repeated.*

*Whether a test failed or is incomplete will be determined by the sampling manager in consultation with principal investigator. Any failed or incomplete data that is not considered to cause an invalidation of a test will be flagged.

2.2 CMMs

As CMMs are still under development not all aspects of the QA/QC procedures have been established. The U.S. Environmental Protection Agency as part of the mercury rule making process for coal-fired power plants has begun establishing these procedures under provision of PS12A. The EERC has also begun establishing it own procedures and criteria, presented below. However, these may be modified prior to the initiation of the on-site testing or additional QA/QC requirement may be added.

- Leak check - leak rate must be less than 2.0% of total sample flow rate.
- Zero and span the analyzer by injecting either zero gas or a known quantity (concentration) of elemental mercury during initial setup.
- Check the span of the analyzer daily by injecting a known quantity (concentration) of elemental mercury at the analyzer or at the probe – the returned value will be within 5% of anticipated value or the instrument will be recalibrated.
- If a span check of the sampling system is performed by injecting a known quantity (concentration) of elemental mercury at location upstream of the particulate removal device – the returned value will be within 7.5% of the span value or +/- 1.5 $\mu g/m^3$ whichever is less restrictive. For this test program, each analyzer will have a complete system span check at a minimum of once per week. However, span checks will be done more frequently if instruments are found to be consistently out of calibration.

- Check the zero of the sampling system daily by sampling ambient air. The returned value will be less than 7.5% of the span value or +/- 1.5 µg/m^3 whichever is least restrictive. If the ambient concentration is greater than 5% of the expected sample concentration, use a source of zero air.

3.0 MERCURY SAMPLING QA/QC REQUIREMENTS

The major project quality control checks for the mercury sampling are presented in Table 2. In the event of an equipment failure or unit disturbance that could impact the validity of results, the principal investigator will be immediately notified by the sampling team member who notices the failure. The principal investigator will discuss the failure or disturbance with the team member, and makes a decision on whether to suspend or cancel sampling. Note that all team members are empowered to suspend sampling at any time for equipment problems. If the failure or disturbance is considered severe enough that the test objective cannot be met, the test will be canceled and repeated.

All sampling equipment will be pre-cleaned and calibrated according to the requirements of the reference methods. Prior to transport to the job site, sample trains are assembled, heated, and leak-checked to ensure operation of all sample train components. In addition, prior to the testing, all gas-sampling equipment will be calibrated according to the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III Stationary Source Specific Methods*. These records are maintained at WKU offices. These records are inspected by the QA/QC officer to ensure calibrations are being correctly done and that they are accurate.

Once equipment is setup for sampling, it is again inspected and tested to ensure everything is working properly. All testing personnel are well trained in sampling procedures and proper maintenance of sampling equipment. When sampling is to be done, enough sampling equipment will be on-site so that common spare parts are available. If necessary, spare parts can be shipped next-day to the site. If problems should arise with equipment on-site, this will be noted by the sampling personnel on the sample data sheet.

All glassware to be used for the tests will be properly cleaned according to the Ontario Hydro mercury speciation method prior to sampling and then checked to ensure that no glassware was broken. If the glassware has an unnoticed crack, it will not pass the pretest leak check and therefore will be replaced prior to testing.

Table 2: Checklist and Limits for EPA Methods 5/17 Sampling

Quality Control Activity	Acceptance Criteria and Frequency/Corrective Action	Reference
Pre-mobilization Checks		
Gas Meter/Orifice Check	Before test series, Y_D ±5% (of original Y_D)	Method 5, Section 5.3
Probe Heating System	Continuity and resistance check on element	
Nozzles	Note number, size, material	
Glassware	Inspect for cleanliness, compatibility	
Thermocouples	Same as Method 2	
Pretest Checks		
Nozzle	Measure inner diameter before first run	Method 5, Section 5.1
Probe Heater	Confirm ability to reach temperature	
Pitot Tube Leak Check	No leakage	Method 2, Section 3.1
Visible Inspection of Train	Confirm cleanliness, proper assembly	
Sample Train Leak Check	≤0.02 ft^3 at 15 in. Hg vacuum	Method 5, Section 4.1.4
During Testing		
Probe and Filter Temperature	Monitor and confirm proper operation	
Manometer	Check level and zero periodically	
Nozzle	Inspect for damage or contamination after each traverse	Method 5, Section 5.1
Probe/Nozzle Orientation	Confirm at each point	
*Post Test Checks**		
Sample Train Leak Check	≤0.02 ft^3 at highest vacuum achieved during test	Method 5, Section 4.1.4
Pitot Tube Leak Check	No leakage	Method 2, Section 3.1
Isokinetic Ratio	Calculate, must be 90%–100%	Method 5, Section 6
Dry Gas Meter Calibration Check	After test series, YD ± 5%	Method 5, Section 5.3
Thermocouples	Same as Method 2	
Barometer	Compare w/standard, ± 0.1 in. Hg	

* If these criteria are not met, the data must be flagged and an explanation given regarding the deviation and its effect on the data.

4.0 ANALYTICAL QA/QC REQUIREMENTS

The QA/QC checklist for the Ontario Hydro method sampling is shown in Table 3. The sample fractions for the Ontario Hydro method will be prepared and analyzed as specified in the method and summarized below:

1. *Ash Sample (Containers 1 and 2)* – The particulate catch will be analyzed using EPA Method 7043 or equivalent. If the particulate catch is greater than 1 gram (as would be the case at most particulate control device inlet locations), an aliquot of the particulate collected on the filter will be subsequently digested using EPA Method 3051.

2. *KCl Impingers (Container 3)* – The impingers are prepared using H_2SO_4, HNO_3, and $KMnO_4$ solutions as specified in the method.

3. *HNO_3–H_2O_2 (Container 4)* – The impinger solution is prepared using HCl and $KMnO_4$ solutions as specified in the method.

4. *H_2SO_4–$KMnO_4$ Impingers (Container 5)* – The impinger solution is prepared using hydroxyl amine sulfate as specified in the method.

Each prepared fraction is analyzed in duplicate for total mercury using cold-vapor atomic absorption spectrometer (CVAAS). CVAAS is a method based on the absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrometer. Mercury concentration is proportional to the indicated absorbance. A soda-lime trap and a magnesium perchlorate trap must be used to precondition the gas before it enters the absorption cell.

The CVAAS to be used for these tests is set up for absorption at 253.7 nm with a carrier gas of nitrogen and 10% stannous chloride in 10% HCl as the reductant. Each day, the drying tube and acetate trap is replaced and the tubing checked. The rinse container is then cleaned and filled with fresh solution of 10% HCl. After the pump and lamp are turned on and warmed up for 45 minutes, the aperture is set to the manufacturer specifications. A four-point calibration curve is then completed using matrix-matched standards. The detector response for a given standard is logged and compared to specifications to ensure the instrument has been properly set up.

A quality control standard of a known analyte concentration is to be analyzed immediately after the instrument is standardized in order to verify the calibration. This quality control standard is to be prepared from a different stock than the calibration standards. It is required that the values obtained read within 5% of the true value before the instrument is used. After the initial QC standardization is completed, standards are run every five samples to check the slope of the calibration curve. All samples are to be run in duplicate, and one in every ten samples is spiked to verify analyte recovery. These calibrations are recorded and maintained at WKU and become part of a quality control chart that is maintained at WKU to monitor the long-term precision of the instrument.

In addition to the routine calibration to be performed by the WKU, WKU will also routinely participate in round-robin studies. These records are to be maintained at the WKU offices.

Table 3: QC Checklist and Limits for Ontario Hydro Mercury Speciation

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Pre-mobilization Activities		
Reagent Grade	ACS reagent-grade	Ontario Hydro, Section 8.1
Water Purity	ASTM Type II, Specification D 1193	Ontario Hydro, Section 8.2
Sample Filters	Quartz; analyze blank for Hg before test	Ontario Hydro, Section 8.4.3
Glassware Cleaning	As described in Method	Ontario Hydro, Section 8.10
Pretest Activities		
Determine SO_2 Concentration	If >2,500 ppm, add more HNO_3–H_2O_2 solution	Ontario Hydro, Section 13.1.13
Prepare KCl Solution	Prepare batch as needed	Ontario Hydro, Section 8.5.1
Prepare HNO_3–H_2O_2 Solution	Prepare batch as needed	Ontario Hydro, Section 8.5.2
Prepare H_2SO_4–$KMnO_4$ Solution	Prepare for each day	Ontario Hydro, Section 8.5.3
Prepare HNO_3 Rinse Solution	Prepare batch as needed; can be purchased premixed	Ontario Hydro, Section 8.6.1
Prepare Hydroxylamine Solution	Prepare batch as needed	Ontario Hydro, Section 8.6.3
Sample Recovery Activities		
Brushes and recovery materials	No metallic material allowed	Ontario Hydro Section 13.2.6
Check for $KMnO_4$ Depletion	If purple color lost in first two impingers, repeat test with more HNO_3–H_2O_2 solution	Ontario Hydro, Section 13.1.13
Probe Cleaning	Move probe to predetermined clean area before cleaning	Ontario Hydro, Section 13.2.1
Impinger 1, 2, 3 Recovery	After rinsing, add permanganate until purple color remains to assure Hg retention	Ontario Hydro, Section 13.2.8
Impinger 5, 6, 7 Recovery	If deposits remain after HNO_3 rinse, rinse with hydroxylamine sulfate. If purple color disappears after hydroxylamine sulfate rinse, add more permanganate until color returns	Ontario Hydro, Section 13.2.10
Impinger 8	Note color of silica gel; if spent, regenerate or dispose	Ontario Hydro, Section 13.2.11
Blank Samples		
0.1 N HNO_3 Rinse Solution	One reagent blank per batch	Ontario Hydro, Section 13.2.12
KCl Solution	One reagent blank per batch	Ontario Hydro, Section 13.2.12
HNO_3–H_2O_2 Solution	One reagent blank per batch	Ontario Hydro, Section 13.2.12
H_2SO_4-$KMnO_4$ Solution	One reagent blank per batch	Ontario Hydro, Section 13.2.12
Hydroxylamine Sulfate Solution	One reagent blank per batch	Ontario Hydro, Section 13.2.12
Unused Filters	Three from same lot	Ontario Hydro, Section 13.2.13
Field Blanks	One per set of tests at each test location	Ontario Hydro, Section 13.4.1
Laboratory Activities		
Assess Reagent Blank Levels	Target <10% of sample value or <10× instrument detection limit. Subtract as allowed.	Ontario Hydro, Section 13.4.1
Assess Field Blank Levels	Compared to greater than 30% of sample values, investigate. Subtraction of field blanks not allowed.	Ontario Hydro, Section 13.4.1
Duplicate/Triplicate Samples	All CVAAS runs in duplicate; every tenth run in triplicate. All samples must be within 10% of each other; if not, recalibrate and reanalyze	Ontario Hydro, Section 13.4.1

5.0 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Samples will be handled in the field by a number of individuals, as listed below:

- The in-field manager will mix reagents, load and recover impinger trains and filters, collect reagent blanks, and maintain all custody records.
- The sampling crews will take custody of the loaded sample trains, transport them to the sample locations, assemble and disassemble the trains as necessary at the sample location, and perform probe and connecting line rinses.
- Coal samples will be collected by Power plant personnel.

Samples and reagents will be maintained in limited-access storage at all times. Chain-of-custody forms and sample labels will be made up prior to each test. The mercury data sheets will provide a detailed record of custody during sampling, with the initials noted of the individuals who load and recover impingers and filters and perform probe rinses.

6.0 DATA MANAGEMENT, DOCUMENTATION, AND RECORDS

The following steps will be taken to maintain data sheet custody and integrity:

1. All data sheets will be initialed by the person completing the data sheet and reviewed for completeness and accuracy.
2. The data sheets will be submitted to the principal investigator or field team leader, who reviews the data sheet for completeness and discusses any areas of concern or question with the person who completed the data sheet.
3. Data sheets are stored in a project notebook, which is kept in the custody of the project manager.
4. All data recorded on computers, such as test spreadsheets, are backed up daily and stored separately from the computer.
5. The data sheets are maintained by the project manager. Any changes or corrections are initialed and noted. These sheets will be made available for later inspection or comparison.
6. Original data sheets are used to make copies for inclusion in the final report and stored in company files with the original report. The length of storage is indefinite, but a minimum of 5 years is required.

Sample train data (filter ID, impinger weights, etc.) are recorded by the individual loading the train. Sampling information is recorded by the sampler. Sample train calculations (averages and total sample volume) are calculated by the sampler (or other available personnel) and recorded on the data sheet. The initials of the person performing the calculations are recorded on the data sheet. Analytical data is recorded by the Project Chemist. Analytical calculations are calculated by the Project Chemist or the Principal Investigator. The initials of the person performing the calculations are recorded on the data sheet.

7.0 ASSESSMENTS AND RESPONSE ACTIONS

The criteria to review and validate data will consist primarily of the comparison of results with the QA objectives and targets detailed in this document. Additionally, specific results will be reviewed to check for consistency and reasonableness. Table 4 presents a results evaluation and verification checklist. It is anticipated that most corrective action items will be minor, and immediate feedback will be given to the appropriate individuals. The QA/QC officer in consultation with the Project Manger will have the power to stop work if there is an issue that cannot be immediately resolved.

In the event there are items uncovered during a review that reveal a systemic problem or are worth communicating to the full project crew, a QA Action Memo will be issued. This will be issued to the entire team, with copies to Power Plant. Should the corrective action require any training in new procedures, such training will be conducted by the Project Manager or Principal Investigators or their designees.

Table 4: Results Evaluation and Verification Checklist

Measure	Objective
Unit Information	
Unit Operating Conditions	No unusual conditions
Air Pollution Control Device Operation	No unusual conditions
Sample Train Information	
Trains Leak-Checked Before/After Each Test	≤0.02 cfm
Pitot Probe Leak-Checked	Zero leakage
Filter Temperature Maintained	Minimum 120°C
Sample Isokinetics	90%–110%
Sample Volume	1 to 2.5 standard cubic meters
Post Test Color of Permanganate Impingers	Purple
*Results**	
Flow Rate for Triplicate Runs	All runs within 10% of mean (adjusted for load if necessary)
Moisture for Triplicate Runs	All runs within 10% of mean
Stack Temperature for Triplicate Runs	All runs within 10% of mean
Mercury for Triplicate Runs	All runs within 35% of mean
% of Mercury in as Particulate-bound	All runs within 25% of mean
% of Mercury in Oxidized Form	All runs within 25% of mean
% of Mercury in Elemental Form	All runs within 25% of mean

*If results are not within the criteria listed, the data must be flagged.

B. Demonstration Plan

AMENDED SILICATES™

CINERGY MIAMI FORT DEMONSTRATION PLAN

DOE NATIONAL ENERGY TECHNOLOGY LABORATORY MERCURY FIELD EVALUATION

Cinergy Miami Power Plant
Sorbent Injection into Cold-Side ESP for Mercury Control

Demonstration Plan Prepared for:

DOE National Energy Technology Laboratory

Cinergy Power Generation Services, LLC

Demonstration Plan Prepared by:

Amended Silicates LLC

December 30, 2005

PROJECT OBJECTIVES

The overall objective of this project is to characterize the effectiveness, cost and balance of plant impacts of mercury control on a coal-fired generating unit using Amended Silicates™ sorbent and activated carbon sorbent. A secondary objective is to show that the injection of Amended Silicates sorbent does not impact the use of fly ash as a cement replacement. The host site is Miami Fort Station's Unit 6. Unit 6 is owned by The Cincinnati Gas and Electric Company, which is a subsidiary of Cinergy Corp. This unit is equipped with a cold side electrostatic precipitator (ESP) for particulate control. In addition to measuring the ability of the candidate sorbents to remove mercury from the host unit flue gas stream, the project will evaluate the impact of sorbent injection on ESP performance and ash marketability. The demonstration will be conducted on the full exhaust gas stream of the unit, which burns eastern bituminous coal to generate a nominal 175 MW of electrical power.

PROJECT OVERVIEW

This demonstration is part of an overall program funded by the Department of Energy's National Energy Technology Laboratory (NETL) to obtain the necessary information to assess the costs of controlling mercury with sorbent injection and impacts on balance of plant equipment at coal-fired utility plants that will be subject to regulation of mercury emissions under recent EPA rulemaking. The economic analyses will be developed from data obtained from a variety of different host sites that reflect the range of plant configurations deployed in the U.S.

Demonstration Site Particulate Control

Miami Fort Station Unit 6 was chosen for this evaluation because of its combination of firing medium- to high-sulfur eastern bituminous coals with a cold-side ESP. The particulate control system is comprised of three electrostatic modules installed on Unit 6 over the life of the facility. In this evaluation dry sorbents will be injected into the ductwork upstream of the unit's ESPs, and vapor-phase mercury emissions measured downstream of the second of the three modules. Sorbent injection ratios will be modified to optimize the performance in terms of both mercury capture and emissions compliance in short-term evaluations, followed by a longer-term demonstration that will more thoroughly evaluate the operational impacts and costs at a specified target injection rate. This project also provides an opportunity to investigate the impact of dry sorbent injection on ESP operation and ash handling at the host site.

General Technical Approach

The demonstration at Miami Fort Station is part of a field evaluation program to study the implementation of mercury control technologies on full-scale coal combustors equipped with electrostatic precipitator (ESP) particulate control. It is the purpose of this project to obtain performance and operational data, and gather samples to determine the impact of these technologies on waste disposal and byproduct reuse. The method for controlling mercury will be dry sorbent injection. These evaluations will be carried out by installing a pre-engineered sorbent injection system and fabricating and installing injection lances in the Unit 6 ductwork late in 2005. Prior to start of the demonstration, the contents of the demonstration plan and operation of the sorbent injection equipment will be discussed in detail with operations personnel at the Miami Fort facility, who will provide technical support to the demonstration activity.

A series of parametric injection trials will be conducted to characterize the mercury removal from the host unit for two levels of mercury control. The maximum injection rate will be chosen based on mercury removal performance and practical limitations of ESP and ash impacts including the requirement for the unit to operate within its air permit requirements. At least two lower injection rates will be included in the trial so that predictive equations can be established to characterize mercury removal as a function of sorbent injection ratio for both the Amended Silicates sorbent material and activated carbon. Based on results from these parametric evaluations, Amended Silicates sorbent will be injected at optimized conditions for a period of thirty days to assess longer term impact to the ESPs, fly ash utilization, and auxiliary equipment operation. During the optimization and long-term sorbent injection segments of the demonstration, mercury levels will be measured upstream of sorbent injection and downstream of the combination ESP box using semi-continuous emissions monitors (S-CEM). On four different occasions during the demonstration, S-CEM measurements will be verified using the Ontario-Hydro wet chemistry mercury measurement method.

Following the Amended Silicate sorbent injection evaluation, an abbreviated parametric trial will be done with activated carbon to characterize its performance under a range of operating conditions. Once the parametric performance of the activated carbon injection has been established, a one-week demonstration at a fixed injection ratio will be completed.

The Amended Silicate sorbent to be injected during the demonstration at the Miami Fort power station was developed by ADA Technologies, Inc., and will be manufactured and marketed by Engelhard Corporation. This sorbent has been designated Amended Silicates G3 sorbent. The effectiveness of this sorbent has been demonstrated in laboratory tests and on a pilot-scale demonstration featuring coal-combustion flue gas. The powdered activated carbon sorbent is a lignite-derived activated carbon, supplied by Norit Americas. The Norit Darco FGD activated carbon has been used in several other full-scale evaluations so that results from this host site can be compared to data from other host sites.

SITE DESCRIPTION

The Cincinnati Gas & Electric Company, (CG&E) a subsidiary of Cinergy Corp. (Cinergy) (Cincinnati, OH) owns and operates the Miami Fort Station located in North Bend, Ohio. The plant operates four (5) coal-fired boilers generating 1,300-MW of electricity. Unit 6 is the planned host unit for this project. The 175-MW unit burns medium- to high-sulfur eastern bituminous coals and is equipped with electrostatic precipitator (ESP) particulate control equipment, a configuration that is representative of a significant number of the U.S. fleet of coal-fired power plants.

The design flow for Unit 6 is 630,000 ACFM at 300°F and an inlet pressure of –8” H_2O. There are three ESPs precipitators for Unit 6, commissioned and put into service over the life of the unit. The three electrostatic precipitators are arranged in series, and have been designated by plant personnel as “old-new”, “new-new”, and “old”. The oldest of the three units is located closest to the fan and stack, and is downstream of the old-new and new-new units. The old-new and new-new ESPs were built back-to-back and fully integrated, with the same cross-sectional dimensions such that there is no transition ductwork between the two. The old-new ESP has 3 rows of 4 sections, the new-new ESP has 3 rows of 4 sections, and the old ESP has 2 rows of 8 sections, but several of the rows of the old unit are currently blocked off. Figure 1 shows a schematic of the ESP layout for Unit 6.

Ash samples from individual ESP hoppers can be retrieved during the demonstration. The hoppers in the front rows of the combined old-new and new-new ESPs collect more of the flyash and thus are dumped more often than the rows toward the rear of the ESPs. The plant uses a wet ash-pull system for transferring ash to one of two ash ponds. Currently, Miami Fort Unit 6 does not market the flyash generated in Unit 6.

Throughout the project mercury concentrations in the flue gas will be quantified. The inlet mercury sampling ports are located downstream of the air pre-heater and upstream of the sorbent injection ports (not shown in Figure 1). The outlet mercury sampling locations are immediately downstream of the old-new/new-new ESP combined box, and upstream of the old ESP.

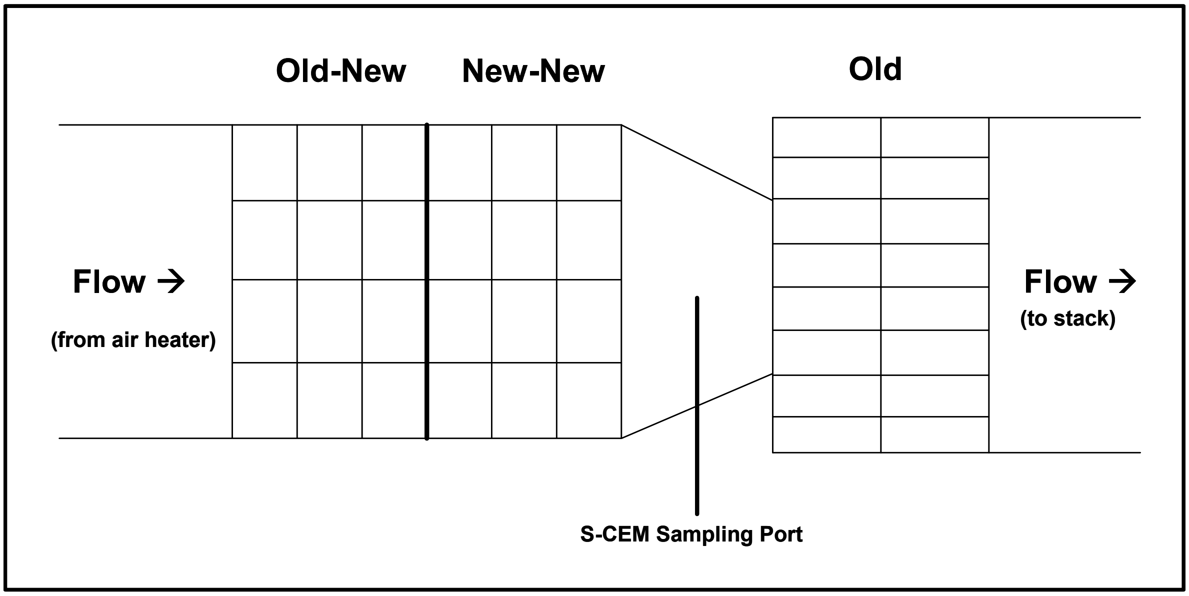


Figure 1 – Schematic of Cinergy's Miami Fort Unit 6 ESP Layout

TECHNICAL APPROACH

Sorbent for mercury control will be injected into the ductwork downstream of the air pre-heater and well upstream of the entrance to the ESPs. The run of duct between the injection location and the ESP entrance will allow a minimum sorbent residence time in the duct of 3 to 4 seconds. The planned evaluation matrix, specified in Table 1, is designed to provide a comprehensive data set that characterizes the performance of Amended Silicates and activated carbon in a full-scale coal-fired generating application.

As the lead implementation organization for Amended Silicates LLC, ADA Technologies, Inc. will provide technical personnel to manage the demonstration activities at the host site. Mr. Tom Broderick of ADA will serve as the site lead for Amended Silicates, directing technical operations during the demonstration and coordinating with the Miami Fort Station site liaison, Mr. Nick Melillo. Other on-site technical support will be provided as needed by ADA and other subcontractors, including CH2M HILL, UNDEERC, and WKU. The latter two organizations are providing specific expertise in the measurement of vapor-phase mercury in the host unit flue gas stream.

Mercury concentrations in the flue gas of the host unit will be measured using two techniques. In the first method, UNDEERC will operate two instruments to monitor mercury concentration semi-continuously upstream of the sorbent injection ports and downstream of the combination ESP box (see Figure 1). The second method will feature Ontario-Hydro wet-chemistry measurements performed manually by a team from Western Kentucky University. Chemical sample trains will be set up and operated by the WKU team at four selected times during the demonstration phase. A significant difference in these measurement techniques is that the semi-continuous monitoring instruments provide a near real-time measurement (data points generated every few minutes) as compared to a time-weighed-average mercury measurement determined over an one-hour sampling time for the Ontario-Hydro method. Mercury concentration measurements are also planned for coal and fly ash samples gathered routinely during sorbent injection, to be used in mercury mass balance calculations for the demonstration.

Table 1 – Project Demonstration Evaluation Matrix

Demonstration Period	Duration	Activities
Baseline	2 weeks	Measure mercury emissions with no sorbent injection
Amended Silicates	7 weeks	Measure mercury emissions for 2 weeks at varying Amended Silicates injection rates and conditions, return to baseline for one week, then operate for an extended period of 30 days at an injection ratio to be selected.
Activated carbon	1 week	Measure mercury emissions at two different activated carbon injection ratios

The demonstration project is comprised of three distinct phases: Preparation, Demonstration, and Analysis. Each phase will be accomplished through a series of tasks to be executed by the project team. Table 2 delineates the tasks, identifies the task leader, and describes task activities. In the last section of Table 2, key project-wide responsibilities are defined, including names of lead staff and their individual activities.

In April of 2005, Amended Silicates LLC signed an agreement with Engelhard Corporation to become a strategic partner to the DOE Cinergy Demonstration project, with primary responsibility for manufacture of the nominal 100,000 lbs of Amended Silicates sorbent needed for the demonstration. Engelhard is a Fortune 500 company whose primary business is the manufacture and supply of catalysts, sorbents, and other commodity chemicals for use in industrial processes. Their expertise in manufacturing will help produce a quality and consistent sorbent product for injection at Miami Fort Station.

Table 2 – Project Phases and Tasks

Task	Lead Staff	Activities
Phase 1, Preparation	**Joe Hammond**	
1.1 Project Planning	Jim Butz, Joe Hammond	Update project plan, budget, and schedule. Conduct kick-off meeting and issue Project Instructions to all project leadership staff. Complete modeling of duct to optimize design and placement of injection lances. Develop database for storage, management and retrieval of data. Initiate Health & Safety planning and QA/QC plan implementation.
1.2 Sorbent Preparation	Stan Mack (Engelhard)	Review and finalize sorbent quantity needs based on any updates to project plan, coordinate with manufacturing partner Engelhard Corporation to produce proper quantity of sorbent, plan for oversight, and delivery of finished product to the host site for protected storage.
1.3 Injection System	Joe Hammond	Design, order, fabricate, and install the injection system, including lances, delivery piping, and leased portable injection system. Include facility for receiving, storing of sorbent in “supersack” type packaging. Check out, calibrate, and test the system for proper operation.
1.4 Monitoring System	Dennis Laudal	Design and install probes, transfer lines, and CEM equipment to accomplish real-time monitoring of mercury emissions upstream of sorbent injection and downstream of first ESP. Start up and check out the system.
Phase 2, Demonstration	**Tom Broderick**	
2.1 Baseline Determination	Tom Broderick	Run CEMs for 2 weeks and collect coal, water, and ash samples, and analyze for mercury content to determine baseline mercury capture and emissions with no sorbent injected to the system. Include one round of Ontario-Hydro sampling to verify mercury emissions measurements.
2.2 Amended Silicates Demonstration	Tom Broderick	Run for 2 weeks over a range of sorbent injection ratios to check out system operation and investigate short-term dose/response relationships. Conduct same measurements, sampling, and analysis as conducted during the baseline task, 2.1. Include one round of Ontario-Hydro sampling to verify mercury emissions measurements. Return to baseline for one week to evaluate preliminary findings.

Task	Lead Staff	Activities
2.2 Amended Silicates Demonstration (continuation)	Tom Broderick	Inject Amended Silicates at a constant rate to be determined for 30 days to demonstrate performance in extended operation across plant operating conditions and to assess impact of sorbent injection on balance of plant equipment. Conduct same measurements, sampling and analysis as in Task 2.1, including two rounds of O-H sampling.
2.3 Activated Carbon Demonstration	Tom Broderick	Inject activated carbon sorbent at two different rates, 2-3 days at each rate. Conduct same measurements, sampling and analysis as conducted during the baseline task 2.1. No O-H sampling.
Phase 3, Analysis	**Jim Butz**	
3.1 Quality Assurance/ Quality Control	Dennis Laudal	Generate a project QA/QC plan for review and approval. Implement plan during demonstrations, providing weekly QA/QC updates. Prepare QA/QC summary for final report.
3.2 Analysis	Jim Butz	Manage transfer of project data into database and QA/QC review. Correlate information from multiple sources to generate data summaries that quantify effects of all project variables on results. As data accumulates, generate trend reports to help identify significant process parameters. Prepare mercury mass balances for each demonstration case. The trial data will be used to prepare a cost estimate for 55% and 80% mercury control based on Amended Silicates sorbent.
3.3 Reporting	Jim Butz	Prepare all administrative and technical reports specified in the contract. Identify appropriate conferences and prepare technical papers to disseminate project results. Develop website for project team communications.
3.4 Project Management	Jim Butz	Monitor progress of project against plan. Conduct review meetings with Advisory Board. Initiate corrective actions as needed to respond to quality, operations, budget or schedule issues. Communicate regularly with NETL program leadership. Approve invoices and payments.
Project-wide Responsibilities		
1. Safety	Ruth McCafferty	Develop project safety plan to cover all activities of the team staff and subcontractors. Instruct the team leadership in the implementation of the plan and conduct periodic reviews (at least twice during the project) to verify that the plan is being implemented properly.
2. QA/QC	Dennis Laudal	Prepare a project QA/QC plan to assure compliance with the latest versions of quality standards for project operations and mercury measurements. Implement the plan to maintain the quality of field data collected during the project.
3. Cinergy Services Project Manager	J. Michael Geers	Serve as overall host project manager.
3. Miami Fort Station Liaison	Nick Melillo	Serve as liaison between the ADA Project team and the plant staff. Approve on-site activities, make plant personnel assignments to support demonstration activities, provide for proper safety instruction regarding the site, coordinate changes that may need to occur in plant operations to accommodate the demonstration plan.

Project and Milestone Schedules

A project schedule documenting the start and end date for each task and dependencies among the tasks is provided in Figure 2. Key project milestones appear in Table 3.

Figure 2 – Project Schedule

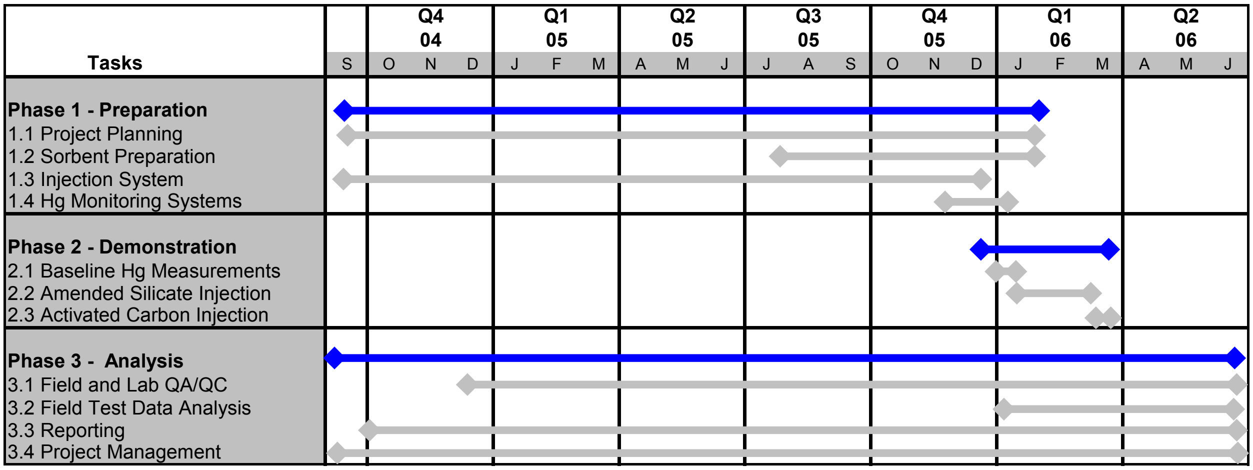


Table 3 – Key Project Milestones

Milestone	Date	Rationale
Project start	April 1, 2004	Signature of cooperative agreement by ASL
Completion of project planning	August 1, 2005	Preparation of detailed
Completion of Amended Silicates sorbents manufacture	December 2005	Manufactured lot of Amended Silicates sorbent must be available to conduct demo
Start of Phase 2, Demonstration	January 2006	Follows installation of injection system and monitoring systems, site delivery of Amended Silicates sorbent
Start of Task 2.3, Amended Silicates Demonstration	Late January 2006	Follows baseline mercury measurements on host unit.
Completion of Demonstration Phase	March 2006	All demonstration tasks completed
Project completion	July 2006	Final reports, invoices, payments all complete

Task 1.1 – Kickoff Meeting, Detailed QA Plan and Demonstration Plan

A kickoff meeting was held February 3, 2005 at Miami Fort Station with appropriate plant, project and environmental personnel from Cinergy. At this meeting the overall scope and timing of the program were discussed, along with the impact of the Clear Skies Initiative, mercury monitoring that will occur during the program, potential impact on plant equipment and operation, environmental permitting issues and site-specific goals. A task list for Cinergy and for other project participants was developed, to define and schedule activities that will require attention before the start of the demonstration effort at the host unit.

The QA/QC plan was drafted by the University of North Dakota Energy and Environmental Research Center in the fall of 2004. The draft document was reviewed by ADA Technologies on behalf of Amended Silicates LLC, and recommendations were developed for revisions to make the document comprehensive. A final version of the QA/QC plan was issued by UNDEERC in December of 2004, and is being used to guide QA and QC activities for the remainder of the project.

This document comprises the Demonstration Plan, and will be used to guide the activities on-site during performance of the demonstration, as well as analysis and interpretation of the data acquired. The results of the demonstration will be incorporated in an economic analysis that quantifies the cost of mercury control using Amended Silicates sorbent for the host unit. ADA Technologies is the lead organization for the preparation of the Demonstration Plan.

Task 1.2 – Sorbent Manufacturing

The demonstration schedule allows for the evaluation of two sorbent materials, Amended Silicates and powdered activated carbon. The powdered activated carbon is included as a benchmark sorbent that has been tested in many commercial demonstration programs to date. We will be using Darco FGD carbon, a lignite-derived activated carbon supplied by NORIT Americas.

The Amended Silicates sorbent has been developed by ADA Technologies, Inc. and is marketed by Amended Silicates LLC (ASL). Engelhard Corporation, a recent strategic addition to the ASL team, will apply their manufacturing and materials handling expertise to the production of a supply of 100,000 lbs of Amended Silicate sorbent material to be used in the demonstration. Engelhard has a long history of manufacturing quality products featuring chemical modification of commodity substrate materials. Engelhard will use its Elyria, Ohio plant for the sorbent manufacturing, which is now scheduled for December of 2005 and January of 2006.

Engelhard will work closely with technical personnel from ADA and CH2M HILL to assure that the commercial-scale sorbent manufacturing produces a consistent and high-quality product suitable for use in the demonstration. The Amended Silicates sorbent will be provided to the demonstration project at no cost to the DOE as a cost-share contribution on behalf of the project team.

Task 1.3 – Design and Fabrication of Site-Specific Equipment Needs

The primary process equipment for this project consists of the sorbent injection lances and sorbent metering system. Prototype injection lances were tested in ADA Technologies' laboratory to evaluate different injection nozzle configurations that can maximize uniform sorbent dispersion in the host unit gas flow. A full set of sorbent injection lances will be fabricated and delivered to the plant by the end of December 2005 for installation prior to the start of demonstration activities. Injection ports, sampling ports and access platforms will also be installed by the plant in December of 2005. Amended Silicates LLC will complete checkout of the mercury control equipment and calibrate the sorbent injection system prior to the delivery of Amended Silicates sorbent to the host site in December. The objective is to have the full sorbent injection system equipment operational by the end of December 2005.

Cinergy is responsible for arranging installation subcontractors and any support equipment such as forklift or crane needed for the installation effort. The installation effort will include anchoring of the injection metering skid, routing and anchoring the flex hose to supply air-conveyed sorbent to the injection lances, mounting the injection manifold, and providing and terminating utilities (electric power and compressed air) to the injection skid.

Sorbents will be injected using a transportable sorbent injection system (PortaPAC) leased from Norit Americas, Inc. The system consists of a super-sack handling overhead winch and a blower/feeder train rated at 350 lb/hr. Sorbent materials will be delivered in bulk 2.4 yd^3 super-sacks. Super sacks are hung in the injection system on a metal frame mounted. The sorbent is metered by variable speed screw feeder into an eductor that provide the motive force to carry the sorbent to the injection location in the host unit ductwork. A regenerative blower supplies the conveying air. A PLC system is used to control system operation and adjust injection rates to reflect programmed mass injection ratios for the host unit. A control signal representative of host unit load (electrical output, flue gas flow rate or other proportional parameter) is used by the PLC to control mass injection rate for the sorbent. The PLC can provide a proportional output signal to monitor speed of the feeder motor. Flexible hoses carry the sorbent from the feeder to a distribution manifold located downstream of the air pre-heater and upstream of the ESP inlet duct, supplying sorbent to the injection lances. The project team completed computation fluid dynamic (CFD) modeling of the sorbent injection and determined that four injection lances are needed to uniformly distribute sorbent materials in the flue gas duct. Amended Silicates LLC is responsible for providing a final list of utility requirements (electric power, water, compressed air) for the injection system. Responsibility for specifying the sorbent injection system and planning for installation rests with CH2M HILL.

Task 1.4 – Monitoring Equipment

UNDEERC will be responsible for installing and operating semi-continuous emissions monitoring (S-CEM) equipment to measure vapor-phase mercury concentrations at two locations in the host unit flue gas. Sample port locations have been identified upstream of the sorbent injection site and downstream of the combined ESPs.

A full temperature, velocity, particulate loading and mercury (total and speciated) traverse at the inlet and outlet sample ports at full load conditions will be conducted to determine profiles for appropriate sampling and sorbent distribution. The S-CEM will be placed at a location having an average flue gas velocity for sampling. While the first S-CEM is operational, the second S-CEM will be connected to the same sample port to verify that both are measuring identical mercury concentrations. The second S-CEM will then be moved to the outlet at a location identified from the traverse to have a duct-average concentration. Full duct traverses at the inlet will be conducted using the S-CEM to document variation in mercury concentration.

Task 2 – Field Demonstration

The field demonstration of mercury removal at Miami Fort Unit 6 using sorbent injection will be accomplished through a series of three subtasks. The use of both powdered activated carbon and Amended Silicates sorbents will be evaluated in the demonstration phase. ADA Technologies, Inc. will provide technical oversight for the activities at Miami Fort, with the presence at the host site of a senior engineer to direct the demonstration effort.

Key to the conduct of a successful demonstration will be the establishment of consistent operation of the host unit. This includes the use of a single coal source throughout the demonstration period, as well as consistent operation of the unit. In a recent trial of its mercury control sorbent, Amended Silicates noted that small differences in boiler operation (the level of excess air fed to the unit) resulted in substantial differences in vapor-phase mercury levels in the flue gas leaving the air preheater. Thus, it will be important to coordinate closely with the Miami Fort Station management to assure that operating conditions for the host unit are consistent throughout the trial. We anticipate that there may be some cycling of the unit, especially on weekends, but we will strive to minimize “one-time” excursions from normal and consistent unit operation.

A decision has been made to conduct the demonstration of Amended Silicates sorbent first, and then move on to the powdered activated carbon demonstration. This is due to the fact that injection of powdered activated carbon has contaminated the fly ash of host units for extended periods of time, as long as several months after injection was stopped. Such contamination would present a major problem to the demonstration, as one objective is to show that the use of Amended Silicates sorbent does not impact the sale of collected fly ash plus sorbent as a cement replacement. If residual carbon contaminated the fly ash during the Amended Silicates injection trial, this aspect of the demonstration could not be realized. By moving the powdered activated carbon injection demonstration to the end of the project, residual effects become a non-issue, as fly ash from the host unit is presently landfilled.

Subtask 2.1 – Baseline Measurements

Prior mercury measurement made at Miami Fort using the Ontario-Hydro measurement method during the ICR tests showed that there is very little or no control of mercury across the ESP. These data also indicated that the majority of mercury is in the vapor-phase as oxidized mercury. In this task, mercury measurements will be made using UNDEERC’s semi-continuous mercury analyzer and the Ontario-Hydro wet chemistry method by WKU. Baseline measurements will give UNDEERC and WKU a chance to check out gas sampling equipment and troubleshoot any difficulties encountered prior to the majority of measurements in this phase of the project. The first campaign of Ontario-Hydro testing will be completed during baseline testing.

All testing personnel will be required to follow written QA/QC procedures to assure the validity of collected data. The QA/QC Plan includes a description of the measurement methods to be used; instrument/equipment testing, maintenance and inspection procedures; instrument calibration and frequency; inspection/acceptance requirements for supplies and consumables;

procedures for checking data reduction and validation; and sample handling and chain of custody requirements. Standard methodologies and procedures have been established for all the vapor-phase mercury measurement methods to be used in the demonstration, therefore no new or unproved techniques will be introduced to the project.

At the same time, Miami Fort Station personnel will collect coal and fly ash samples during this effort to establish a database of mercury levels in coal and fly ash material. Collection protocols to be followed in this effort are presented in Appendices A to this plan. Fly ashes from the "old-new" and "new-new" ESP hoppers are not combined, so it is possible to retrieve ash samples from the individual ash hoppers. Fly ash samples will be collected during system checkout and tested for total mercury and leachable mercury using TCLP. Throughout the baseline tests, 5-gallon buckets of fly ash samples will be taken and held for DOE to perform some specific tests. At the same time multiple 5-gallon buckets of fly ash will be sent to Boral Material laboratories for use in concrete tests. Towards the end of the baseline study, four 55-gallon drums of fly ash material will be collected to supply Separations Technology, LLC with enough material to prepare a concrete test pad for evaluation of concrete strength and performance.

The fly ash collected from Unit 6 is not sold to a fly ash broker but instead is slurried and transferred to ash holding ponds. Miami Fort Station has an NPDES permit to discharge water from these ponds to the Ohio River as long as the total suspended solids (TSS) are within the permit limits. During baseline evaluations, pond water sample will be gathered for the analysis of TSS and/or other parameters. These data will be used for comparison to determine if there is a change in TSS or other water parameters when Amended Silicate or powdered activated carbon sorbents are injected into Unit 6.

Consistent operation of Unit 6 is important in order to validate the comparability of results from the several sorbents included in the demonstration and to confirm that the demonstrations are conducted under typical, sustainable operating conditions. It will be important to document fully the operating conditions of the host unit during the entire period of the demonstration. The main operating indicators of interest are described in Table 4. Operation of the ESP is critical to the success of sorbent injection for mercury control and will need to be well-characterized.

Table 4 - Data Elements Collected during Demonstration

PARAMETER	SAMPLE/SIGNAL/ EVALUATION	BASELINE	PARAMETRIC/ LONG-TERM
Coal	Batch sample	Yes	Yes
Coal	Plant signals: Burn rate (lb/hr) Quality (Btu/lb, % ash, % sulfur, ppb Hg)	Yes	Yes
Fly ash	Sample at each ESP hopper	Yes	Yes
Fly ash	Quality (% LOI, ppm tracer content, ppb mercury)	Yes	Yes
Unit Operation	Plant Signal: Boiler load Flow rates and temperatures Oxygen levels	Yes	Yes
Temperature	Plant signal at inlet and outlet of ESPs	Yes	Yes
Duct Gas Velocity	Full traverse, inlet and outlet	Yes	No/Yes
Mercury (total and oxidized)	Ontario-Hydro, inlet and outlet	Yes (1 set)	No/Yes (2 sets)
Mercury (total and oxidized)	S-CEM, full traverse, inlet and outlet	Yes	Yes
Sorbent Injection Rate	PLC, lb/hr	Yes	Yes
CEM data (NO_x, O_2, SO_2)	Plant data – at stack	Yes	Yes
Stack Opacity	Plant data	Yes	Yes
ESP Operation	Plant data (Primary and secondary ESP voltages and currents, rapper rates, hopper discharge, etc.)	Yes	Yes

Subtask 2.2 –Mercury Removal with Amended Silicate Sorbent

A series of parametric runs will be conducted at full-load and load-cycling conditions to document mercury removal performance for a minimum of three sorbent injection rates. These initial evaluations will be conducted over a 12-day period. The injection rates will be selected based on real-time response of the host unit in terms of mercury emissions reduction. Sorbent injection rates higher than about 20 lb/MMacf are thought to be impractical from an economic standpoint. Evaluations at higher injection rates may be considered as long as the ESP performance is not adversely affected, or air permit limitations are not exceeded. The removal rates will be determined from S-CEM measurements upstream of sorbent injection and at the outlet of the ESP. A low and an intermediate injection ratio will be evaluated in order to develop the data needed to identify the trend of removal efficiencies as a function of injection rates. Host unit operating and performance parameters to be monitored during the parametric runs are documented in Table 5.

It is imperative to fire the same coal in the host unit during the demonstration to allow valid comparison of Amended Silicate and powdered activated carbon sorbents. Arrangements with Cinergy's fuels group will be made in advance to procure sufficient quantities of the selected coal. Only the S-CEM will be used for continuous monitoring of mercury removal. Impact of sorbent injection on plant operations of equipment such as the host unit ESPs, changes in fly ash handling properties, and other parameters will be monitored throughout this period. On a periodic basis, data from the demonstration will be posted to the project website for team members' review. The on-site project engineer will be responsible for keeping the website database updated. At the end of the parametric trial period, Amended Silicates sorbent injection will be suspended while the project team reviews the data set to select operating conditions for the 30-day continuous injection trial that will complete the demonstration of Amended Silicates sorbent. This is anticipated to take no more than one week, during which additional baseline mercury removal data will be collected using the S-CEM instruments.

Table 5 – Data Collected During Amended Silicate Sorbent Evaluation

SAMPLE/SIGNAL/ EVAULATION	BASLINE EVALUATION	PARAMETRIC EVALUATION	LONG-TERM EVALUATION
Host unit operating parameters (see Table 4)	Yes	Yes	Yes
ESP Operation	Yes	Yes	Yes
Mercury S-CEM	Yes	Yes	Yes
Mercury Ontario-Hydro	**Yes**	**Yes**	**Yes**
Coal Samples	Yes	Yes	Yes
Hopper Ash Samples	Yes	Yes	Yes
Flyash Pond Water Samples	Yes	Yes	Yes

After reviewing the parametric demonstration data, mercury removal validation will be conducted for a long-term demonstration scheduled to last 30 days. During the demonstration the sorbent injection system will be operated to meet removal targets as agreed upon by the project team in consideration of the parametric trial results. The S-CEM will be used for continuous monitoring of mercury removal. Ontario Hydro measurements at the inlet and outlet will be conducted twice during the long-term demonstration. Unit operating data and mercury measurements will be compiled on a daily basis and posted on the project internet site by the on-site project engineer. The website will be secure and accessible only by project team members.

Throughout the 30-day demonstration, composite coal samples from each of the coal circuits and fly ash samples from individual ESP hoppers will be collected for chemical analyses. On a routine basis multiple 5-gallon buckets of fly ash will be sent to Boral Material laboratories for use in concrete tests. Buckets of fly ash will also be held for DOE for performing specific tests. In the third week of the long-term demonstration, four 55-gallon drums of fly ash material will be taken to supply Separations Technology, LLC with enough material to prepare a concrete test pad for evaluation of concrete strength and performance.

Subtask 2.3 –Mercury Removal with Benchmark Powdered Activated Carbon (Darco FGD) at Three Injection Rates

In a manner similar to the Amended Silicate sorbent demonstration, a series of parametric trials will be conducted at full-load and load-cycling conditions to document mercury removal rates for at least three sorbent injection ratios. The maximum injection rate is not to exceed 20 lb/MMacf carbon concentration in the flue gas. This maximum has been set because of the results of previous testing by others that show diminishing returns as well as precipitator performance impacts at high injection rates. Injection rates higher than about 20 lb/MMacf are thought to be impractical. Injection ratios approaching 20 lb/MMACF could result in unacceptable degradation of precipitator performance, which may prove to be the limited factor. The removal rates will be calculated using near real-time measurements from the S-CEM instruments sampling upstream of sorbent injection and downstream of the Unit 6 first ESP box. Two lower injection ratios will be evaluated in order to obtain data on mercury removal trends as a function of sorbent injection rates. Host unit operating and performance parameters to be monitored during this test are documented in Table 6. This phase of the demonstration is scheduled for one week.

Table 6 – Data Collected During Activated Carbon Evaluation

SAMPLE/SIGNAL/ EVALUATION	PARAMETRIC EVALUATION
Host unit operating parameters (see Table 4)	Yes
ESP Operation	Yes
Mercury S-CEM	Yes
Mercury Ontario-Hydro	**No**
Hopper Ash Samples	Yes
Flyash Pond Water Samples	Yes

Task 3 – Data Analysis

A comprehensive database will be established and populated as the demonstration trials are completed. ADA Technologies will take the lead in compiling records and performing trend analyses to identify relationships among the multiple parameters included in the study. To facilitate comparisons to other DOE demonstration projects, all mercury capture results will be presented in multiple formats, including emissions, expressed as lbs of vapor-phase mercury per trillion Btu, and mercury capture expressed as percent of upstream vapor-phase mercury content. The mercury capture data will be further analyzed to determine the incremental capture from the injected sorbent; that is, the mercury capture by the native fly ash will be subtracted from the inlet concentration and the adjusted mercury concentration used to calculate a “net” mercury capture by the sorbent, expressed as a percent of the revised upstream concentration.

Data collected during the field trials for the Amended Silicates and powdered activated carbon sorbents will be used to prepare a summary report on the effects of sorbent injection on mercury control and the impact on existing pollution control equipment. Various plant parameters will be monitored to determine if any correlation exists between changes in mercury concentration and measured plant operating conditions. This analysis will include a characterization of mercury levels and plant operation for baseline conditions, various injection rates, various temperatures (if determined appropriate), and the two sorbents used in the evaluation. This analysis will also identify effects of sorbent injection on operations and predict long term impacts.

Coal and fly ash samples taken during baseline and long term trials will be sent to a laboratory with experience in mercury measurements for analysis. Ultimate and proximate analysis and measurements for mercury, chlorine and sulfur of the coal will be performed. Ash samples will be analyzed for mercury, carbon and trace metal content. Since there are specific metals in the Amended Silicates sorbent material that do not typically appear in coal, trace metal content of the flyash can be used to determine the distribution of sorbent material among the various ESP ash hoppers.

Gas-phase mercury data from the S-CEM and Ontario-Hydro measurements will be reviewed to compare the form (total and oxidized) and concentration of vapor-phase mercury at the upstream and ESP outlet locations at full load and load-cycling conditions. By including with mercury content data for the coal and flyash samples, a mercury mass balance around the plant will be made for baseline and long-term trials. When preparing technical reports, articles, or presentations for this project, the mercury removals and outlet mercury concentrations gathered during the field evaluations will be reported on a pound Hg/trillion Btu basis. The calculation to determine the concentration of mercury on a pound Hg/trillion Btu basis shall be based on the following reference: 40 CFR, 7/1/04 edition, Ch 1, Appendix F to Part 75, supplemented by the amendment, Procedure for Hg Mass Emissions in EPA's 3/16/04 proposed mercury rules. In the case where a fuel analysis is available, the use of a calculated F-factor is recommended. In the case of coal blends, a proportional weighted F factor can be calculated based on the blend percentage on a Btu basis. If a fuel analysis is not available, the use of the F factors listed in Table 1 of Part 75, Appendix F will be used for these calculations.

Subtask 3.1 Waste Characterization

Ash generated by other units at Miami Fort Station is beneficially reused. There are two main concerns of the waste characterization effort: one is assessing the stability of the mercury contained on the ESP collected materials, and the other is whether the presence of the sorbent collected with the ash affects its marketability and/or mercury leachability. The standard testing technique used for assessing hazardous waste characteristics is the Toxicity Characteristic Leaching Procedure (TCLP, SW846-1311). Tests to determine the marketability of fly ash materials are described below and will be conducted by Boral Material Technologies, a fly ash broker. These tests will be performed to establish a record of the wastes generated during the program.

Fly Ash Characterization:

Project samples representing baseline fly ash, fly ash samples collected during Amended Silicates sorbent injection demonstrations and fly ash collected during activated carbon evaluations at two different injection rates will be characterized by chemical and physical testing methods consistent with industry standards such as ASTM C618 and C311. The results from this testing will contribute to an evaluation of the suitability of host unit fly ash mixed with Amended Silicates sorbent for use in concrete as a cement replacement. Most of this testing will be performed by Boral Material Technologies as a cost-share component of the project. Boral is a major marketer of fly ash from coal-burning power plants in the U.S. They are contributing performance of the planned testing as a cost-share item to the project. Boral has specified that a sample size of about five gallons will be adequate for their test suite.

The host unit is known to generate elevated levels of unburned carbon (also known as LOI, or loss on ignition, material) under certain operating conditions. Separation Technologies, LLC (STL) has commercialized a process for the removal of unburned carbon from fly ash with a high LOI content and has expressed interest in evaluating the use of Amended Silicates sorbent for mercury control in conjunction with their separation process. STL has agreed to perform separation tests on a 100-lb sample of fly ash mixed with Amended Silicates sorbent. The separation test will be run in a pilot facility at STL's laboratory in Massachusetts. The low-carbon fraction from the STL process will be subjected to several tests to validate its suitability for use in concrete. This fraction will also be analyzed to confirm that the Amended Silicates sorbent resides primarily in the low-carbon fraction. This is important since a bonus feature of the STL process is that the high-carbon fraction can be recycled to the furnace to recover its heating value. STL has offered to complete this analysis at no cost to the project. To provide material to STL, samples of fly ash with high LOI content will be extracted from the host unit under appropriate operating conditions during baseline mercury measurements and during injection of Amended Silicates sorbent. These samples will then be shipped to STL for separation and subsequent testing. Results will be discussed in the project final report and in presentations of project data at conferences.

Evaluation of Fly Ash Impact on Air Entrainment in Mortar (Boral Material Technologies):

Testing of the above referenced samples with respect to the impact of Amended Silicates sorbent on air entrainment will be conducted in mortar. The samples shall be tested per a suite of ASTM test protocols, including ASTM C143, C231, C39, and C138. Data shall be inserted into the project database for analysis and inclusion in the final report. Testing will be conducted on fly ash samples from the host unit mixed with varying dosages of common commercial air entraining chemical admixtures. From the test results air response curves will be generated which accurately reflect the influence of Amended Silicates on air entrainment. Boral has significant testing experience with this type of approach and has found good correlations of mortar air test results with concrete air entraining agent data. The mortar air method allows one to quickly run a number of small-scale screening tests prior to initiating large concrete tests.

Evaluation of Fly Ash Impact on Air Entrainment in Concrete (Boral Material Technologies):

Testing of the above referenced samples will be conducted in concrete to corroborate mortar test results and to characterize the samples' influence on air entrainment in concrete. Laboratory scale concrete batches will be prepared and tested in accordance with industry standards.

Evaluation of Concrete Performance (Boral Material Technologies):

Laboratory batches of air entrained concrete, incorporating the above referenced samples, will be produced at a constant water content, and air content for testing of fresh and hardened concrete properties including: slump, unit weight, yield, temperature, air content, compressive strength (at ages of 3, 7, 28, and 56 days), and permeability. Testing will be conducted in accordance with industry practices.

Mercury Leachability Testing (ADA Technologies, Inc.):

The standard test protocol to assess leachability of metals in wastes is the TCLP. This test involves exposing a 100-gram sample of ash to 1-liter of acidic solution (acetic acid-or acetate based) for 18+/-2 hours. The solution is then analyzed for several metals (including mercury) to determine how much of each target metal was leached from the solid sample. Results are compared against limits established by regulation. In the case of mercury, a maximum leachable level of 0.2 mg/liter has been established. (Note: in most cases the TCLP limits for mercury cannot be exceeded even if all the mercury leaches from the sample, as the concentrations of mercury are quite low).

In addition to TCLP testing on selected fly ash samples, a second series of tests will be performed to address the potential long-term environmental impact of the mercury-laden ash plus sorbent. Stability of mercury on fly ash will be characterized by conducting leaching tests using a method known as the synthetic groundwater leaching procedure (SGLP) (Hassett, et al., 1987). This test is modeled after the TCLP, with modifications to allow for disposal scenarios. A shake extraction technique is used to mix the solid sample with an aqueous leachate solution. Aliquots of the liquid are then analyzed after 18 hours, 2 weeks, and 4 weeks. Total mercury on the ash plus sorbent samples will also be determined using U.S. EPA Method 245. In this method, samples are digested in aqua-regia solution to solubilize the associated mercury. The leachate from the digestion is then analyzed for total mercury by spectroscopic analysis using cold vapor atomic absorption. Both of these tests will be conducted by ADA Technologies, Inc.

Subtask 3.2 – Analysis of Field Trial Data Set

Project data will be collected and stored in a database to be located on the project website. The database will include information on host unit operating conditions as well as data from S-CEM and Ontario-Hydro mercury measurements and sorbent injection system performance. Access to the project website and its associated data base will be restricted to project team members and the DOE technical specialists providing oversight to the cooperative agreement. The database will offer a means to allow comprehensive access to the data collected during the trial to those with a specific interest in the project. Data will not be posted to the database until it has been subjected to a QA/QC review.

The database will be comprised of the following elements:

- Daily records of unit operating conditions from the plant digital control system, as hourly averages;
- Spreadsheets of manually recorded data from the ESP (primary and secondary voltages and currents for the multiple TR sets, rapping and ash-handling schedules);
- Daily records from the S-CEMS used for mercury measurements upstream of sorbent injection and downstream of the plant ESP;
- Summaries of results from Ontario-Hydro wet chemistry sampling of flue gas for mercury content;
- Mercury analyses of coal and fly ash samples to be used in the preparation of mercury mass balances for the host unit;
- Daily operation logs that describes activities undertaken in support of the sorbent trial;
- A daily record of the sorbent injection rate, generated from the injection skid.

An ADA technical staff member will be on-site for the entire trial period, to oversee operations and to maintain a strong interface with plant personnel assisting in the trial. This engineer will also spend considerable time analyzing the data, correlating information from the multiple sources and exploring the full data set to identify trends. These analyses will also be posted to the website to provide insight to the trial for all interested team members.

Subtask 3.3 – Design and Economics of Site Specific Control System

After completion of testing and analysis of the data, the requirements and costs for full-scale, permanent commercial implementation of the necessary equipment for mercury control using sorbent injection technology will be determined. Team member CH2M HILL will generate a cost model including process equipment for plant-specific requirements (reagent storage capacity, plant arrangement, retrofit issues, winterization, controls interface, etc.). A conceptual design document shall be developed with equipment lists. Modifications to existing plant equipment shall be determined and a work scope document developed based on input from the plant that may include modifications to the particulate collector, ash handling system, compressed air supply, electric power capacity, other plant auxiliary equipment, utilities and other balance of plant engineering requirements.

A cost estimate to implement the control technology will be developed. This shall include capital cost estimates for mercury control process equipment as well as projected annual operating costs, and mitigating factors such as ash sales. Where possible, an order-of-magnitude estimate will be included for plant modifications and balance of plant items. The cost estimate will be presented in terms of dollars per pound of mercury captured from the flue gas and as a levelized bus bar cost in mills per kilowatt-hour.

Subtask 3.4 – Final Report

A project final report documenting all measurements, test procedures, analyses, and results obtained during the trial will be prepared. This report shall be a stand-alone document providing a comprehensive review of the evaluation data analysis.

KEY PERSONNEL

Mr. James Butz is the overall program manager and principal investigator for Amended Silicates LLC. Mr. Butz is the General Manager of ASL, as well as Vice President of Operations for ADA Technologies, Inc. one of ASL's parent companies. Mr. Tom Broderick is coordinating the efforts on site on behalf of ASL. He is also acting as project manager for the field evaluation at Miami Fort. Mr. Michael Geers of Cinergy Services is the principal contact for the host utility, and Mr. Dominic Melillo is serving as the technical interface at Miami Fort Station. Table 7 presents contact information on key personnel, their roles, phone numbers, and e-mail addresses for the Miami Fort field evaluation.

Table 7 - Key Project Personnel for Miami Fort Sorbent Injection Evaluation

NAME	COMPANY	ROLE	PHONE # & EMAIL
J. Michael Geers	Cinergy Corp.	Project Manager	(513) 287-3839 Michael.Geers@Cinergy.com
Dominic Melillo	Cinergy Corp.	Project Engineer Miami Fort Station	(513) 467-4963 Nick.Melillo@Cinergy.com
Darwin Yung	Cinergy Corp.	Engineering & Construction Team Group Leader, Miami Fort Station	(513) 467-4875 Darwin.Yung@Cinergy.com
Jim Butz	Amended Silicates LLC	Principal Investigator	(303) 874-8276 Jimb@adatech.com
Joe Hammond	CH2M HILL	Deputy Principal Investigator	(720) 286-5919 (cell) Joe.Hammond@ch2m.com
Tom Broderick	ADA Technologies, Inc.	Demonstration Phase Leader	(303) 913-6621 (cell) Tomb@adatech.com
Stan Mack	Engelhard Corporation	Manager, Stationary Source Business	(732) 205-6174 Stan_Mack@engelhard.com

REFERENCES

Hassett, D.J., 1987, "A Generic Test of Leachability: The Synthetic Groundwater Leaching Method," North Dakota Mining and Mineral Resources Research Institute, Grand Forks, North Dakota.

Coal and Fly Ash Sampling Protocols

Coal and Flyash Sampling Protocols

In addition to the gas-phase mercury measurements, ADA Technologies will obtain samples of coal and fly ash during baseline and sorbent injection tests. Samples will be analyzed for mercury by Cinergy to perform an overall mercury balance on Unit 6. This section describes the methods by which coal and fly ash samples are to be taken from the Cinergy Unit 6 equipment.

Safety Considerations

Safety must be first and foremost. The proper personal protective equipment (PPE) must be used during all operations at the Miami Fort Station during the demonstration project. PPE should include but not limited to a hardhat and safety glasses with side-shields. A pair of leather work gloves may also be useful.

Coal Sample Collection Protocol

The Miami Fort Station burns run-of-the-river coal and hence can vary widely. Performing a mercury material balance during the demonstration project requires knowledge of mercury content in the coal. Typically, coal has a mercury content ranging from 0.5 to 1.0 ppb (weight) depending on the type of coal. Because of the expected variability in the coal material, coal samples shall be taken daily throughout the demonstration period and analyzed for mercury content. Samples shall be labeled and handed off to a Miami Fort representative for delivery to an analytical laboratory for analysis. Coal sampling will be done only Monday through Friday by plant technicians or co-op workers. ADA representatives will need to collect composite coal samples during the weekends.

Unit 6 has five coal systems that supply coal to the boiler. Each system has a bunker to store roughly sized coal, a feeder to control coal flow to the pulverizer, a pulverizer to grind the coal to a fine powder, and several distribution lines to feed the pulverized coal to the burners. Each feeder has a 12” X 6” sampling port that can be used to extract coal as it is fed to the pulverizer.

The sampling procedure is as follows. There is a sample port on each of the coal circuits to pull a coal sample. The sample port has a dead volume that fills with coal from days gone by. In order to get a representative coal sample of the coal being fed to pulverizes, coal in the dead volume must be taken out of the sampling port and discarded. Once the sample port has been purged of old coal, a representative coal sample can be taken. Coal samples shall be taken from each of the operating feeders. Obtain approximately one (1) pound of coal from each feeder. Transfer individual coal samples to a 5-gallon bucket and combine. Take approximately one (1) pound of the composite coal and place in a plastic bag. Laminate the bag to prevent spillage. Label each bag as follows:

Study: Cinergy Sorbent Injection Demonstration

Sample Type: Coal

Date: 2/09/06

Time: 15:23

Unit: 6

Promptly clean up any coal spills in the area. Accumulate the excess coal in a 5-gallon bucket. At the end of the day empty the contents of the bucket into the bunker. Deliver coal samples to a Miami Fort representative for analysis. See Table 1-A for requested analyses for coal samples.

Fly Ash Sample Collection Protocol

Fly ash is separated from the combustion gas in a series of three electrostatic precipitators (ESP) designated by plant personnel as “old-new”, “new-new”, and “old”. The old ESP is not included in the demonstration. Ash samples from individual ESP hoppers can be retrieved during the demonstration. The hoppers in the front rows of the combined old-new and new-new ESPs collect more of the flyash and thus are dumped more often than the rows toward the rear of the ESPs. The plant uses a combination of dry and wet ash-pull system for transferring ash to one of two ash ponds.

In all, there are 30 fly ash hoppers associated with the ESP (See Figure 1-A for the fly ash hopper numbering scheme). Sampling will be done using two methods. The first method will be to sample all thirty hoppers. This method will only be done three times during the program; once to determine which hoppers collect representative ash material (baseline test), once to verify where in the ESP system the Amended Silicate sorbent material accumulates (Amended Silicate parametric tests); and a final time during the 30-day Amended Silicate injection trial. An on-site ADA engineer will determine and request when this method should be implemented. The second method will be the normal procedure and calls for sampling specific hoppers on a daily basis. The actual hoppers to sample will be determined during the baseline test period. Fly ash sampling will be done only Monday through Friday by plant technicians or co-op workers. ADA representatives will need to sample fly ash hoppers on the weekends.

The procedure to obtain fly ash samples is now described. The gate valve that dumps the fly ash into the header pipe is pneumatically operated. Above each of the gate valves is a pipe extension with a 3” ball valve that can be used to extract a fly ash sample. The procedure for obtaining a fly ash sample is as follows:

- Open the 3” ball valve on the pipe extension located above the gate valve
- Insert extraction stick (with bottle connected on the end) into the pipe extension and scoop the ash into the bottle
- Close the 3” valve

Obtain approximately one (1) pound of fly ash from each hopper. Keep the fly ash samples in separate plastic bags. Laminate bags to seal. Label each bag as follows:

Study: Cinergy Sorbent Injection Demonstration

Sample Type: Fly ash

Date: 2/09/06

Time: 15:23

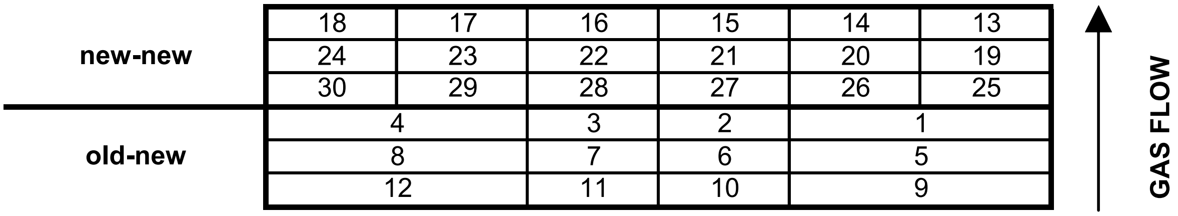
Unit: 6

Hopper # (1-30): 9

Promptly clean up any fly ash that spills while sampling. Excess fly ash can be accumulated in a 5-gallon bucket. At the end of the day the contents of the bucket can be vacuumed into the header pipe using a hose. Deliver fly ash samples to a Miami Fort representative for analysis. See Table 1-A for requested analyses for fly ash samples.

Table 1-A - Chemical Analyses Requested for Coal and Fly Ash Samples

Sample Matrix	Analyte
Coal	Btu/pound
	Percent Ash
	Mercury Content (ppb)
Fly Ash	Percent LOI
	Trace Metal Content (ppb)
	Mercury Content (ppb)



	18	17	16	15	14	13
new-new	24	23	22	21	20	19
	30	29	28	27	26	25
	4		3	2	1	
old-new	8		7	6	5	
	12		11	10	9	

flow is thru hoppers 9-12 first, and 13-18 last

Figure 1-A – Fly Ash Hopper Numbering

C. SCEM Report (UNDEERC)

November 9, 2006

Mr. James Butz
Vice President of Operations
ADA Technologies, Inc.
8100 Shaffer Parkway, Suite 130
Littleton, CO 80127-4107

Dear Mr. Butz:

Subject: Final Report Entitled "Evaluation of an Amended Silicates, LLC, Mercury Sorbent Using Mercury Continuous Emission Monitors as Part of a Full-Scale Demonstration"
EERC Fund 5152

Enclosed please find the original and one copy of the subject report. Also enclosed are two copies of the electronic version of the subject report. I believe I have addressed your comments on the draft final sent to me on September 1, 2006. If you have any comments or questions, please contact me by phone at (701) 777-5138, by fax at (701) 777-5181, or by e-mail at dlaudal@undeerc.org.

Sincerely,

Dennis L. Laudal
Senior Research Advisor

DLL/jlk

Enclosures

EVALUATION OF AN AMENDED SILICATES, LLC, MERCURY SORBENT USING MERCURY CONTINUOUS EMISSION MONITORS AS PART OF A FULL-SCALE DEMONSTRATION

Final Report

(For the period of June 15, 2004, through June 30, 2006)

Prepared for:

Mr. James Butz

Vice President of Operations
ADA Technologies, Inc.
8100 Shaffer Parkway, Suite 130
Littleton, CO 80127-4107

Prepared by:

Dennis L. Laudal

Energy & Environmental Research Center
University of North Dakota
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2006-EERC-11-04

November 2006

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EERC DISCLAIMER

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EVALUATION OF AMENDED SILICATES, LLC, MERCURY SORBENT USING MERCURY CONTINUOUS EMISSION MONITORS AS PART OF A FULL-SCALE DEMONSTRATION

1.0 INTRODUCTION

In 2004, ADA Technologies was selected for an award as part of the U.S. Department of Energy's (DOE's) Phase II Mercury Program. The contract was then novated to Amended Silicates, LLC (ASL), to do a full-scale demonstration of its novel Amended Silicate^{TM} sorbent at Cinergy's Miami Fort Station. The overall objective was to demonstrate 55% mercury control above baseline in a manner that would not impact fly ash salability at a cost significantly less than using standard powdered activated carbons (PACs) to obtain the same level of control.

To provide speciated mercury measurement data to support this project, ASL contracted with the Energy & Environmental Research Center (EERC) to provide two continuous mercury monitors (CMMs) to be located upstream of the electrostatic precipitator (ESP) (upstream of the Amended Silicate injection) and at the ESP outlet. In this way, the mercury removal resulting from sorbent injection could be determined. ADA Technologies also contracted with Western Kentucky University (WKU) to do periodic Ontario Hydro (OH) sampling to provide additional mercury speciation data and to support the CMM data.

In addition to providing CMMs for the project, a second EERC objective was to provide overall quality control/quality assurance (QA/QC) for the project. The QA/QC objectives for the project are provided in Appendix A.

2.0 DESCRIPTION OF THE CMMS USED FOR THE PROJECT

Both of the CMMs used for this project were PS Analytical (PSA) Sir Galahads with wet-chemistry pretreatment/conversion systems. The instrument located upstream of the ESP was equipped with a Baldwin inertial separation probe (ISP). Because of the low dust loading at the outlet of the ESP, initially only a thimble filter was used. However, later in the test an Apogee ISP was installed.

The PSA uses a batch process in which mercury is collected on a specialized gold trap and then desorbed into a cold-vapor atomic fluorescence (CVAF) analyzer. Between 0.5 and 2 L/min of flue gas (depending on mercury concentration) is pumped through a gold trap, which is maintained at a constant temperature. Once the mercury has been adsorbed on the gold trap, the trap is removed from the flue gas stream and flushed with argon. The mercury is then desorbed from the gold trap at 500°C using a heating coil. The mercury is then carried to the CVAF analyzer using argon as a carrier gas. Once the mercury has been desorbed from the trap, it is rapidly cooled with additional argon. To speed up the measurement process, a dual gold trap is used. As one trap is adsorbing mercury, the second trap is being desorbed. The approximate time for each measurement is 2–5 minutes. The mercury concentrations can be measured from about 1 ng/m^3 to 150 µg/m^3, making this instrument ideal for measuring the low concentrations (<5 µg/m^3) often found in flue gas generated from coal-fired systems.

Both of the PSA CMMs are calibrated using two different methods, but both use Hg^0 as the primary standard. The first method uses direct injection. In this method, the Hg^0 is contained in a closed vessel held in a thermostatic bath. The temperature of the mercury is monitored, and the amount of mercury is calculated using vapor pressure calculations. The second method involves the use of a CAVkit. This is essentially the same method except that it is automated. Rather than using a syringe to inject the mercury, a constant stream of a known concentration of mercury vapor is produced. Typically, the calibration has proved stable over a 24-hr period. For this test, the inlet CMM was calibrated using direct injection and the outlet using a CAVkit. Based on extensive testing done in the past year, we have noticed a small difference between the two calibration methods of about 15% (CAVkit being higher). This is due to inconsistencies in the mercury vapor pressure curves. The National Institute of Standards and Testing is currently attempting to develop new and more accurate vapor pressure curves for mercury.

The gas pretreatment/conversion system used to protect the gold trap from HCl and convert all the mercury to Hg^0 was a wet-chemistry system developed by PSA and the EERC. A schematic of the wet conversion system is shown in Figure 1. The system uses a once-through sodium hydroxide solution to remove the SO_2 and HCl and stannous chloride to reduce oxidized mercury (Hg^{2+}) to elemental mercury (Hg^0). Following the sodium hydroxide once-through, the flue gas passes through the KCl solution, thereby removing the Hg^{2+} and allowing measurement of Hg^0 alone.

3.0 TEST DESCRIPTION

The project was divided into four distinct phases as follows:

- Baseline testing, beginning January 9–25, 2006
- Parametric testing, January 26 – February 12, 2006
- Longer-term testing, February 13 – March 15, 2006
- Testing with Norit PAC, March 16–22, 2006

The baseline tests were designed to determine the mercury concentration and speciation at the inlet and outlet of the ESP at the Cinergy Miami Fort Station without injection of any sorbent material. The parametric tests were to optimize the process, and the longer-term tests were to evaluate the sorbent's effectiveness over a 1-month period. At the end of the project, it was decided to also compare the mercury removal of the ADA sorbent with that obtained with the standard Norit PAC.

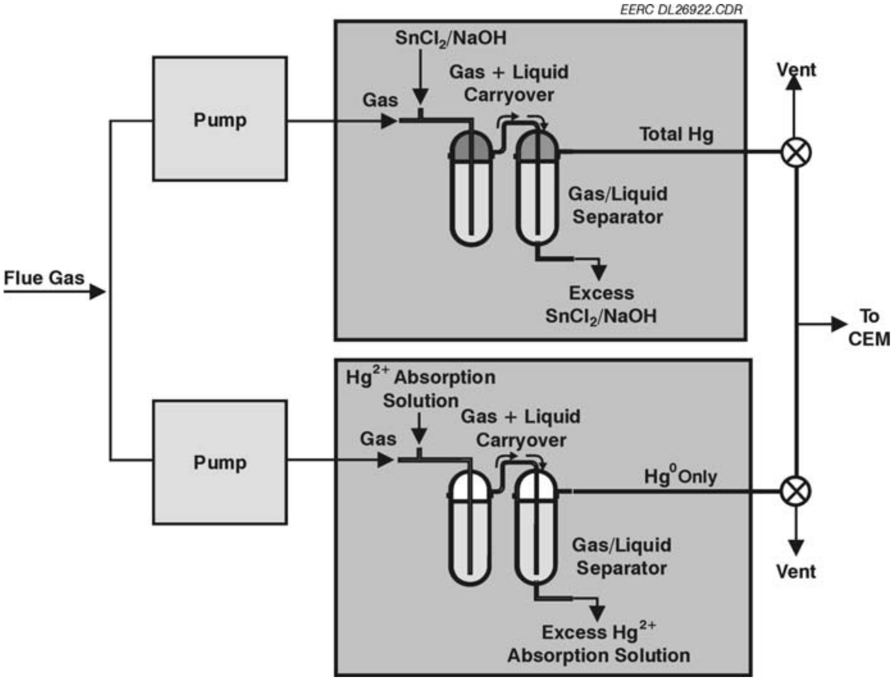

Figure 1. Schematic of pretreatment/conversion system used with CMM.

For each portion of the test program, the EERC operated CMMs as continuously as possible. Also, at various times in the program, WKU did OH method testing at the same locations, allowing a comparison of two different measurement methods.

4.0 INSTRUMENT AND PROCESS VARIABILITY

There was substantial variability in the CMM data collected at Miami Fort as a result of two factors. The first is the natural variability in the coal mercury. As is typical for utilities firing eastern bituminous coal, Miami Fort purchased coal from several different mines. As a result, there were several times during the test where marked changes in the mercury concentration measured both upstream and downstream of the ESP. This variability has been noted elsewhere. For example, it was observed during the U.S. Environmental Protection Agency (EPA) relative accuracy test audit (RATA) being performed at the Trimble County Power Plant that step changes in mercury concentrations occur in relatively short time frames (1).

The second source of the variability is a direct result of the CMM. An important factor determining monitor variability is temperature. In fact, ambient, probe, and heat trace line temperatures all can impact mercury variability. During the testing, attempts were made to keep the probe and heat trace line as hot as possible to prevent acid condensation from occurring in the instrument. Small acid condensate droplets that can absorb mercury form in the sample lines, and once these droplets get large enough, they disperse into the conversion/stripping solution, resulting in high mercury spikes for one or two readings. This clearly occurred at both the inlet and outlet locations. This was evidenced by very high short-term mercury values, often >50$\mu g/m^3$. Although this effect can never be totally eliminated when using wet CMM systems, it can be reduced by adding more heating and insulation. To reduce this problem, the following measures were taken:

- The temperature of the CMM shed was better controlled. The ambient temperature varied greatly during the testing.
- The temperature of the probe was maintained above 325°F by adding additional heating elements and ensuring there was no air leakage through the flange that cooled the probe.
- More heating elements were added to the umbilical cord to consistently bring the temperature above 300°F.
- Additional insulation was added to the entire pretreatment conversion system.
- The bubbler system was changed to help prevent condensation droplets from forming.

In presenting the data for the tests, these large spikes were eliminated by using a 200% criteria. If any single point was >200% of the average for that hour, then it was eliminated from the data set. The overall effect on the data set was small. At the ESP outlet location, for the longer-term test, a total of 7.5% of the data was eliminated using these criteria. Specific standard deviation of the data and data distribution curves are presented in Section 5.0, Test Results. The overall availability of the instruments is provided in Table 1. For purposes of this report, the availability of the instrument is defined as the period of time the CMM was operating and generating data that was used in the graphs discussed in Section 5.0. Therefore, when the instrument was being manually calibrated, automatically spanned, and zeroed or when the instrument was down for maintenance, it was considered unavailable. In addition, when data were eliminated as a result of the 200% criteria, the instrument was also considered unavailable. It should be noted that for the baseline test at the ESP outlet, the instrument was initially set up to automatically span and zero every hour. Spanning and zeroing of the instrument takes approximately 15 minutes to complete, resulting in 25% unavailability of the instrument. This was later changed, and the sampling interval was set to match that of the instrument located upstream of the ESP. Calibrations, zeroing, and spanning of the instrument are discussed in more detail in Section 5.0, Quality Assurance/Quality Control, of this report.

Table 1. Instrument Availability

		Upstream of ESP		ESP Outlet	
Test	Total Test Time, hr	CMM Operation, hr	Availability, %	CMM Operation, hr	Availability, %
Baseline	384*	305.3	79.5**	235.6	61.4
Parametric	225	217.6	96.7	191.2	85.0
Longer-Term	624	578.4	92.7	527.2	84.5

*Based on a start of midnight January 10, 2006.

**The first reading was 10:00 January 11, 2006; if that time is used as the start point, the availability is 87.2%.

5.0 TEST RESULTS

5.1 Baseline Test

The CMM data for the baseline test upstream of the ESP and at the ESP outlet location are shown in Figures 2 and 3, and a comparison between the two is provided in Figure 4. As the figure shows, there appears to be a substantial change in the mercury concentration in the coal beginning January 18, 2006. Based on the CMM data, the average mercury concentration upstream of the ESP from January 11 to January 18 averaged 14.14 μg/m^3 and was quite variable, with a standard deviation of 5.59 μg/m^3. Beginning on January 19, the ESP upstream concentration decreased to 6.59 μg/m^3, with a standard deviation of only 1.59 μg/m^3. The OH results for the baseline test are provided in Table 2 and are compared to the CMM data in Figures 5 and 6. There was quite good agreement between the OH method results and the CMM data. However, at the ESP outlet location, the standard deviation for the CMM data was higher than that obtained upstream of the ESP. There also appeared to be an effect of plant load at the ESP outlet as, each night, the mercury concentration would decrease. This is primarily a result of an increase in excess air that occurs as a result of decreased plant load. As was discussed previously in this report, there also was a problem maintaining the proper probe temperature at the outlet. It was later found that the problem was a result of a combination of air leakage (the unit had a high negative pressure) around the probe and not enough heating of the probe.

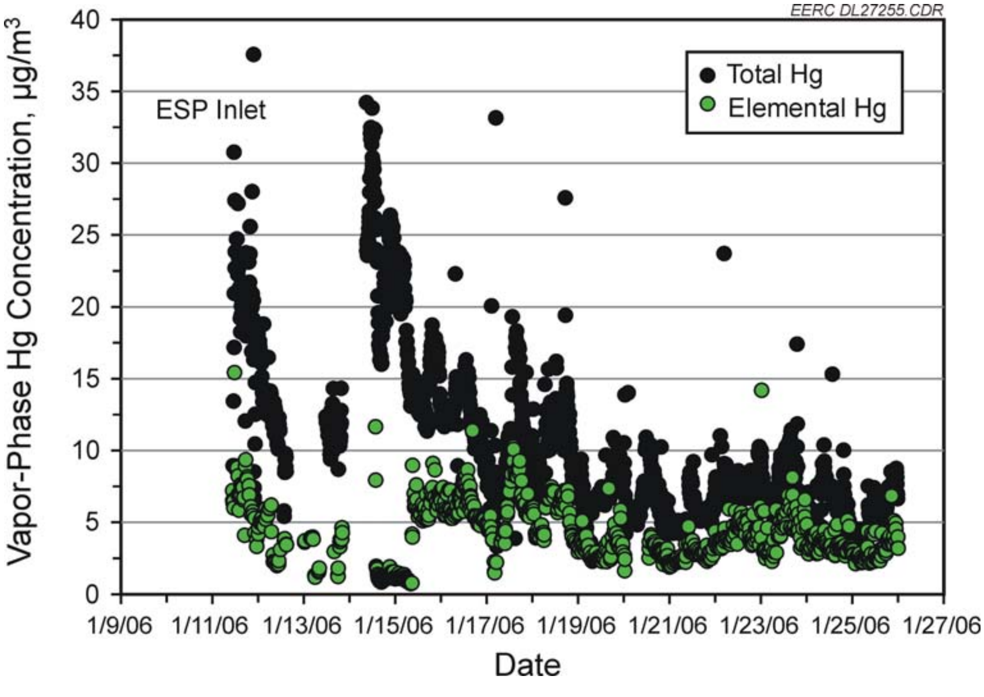

Figure 2. Baseline mercury speciation data as measured at the ESP inlet location.

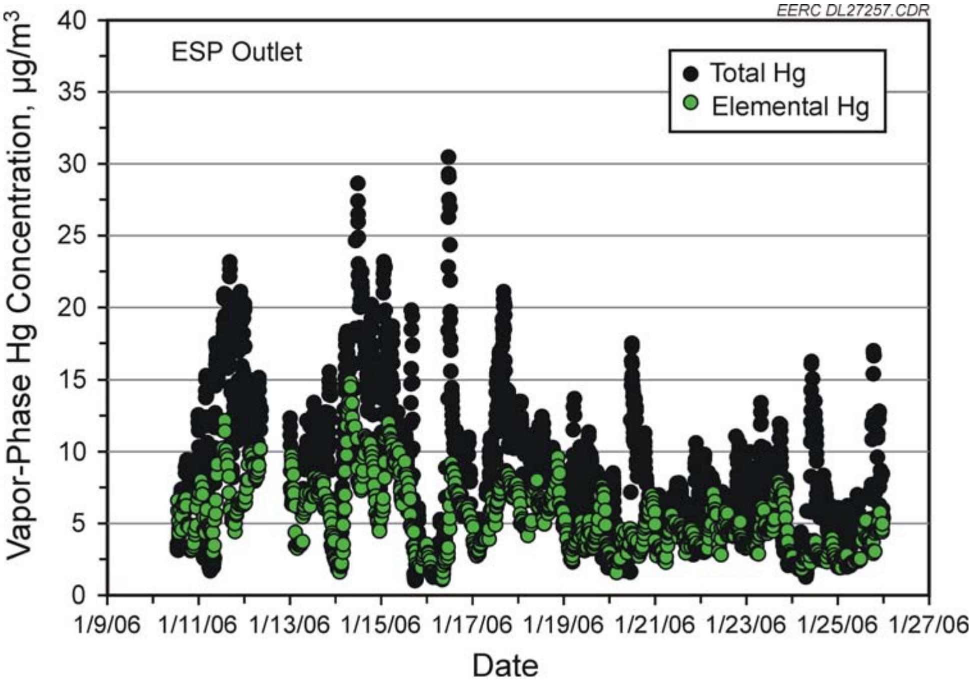

Figure 3. Baseline mercury speciation data as measured at the ESP outlet location.

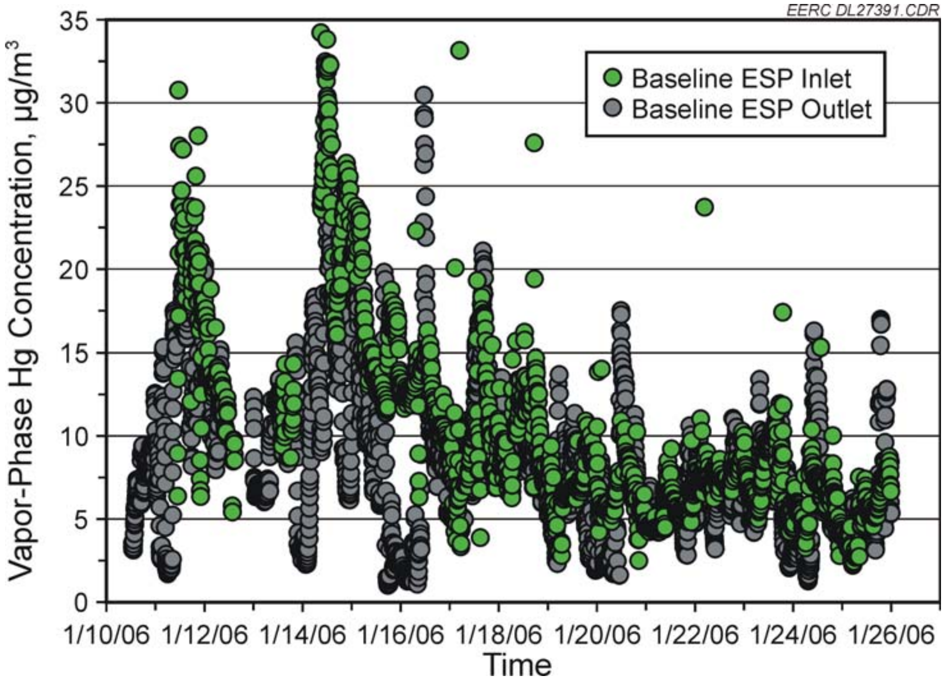

Figure 4. Comparison of ESP inlet and outlet CMM data for baseline test.

Table 2. Baseline OH Results

Sample Location:	Upstream of ESP		ESP Outlet	
Date	Hg^0 Concentration, μg/Nm^3*	Hg(total) Concentration, μg/Nm^3*	Hg^0 Concentration, μg/Nm^3*	Hg(total) Concentration, μg/Nm^3*
1/17/2006	1.93	11.43	7.17	14.52
1/17/2006	2.92	17.33	5.68	16.07
1/18/2006	8.57	14.28	4.54	12.48
1/18/2006	9.33	14.50	4.69	13.42
1/18/2006	8.35	13.43	4.16	11.38
Average	6.22	14.19	5.25	13.57
Std. Dev.	3.50	2.13	1.21	1.81

* The mercury concentrations are based on actual O_2 to match the CMM data.

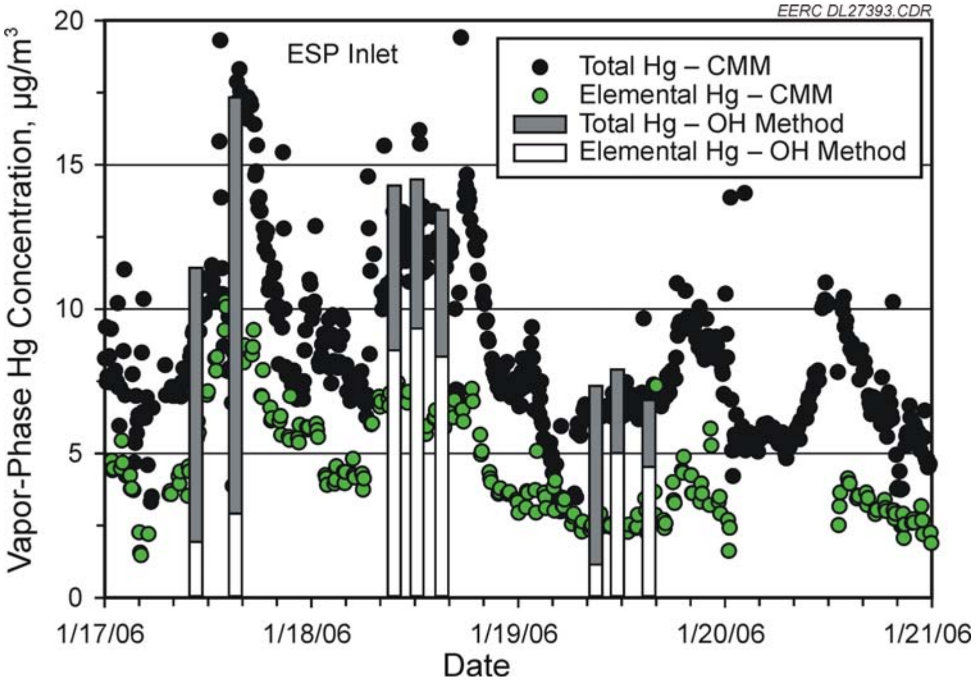

Figure 5. Baseline ESP inlet mercury speciation data as measured using CMMs compared to that measured using the OH method.

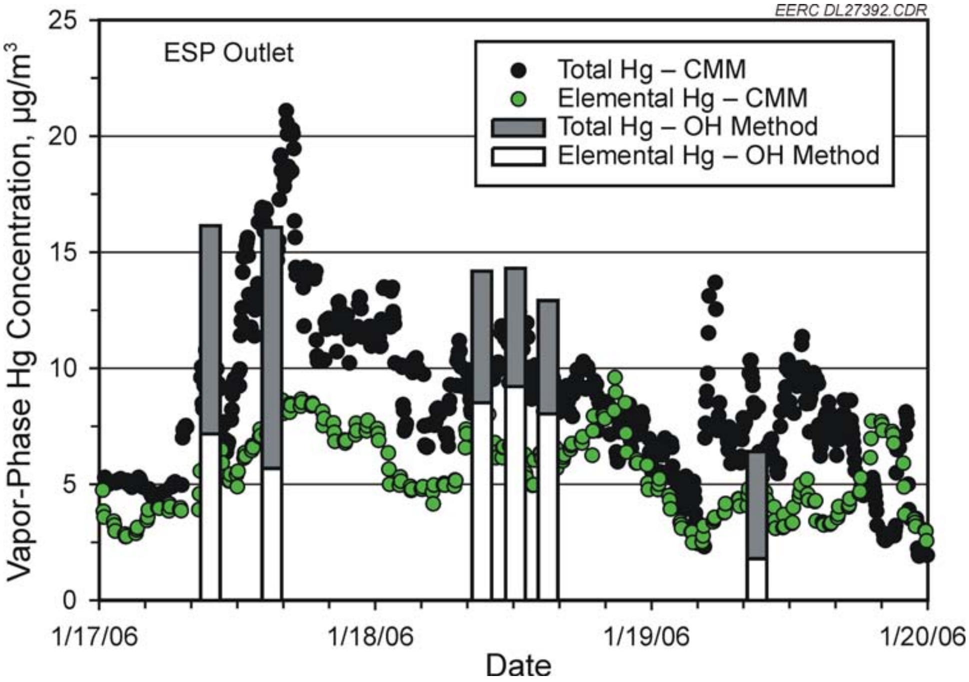

Figure 6. Baseline ESP outlet mercury speciation data as measured using CMMs compared to that measured using the OH method.

5.2 Parametric Tests

For the parametric tests (January 24 – February 12, 2006), the primary variable was sorbent feed rate, varying from a low of 1.18 lb/MMacf to a high of 9.19 lb/MMacf. During several of the test periods, there were plugging problems encountered with the sorbent feed at the higher feed rates. The CMM results for each of the different periods of injection are shown in Figures 7–18. In general, the data upstream of the ESP were reasonably steady for each of the parametric tests. However, there was substantially more variability in the ESP outlet data. The results are shown in Table 3. A comparison of the CMM results to the OH samples completed during parametric testing is shown in Table 4. The mercury concentration upstream of the ESP, as measured by the CMM, compared very well with the OH method. However, at the outlet (not taking the data variability into account), the OH method appeared to indicate somewhat better mercury removal than the CMM for the first and last days of the testing. It should be noted that the sorbent feed rates were the same for all three days of testing.

5.3 Longer-Term Tests

The longer-term test began on February 13, 2006, and continued through March 15, 2006. During this period, the sorbent feed rate was maintained at a single rate. Triplicate OH samples were completed upstream of the ESP and at the ESP outlet at the beginning, toward the middle, and at the end of the longer-term test. CMMs were operated during the entire test period. The overall total vapor-phase mercury concentration comparison upstream of the ESP and at the ESP

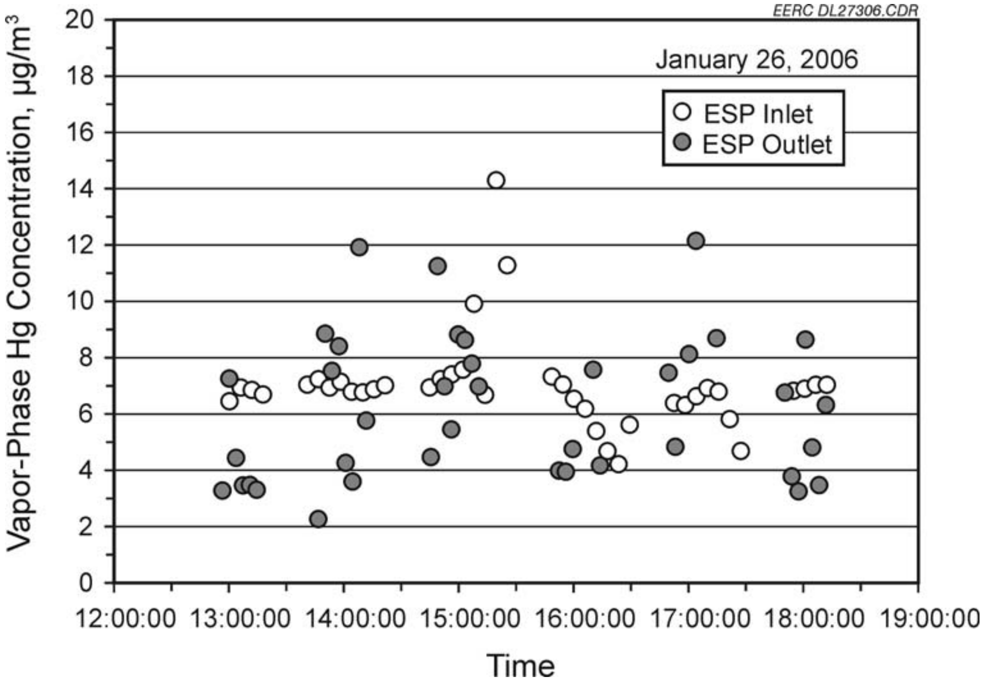

Figure 7. Parametric results for Sorbent Injection Test 1 (January 26, 2006).

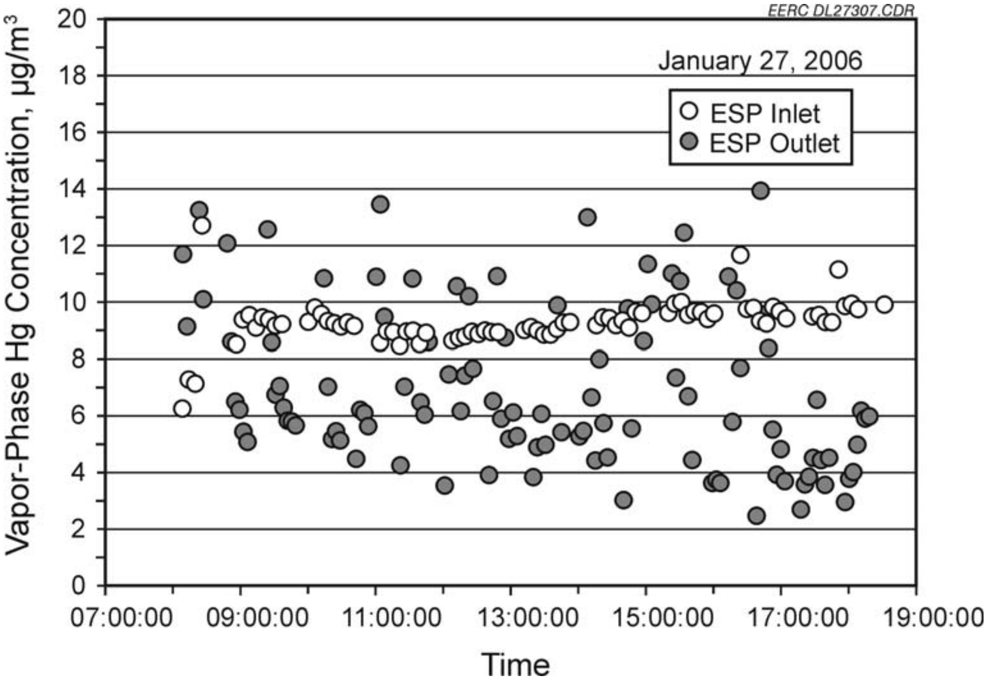

Figure 8. Parametric results for Sorbent Injection Test 2 (January 27, 2006).

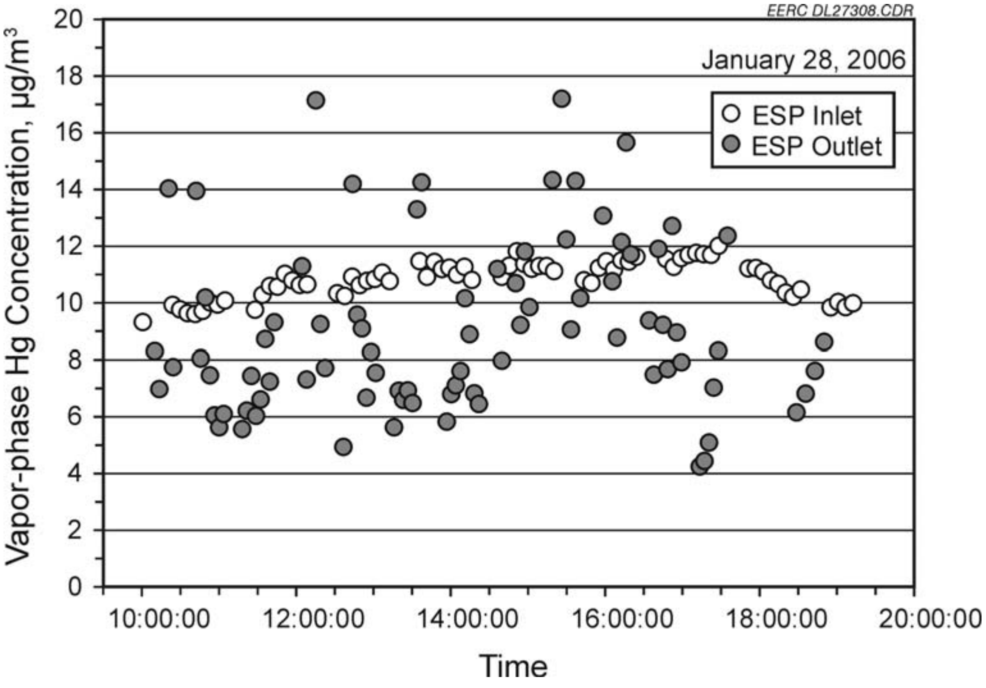

Figure 9. Parametric results for Sorbent Injection Test 3 (January 28, 2006).

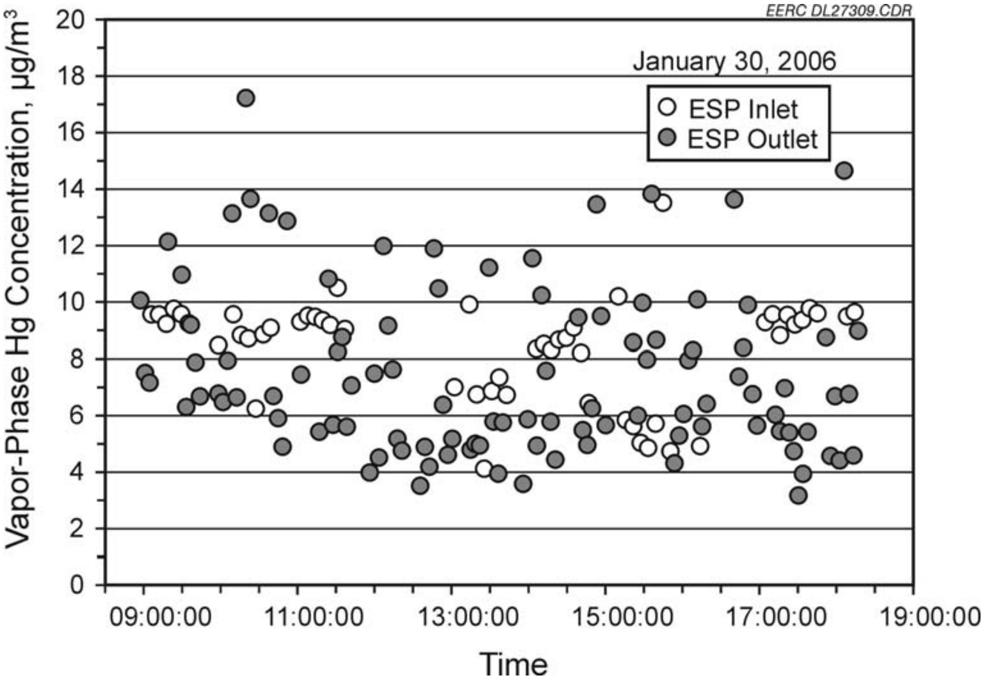

Figure 10. Parametric results for Sorbent Injection Test 4 (January 30, 2006).

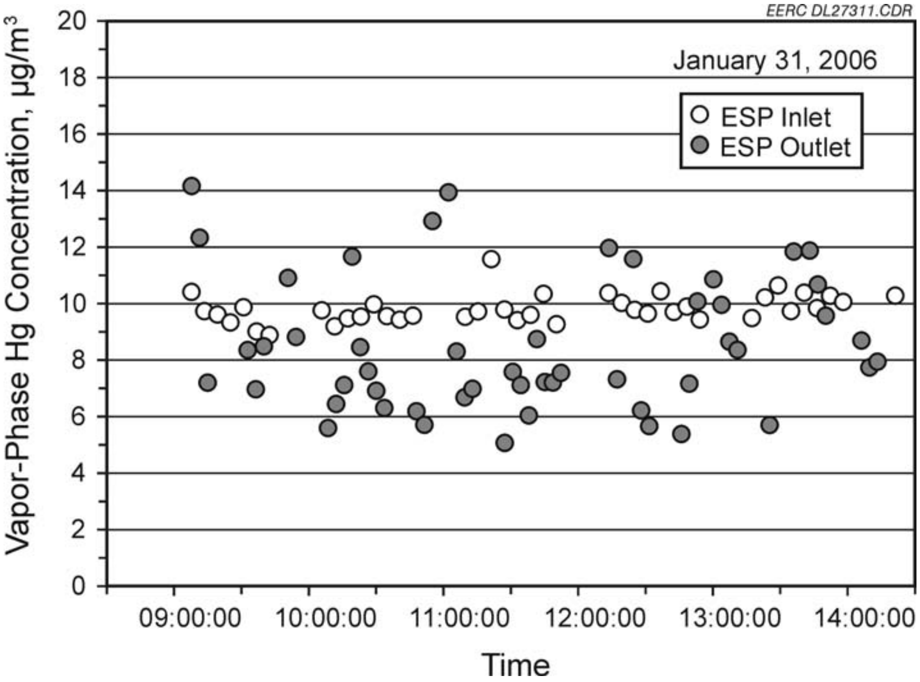

Figure 11. Parametric results for Sorbent Injection Test 5 (January 31, 2006).

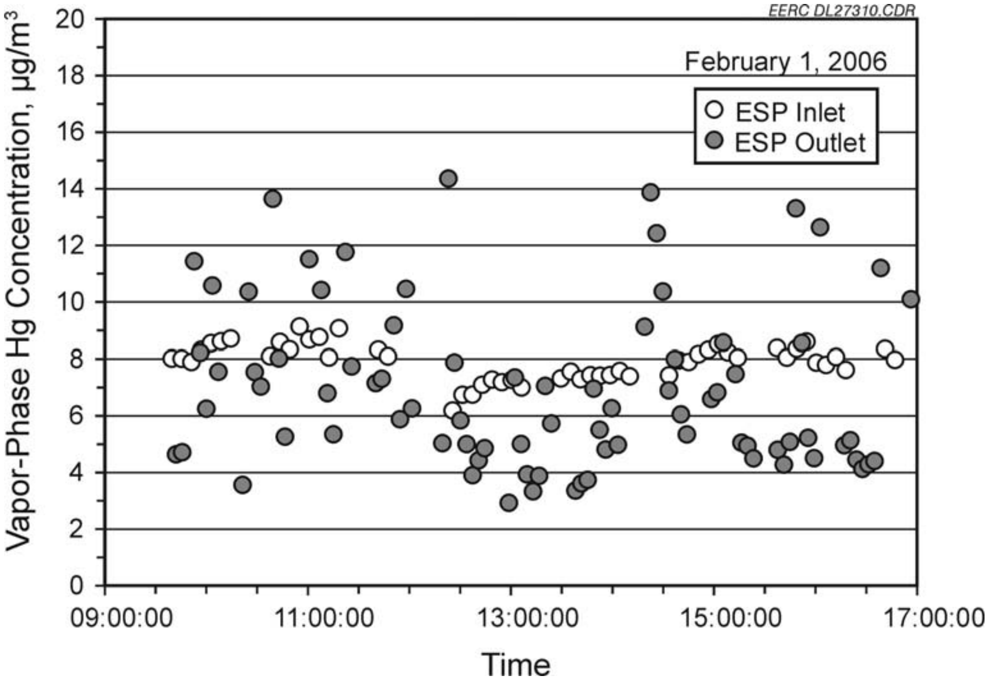

Figure 12. Parametric results for Sorbent Injection Test 6 (February 1, 2006).

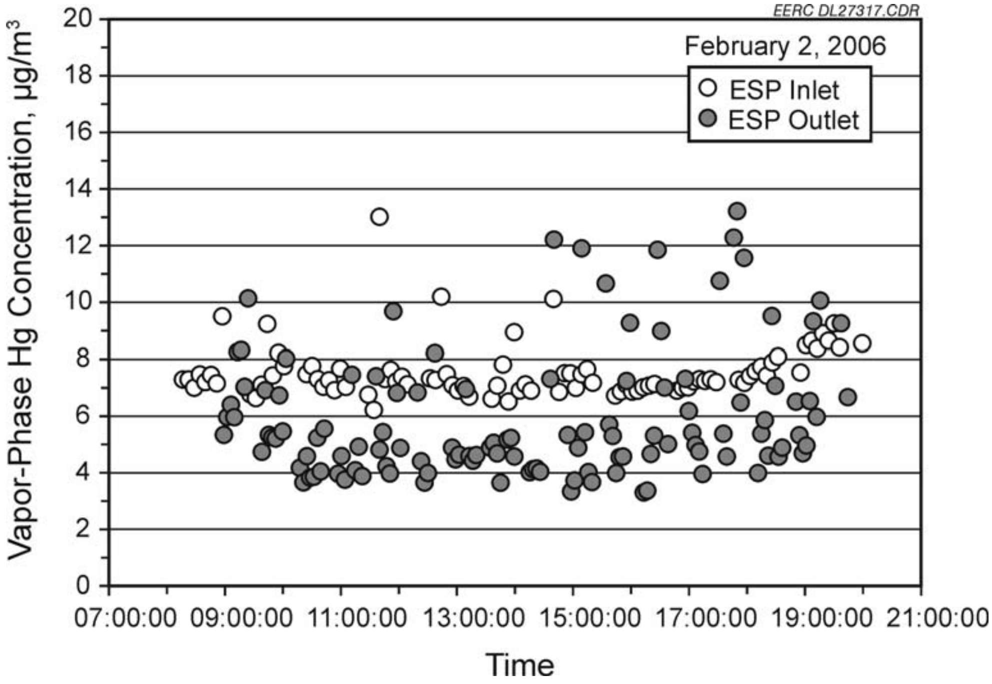

Figure 13. Parametric results for Sorbent Injection Test 7 (February 2, 2006).

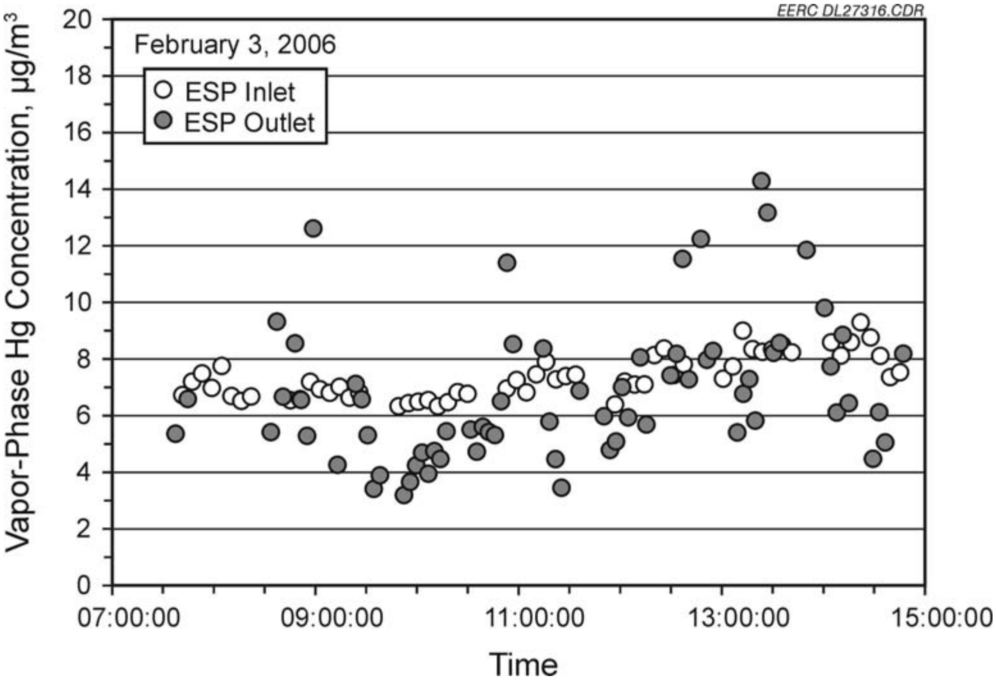

Figure 14. Parametric results for Sorbent Injection Test 8 (February 3, 2006).

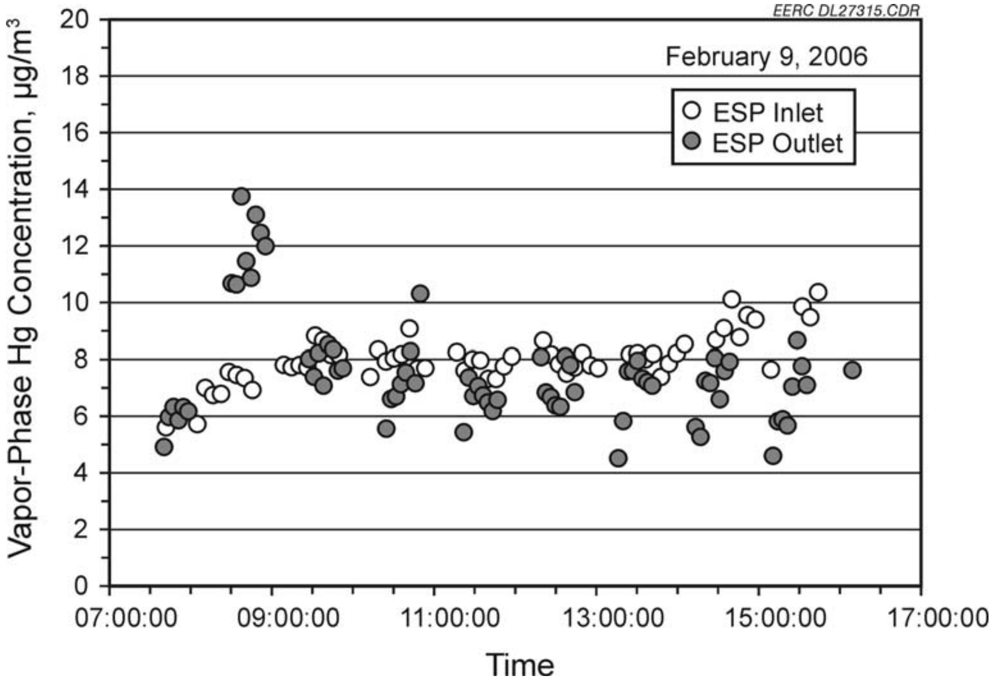

Figure 15. Parametric results for Sorbent Injection Test 9 (February 9, 2006).

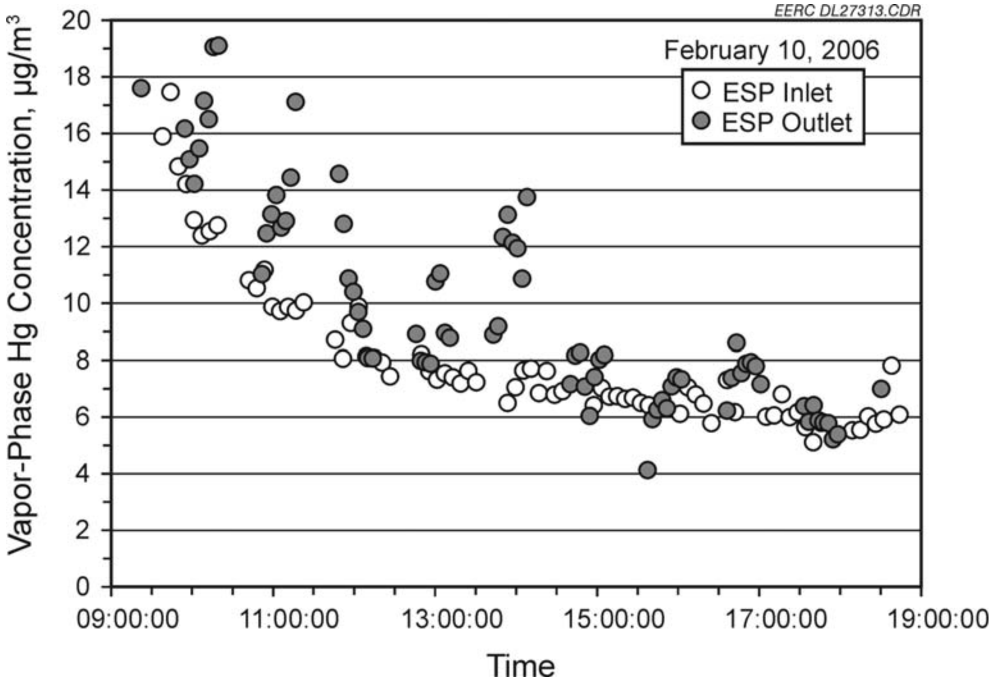

Figure 16. Parametric results for Sorbent Injection Test 10 (February 10, 2006).

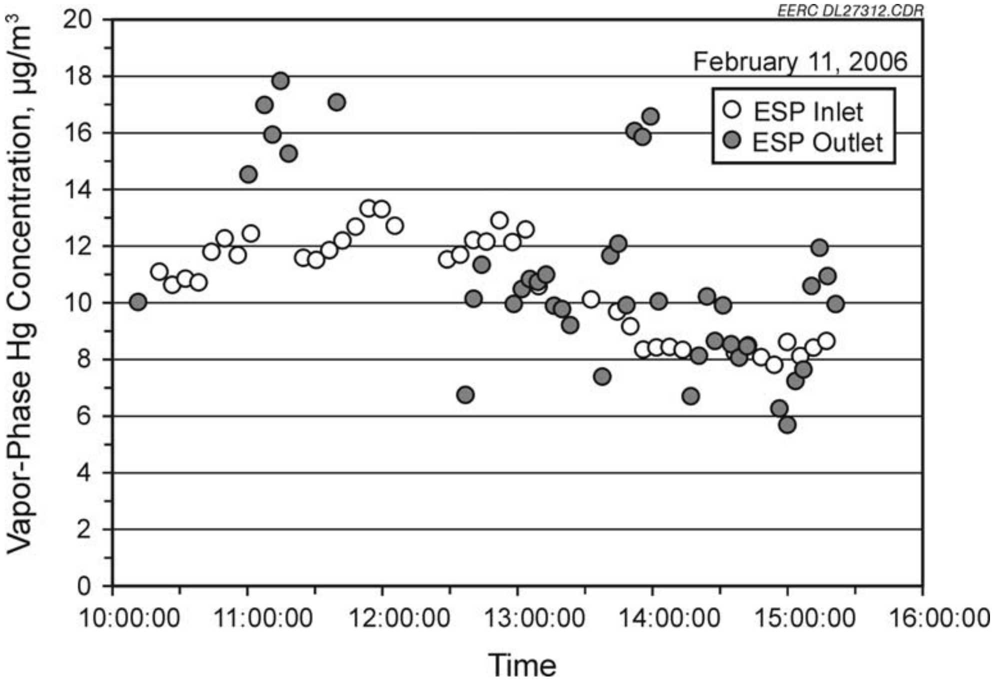

Figure 17. Parametric results for Sorbent Injection Test 11 (February 11, 2006).

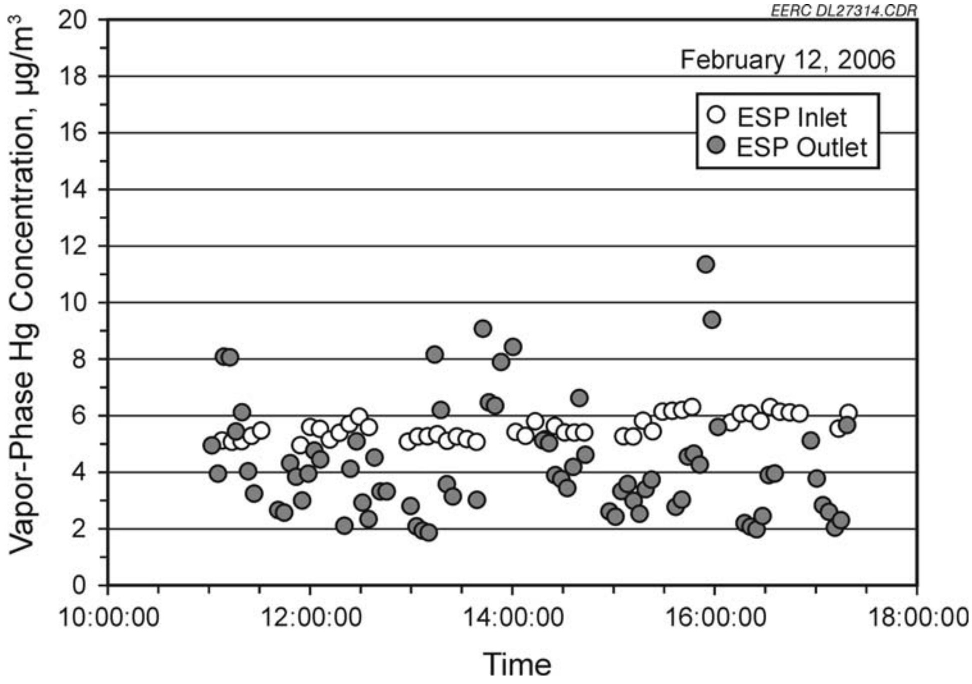

Figure 18. Parametric results for Sorbent Injection Test 12 (February 12, 2006).

Table 3. Parametric Test CMM Results

Date	Test Time, hr	Load, MW	Nominal Feed Rate, lb/Macf	Sorbent Feed Rate, lb/Macf	ESP Inlet, µg/m^3 Hg Conc.	ESP Inlet, µg/m^3 Std. Dev.	ESP Outlet, µg/m^3 Hg Conc.	ESP Outlet, µg/m^3 Std. Dev.
1/26/06	5	168.3	1	1.18–1.19	6.98	1.68	6.18	2.57
1/27/06	10	171.1	2	2.33–2.35	9.28	0.80	6.93	2.80
1/28/06	9	166.9	3	3.48–3.53	10.81	0.65	9.03	2.98
1/30/06	9	166.4	5	4.35–4.46	8.38	1.80	7.47	2.94
1/31/06	5	168.3	8	5.45–7.59	9.81	0.50	8.46	2.35
2/01/06	7	166.6	4.5	2.32–4.68	7.92	0.62	6.93	2.87
2/02/06	12	169.2	2–5	1.63–4.60	7.54	0.96	5.93	2.25
2/03/06	7	167.5	2–5	2.30–4.67	7.37	0.76	6.80	2.48
2/09/06	8	165.4	2–9	2.37–9.13	8.03	0.89	7.51	1.89
2/10/06	9	166.0	4–6	4.07–5.49	8.02	2.63	9.88	3.72
2/11/06	5	167.9	5.5	5.41–5.45	10.65	1.80	10.86	3.24
2/12/06	6	148.7	5	3.99–5.26	5.36	0.40	4.26	2.00

* Minimum and maximum mercury removal based on the measured standard deviation at the ESP inlet and outlet.

Table 4. Comparison of the CMM and OH Method Results for the Longer-Term Test

Date	Sorbent Feed Rate, lb/Macf	Upstream of the ESP, µg/m^3 Hg Conc. CMM	Upstream of the ESP, µg/m^3 Hg Conc.* OH Method	ESP Outlet, µg/m^3 Hg Conc. CMM	ESP Outlet, µg/m^3 Hg Conc.* OH Method
2/01/06	2.32 – 4.68	7.92	7.41	6.93	4.91
2/02/06	1.63 – 4.60	7.54	8.03	5.93	6.42
2/03/06	2.30 – 4.67	7.37	7.25	6.80	4.13

* The mercury concentrations are based on actual O_2 to match the CMM data.

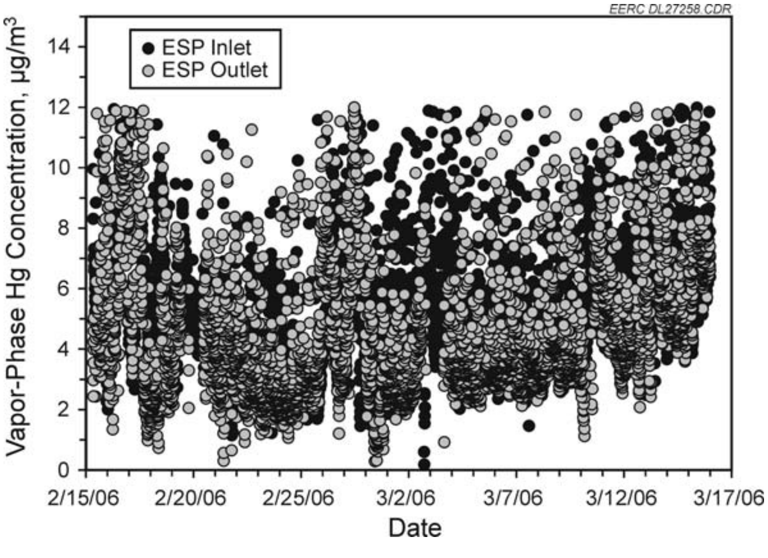

Figure 19. Comparison of the CMM ESP inlet data to the ESP outlet data for the longer-term test.

outlet is shown in Figure 19. To help eliminate some of the data scatter, the results are also presented in Figure 20 based on an hourly average.

Clearly, over the approximately 1-month period (February 13 – March 15, 2006), there was more variability in the data than would be expected. The mercury concentration data distribution curves upstream of the ESP and at the ESP outlet are compared in Figure 21. Although this is a typical data distribution curve, it would have been more desirable that the peaks be sharper.

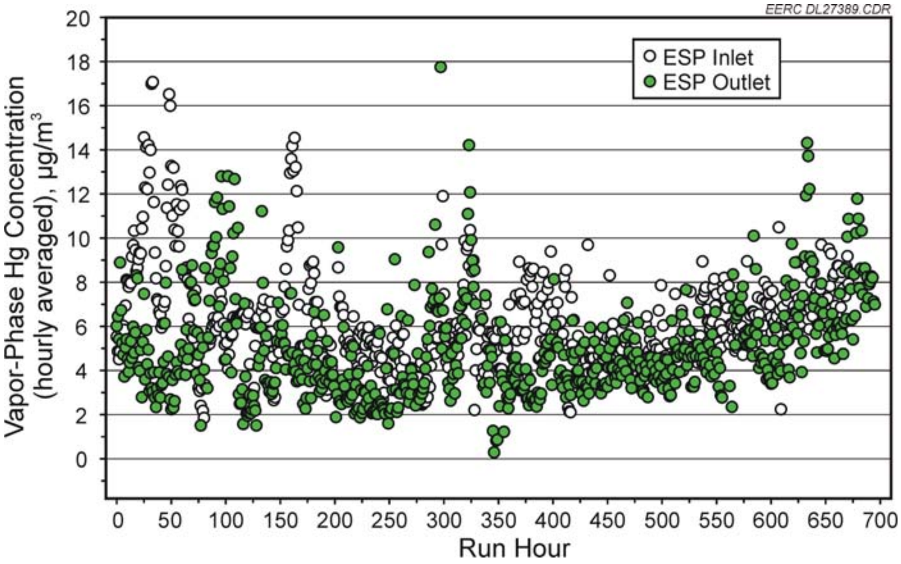

Figure 20. Comparison of the CMM ESP inlet data to the ESP outlet data for the longer-term test on an hourly averaged basis.

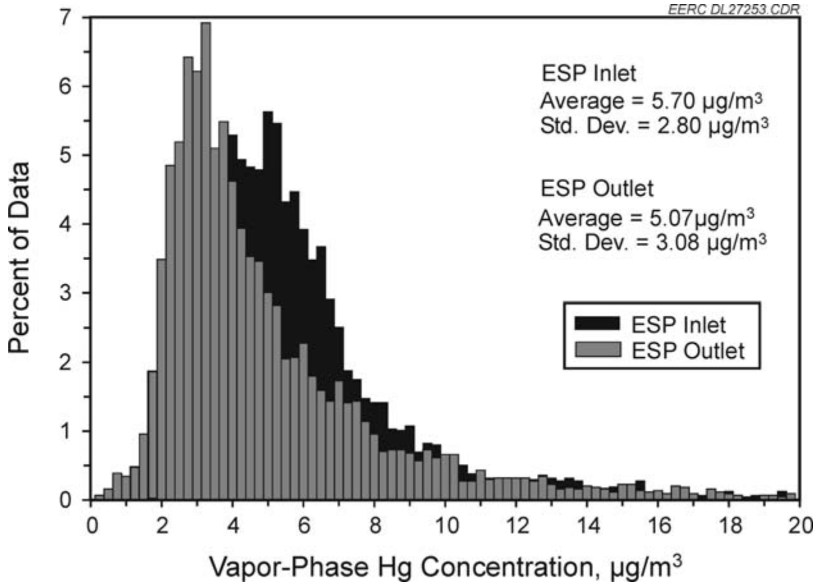

Figure 21. CMM data variability curves for the longer-term test.

Although there was variability in the data as discussed above, the data should be considered valid. This can be demonstrated by comparing the CMM data to the OH data taken during the longer-term tests. Although the CMM data are somewhat lower than the OH results, as shown in Table 5, the mercury removal measured was similar. The results are shown graphically in Figures 22 and 23.

Table 5. Comparison of the CMM and OH Method Results for the Longer-Term Test

	ESP Inlet, µg/m^3		ESP Outlet, µg/m^3			
Date	Hg Conc. CMM	Hg Conc.* OH Method	Hg Conc. CMM	Hg Conc.* OH Method	CMM Hg Removal, %	OH Removal, %
2/28/06	4.19	6.60	3.26	4.91	22.2	25.6
3/01/06	5.40	7.33	3.61	5.53	33.1	24.6
3/01/06	7.02	6.42	3.08	5.13	56.1	20.1
3/01/06	4.37	6.00	3.19	5.23	27.0	12.8
3/02/06	6.72	5.81	4.44	5.08	33.9	12.6
3/02/06	6.41	7.13	4.94	5.77	22.9	19.1
3/02/06	5.78	8.06	5.38	6.04	6.9	25.1

* The mercury concentrations are based on actual O_2 to match the CMM data.

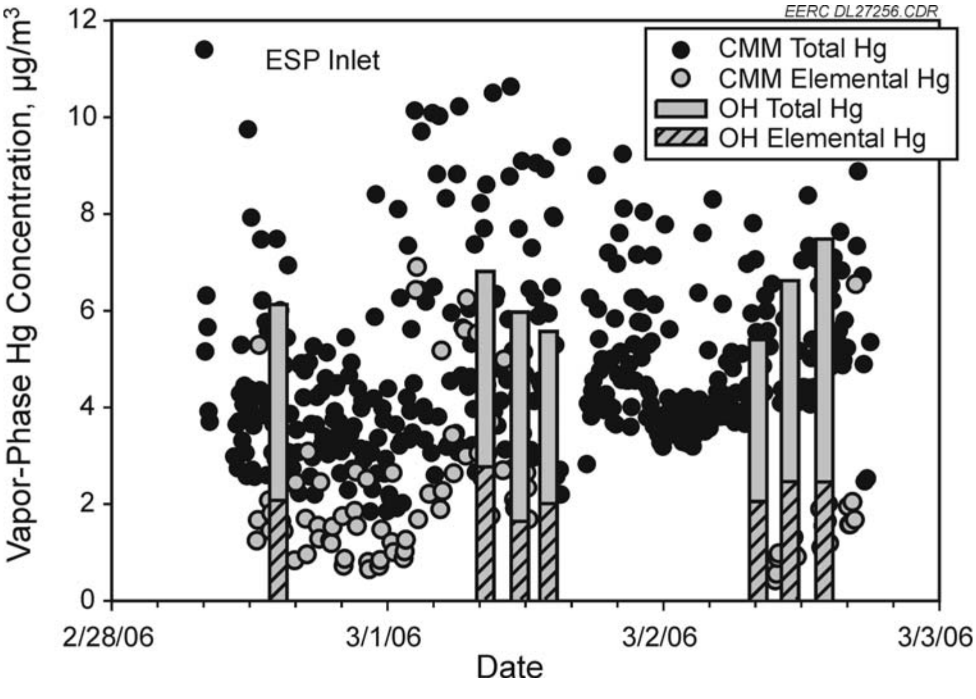

Figure 22. Comparison of longer-term ESP inlet mercury speciation data as measured using CMMs to that measured using the OH method.

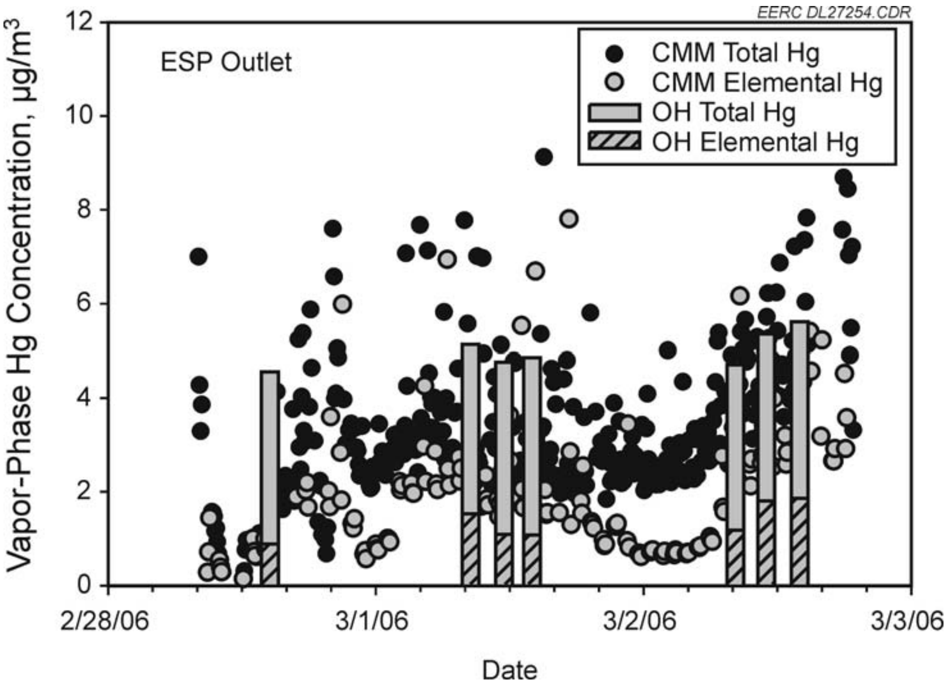

Figure 23. Comparison of longer-term ESP outlet mercury speciation data as measured using CMMs to that measured using the OH method.

5.4 Tests with Standard Activated Carbon

The results for the test with standard Norit PAC (March 16–22, 2006) are shown in Figure 24. There was little mercury removal achieved during this period. Based on the tests conducted by ADA-ES and URS at a PAC feed rate of 3–5 lb/MMacf, it would be expected that 60%–70% mercury removal would be achieved for an eastern bituminous coal (2). However, the results at American Electric Power's Conesville plant indicated only 30% removal when injecting activated carbon (3). Therefore, factors other than activated carbon add rate such as high levels of SO_3 also play a role in mercury removal.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

As part of this project, the EERC agreed to provide QA/QC, which includes QA/QC control for the sorbent feed, operation of the CMMs, completion of OH method tests, and general operation of the project.

6.1 CMMs

As the CMMs are still under development, some aspects of the QA/QC procedures are still being developed. However, in April 2005, EPA, as part of the mercury rule-making process for coal-fired power plants, established a program for monitor certification and QA/QC under 40 Code of Federal Regulations (CFR), Part 60 and Part 75. For this project, the EERC intended to follow the QA/QC guidelines in Part 75, including daily calibrations. Although a complete relative accuracy test was not done, during the longer-term test, OH sampling was done during three periods for comparison purposes. One difference between the Part 75 requirements and the QA/QC completed for this test was that the instrument was only calibrated on Hg^0. There were no technical or budgetary provisions made for doing Hg^{2+} calibrations when this project was originally proposed. The following are the QA/QC requirements for the CMM:

- The leak rate was required to be less than 2.0% of the total sample flow rate.
- The analyzer was zeroed and spanned by injecting either zero gas or a known quantity (concentration) of Hg^0 during the initial setup and daily thereafter. The returned value was required to be within 5% of the anticipated value, or the instrument was recalibrated.
- For this test program, a complete span was done on each analyzer at a minimum of one per week. However, more were done as needed. A complete span includes not only spanning and zeroing the instrument but also injecting a known quantity (concentration) of Hg^0 and zero gas at a location upstream of the particulate removal device. The QA/QC requirement of this portion of the span required the returned value to be within 7.5% of the span value.

The calibration data for the CMMs are shown in Tables 6 and 7. As can be seen, the calibration data were very good. As stated above, the intent was to calibrate the instruments daily. However, when the CMMs were operating well, the decision was made to calibrate every other day rather than miss the data during that time. As an additional QA/QC check at the ESP outlet location, a second calibration check was periodically done using a different mercury vapor generator. These results are shown, as in Table 7, as Injection 2. A copy of the log notes for the test showing the calibration schedule and troubleshooting that was done on the CMMs is provided in the Appendix B.

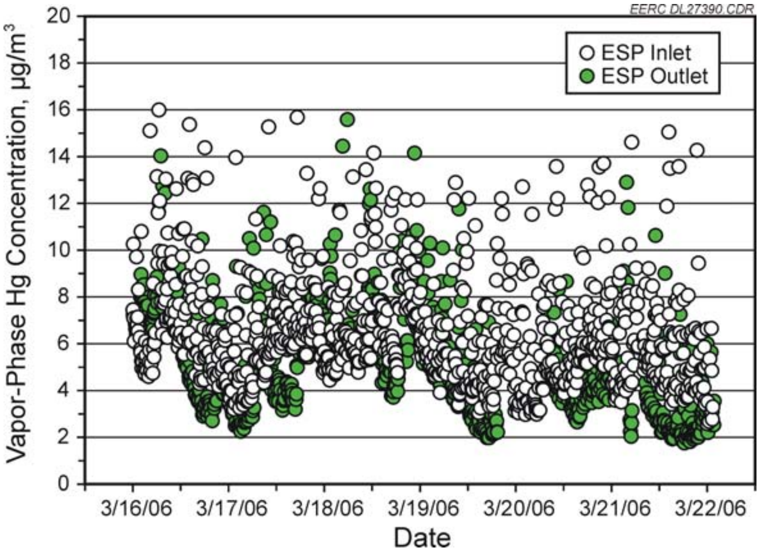

Figure 24. Comparison of the ESP inlet and outlet CMM data using standard Norit PAC injection.

Table 6. CMM Calibration Data Upstream of the ESP

Date	Injection, µg	Measured, µg	Recovery, %
1/10/2006	9.353	11.709	125.19
1/11/2006	9.353	9.353	100.00
1/13/2006	9.373	9.373	100.00
1/14/2006	9.370	9.420	100.53
1/16/2006	9.353	9.446	100.99
1/17/2006	9.353	9.539	101.99
1/20/2006	9.353	8.914	95.31
1/21/2006	9.353	9.368	100.16
1/26/2006	9.353	9.387	100.36
1/28/2006	9.353	9.444	100.97
1/30/2006	9.353	9.406	100.57
2/01/2006	9.353	9.377	100.26
2/02/2006	9.353	9.377	100.26
2/11/2006	9.352	9.424	100.77
2/13/2006	9.353	9.506	101.64
2/17/2006	9.353	9.273	99.14
2/23/2006	9.353	9.567	102.29
3/07/2006	9.353	9.481	101.37
3/09/2006	9.353	9.380	100.29
3/11/2006	9.353	9.345	99.91
3/13/2006	9.361	9.426	100.69
3/15/2006	9.353	9.350	99.97
3/17/2006	9.353	9.399	100.49
3/19/2006	9.361	9.414	100.57
3/21/2006	9.369	9.352	99.82

6.2 OH Method

The OH testing for this project was done by WKU. The EERC has worked with WKU in the past, and its experience has been that they do good work. One difficulty with this project was a problem of communication. The personnel from WKU were graduate students who did not speak English well. As a result, they were largely unresponsive during pretest conference calls, and during the test it was difficult for both EERC and ADA personnel to discuss WKU results with them so that the CMM results could be compared for troubleshooting purposes.

As part of the QA/QC, it was requested that several sets of OH samples be sent to the EERC for analysis for comparison purposes. However, because of a miscommunication, WKU had discarded these samples after the analyses had been completed. That being said, WKU met the major criteria for blank and spiked samples as discussed below.

Table 7. CMM Calibration Data for ESP Outlet

Date	Injection 1, µg	Measured, µg	Recovery, %	Injection 2,* µg	Measured, µg	Recovery, %
1/09/2006	9.631	9.340	96.98	8.828	8.560	96.96
1/10/2006	8.560	8.533	99.68			
1/12/2006	8.650	8.270	95.61	8.560	8.439	98.59
1/13/2006	8.560	8.525	99.59	8.560	8.548	99.86
1/14/2006	8.560	8.704	101.68	8.560	8.181	95.57
1/15/2006	8.560	8.180	95.56			
1/16/2006	8.560	8.296	96.92			
1/17/2006	8.560	8.397	98.10			
1/18/2006	8.560	8.441	98.61			
1/19/2006	8.560	7.962	93.01			
1/20/2006	8.560	8.304	97.01			
1/21/2006	8.560	8.355	97.61	8.560	9.343	109.15
1/22/2006	8.560	8.602	100.49	8.560	8.602	100.49
1/24/2006	8.560	8.617	100.67			
1/25/2006	8.560	8.634	100.86			
1/26/2006	8.560	8.433	98.52	8.560	8.454	98.76
1/28/2006	8.560	8.830	103.15			
1/29/2006	8.560	8.695	101.58			
1/30/2006	8.560	8.953	104.59			
1/31/2006	8.560	8.694	101.57			
2/1/2006	8.560	8.686	101.47			
2/2/2006	8.560	8.582	100.26			
2/3/2006	8.560	8.850	103.39			
2/10/2006	8.560	8.592	100.37			
2/11/2006	8.560	9.201	107.49			
2/12/2006	8.560	7.972	93.13			
2/13/2006	8.560	9.168	107.10	8.560	8.487	99.15
2/16/2006	8.560	8.878	103.71			
2/17/2006	8.560	9.069	105.95			
2/22/2006	8.560	9.738	113.76			
2/23/2006	8.560	9.332	109.02			
2/24/2006	8.560	11.519	134.57			
2/25/2006	8.560	8.577	100.20			
2/26/2006	8.560	10.480	122.43	8.560	9.779	114.24
2/27/2006	8.560	12.056	140.84	8.560	12.672	148.04
2/28/2006	9.352	9.352	100.00	9.353	9.463	101.18
3/1/2006	9.353	9.884	105.68	9.353	9.972	106.62
3/2/2006	9.401	8.829	93.92	9.369	9.193	98.12
3/3/2006	8.560	8.421	98.38	8.560	8.368	97.76
3/7/2006	8.560	8.550	99.88	8.560	8.550	99.88
3/12/2006	8.560	8.550	99.88	8.560	8.501	99.31
3/14/2006	8.560	8.589	100.34	8.560	8.582	100.26
3/16/2006	8.560	8.620	100.70	8.560	8.709	101.74
3/18/2006	8.560	8.747	102.18	8.560	8.691	101.53

*As an additional QA/QC check a second calibration check was made.

6.2.1 Reagent Blanks

The requirement for the reagent blanks was that the value had to be less than 10% of the sample value. The regent blank concentrations for each of the test periods are shown in Table 8. Using one of the samples as an example, it can be seen in Table 9 that the reagent blank values easily met the required 10% target.

6.2.2 Field Blanks

The field blank consisted of a sample train that was assembled, taken to the same location as a test sample, leak-checked, and recovered. The quality objective for the field blank was less than 15% of the typical sample values. If the field blank did not meet this criterion, the data were required to be flagged and corrective action taken to discover the source of the contamination. (Note: This was possible because WKU was doing the analyses of the samples on-site.) The results of the field blanks are shown in Table 10. All of the samples met the quality objectives.

Table 8. Mercury Concentration Measured in the Reagent Blanks, µg/l

Reagent	Jan 17–19, 2006	Feb 1–3, 2006	Feb 28–Mar 2, 2006	Mar 14, 2006
KCl	0.00	0.08	0.01	0.03
H_2O_2/HNO_3	0.03	0.14	0.22	0.10
$KMnO_4/H_2SO_4$	0.03	0.00	0.00	0.02

Table 9. Example Comparing the Reagent Blanks to a Measured Mercury Concentration in the Flue Gas

	ESP Inlet, ppb			ESP Outlet, ppb		
Reagent	Measured	Max. Allowed	Actual	Measured	Max. Allowed	Actual
KCl and H_2O_2/HNO_3 Solution	8.54	0.85	0.13	9.32	0.93	0.13
$KMnO_4/H_2SO_4$	3.35	0.34	0.02	2.54	0.25	0.02

6.2.3 Field Spikes

A field spike consisted of a sample train that was assembled with each solution spiked with a known amount of mercury, taken to the same location as a test sample, leak-checked, and recovered. The quality objective for the field blank was 15% of the true spiked value. If the field spike did not meet this criterion, the data were flagged and corrective action taken to discover the source of the contamination. As was the case for the field blank, this was possible because WKU was doing the analyses of the samples on-site. From Table 11, it can be seen that all field spikes with one exception met the quality objectives. The one exception was just outside the acceptable range at 116%. This is not a concern as very little mercury is typically found in the H_2O_2/HNO_3 impingers.

Table 10. Results of WKU OH Method Field Blanks

	KCl and H_2O_2/HNO_3, ppb						$KMnO_4/H_2SO_4$, ppb					
	ESP Inlet			ESP Outlet			ESP Inlet			ESP Outlet		
Date	Meas.	Allowed	Actual	Meas.	Allowed	Actual	Meas.	Allowed	Actual	Meas.	Allowed	Actual
1/17/06	19.46	2.92	0.13	15.55	2.33	0.00	3.95	0.59	0.03	15.16	2.27	0.03
1/17/06	27.24	4.09	0.13	22.71	3.41	0.00	5.51	0.83	0.03	12.43	1.86	0.03
1/18/06	10.91	1.64	0.13	15.63	2.34	0.00	16.40	2.46	0.03	8.94	1.34	0.03
1/18/06	9.79	1.47	0.13	18.71	2.81	0.00	17.69	2.65	0.03	10.06	1.51	0.03
1/18/06	9.96	1.49	0.13	15.50	2.33	0.00	16.40	2.46	0.03	8.93	1.34	0.03
1/19/06	11.53	1.73	0.13	10.01	1.50	0.00	2.18	0.33	0.03	3.91	0.59	0.03
1/19/06	5.49	0.82	0.13	–	–	–	9.48	1.42	0.03	–	–	–
1/19/06	4.81	0.72	0.13	–	–	–	7.96	1.19	0.03	–	–	–
2/1/06	3.46	0.52	0.10	3.52	0.53	0.27	8.71	1.31	0.46	5.67	0.85	0.39
2/1/06	7.59	1.14	0.10	4.51	0.68	0.27	8.60	1.29	0.46	8.61	1.29	0.39
2/2/06	5.18	0.78	0.10	4.09	0.61	0.27	9.64	1.45	0.46	8.68	1.30	0.39
2/2/06	7.36	1.10	0.10	5.23	0.78	0.27	8.58	1.29	0.46	8.79	1.32	0.39
2/3/06	5.45	0.82	0.10	2.93	0.44	0.27	8.63	1.29	0.46	6.15	0.92	0.39
2/28/06	8.10	1.22	0.35	9.42	1.41	0.22	4.28	0.64	0.01	2.06	0.31	0.05
3/1/06	7.97	1.20	0.35	8.68	1.30	0.22	5.69	0.85	0.01	3.32	0.50	0.05
3/1/06	8.54	1.28	0.35	9.32	1.40	0.22	3.35	0.50	0.01	2.54	0.38	0.05
3/1/06	7.07	1.06	0.35	9.64	1.45	0.22	4.06	0.61	0.01	2.50	0.38	0.05
3/2/06	6.77	1.02	0.35	7.93	1.19	0.22	4.10	0.62	0.01	2.41	0.36	0.05
3/2/06	8.37	1.26	0.35	9.11	1.37	0.22	4.95	0.74	0.01	4.17	0.63	0.05
3/2/06	9.99	1.50	0.35	9.87	1.48	0.22	4.92	0.74	0.01	4.41	0.66	0.05
3/14/06	9.44	1.42	0.13	9.35	1.40	0.11	2.21	0.33	0.04	2.76	0.41	0.06
3/14/06	10.91	1.64	0.13	12.30	1.85	0.11	3.14	0.47	0.04	2.95	0.44	0.06
3/14/06	12.58	1.89	0.13	11.74	1.76	0.11	4.48	0.67	0.04	3.12	0.47	0.06
3/14/06	9.16	1.37	0.13	17.10	2.56	0.11	3.84	0.58	0.04	1.67	0.25	0.06
3/14/06	9.12	1.37	0.13	–	–	–	4.02	0.60	0.04	–	–	–

Table 11. Results of WKU OH Method Field Spikes

	KCl			H_2O_2/HNO_3			$KMnO_4/H_2SO_4$		
	Spike	Measured	Recovery, %	Spike	Measured	Recovery, %	Spike	Measured	Recovery, %
Jan 17–19, 2006	5.0	5.58	111.6	0.5	0.53	106.0	5.0	4.97	99.4
Jan 17–19, 2006	5.0	5.65	113.0	0.5	0.52	104.0	5.0	5.08	101.6
Feb 1–3, 2006	5.0	5.13	102.6	0.5	0.58	116.0	5.0	5.27	105.4
Feb 28–Mar 2, 2006	5.0	4.77	95.4	0.5	0.46	92.0	5.0	4.35	87.0
Mar 14, 2006	5.0	5.33	106.6	0.5	0.47	94.0	5.0	4.79	95.8

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APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES

QUALITY CONTROL/QUALITY ASSURANCE OBJECTIVES
LONGER-TERM EVALUATION AMENDED SILICATES, LLC SORBENT AT CINERGY'S MIAMI FORT PLANT

1.0 INTRODUCTION

The project team of Amended Silicates, LLC (ASL), ADA Technologies, CH2M, WKU, and the EERC is committed to delivering consistent, high-quality research that meets our clients' needs and expectations. In order to ensure that the goals of this project are realized, an organizationwide quality management system (QMS), authorized and supported by ASL, ADA, CH2M, WKU, and EERC managers, is in effect and governs all programs. As the quality assurance/quality control (QA/QC) team leader, the EERC has an independent QA manager who oversees all aspects of QA/QC for projects involving the EERC. ALS, ADA, CH2M, WKU, and EERC project managers are responsible for ensuring that project- specific QA/QC protocols are followed.

2.0 QUALITY OBJECTIVES AND CRITERIA

The purpose of the project is to determine the effectiveness of the Amended Silicates™ sorbent technology for removing mercury from coal-fired flue gas at Cinergy's Miami Fort power plant. Therefore, the important data are the measurements of mercury concentration in the flue gas upstream of sorbent injection and downstream of the electrostatic precipitator (ESP) at the host site.

To measure mercury concentrations at the designated sampling locations two methods will be used, the first is mercury sampling by WKU involving using the OH mercury speciation method (American Society for Testing and Materials [ASTM] D6784-02). This is the generally accepted method for measuring speciated mercury in combustion flue gases. This method was selected by EPA for the 1998 information collection request (ICR) and is considered a reference method for EPA rule making. The second method uses CMMs. This portion of the project will be conducted by the EERC. The most important QA/QC approach is for personnel doing the sampling and analyzing to be highly trained in the procedures. All responsible organizations have done substantial testing using these methods.

2.1 OH Mercury Speciation Method

Table 1 presents data quality objectives for accuracy, precision, and completeness using the OH method. As shown in Table 1, to help ensure the accuracy of the measurement, one field blank and one field spike will be collected at each sample location for each test condition. The field blanks and spikes consist of a sample train that is assembled, taken to the same location as a test sample, leak-checked, and recovered. The quality objective for a field blank is less than 15% of the typical sample value and 15% of the true spiked value for the field spike. If the field blank does not meet these criteria, the data must be flagged and corrective taken to uncover the source of the contamination (Note: This is possible because WKU will conduct sample analyses on-site. Therefore, results will be obtained within 24 hours of receiving the samples). Based on previous experience, the field blanks should be at or near detection limits.

Table 1. Data Quality Objectives for Flue Gas Mercury Analysis

Measure	Objective	Approach
Accuracy	<10% of sample value or <10 × instrument detection limit	Reagent blanks – analyze one blank per batch of each reagent.
Accuracy	Field blank <15% of sample value	Collect and analyze one field blank at inlet and one at outlet per test condition.
Accuracy	Field and laboratory spikes <15% of true value	Collect and analyze one field spiked sample at inlet per test condition.
Precision	<10%	All laboratory samples analyzed in duplicate; every tenth sample analyzed in triplicate.
Completeness	100%	Any failed or incomplete test will be reviewed and, if necessary, repeated.*

*Whether a test failed or is incomplete will be determined by the sampling manager in consultation with the principal investigator. Any failed or incomplete data that are not considered to cause an invalidation of a test will be flagged.

2.2 CMMs

As CMMs are still under development, not all aspects of the QA/QC procedures have been established. EPA as part of the mercury rule-making process for coal-fired power plants has begun establishing these procedures under provision of PS12A. The EERC has also begun establishing it own procedures and criteria, presented below; these may be modified prior to the initiation of the on-site testing or additional QA/QC requirements may be added.

- Leak-check – leak rate must be less than 2.0% of total sample flow rate.
- Zero and span the analyzer by injecting either zero gas or a known quantity (concentration) of elemental mercury during initial setup.
- Check the span of the analyzer daily by injecting a known quantity (concentration) of elemental mercury at the analyzer or at the probe – the returned value will be within 5% of the anticipated value or the instrument will be recalibrated.

- If a span check of the sampling system is performed by injecting a known quantity (concentration) of elemental mercury at a location upstream of the particulate removal device, the returned value will be within 7.5% of the span value or ±1.5 $\mu g/m^3$, whichever is less restrictive. For this test program, each analyzer will have a complete system span check at a minimum of once per week. However, span checks will be done more frequently if necessary.

- Check the zero of the sampling system daily by sampling ambient air. The returned value will be less than 7.5% of the span value or ±1.5 $\mu g/m^3$, whichever is least restrictive. If the ambient concentration is greater than 5% of the expected sample concentration, use a source of zero air.

It is expected that the CMMs used for testing will have inertial filtration systems to prevent reaction between the fly ash and mercury that might occur across a standard filter system.

3.0 MERCURY SAMPLING QA/QC REQUIREMENTS

The major QC checks for the mercury sampling are presented in Table 2. In the event of an equipment failure or unit disturbance that could impact the validity of results, the principal investigator (PI) will be immediately notified by the sampling team member who notices the failure. The PI will discuss the failure or disturbance with the team member and will decide whether to suspend or cancel sampling. Note that all team members are empowered to suspend sampling at any time for equipment problems. If the failure or disturbance is considered severe enough that the test objective cannot be met, the test will be canceled and repeated.

All sampling equipment will be precleaned and calibrated according to the requirements of the reference methods. Prior to transport to the job site, sample trains are assembled, heated, and leak-checked to ensure operation of all sample train components. In addition, prior to the testing, all gas-sampling equipment will be calibrated according to the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III Stationary Source Specific Methods*. These records are maintained at WKU offices. These records are inspected by the QA/QC officer to ensure calibrations are being correctly and accurately completed.

Once sampling equipment is set up, it is again inspected and tested to ensure everything is working properly. All testing personnel are well trained in sampling procedures and proper maintenance of sampling equipment. When sampling is to be done, enough sampling equipment will be on-site and common spare parts will be available. If necessary, spare parts can be shipped next-day to the site. Equipment problems on-site will be noted by the sampling personnel on the sample data sheet.

All glassware to be used for the tests will be properly cleaned according to the OH method prior to sampling and checked to ensure that no glassware was broken. If the glassware has an unnoticed crack, it will not pass the pretest leak check and will be replaced prior to testing.

4.0 ANALYTICAL QA/QC REQUIREMENTS

The QA/QC checklist for the OH method sampling is shown in Table 3. The sample fractions for the OH method will be prepared and analyzed as specified in the method and summarized below.

Table 2. Checklist and Limits for EPA Methods 5/17 Sampling

Quality Control Activity	Acceptance Criteria and Frequency and Corrective Action	Reference
Premobilization Checks		
Gas Meter/Orifice Check	Before test series, Y_D ±5% (of original Y_D)	Method 5, Section 5.3
Probe Heating System	Continuity and resistance check on element	
Nozzles	Note number, size, material	
Glassware	Inspect for cleanliness, compatibility	
Thermocouples	Same as Method 2	
Pretest Checks		
Nozzle	Measure inner diameter before first run	Method 5, Section 5.1
Probe Heater	Confirm ability to reach temperature	
Pitot Tube Leak Check	No leakage	Method 2, Section 3.1
Visible Inspection of Train	Confirm cleanliness, proper assembly	
Sample Train Leak Check	≤ 0.02 ft^3 at 15 in. Hg vacuum	Method 5, Section 4.1.4
During Testing		
Probe and Filter Temperature	Monitor and confirm proper operation	
Manometer	Check level and zero periodically	
Nozzle	Inspect for damage or contamination after each traverse	Method 5, Section 5.1
Probe–Nozzle Orientation	Confirm at each point	
*Post Test Checks**		
Sample Train Leak Check	≤ 0.02 ft^3 at highest vacuum achieved during test	Method 5, Section 4.1.4
Pitot Tube Leak Check	No leakage	Method 2, Section 3.1
Isokinetic Ratio	Calculate, must be 90%–100%	Method 5, Section 6
Dry Gas Meter Calibration Check	After test series, YD ± 5%	Method 5, Section 5.3
Thermocouples	Same as Method 2	
Barometer	Compare w/standard, ± 0.1 in. Hg	

* If these criteria are not met, the data must be flagged and an explanation given regarding the deviation and its effect on the data.

Table 3. QC Checklist and Limits for OH Mercury Speciation Method

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Premobilization Activities		
Reagent Grade	ACS reagent-grade	OH, Section 8.1
Water Purity	ASTM Type II, Specification D 1193	OH, Section 8.2
Sample Filters	Quartz; analyze blank for Hg before test	OH, Section 8.4.3
Glassware Cleaning	As described in method	OH, Section 8.10
Pretest Activities		
Determine SO_2 Concentration	If >2500 ppm, add more HNO_3–H_2O_2 solution	OH, Section 13.1.13
Prepare KCl Solution	Prepare batch as needed	OH, Section 8.5.1
Prepare HNO_3–H_2O_2 Solution	Prepare batch as needed	OH, Section 8.5.2
Prepare H_2SO_4–$KMnO_4$ Solution	Prepare for each day	OH, Section 8.5.3
Prepare HNO_3 Rinse Solution	Prepare batch as needed; can be purchased premixed	OH, Section 8.6.1
Prepare Hydroxylamine Solution	Prepare batch as needed	OH, Section 8.6.3
Sample Recovery Activities		
Brushes and Recovery Materials	No metallic material allowed	OH Section 13.2.6
Check for $KMnO_4$ Depletion	If purple color lost in first two impingers, repeat test with more HNO_3–H_2O_2 solution	OH, Section 13.1.13
Probe Cleaning	Move probe to predetermined clean area before cleaning	OH, Section 13.2.1
Impinger 1, 2, 3 Recovery	After rinsing, add permanganate until purple color remains to assure Hg retention	OH, Section 13.2.8
Impinger 5, 6, 7 Recovery	If deposits remain after HNO_3 rinse, rinse with hydroxylamine sulfate. If purple color disappears after hydroxylamine sulfate rinse, add more permanganate until color returns	OH, Section 13.2.10
Impinger 8	Note color of silica gel; if spent, regenerate or dispose	OH, Section 13.2.11
Blank Samples		
0.1 N HNO_3 Rinse Solution	One reagent blank per batch	OH, Section 13.2.12
KCl Solution	One reagent blank per batch	OH, Section 13.2.12
HNO_3–H_2O_2 Solution	One reagent blank per batch	OH, Section 13.2.12
H_2SO_4-$KMnO_4$ Solution	One reagent blank per batch	OH, Section 13.2.12
Hydroxylamine Sulfate Solution	One reagent blank per batch	OH, Section 13.2.12
Unused Filters	Three from same lot	OH, Section 13.2.13
Field Blanks	One per set of tests at each test location	OH, Section 13.4.1
Laboratory Activities		
Assess Reagent Blank Levels	Target <10% of sample value or <10× instrument detection limit; subtract as allowed	OH, Section 13.4.1
Assess Field Blank Levels	Compared to greater than 30% of sample values, investigate Subtraction of field blanks not allowed	OH, Section 13.4.1
Duplicate and Triplicate Samples	All CVAAS runs in duplicate; every tenth run in triplicate All samples must be within 10% of each other; if not, recalibrate and reanalyze	OH, Section 13.4.1

There are four different samples collected as a result of using the OH method. These are as follows:

1. *Ash Sample (Containers 1 and 2)* – The particulate catch will be analyzed using EPA Method 7043 or equivalent. If the particulate catch is greater than 1 g (as would be the case at most particulate control device inlet locations), an aliquot of the particulate collected on the filter will be subsequently digested using EPA Method 3051.
2. *KCl Impingers (Container 3)* – The impingers are prepared using H_2SO_4, HNO_3, and $KMnO_4$ solutions as specified in the method.
3. *HNO_3–H_2O_2 (Container 4)* – The impinger solution is prepared using HCl and $KMnO_4$ solutions as specified in the method.
4. *H_2SO_4–$KMnO_4$ Impingers (Container 5)* – The impinger solution is prepared using hydroxyl amine sulfate as specified in the method.

As shown above, the mercury measured in the ash sample consists of the mercury present in the ash collected on the filter (Container 1) and the mercury measured in the rinse of the probe section prior to the filter (Container 2).

Once the OH samples have been recovered and prepared, each of the above fractions are analyzed in duplicate for total mercury using cold-vapor atomic absorption spectroscopy (CVAAS). CVAAS is based on the absorption of ultraviolet radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrometer. Mercury concentration is proportional to the indicated absorbance. A soda–lime trap and a magnesium perchlorate ($Mg[ClO_4]_2$) trap must be used to precondition the gas before it enters the absorption cell.

The CVAAS to be used for these tests is set up for absorption at 253.7 nm with a carrier gas of nitrogen and 10% stannous chloride ($SnCl_2$) in 10% HCl as the reductant. Each day, the drying tube and acetate trap is replaced and the tubing checked. The rinse container is then cleaned and filled with fresh solution of 10% HCl. After the pump and lamp are turned on and warmed up for 45 minutes, the aperture is set to manufacturer specifications. A four-point calibration curve is then completed using matrix-matched standards. The detector response for a given standard is logged and compared to specifications to ensure that the instrument has been properly set up.

A QC standard of a known analyte concentration is to be analyzed immediately after the instrument is standardized in order to verify the calibration. This QC standard is to be prepared from a different stock than the calibration standard. The values obtained must read within 5% of the true value before the instrument is used. After the initial QC standardization is completed, standards are run every five samples to check the slope of the calibration curve. All samples are to be run in duplicate, and one in every ten samples is spiked to verify analyte recovery. These calibrations become part of a QC chart that is maintained at WKU to monitor the long-term precision of the instrument.

In addition to the routine calibration, WKU also will routinely participate in round-robin studies. These records also will be maintained at WKU.

5.0 SAMPLE-HANDLING AND CUSTODY REQUIREMENTS

Samples will be handled in the field by a number of individuals, as listed below:

- The in-field manager will mix reagents, load and recover impinger trains and filters, collect reagent blanks, and maintain all custody records.
- The sampling crews will take custody of the loaded sample trains, transport them to the sample locations, assemble and disassemble the trains as necessary at the sample location, and perform probe and connecting line rinses.
- Coal and ESP hopper ash samples will be collected by power plant personnel.

A composite ash sample will be collected from one row of hoppers that includes all the fields of the ESP. Prior to collecting the ESP hopper ash samples, the hoppers will be emptied. Although a truly representative ESP hopper ash sample is extremely difficult or impossible to obtain, this procedure provides the best approach.

Samples and reagents will be maintained in limited-access storage at all times. Chain-of-custody forms and sample labels will be made up prior to each test. The mercury data sheets will provide a detailed record of custody during sampling, with the initials noted of the individuals who load and recover impingers and filters and perform probe rinses.

6.0 DATA MANAGEMENT, DOCUMENTATION, AND RECORDS

The following steps will be taken to maintain data sheet custody and integrity:

1. All data sheets will be initialed by the person completing them and reviewed for completeness and accuracy.
2. Data sheets will be submitted to the principal investigator or field team leader, who reviews them for completeness and discusses any areas of concern or question with the person who completed the data sheet.
3. Data sheets are stored in a project notebook, which is kept in the custody of the project manager.

4. Data recorded on computers, such as test spreadsheets, are backed up daily and stored separately from the computer.

5. Data sheets are maintained by the project manager. Any changes or corrections are initialed and noted. These sheets will be made available for later inspection or comparison.

6. Original data sheets are used to make copies for inclusion in the final report and stored in company files with the original report. The length of storage is indefinite, but a minimum of 5 years is required.

Sample train data (filter ID, impinger weights, etc.) are recorded by the individual loading the train. Sampling information is recorded by the sampler. Sample train calculations (averages and total sample volume) are calculated by the sampler (or other available personnel) and recorded on the data sheet. The initials of the person performing the calculations are recorded on the data sheet. Analytical data are recorded by the project chemist. Analytical calculations are calculated by the project chemist or the PI. The initials of the person performing the calculations are recorded on the data sheet.

7.0 ASSESSMENTS AND RESPONSE ACTIONS

The criteria to review and validate data will consist primarily of comparing results with the QA objectives and targets detailed in this document. Additionally, specific results will be reviewed to check for consistency and logic. Table 4 presents a results evaluation and verification checklist. It is anticipated that most corrective action items will be minor, and immediate feedback will be given to the appropriate individuals. The QA/QC officer, in consultation with the project manager, will have the authority to stop work if there is an issue that cannot immediately be resolved.

In the event that a review reveals a systemic problem or items that are worth communicating to the full project crew, a QA action memo will be issued to the entire team, with copies to the power plant. Should the corrective action require any training in new procedures, such training will be conducted by the Project Manager or PIs or their designees.

Table 4. Results Evaluation and Verification Checklist

Measure	Objective
Unit Information	
Unit Operating Conditions	No unusual conditions
Air Pollution Control Device Operation	No unusual conditions
Sample Train Information	
Trains Leak-Checked Before and After Each Test	≤ 0.02 cfm
Pitot Probe Leak-Checked	Zero leakage
Filter Temperature Maintained	Minimum 120°C
Sample Isokinetics	90%–110%
Sample Volume	1 to 2.5 scm
Post Test Color of Permanganate Impingers	Purple
*Results**	
Flow Rate for Triplicate Runs	All runs within 10% of mean (adjusted for load if necessary)
Moisture for Triplicate Runs	All runs within 10% of mean
Stack Temperature for Triplicate Runs	All runs within 10% of mean
Mercury for Triplicate Runs	All runs within 35% of mean
% of Mercury in as Particulate-Bound	All runs within 25% of mean
% of Mercury in Oxidized Form	All runs within 25% of mean
% of Mercury in Elemental Form	All runs within 25% of mean

*If results are not within the criteria listed, the data must be flagged.

APPENDIX B

ESP INLET AND OUTLET DATA LOG BOOK

Miami Fort Unit-6 ESP
Inlet Data

01-09-06
1406-start SG, sys warming up, sample ambient

01-10-06
0909-cal
0922-sample ambient

01-11-06
0946-sample ambient thru ISP, heated line, conversion unit
1029-sample flue gas, both
1202-cal
1225-sample flue gas, both
1646-sample ambient
1712-flue gas, both

01-12-06
1123-ambient, restricted excess flows, changed ISP metal filter
1330-sample both

01-13-06
0830-ambient, no flow, heated line tripped off
1103-hooked up separate heater controller to heated line, cleaned conv unit bubbler T's
1113-cal
1132-sample, Hg tot only
1413-excess flows down
1534-fixed ISP pump
1742-sample both

01-14-06
0830-no flow as of 2100/01-13-06
0851-bubbler T's clogged, cleaned & reestablished flow
0853 sample total only
1042-cal
1059-total only
1332-elem only
1346-total only

01-15-06
0850-elem only
0900-sample both

01-16-06
0830-cleaned bubbler T's
0902-cal
0918-sample both

<u>01-17-06</u>
0630-restablished flow
0709-cal
0726-sample both
1330-flow restrichted
1452-cleaned bubbler T reestablished flow

<u>01-18-06</u>
0700-low flow Hg tot, cleaned T, reestablished flow
1207-low flow Hg elem, cleaned T, reestablished flow

<u>01-19-06</u>
0635-total flow down approx. 0330
0642-cleaned bubbler T's reestablish flow, sample both

<u>01-20-06</u>
O_2=7.8%
1100-both excess flows restricted approx 0130. cleaned bubbler T's reestablished flow
1159-cal
1230-low flows after cleaning T's, changed ISP pump
1232-sample ambient SG only
1257-sample ambient, ISP pump, HL, Conv unit
1302-sample flue gas, both

<u>01-21-06</u>
O_2=9.8%
0845-sys ran good thru the night
0922-cal
0950-sample flue gas, both

<u>01-22-06</u>
O_2=10.4%
0800-sys ran good thru the night
0900-cleaned bubbler T's and adjusted excess flows
0901-sample flue gas, both

<u>01-23-06</u>
O_2=7.2%
0735-sys ran good thru the night
0745-lap top quite?
0756-cleaned bubbler T's, restarted sys, adjusted excess flows
0800-sample flue gas, both

<u>01-24-06</u>
O_2=7.2%
0738-clean bubbler T's and adjust excess flows
0744-sample flue gas, both

01-25-06
O_2=7.7%
0749-clean T's and adjust excess flows
0813-sample flue gas, both

01-26-06
O_2=7.6%
0830-cleaned T's and adjusted excess flows
0842-cal
0903-sample flue gas, both
1721-clean T's and adjust excess flows
1733-sample flue gas, both

01-27-06
O_2=7.1%
0750-sys ran good thru the night
0826-stop sys to transfer data
0829-restart sys sample flue gas, both

01-28-06
O_2=7.7%
0800-elem bubbler T clogged off approx 0500, cleaned both T's and adjusted excess flows
0813-cal
0842-restart sys. Comm error reading data stick
0858-sample flue gas, both

01/29/06
O_2=10.6%
0843-sys running good, clean T's and adjust excess flows sample flue gas, both

01/30/06
O_2=7.2%
0700-elem excess flow down
0723-cleaned bubbler T's and adjusted excess flows
0735-sample flue gas, both
1237-restart sys cooling gas (house air) interrupted
1600-data points all over will recal
1615-cal
1642-sample, both

01/31/06
O_2=6.8%
0730-sys running good
1525-cooling air interrupted
1606-restart sys, sample both

02/01/06
O_2=9.0%
0628-sys running good
0715-excess flows went to zero, ADA maint with house air
0828-adjust excess flows
1147-sys shut down for house air maint
1200-restart sample both

02/02/06
O_2=7.5%
0730-cal
0754-sample both
1527-cleaned T's adjusted excess flows
1533-sample both

02/03/06
O_2=7.6%
0725-cleaned T's, adjust excess flows
0731-sample both

02/04/06
0750-ambient thru ISP pump
0824-ambient, SG only
0834-sys turned off

02/09/06
O_2=7.0%
0800-cleaned T's and adjusted excess flows
sample both

02/10/06
O_2=7.4%
0800-sys running good
0833-cleaned T's adjusted excess flow
resume sampling

02/11/06
O_2=7.2%
0912-sys running good
0915-cal
0935-sys froze up while inserting data stick, (suspect static electricity)
0958-restart, resume sampling

02/12/06
O_2=10.2%
0900-excess flows down approx. 0500/02-12-06
0922-cleaned T's, adjusted excess flows, resume sampling

02/13/06
O_2=7.8%
0720-sys running good
0745-cal
0815-resume sampling

02/14/06
O_2=7.3%
0841-sys running good

02/15/06
O_2=7.4%
0745-total T plugged off approx 2000/02-14-06 0810-cal 0832-resume sampling 1229-total T plugged off 1250-resume sampling

02/16/06
O_2=7.2%
0115-total T clogged off
0420-cleaned T's, readjusted excess flows 0425-resume sampling

02/17/06
O_2=7.2%
0727-sys running good
0807-cal
0829-resume sampling

02/18/06
O_2=8.3%
0834-cleaned T, adjusted excess flows
0841-resume sampling

02/19/06
O_2=7.1%
0450-total T plugged off and water slip elem side 0900-sample ambient 1045-cal 1111-resume sampling

02/20/06
O_2=7.2%
0700-sys running good
0700-resume sampling
1055-sample ambient to clean T's and hot box lines to T's 1100-found airleak elemental bubbler T, replaced T, cleaned reddish/brown
residue out of hot box lines to bubbler T's, reestablished excess
flows
1140-resume sampling

02/21/06
O_2=7.7%
0700-total T plugged off approx. 2300/02-20-06 0745-reestablished flo0755-cal 0822-sample ambient,plating plug total supply line just before bubbler T.
Replaced supply line from paristaltic pump to bubbler T 0852-resume sampling 1409-total T clogged off 1545-resume saqmpling

02/22/06
O_2=6.8%
0720-total T clogged off approx. 0100/02-22-06 0733-switching box shut down 0739-restart sys, resume sampling

02/23/06
O_2=7.7%
0801-sys running good
0810-cal
0841-resume sampling
1830-got called in cleaned both bubbler T's and adjusted excess flows 1938-resume sampling 1941-switching box shut down 1946-restart sys, resume sampling

02/24/06
O_2=7.4%
0750-sys running good, cleaned T's readjusted excess flows 0800-resume sampling 1540-sample ambient from ISP pump 1614-sample ambient thru S.G. only 1723-sample ambient thru ISP pump 1741-resume sampling, moved conv unit into shed and installed 2nd AC

02/25/06
O_2=6.9%
0845-gas leak inside shed, sample ambient thru ISP pump 0933-resume sampling, found elem teflon filter plugged up 1010-cal 1038-resume sampling

02/26/06
O_2=7.2%
0901-sys spikes just like outlet at beginning, bumping hot box to 325f
and insulateing T's, still getting gas leak inside shed, found
elem teflon filter after conv unit leaking, R2 filter holder 0904-sample ambient, lost gas flow 0958-sample tot only for trouble shooting gas leak 1005-resume sampling both w/HB @ 320f

02/27/02
O_2=6.7%
0826-found excess flows low to zero, readjusted excess flows 0830-cal 0904-resume sampling w/ HB@330f and HL@310f 1048-bump HB to 340f 1430-elem excess flow down to zero readjust 1443-bump HB to 350f readjust excess flows 1445-resume sampling 1510-sample ambient for trouble shooting maint
found moisture in teflon lines from conv unit to teflon filters,
cleaned up, cleaned T's,flushed DI H_2O thru ISP pump and HL 1638-sample ambient thru ISP pump 1648-sample total only 2030-shut down sys to adjust detector 2037-restart sys 2055-sample total 2158-found leak Hgtot cooler impinger, fixed

02/28/06
O_2=6.8%
0823-excess flows low, readjusted
0829-changed out ISP metal filter, and quartz filter 1031-resume sampling, Hgt 1204-sample ambient for maint

03/01/06
O_2=6.3%
0742-detector test, good

1226-sample Hgt only
1440-changed out ISP pump
1507-water slip
1648-sample Hgt only
1841-change paristaltic pump tubing

<u>03/02/06</u>
0740-detector test
0916-sample Hgt only
0932-sample Hgo only
1000-Hgt only1028-cal
1049-sample ambient
1112-sample Hgo only
1141-sample Hgt only
1639-sample ambient
1716-Hgt only
1736-samble both

<u>03/03/06</u>
0815-sys running good
1441-raise ISP hot box to 325f, HL to 315f, C.U. hb to 340f 1445-resume sampling

<u>03/04/06</u>
0900-excess flows down, total solution supply tube clogged 0920-resume sampling with ISP HB@335f, HL@325f, C.U. HB@350f

<u>03/05/06</u>
0830-sys running good
0900-stop sys not recognizing removeable disk 0915-restart sys 0919-cal 0948-resume sampling

<u>03/06/06</u>
0800-sys running great, ain't touch'n nuttin!

<u>03/07/06</u>
0800-sys running great
0841-cal
0918-sample ambient due to Hgo HB needle valve body cracked and leaking 0931-resume sampling

<u>03/08/06</u>
0800-sys running great
0801-resume sampling

<u>03/09/06</u>
0800-sys running great
0844-cal
0913-resume sampling

<u>03/10/06</u>
0800-sys running great
0801-resume sampling

03/11/06
0830-sys running great
0838-cal
0908-resume sampling

03/12/06
0900-sys running great
0901-resume sampling

03/13/06
0800-sys running good
0834-cal
0908-sample ambient ISP pump inop
1002-resume sampleing

03/14/06
0600-sys running great
0601-resume sampling

03/15/06
0730-sys running great
0756-cal
0825-resume sampling

03/16/06
0800-sys running great
0801-resume sampling

03/17/06
0730-sys running great
0751-cal
0818-resume sampling

03/18/06
0900-sys running great
0901-resume sampling

03/19/06
0722-sys running great
0727-cal
0756-resume sampling

Miami Fort Unit-6 ESP
Outlet Data

01-07-06
1400-start SG to warm up, sample ambient

01-08-06
1130-sample ambient thru heated line, conv unit/w DI water
1141-injection cal
1314-sample flue gas, both

01-09-06
0806-cav kit cal gas thru probe filter
0849-cav kit cal gas direct to SG
0924-inj cal
0942-cav kit to SG
1018-cal with cav kit
1031-cav kit to SG
1042-sample flue gas, both

01-10-06
0830-sys seems ok
0841-sample ambient, to rinse heated line
0928-sample ambient SG only
1003-sample ambient thru heated line, conv unit
1030-ambient thru conv unit
1056-ambient thru HL, conv unit
1122- cal w/cav kit
1244-sample both

01-11-06
1013-found contamination in slip cencurs
1111-sys shut down due to comm alarm
1215-sample ambient
1247-sample flue gas, both
1540-ambient
1605-sample both

01-12-06
0858-cav kit cal
0922-cav kit gas thru probe filter
0957-cal w/cav kit
1050-sample flue gas, both

01-13-06
0911-cav kit cal
0958-adjust lamp voltage, recal w/cav kit
1022-sample flue gas, both

01-14-06
0931-cal w/cav kit
0953-sample flue gas, both

01-15-06
0941- cal w/cav kit
1003-sample both
1159-recal,new argon tank
1219-sample, both

01-16-06
0930-found probe and muff, tripped, reset and changed filter
1035-cal
1055-sample both

01-17-06
0801-cal
0838-sample both

01-18-06
0835-cal
0901-sample both

01-19-06
0703-cal
0730-sample both
1600-check probe filter (clean after 3 days w/90degree nozzle inst)
1620-sample both

01-20-06
O_2=6.8%
0930-probe tripped off, reset
1005-cal
1031-sample flue gas, both

01-21-06
O_2=9.0%
1019-sys ran good thru night
1020-start cal
1046-sample flue gas, both
1145-recal with 2ea. 30sec cav/kit
1212-sample both

01-22-06
O_2=10.2%
0940-muff tripped off approx 0730, reset
1007-start cal
1030-change probe filter
1037-sample flue gas, both
1136-restart cal
1201-sample flue gas, both

<u>01-23-06</u>
O_2=6.7%
0811-numbers all over, found Hg elem excess flow at zero
0819-adjusted excess flows
0820-sample flue gas, both

<u>01-24-06</u>
O_2=6.6%
0830-found probe tripped off, reset
0905-cal
0933-sample flue gas, both

<u>01-25-06</u>
O_2=6.7%
0830-adjust excess flows
0926-cal
0954-sample flue gas, both

<u>01-26-06</u>
O_2=6.9%
0920-muff tripped off, reset
0922-sample flue gas, both
1509-change gain to 100 and recalibrate
1514-cal
1540-sample flue gas, both

<u>01-27-06</u>
O_2=6.1%
0650-sys running good, adjust tot excess flow
0707-cal
0752-sample flue gas, both
1710-raised heated line to 340f, muff to 290f, probe to 290f

<u>01-28-06</u>
O_2=6.6%
0700-sys running good
0715-cal
0750-sample flue gas, both
1702-change probe filter
1715-probe, muff, and filter holder reheating to temp,
    Sample flue gas, both
1739-blanks thru probe filter
1800-blanks thru probe filter
1821-sample ambient thru probe filter, HL, CU, both
1854-sample ambient thru Teflon filters only
1909-sample ambient thru conv unit solenoid valves on back door
1916-sample ambient thru Teflon lines after slip sensors
1923-ambient thru slip sensors
1930-ambient thru Teflon lines before slip sensors
1937-ambient thru cooler impingers, 1 microgram contamination tot cooler impinger
2035-ambient thru hot box pumps

2038-ambient thru heated line
2102-ambient thru probe filter
2119-sample flue gas, both

<u>01/29/06</u>
O_2=11.6%
0816-sys running good
0819-cal
0912-sample flue gas, both

<u>01/30/06</u>
O_2=8.8%
0738-sys running good
0751-cal
0825-sample, both

<u>01/31/06</u>
O_2=8.0%
0700-sys running good
0717-cal
0757-sample, both

<u>02/01/06</u>
O_2=8.1%
0700-sys running good
0721-cal
0810-sample, both

<u>02/02/06</u>
O_2=6.7%
0805-cal
0845-sample, both

<u>02/03/06</u>
O_2=6.7%
0746-cal
0820-sample, both

<u>02/04/06</u>
0800-ambient thru heated line
0847-ambient, SG only
0857-sys shut down

<u>02/09/06</u>
O_2=6.7%
0819-sys running good
  sample, both

02/10/06
O_2=6.9%
0730-sys running good
0811-cal
0846-resume sampling

02/11/06
O_2=6.7%
1000-outlet numbers higher than inlet
1012-cal
1150-sample ambient thru heated line, new probe w/n heat over 252 degrees
1226-old probe installed with clean filter
1235-resume sampling, while probe and filter housing comming up to temp
1330-old probe set to 305f, muff @330f, HL @ 335f, conv unit HB @ 350f

02/12/06
O_2=10.3%
0830-sys running good, switch back to gain 10
0908-cal
0957-resume sampling, Hgtot excess flow restricted
1018-replace low volumn T with reg T, resume sampling

02/13/06
O_2=7.2%
0817-sys running good
0829-cal
0909-resume sampling
1210-change sample method to 2min quick extra flush gain 10

02/14/06
O_2=8.7%
0727-sys running good, probe steady @ 305f 0749-cal., change gain to 100 0827-resume sampling

02/15/06
O_2=7.8%
0835-sys running good, loaded 2min method to match inlet 0850-cal 1014-resume sampling with new 2min long method

02/16/06
O_2=6.4%
0440-sys running good
0446-cal
0532-resume sampling
0950-data maxed out due to gain 100
1023-change probe filter, change gain to 10, recalibrate 1030-cal 1130-resume sampling

02/17/06
O_2=8.0%
0830-sys running good
0848-cal
0935-resume sampling
1245-change filter and filter glass housing 1300-resume sampling

02/18/06
O_2=7.6%
0844-sys running good,change gain to 100 0901-cal 0940-sys locked up, had to manual shutdown 0945-restart sys 0949-cal 1019-resume sampling

02/19/06
O_2=6.3%
1000-suspect probe tripped off approx 0300 1049-cal 1115-resume sampling 1150-cooling air alarm, zero psi, no pressure, confirmed frozen air line 1815-air lines thawed, restart sys 1855-sys shut down, air lines frozen again

02/20/06
O_2=6.1%
1011-replaced air lines (cooling air), restart sys
resume sampling

02/21/06
O_2=7.0%
0850-sys running good
0900-sample ambient thru S.G. only for maint 0942-cal 1045-resume sampling,changed out probe to 9' probe, changed filter,
changed out elem pump
new probe-335f
muff-335f
heated line-340f
Hot box-350f

02/22/06
O_2=10.9%
0740-sys running good
0748-cal
0839-resume sampling

02/23/06
O_2=10.3%
0845-sys running good, ck probe filter, clean bubbler T's, flush all
teflon lines in conv unit
0909-cal
0957-resume sampling

02/24/06
O_2=10.2%
0810-sys running good, ck probe filter, clean T's, flush all conv unit teflon lines with D.I. water
0818-cal
0910-resume sampling

02/25/06
O_2=9.7%
0930-sys running good
1044-blanks to S.G.
1053-high spans to S.G.
1105-cal
1205-resume sampling

02/26/06
O_2=11.2%
0840-sys running good
0921-cal
1015-resume sampling

02/27/06
O_2=6.1%
0800-sys running good
0921-cal
1015-resume sampling
1730-stop sys to change out quick drawer for reg drawer 1920-detector test 2230-reg drawer inop, reinstall quick drawer 2250-restart sys, resuming sampling

02/28/06
O_2=6.4%
0820-sys running good
0826-cal
0850-resume sampling
0854-sample ambient thru HL
0912-sample ambient thru probe
1021-blanks thru probe
1151ambient thru HL
1201-resume smpling with ADA QSIS probe
1459-convert quick drawer to regular drawer 1531-injection cal 1537-detector test 1544-recal 1548-sample Hgt only 1803-cavkit zeros and high spans 1829-blanks to SG 1846-inj spike 1853-sample Hgt 1935-found HB off since 1745

03/01/06
O_2=6.1%
0757-detector test
0759-cal
1003-resume sampling
1851-cal
1910-resume sampling

03/02/06
0800-detector test
0812-cal
0820-sample Hgo
0838-sample Hgt
1740-total waste line from cooler impinger came loose approx 1500 1745-resume sampling, both

03/03/06
0844-no flows, needle valve to bubbler impingers lines plugged up
sample ambient
1203-cav kit cal w/30 sec method
1314-resume sampling
1317-switching box quit
1322-restart sys,resume sampling both
1351-water slip
1449-resume sampling
1531-sample ambient for sys leak check
1540-blanks and spikes from cav kit directly to S.G.(7.7 recovery) 1634-blanks to end of heated line
1710-spans to HL Hgo only (7.1 recovery) 1739-spans to HL Hgt only (7.0 recovery) 1817-resume sampling w/9' probe@335f, muff@335f,HL@340f, C.U. hb@350f

03/04/06
0925-total excess flow down, readjusted
0926-resume sampling
1150-change back to QSIS probe
1200-resume sampling with QSIS probe

03/05/06
0940-total cooler impinger drain line clogged, slip sensor inop 0956-cal 1104-resume sampling

03/06/06
0830-running great also, ain't touchn this one also!
1230-swap to 9' probe, QSIS probe dided
1245-resume sampling w/9' probe

03/07/06
0910-Conv Unit HB off to steal Vent needle valve 0925-resume sampling with 9' probe 0957-resume sampling with QSIS probe 1244-sample ambient from HL to check for contamination
1356-resume sampling with QSIS probe

03/08/06
0820-sys running great
0824-cal
0936-resume sampling

03/09/06
0800-sys running great
0801-resume sampling

03/10/06
0843-QSIS probe in total shutdown as of approx. 0345 0850-cal 1002-resume sampling with 9' probe

03/11/06
0800-sys running great
0801-resume sampling

03/12/06
0920-sys running great
0933-cal
1044-resume sampling

03/13/06
0830-sys running great
0831-resume sampling

03/14/06
0600-sys running great
0639-cal
0750-resume sampling

03/15/06
0830-sys running great
0831-resume sampling

03/16/06
0800-sys running great
0830-cal
0930-adjust detector, detector low alarm 1000-recal 1030-resume sampling

03/17/06
0822-sys running great
0823-resume sampling

03/18/06
0910-sys running great
0921-cal
1032-resume sampling

03/19/06
0800-sys running great
0801-resume sampling

D. Data Smoothing and Acceptance Routine

The mercury measurements taken during the Cinergy Amended Silicate sorbent injection project was done by UNDEERC. For whatever reasons, the mercury levels determined by UNDEERC were extremely noisy and required a great deal of post-processing to yield a dataset that could be used for calculations. Method(s) used for post-processing the data had to be objective and unbiased so that the resulting dataset was not favored to eliminate low or high mercury measurements, but instead picked out the natural trends in the data. The following is an explanation of the filtering and smoothing routines used to process the mercury measurement data such that the data could be used for subsequent calculations.

Assumptions:

(1) Mercury measurements are is well behaved

(2) The variation between data points is within statistical variance

(3) Allowable variance between sequential data points does not change substantially over short time periods

Procedure:

The assumption that the Semi-Continuous Emissions Monitor (SCEM) data is well behaved implies that value of sequential mercury measurements should be within a statistical variance. To assess the allowable variance in the mercury measurements, the distance between sequential data point was calculated by the following equation, where the Δy value is the change in mercury concentration between two sequential measurements and Δx is the time interval between mercury measurements.

$$\overline{D} = \sqrt{\Delta y^2 + \Delta x^2} \quad \textbf{(1)}$$

During the tests, the SCEM was configured to measure both total and elemental mercury; typically eight total mercury measurements were made followed by three elemental mercury measurements. The SCEM was also calibrated on a daily basis and took as long as an hour to complete. Other maintenance items were also performed on an as-needed basis such as servicing sample pumps and cleaning glassware. All of the procedures required the SCEM instrument to be off-line for an unspecified amount of time to complete the task. As a result, the SCEM data files were an array of mercury data with irregular time intervals between measurements. The unequal time intervals made the statistical analysis difficult. For this reason, the added assumption that the statistical variance between sequential data points is valid over short periods of time transforms the dataset into one with equal time intervals between data points. This assumption is realistic if the first assumption is valid as would be the case for a steady-state operation. However, there are changes in steady-state conditions such as changes in plant load which affect mercury concentration in the flue gas. To account for normal fluctuations in plant operations, the data used to evaluate the expected variance criterion for the mercury data included mercury measurements taken during high-load and low-load conditions to determine the overall variance for typical operations. The distance calculations were performed using a typical time interval of five minutes. The time interval is somewhat arbitrary, but a time is needed to perform the calculations. Five minutes is reasonable given that most of the total mercury measurements were taken in five minute intervals. The distance dataset was then sorted in ascending order and a frequency plot of the data was prepared.

To assess the variance in our distance variable, it is necessary to calculate the mean and standard deviation of the distance data. The first approach investigated whether the distance frequency plot fit known probability distribution functions for which formulas for the mean and variance for these distribution functions have been derived. The shape of the distribution curve for the distance frequency plot is shown in Figure 1. It is seen that the data starts at a minimum value based on the time interval used in the distance calculation.

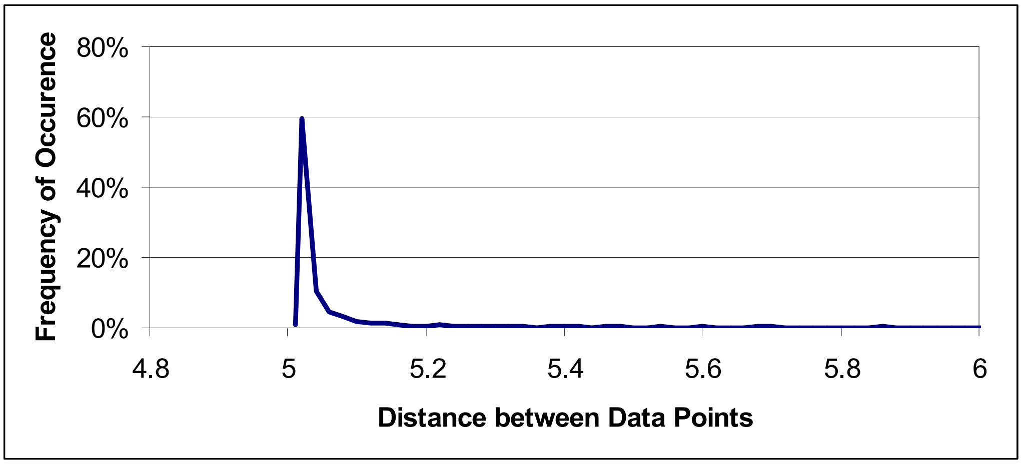

Figure 1 – Probability Distribution Function for the Distance Variable

It was found that the probability distribution for the distance data did not follow typical distribution curves such as the gamma, chi-square or an exponential function. The function that most closely fits the shape of the data distribution was a hyperbola, but even this function is difficult to deal with given that the function does not decay in a manner characteristic of the distance dataset. As an alternative to curve fitting a probability distribution function to the distance dataset for determining values for the mean and variance, a simplified approach was used to calculate the statistics of our distance data. The mean or expected value of the distance variable was calculated by multiplying each of the distance values by its corresponding probability and summing the products using Equation 2.

$$\mu = \sum_x x f(x) \tag{2}$$

The variance for a discrete variable is calculated from Equation (3) by summing the product of the square of the distance value multiplied by its probability and subtracting the square of the mean calculated from Equation (2) above.

$$\sigma^2 = \sum_x x^2 f(x) - \mu^2 \tag{3}$$

After calculating the mean and variance for several datasets, it was found that over 90% of the distance values fell between 5 and 7 distance units with some data having values as high as 60 units. Clearly, these higher values are not typical for a well-behaved dataset and only serve to skew the mean and variance values. For this reason, the mean and variance calculations were performed over a two unit spread (5 to 7 units). The calculated statistics were used to establish the upper limit for the distance between data points defined as the mean plus three standard deviations, where the standard deviation is the square root of the variance. The upper limit then became the filter or criterion for accepting or rejecting SCEM data points. It should be noted, that the filter is not biased towards high mercury measurements but it is just as likely to disallow low mercury values as well as high mercury values. Instead, the filter examines the natural trend of the SCEM data.

Application of the filtering routine was a two part process. In the first process, the unfiltered distance data was calculated and the upper limit filter value was determined as described above. The calculated distance between data points was then compared to the filter value. If the calculated distance was less than the filter value then the SCEM data point was accepted and the next data point was considered. At the same time, a rolling average of the filtered SCEM data was calculated and represented the natural trend of the data. If however the calculated distance exceeded the filter value, the SCEM data point was replaced with the current rolling average value. In the second process, the entire filtered data set was smoothed using a weighted rolling average having the formula:

$$\frac{\sum 2x_{i-2} + 4x_{i-1} + 8x_i + 4x_{i+1} 2x_{i+2}}{20} \qquad \textbf{(4)}$$

Figure 2 shows the results of a dataset after applying the filter routine showing the reported mercury measurements (dark blue diamonds), the filtered mercury measurements (magenta symbols) and the smoothed data (red line). The data shown spans two days displaying changes in mercury concentrations during high and low load conditions.

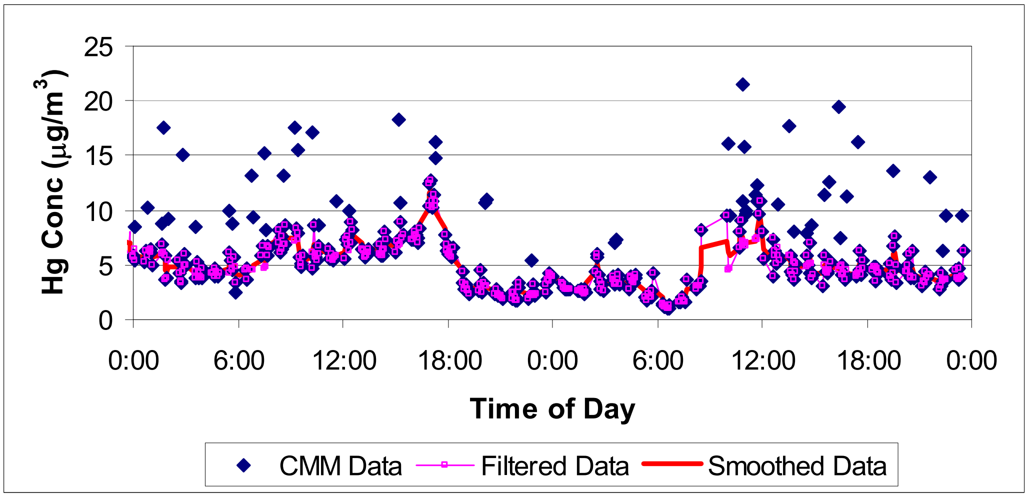

Figure 2 – Application of Filter Routine

E. Ontario-Hydro Sampling Report (WKU)

Institute for Combustion Science and Environmental Technology
2413 Nashville Road, Bowling Green, KY 42101 Tel: (270) 745-2220 Fax: (270) 745-2221

Final Report for

Longer-Term Evaluation of ADA Amended Silicates at a Coal-fired Power Plant by Ontario Hydro Mercury speciation Method (ASTM D6784-02)

PHASE II FIELD TESTING OF ADVANCED MERCURY CONTROL TECHNOLOGY

DOE National Energy Technology Laboratory

A Proposal Submitted to:

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September 5, 2006

WESTERN KENTUCKY UNIVERSITY

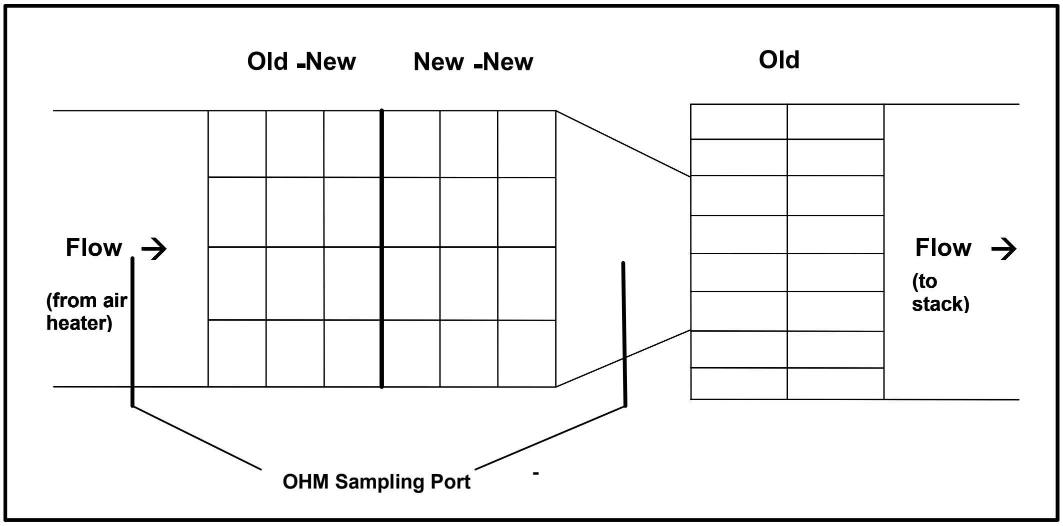
Appendix E

1 Test Event

This demonstration is part of an overall program funded by the Department of Energy (DOE)'s National Energy Technology Laboratory (NETL) to obtain the necessary information to assess the costs of controlling mercury with sorbent injection, which is specific in this project to be the injection of ADA's Amended Silicates sorbent. The host site is Cinergy Corp's Miami Fort Station Unit 6, which burns eastern bituminous coal with load capacity of 175 MW in electrical power generation. The tests were conducted on the full exhaust gas stream of the unit before and after (Electrostatic precipitator) ESP.

There are three ESPs for Unit 6, which are arranged in series and designated by plant personnel as "old-new", "new-new", and "old". The oldest of the three units is located closest to the fan and stack, and is downstream of the old-new and new-new units. The old-new and new-new ESPs were built close back-to-back and fully integrated, with the same cross-sectional dimensions.

Figure 1 – Schematic of Unit 6 ESP Layout



During demonstration, speciated mercury concentrations in the flue gas were measured using the Ontario-Hydro (OHM) wet-chemistry measurements performed manually by Western Kentucky University (WKU)'s Institute for Combustion Science and Environmental Technologies (ICSET) and Semi-Continuous Mercury Monitor (SCEM) by University of North Dakota's Energy & Environmental Research Center (UNDEERC). The inlet mercury sampling ports are located downstream of the air pre-heater and upstream of the sorbent injection ports. The outlet mercury sampling locations are immediately downstream of the old-new/new-new ESP combined box and upstream of the old ESP. OHM sampling access the selected ports near

UNDEERC's SCEM to do traverse samplings with 2x2. In order to deliver consistent, high-quality data, an organization-wide quality management system (QMS), authorized and supported by ADA, WKU, and EERC managers, is in effect and governs all programs. WKU project managers are responsible for ensuring that the project- specific QA/QC protocols for OHM sampling, sample analysis and QA/QC activities.

In order to provide a comprehensive data set that characterizes the performance of Amended Silicates in a full-scale coal-fired utility, OHM chemical sample trains were set up and operated by the ICSET team at four selected times during the demonstration phase, as indicated below.

Sampling activities:

Jan 17-19, 2006 - Baseline test, totally 14 OHM samples;
Feb 01-03, 2006 - Parametric test, totally 10 OHM samples;
Feb 28- Mar 02, 2006 - 1st period of long term test, totally 12 OHM samples
Mar 14 , 2006 – the 2nd period of long term test, totally 9 OHM samples

QA/QC activities:

Jan 17-18, 2006 - Baseline test, 1 reagent blank, 2 filed blanks, 2 spikes;
Feb 01-03, 2006 - Parametric test, 1 reagent blank, 2 filed blanks, 1 spikes;
Feb 28, 2006 - 1st period of long term test, 1 reagent blank, 2 filed blanks, 1 spikes;
Mar 14 , 2006 - the 2nd period of long term test, 1 reagent blank, 2 filed blanks, 1spikes.

2 OHM Methodology and Instrumentation

Ontario Hydro Method - ASTM D6784-02

The versatile Apex Instruments specific isokinetic sampling train (probe with quartz liner, Method 17 glassware set, U-cord, pumps and metering console) was used. After sampling, solutions were analyzed using a Leeman Lab Hydra and Hydra Prep automated mercury analysis system. This mercury analyzer is fully compliant, automated and employs a dual beam, cold vapor AA system. This system features a mercury detection limit of 1 part per trillion (ppt).

Sampling probes

Generally we used EPA Method 17 or 5 for the OHM sampling. In these methods, the sample gas is passed through a filter located in front of sampling probe or back of sampling probe depending on stack temperature. The configuration of the Method 17 probe is shown in Figure 2, and was used in the OHM sampling activities for the ESP outlet samples.

The Method 17 sampling probe was used for the inlet ESP gas samples during the baseline tests. With the sample probe oriented into the gas flow, the ash-laden sample gas passes through a filter to separate the particulate matter from the gas sample. The fly ash layer can dramatically change the speciation of the mercury in the gas by the oxidation of elemental mercury. Thus, during baseline tests, the EPA Method 17 probe was used, however, with the probe oriented out of gas flow. In this orientation, fly ash did not build-up on the filter to an appreciable extent and the bias effect of the ash layer on Hg oxidation was minimized. During the parametric and long-term test periods, the WKU team brought an inertial probe sampling at ESP inlet location and eliminated the bias introduced with the traditional filter (See Figure 3).

Figure 2. EPA Method 17 sampling probe

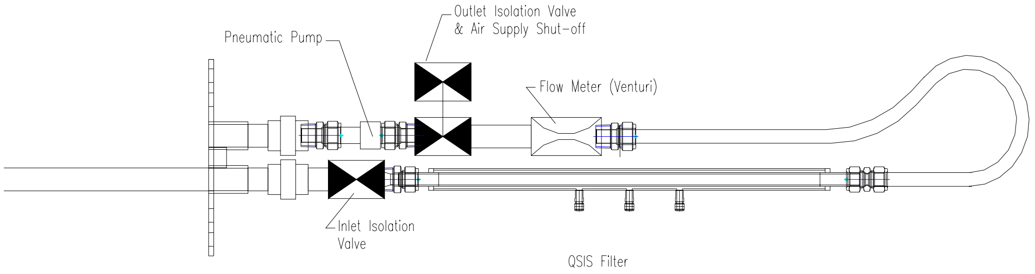


Figure 3. The inertial probe

Leeman Mercury Analyzer

The Leeman Hydra Prep was employed to replace manual solution digestion in the OHM method. After solution preparation, 4-mL aliquots of the KCl, H_2O_2/HNO_3, and $KMnO_4/H_2SO_4$ solutions used for absorbing mercury species were transferred to 15-mL digestion cups, in which 0.2 mL concentrated H_2SO_4, 0.1 mL concentrated HNO_3, 1.2 mL 5% $KMnO_4$, and 0.32 mL of 5% $K_2S_2O_8$ were added automatically to each cup through a dispenser installed on the auto-sampler. The cups were placed in a water bath set at 95^oC and heated for two hours. After cooling, 1.333 mL of 12%:12% NaCl: hydroxylamine sulfate is added. The digested samples were taken to the Leeman Hydra AA for mercury determination.

Determination of mercury by the Leeman Hydra AA instrument is based on cold vapor atomic absorption spectrometry. In our test, 5% HNO_3 was used as the rinse solution, and 10% $SnCl_2$:10% HCl used as the reductant solution. The pump rate of the $SnCl_2$ / HCl solution was controlled at 5 mL/min. The carrier gas used for the AA was ultra-high purity grade nitrogen flowing at a rate of 0.6 LPM. A flow chart for the analytical procedure is shown in Figure 4. Each prepared fraction was analyzed in duplicate for total mercury using cold-vapor atomic absorption spectrometer (CVAAS). The average of the two analyses was used in the data report.

A schematic of the OHM QA/QC procedure is shown in Figure 5. The diagram for quality control follows the instructions for the OHM procedure (**ASTM D6784-02**) and protocols outlined in the project QA/QC document (**QUALITY ASSURANCE PROJECT PLAN, prepared by UNDEERC).**

Figure 4. OHM analysis flow chart

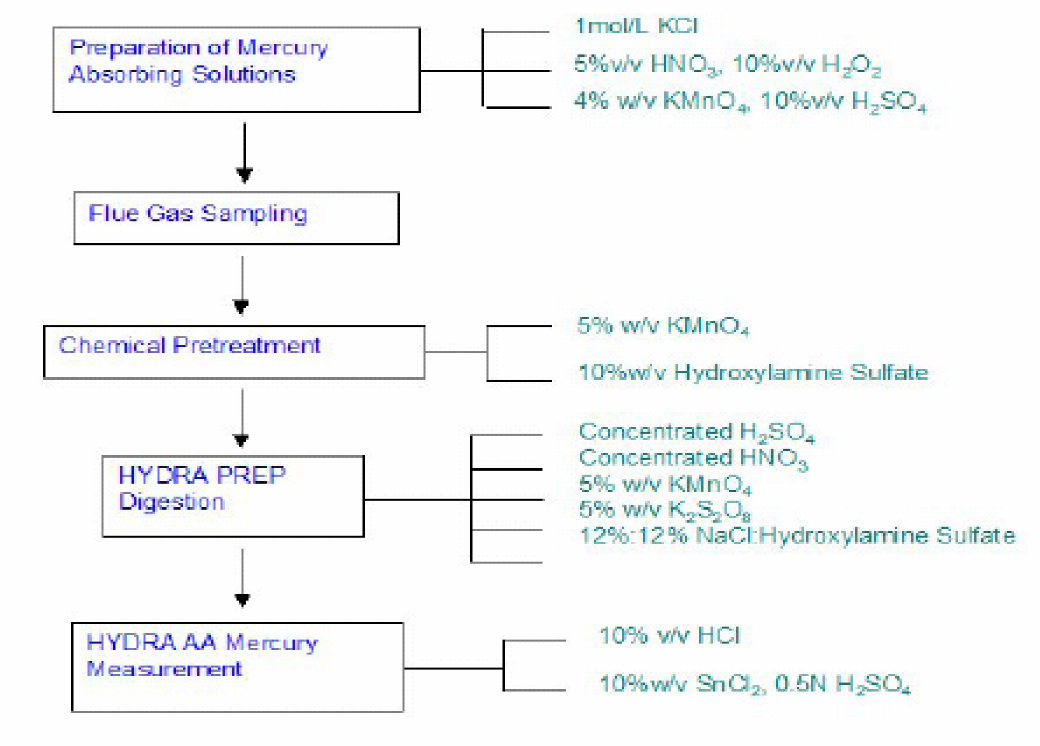
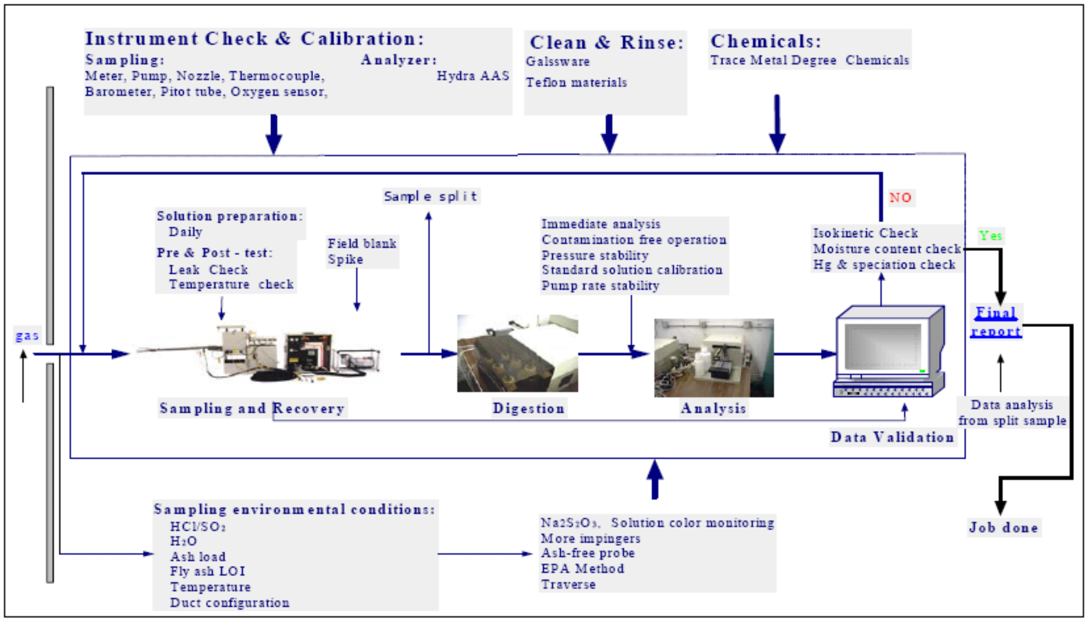


Figure 5. The OHM QA/QC and sampling and analysis flow chart



3 Test Results

The flue gas parameters at each sampling location were recorded every 5 minutes during the OHM sampling procedure. The average flue gas temperature at ESP inlet varied between 140 ^{o}C to 145 ^{o}C with an average gas temperature of 140 ^{o}C. The static pressure was about -10" H_2O on average. The average flue gas temperature at ESP outlet was between 130 ^{o}C to 135 ^{o}C with an average gas temperature of 133 ^{o}C. The static pressure was about -14" H_2O on average. Flue gas was sampled through the impinger trains for a 2-hour period for all OHM tests.

During Jan 17 to 19, 2006, WKU team conducted baseline OHM tests at the ESP inlet and outlet locations for Unit 6. After discussion with ADA project manager, WKU team carried out a sampling matrix based on standard and modified OHM methods (only for sampling activities) at ESP inlet location (totally 8 samples). In total there were eight sample ports at the inlet location; 4 ports in each of two ducts. Just above the sample port location, the two ducts converged into a common duct that connected to the ESP. Tests indicated that mercury concentrations in each of the two ducts were consistent with each other, as indicated in Table 1. At the ESP outlet, only the standard OHM method was used (totally 6 samples).

Test results indicated that the total mercury in the flue gas varied from about 10 $\mu g/Nm^3$ to 20 $\mu g/Nm^3$ at both sampling locations during the 3-day baseline tests. It seemed that less mercury was bound to the fly ash than anticipated, thus, mercury removal by the fly ash was as low as 15% on average during the baseline tests. At the ESP outlet location, very little ash was found on the sampling filter. Mercury speciation was showed to be almost constant throughout baseline sampling term. However, at ESP inlet location, fly ash built-up on the filter dramatically changed the proportions of oxidized and elemental mercury. The Hg(0)/Hg(VT) varied from approximately 15% when the OHM probe nozzle was oriented into the gas flow as specified in the standard OHM procedure, to approximately 65% when probe nozzle was inversed and the probe was oriented out of the gas. The difference being that less ash material accumulated on the filter when the sample probe was oriented out of gas flow. All sampling parameters and laboratory analytical results are presented in Table 2-1 to 2-6.

In the 2nd term (Feb 01-03, 2006), sorbent was injected in Unit 6 upstream of the ESP inlet. Injection rates were adjusted during these tests to optimize sorbent injection rate conditions. During this sampling term, an inertial probe was used for OHM sampling at the ESP inlet location to minimize the impact of the filter ash on mercury speciation in the sample gas. With the inertial probe at ESP inlet and a conventional OHM probe at ESP outlet, net mercury removal efficiencies were observed. In the 1st day of this term, the mercury removal efficiency varied between 28.3% and 37.5% with an average of 32.9%. On the 2nd day, the mercury removal efficiency decreased to 17.3% on average, which was reported to be attributed to troubles with the sorbent injection system. After troubleshooting and improving components of the injection system, the mercury removal efficiency increased to around 41.4% on third day. The mercury removal efficiencies reported in Table 3 are the solely the result of sorbent material injected into the flue gas. All sampling parameters and laboratory results are presented in Table 4-1 to 4-5.

The long-term evaluation of sorbent injection tests started February 13th and continued through March 14th. During that time sorbent was injected continuously into Unit 6. WKU conducted the 3rd and 4th OHM sampling terms Feb 28-Mar 2 and Mar 14. An inertial probe was used for OHM sampling at the ESP inlet location to minimize impact of the ash on mercury speciation. Thus, all data presented in the summaries table are net mercury removal efficiencies as a result of sorbent injection (See Table 5 and 7). All sampling parameters data and laboratory results are collected in Table 6-1 to 6-3 and Table 8-1 to 8-2, respectively.

In the 3rd term of OHM test, the mercury removal efficiency varied between 5% and 18.3%. In the 4th term, the mercury removal efficiency was somehow improved with the maximum net mercury removal efficiency to be 31.5%, which is comparable to the net mercury removal efficiency at the mid-level injection rates (32.9%) during the parametric test period (the maximum net mercury removal efficiency was 41.4% during the parametric test period). During this term, an additional test at the ESP inlet location using a conventional OHM sampling probe was conducted in order to obtain the total mercury removal efficiency achieved by ESP ash-bound mercury and sorbent-bound mercury. Results indicated the mercury removal efficiency by ash-bound mercury only was about 14% (100%*(10.93-9.37)/10.93), which is close to the baseline tests during the 1st term. The data consistency was found to be in good agreement.

Table 1. OHM data summary (Jan 17-19, 2006 for baseline test)

	in ug/NM^3 (3% O_2 correction)					%		
	Hg(0)	Hg(2+)	Hg(P)	Hg(VT)	Hg(T)	Hg(0)/Hg(VT)	Hg(P)/Hg(T)	Removal efficiency across ESP
17-Jan	ESP inlet-nozzle in flow direction on the right duct							-3.1
Inlet								
No.1	2.32	11.40	1.13	13.72	14.85	16.9	7.6	
No.2	3.48	17.18	0.79	20.66	21.45	16.8	3.7	
Average					18.15			
Outlet								
No.1	8.84	9.06		17.90		49.4		
No.2	6.91	12.63		19.54		35.4		
Average				18.72				
18-Jan	ESP inlet-nozzle out of flow direction on the left duct							12.6
Inlet								
No.1	10.28	6.85	0.04	17.13	17.17	60.0	0.23	
No.2	11.12	6.16		17.28		64.4		
No.3	9.70	5.90		15.60		62.2		
Average					17.17			
Outlet								
No.1	5.49	9.59		15.08		36.4		
No.2	5.67	10.54		16.21		35.0		
No.3	5.03	8.72		13.75		36.6		
Average				15.01				
19-Jan	ESP inlet-nozzle NO. 1 in flow direction on the left duct, NO.2 and 3 out of flow direction on the right duct							17.5
Inlet								
No.1	1.40	7.53	0.71	8.93	9.64	15.7	7.4	
No.2	5.93	3.43		9.36		63.4		
No.3	5.40	2.76		8.16		66.2		
Average				8.76	9.64			
Outlet								
No.1	2.22	5.73		7.95		27.9		

Table 2-1 Sampling parameters and analysis results at ESP inlet on Jan 17, 2006

Reset/Clean Sample ID		Miami FontESP InletJAN172006OHM#1	Miami FontESP InletJAN172006OHM#2
Date		JAN172006	JAN172006
Start Time		10:45:00 AM	3:10:00 PM
Run #	Unit		
Time	(minutes)	103	97
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	146	145
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10	-10
Temperature at Console Meter (Tm)	°C	39.0	38.0
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.8	12.5
CO_2 Concentration in Flue Gas	%	13.0	13.1
O_2 Concentration in Flue Gas	%	6.0	5.9
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745	745
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1104	1016
Flue Gas Velocity Head at Sampling Location	mm-WC	17	15
H_2O Amount Collected from Sampling Period	g	58.2	56.2
Ash (Dust) Weight Collected From Sampling Period	g	11.97	6.32
4. Other Information			
Console Meter Correction Coefficient	-	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb	80	100
Oxidiation Hg Concentration in Solution (500 ml)	ppb	19.46	27.24
Elemental Hg Concentration in Solution (500 ml)	ppb	3.95	5.51

Table 2-2 Sampling parameters and analysis results at ESP outlet on Jan 17, 2006

Reset/Clean Sample ID		MIAMIESP outletJan.17,2006OHM#1	MIAMIESP outletJan.17,2006OHM#2
Date		Jan.17,2006	Jan.17,2006
Start Time		9:40:00 AM	3:00:00 PM
Run #	Unit		
Time	(minutes)	74	77
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	138	138
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14	-14
Temperature at Console Meter (Tm)	°C	13.4	9.7
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	16.9	17.6
CO_2 Concentration in Flue Gas	%	12.6	12.9
O_2 Concentration in Flue Gas	%	6.4	6.2
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745	745
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1045	1065
Flue Gas Velocity Head at Sampling Location	mm-WC	22.5	22.8
H_2O Amount Collected from Sampling Period	g	81.00	76.90
Ash (Dust) Weight Collected From Sampling Period	g		
4. Other Information			
Console Meter Correction Coefficient	-	1.006	1.006
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	15.55	22.71
Elemental Hg Concentration in Solution (500 ml)	ppb	15.16	12.43

Table 2-3 Sampling parameters and analysis results at ESP inlet on Jan 18, 2006

Reset/Clean Sample ID		Miami FontESP InletJAN182006OHM#1	Miami FontESP InletJAN182006OHM#2	Miami FontESP InletJAN182006OHM#3
Date		JAN182006	JAN182006	JAN182006
Start Time		9:25:00 AM	12:15:00 PM	3:08:00 PM
Run #	Unit			
Time	(minutes)	95	95	95
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	140	140	140
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10	-10	-10
Temperature at Console Meter (Tm)	°C	31.4	33.9	33.9
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.4	12.4	13.3
CO_2 Concentration in Flue Gas	%	13.0	13.1	13.5
O_2 Concentration in Flue Gas	%	6.0	5.9	5.5
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745	745	745
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1005	1006	1041
Flue Gas Velocity Head at Sampling Location	mm-WC	16	16	17
H_2O Amount Collected from Sampling Period	g	63.90	67.50	68.40
Ash (Dust) Weight Collected From Sampling Period	g	0.30	0.29	0.22
4. Other Information				
Console Meter Correction Coefficient	-	1.006	1.006	1.006
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb	50	10	10
Oxidiation Hg Concentration in Solution (500 ml)	ppb	10.91	9.79	9.96
Elemental Hg Concentration in Solution (500 ml)	ppb	16.40	17.69	16.40

Table 2-4 Sampling parameters and analysis results at ESP outlet on Jan 18, 2006

Reset/Clean Sample ID		MIAMIESP outletJan.18,2006OHM#1	MIAMIESP outletJan.18,2006OHM#2	MIAMIESP outletJan.18,2006OHM#3
Date		Jan.18,2006	Jan.18,2006	Jan.18,2006
Start Time		9:15:00 AM	12:10:00 PM	3:00:00 PM
Run #	Unit			
Time	(minutes)	73	79	78
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	132	132	133
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14	-14	-14
Temperature at Console Meter (Tm)	°C	1.8	4.9	4.2
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	16.4	17.1	18.0
CO_2 Concentration in Flue Gas	%	12.9	12.9	12.9
O_2 Concentration in Flue Gas	%	6.1	6.1	6.1
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745	745	745
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	935	1031	1026
Flue Gas Velocity Head at Sampling Location	mm-WC	22.3	23.2	24
H_2O Amount Collected from Sampling Period	g	76.9	63.3	67.4
Ash (Dust) Weight Collected From Sampling Period	g			
4. Other Information				
Console Meter Correction Coefficient	-	1.006	1.006	1.006
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb			
Oxidiation Hg Concentration in Solution (500 ml)	ppb	15.63	18.71	15.50
Elemental Hg Concentration in Solution (500 ml)	ppb	8.94	10.06	8.93

Table 2-5 Sampling parameters and analysis results at ESP inlet on Jan 19, 2006

Reset/Clean Sample ID		Miami FontESP InletJAN192006OHM#1	Miami FontESP InletJAN192006OHM#2	Miami FontESP InletJAN192006OHM#1
Date		JAN192006	JAN192006	JAN192006
Start Time		9:00:00 AM	11:33:00 AM	3:10PM
Run #	Unit			
Time	(minutes)	91	108	90
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	143	145	144
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10	-10	-10
Temperature at Console Meter (Tm)	°C	36.2	38.0	40.1
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	13.4	10.0	13.4
CO_2 Concentration in Flue Gas	%	12.8	13.2	13.1
O_2 Concentration in Flue Gas	%	6.2	5.8	5.9
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745	745	745
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1009	1021	1009
Flue Gas Velocity Head at Sampling Location	mm-WC	17	13	17
H_2O Amount Collected from Sampling Period	g	75.20	81.70	72.90
Ash (Dust) Weight Collected From Sampling Period	g	7.000		
4. Other Information				
Console Meter Correction Coefficient	-	1.006	1.006	1.006
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb	90		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	11.53	5.49	4.81
Elemental Hg Concentration in Solution (500 ml)	ppb	2.18	9.48	7.96

Table 2-6 Sampling parameters and analysis results at ESP outlet on Jan 19, 2006

Reset/Clean Sample ID		MIAMIESP outletJan.19,2006OHM#1
Date		Jan.19,2006
Start Time		9:10:00 AM
Run #	Unit	
Time	(minutes)	85
1. Flue Gas Parameters		
Flue Gas Temperature at Sampling Location (Ts)	°C	135
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14
Temperature at Console Meter (Tm)	°C	8.5
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	17.8
CO_2 Concentration in Flue Gas	%	12.5
O_2 Concentration in Flue Gas	%	6.5
2. Ambient Conditions and Nozzle Information		
Barometer Pressure (Pbaro)	mm-Hg	745
Nozzle Size	in	0.1875
3. Sampling Information		
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1058
Flue Gas Velocity Head at Sampling Location	mm-WC	24.1
H_2O Amount Collected from Sampling Period	g	69.0
Ash (Dust) Weight Collected From Sampling Period	g	
4. Other Information		
Console Meter Correction Coefficient	-	1.006
Pitot Tube Coefficient	-	0.84
5. Hg Analysis Information		
Hg Concentration in Particulate	ppb	
Oxidiation Hg Concentration in Solution (500 ml)	ppb	10.07
Elemental Hg Concentration in Solution (500 ml)	ppb	3.91

Table 3. OHM data summary (Feb 01-03, 2006 for parametric test)

Date/time	Inlet, in ug/NM3				Oulet, in ug/NM3			Removal efficiency, %
	Hg0	Hg(2+)	Hg(VT)	Hg(0)/Hg(VT), %	Hg0	Hg(VT)	Hg(0)/Hg(VT), %	
Feb 01 run 1	5.50	2.18	7.68	71.6	2.96	4.80	61.7	37.5
Feb 01 run 2	5.28	4.53	9.81	53.8	4.61	7.03	65.6	28.3
Average	5.39	3.36	8.75	62.72	3.79	5.92	63.62	32.9
Feb 02 run 1	5.82	3.13	8.95	65.0	5.17	7.60	68.0	15.1
Feb 02 run 2	5.29	4.53	9.82	53.9	4.96	7.91	62.7	19.5
Average	5.56	3.83	9.39	59.45	5.07	7.76	65.37	17.27
Feb 03 run 1	5.23	3.30	8.53	61.3	3.38	5.00	67.6	41.4
Average	5.23	3.30	8.53	61.3	3.38	5.00	67.6	41.4

Note: At inlet location, Inertial probe was used for OHM sampling, no Hg(P)

Table 4-1 Sampling parameters and analysis results at ESP inlet on Feb 01, 2006

Reset/Clean

Sample ID		Miami FortESP InletFEB012006OHM#1	Miami FortESP InletFEB012006OHM#2
Date		FEB012006	FEB012006
Start Time		12:30:00 AM	3:30:00 PM
Run #	Unit		
Time	(minutes)	96	99
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	142	143
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10	-10
Temperature at Console Meter (Tm)	°C	35.0	36.9
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	15.0	15.0
CO_2 Concentration in Flue Gas	%	13.1	13.4
O_2 Concentration in Flue Gas	%	5.9	5.6
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1005	1050
Flue Gas Velocity Head at Sampling Location	mm-WC	12	12
H_2O Amount Collected from Sampling Period	g	61.10	69.60
Ash (Dust) Weight Collected From Sampling Period	g		
4. Other Information			
Console Meter Correction Coefficient	-	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	3.460	7.590
Elemental Hg Concentration in Solution (500 ml)	ppb	8.710	8.860

Table 4-2 Sampling parameters and analysis results at ESP outlet on Feb 01, 2006

Reset/Clean

Sample ID		MIAMIESP outletFeb, 1,2006OHM#1	MIAMIESP outletFeb, 1,2006OHM#2
Date		Feb, 1,2006	Feb, 1,2006
Start Time		9:10:00 AM	3:30:00 PM
Run #	Unit		
Time	(minutes)	85	83
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	135	136
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-13	-13
Temperature at Console Meter (Tm)	°C	10.4	15.6
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	16.6	16.6
CO_2 Concentration in Flue Gas	%	13.1	13.0
O_2 Concentration in Flue Gas	%	6.0	6.1
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1120	1121
Flue Gas Velocity Head at Sampling Location	mm-WC	23.0	23.1
H_2O Amount Collected from Sampling Period	g	66.70	70.60
Ash (Dust) Weight Collected From Sampling Period	g		
4. Other Information			
Console Meter Correction Coefficient	-	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	3.520	4.510
Elemental Hg Concentration in Solution (500 ml)	ppb	5.665	8.605

Table 4-3 Sampling parameters and analysis results at ESP inlet on Feb 02, 2006

Reset/Clean

Sample ID		**Miami FortESP InletFEB022006OHM#1**	**Miami FortESP InletFEB022006OHM#2**
Date		FEB022006	FEB022006
Start Time		10:00:00 AM	3:00:00 PM
Run #	Unit		
Time	(minutes)	98	94
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	144	144
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10	-10
Temperature at Console Meter (Tm)	°C	36.5	37.2
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	15.0	15.0
CO_2 Concentration in Flue Gas	%	13.3	13.5
O_2 Concentration in Flue Gas	%	5.7	5.5
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1042	1010
Flue Gas Velocity Head at Sampling Location	mm-WC	12	12
H_2O Amount Collected from Sampling Period	g	60.10	68.60
Ash (Dust) Weight Collected From Sampling Period	g		
4. Other Information			
Console Meter Correction Coefficient	-	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	5.180	7.355
Elemental Hg Concentration in Solution (500 ml)	ppb	9.640	8.580

Table 4-4 Sampling parameters and analysis results at ESP outlet on Feb 02, 2006

Reset/Clean

Sample ID		**MIAMIESP outletFeb, 2,2006OHM#1**	**MIAMIESP outletFeb, 2,2006OHM#2**
Date		Feb, 2,2006	Feb, 2,2006
Start Time		10:00:00 AM	3:00:00 PM
Run #	Unit		
Time	(minutes)	78	79
1. Flue Gas Parameters			
Flue Gas Temperature at Sampling Location (Ts)	°C	136	136
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-12	-12
Temperature at Console Meter (Tm)	°C	25.2	25.2
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	17.0	17.6
CO_2 Concentration in Flue Gas	%	12.8	13.0
O_2 Concentration in Flue Gas	%	6.2	6.0
2. Ambient Conditions and Nozzle Information			
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00
Nozzle Size	in	0.1875	0.1875
3. Sampling Information			
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1050	1096
Flue Gas Velocity Head at Sampling Location	mm-WC	23.7	24.5
H_2O Amount Collected from Sampling Period	g	64.80	73.90
Ash (Dust) Weight Collected From Sampling Period	g		
4. Other Information			
Console Meter Correction Coefficient	-	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84
5. Hg Analysis Information			
Hg Concentration in Particulate	ppb		
Oxidiation Hg Concentration in Solution (500 ml)	ppb	4.085	5.230
Elemental Hg Concentration in Solution (500 ml)	ppb	8.675	8.785

Table 4-5 Sampling parameters and analysis results at ESP inlet on Feb 03, 2006

Reset/Clean		
Sample ID		Miami FortESP InletFEB032006OHM#1
Date		FEB032006
Start Time		10:15:00 AM
Run #	Unit	
Time	(minutes)	92
1. Flue Gas Parameters		
Flue Gas Temperature at Sampling Location (Ts)	°C	143
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-10
Temperature at Console Meter (Tm)	°C	35.7
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.0
CO_2 Concentration in Flue Gas	%	13.3
O_2 Concentration in Flue Gas	%	5.7
2. Ambient Conditions and Nozzle Information		
Barometer Pressure (Pbaro)	mm-Hg	745.00
Nozzle Size	in	0.1875
3. Sampling Information		
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1034
Flue Gas Velocity Head at Sampling Location	mm-WC	15
H_2O Amount Collected from Sampling Period	g	67.90
Ash (Dust) Weight Collected From Sampling Period	g	
4. Other Information		
Console Meter Correction Coefficient	-	1.0060
Pitot Tube Coefficient	-	0.84
5. Hg Analysis Information		
Hg Concentration in Particulate	ppb	
Oxidiation Hg Concentration in Solution (500 ml)	ppb	5.450
Elemental Hg Concentration in Solution (500 ml)	ppb	8.630

Table 4-6 Sampling parameters and analysis results at ESP outlet on Feb 03, 2006

Reset/Clean		
Sample ID		Miami FortESP OutletFEB032006OHM#1
Date		FEB032006
Start Time		10:18:00 AM
Run #	Unit	
Time	(minutes)	83
1. Flue Gas Parameters		
Flue Gas Temperature at Sampling Location (Ts)	°C	136
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-13
Temperature at Console Meter (Tm)	°C	13.8
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	17.1
CO_2 Concentration in Flue Gas	%	12.9
O_2 Concentration in Flue Gas	%	6.1
2. Ambient Conditions and Nozzle Information		
Barometer Pressure (Pbaro)	mm-Hg	745.00
Nozzle Size	in	0.1875
3. Sampling Information		
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1087
Flue Gas Velocity Head at Sampling Location	mm-WC	24
H_2O Amount Collected from Sampling Period	g	77.40
Ash (Dust) Weight Collected From Sampling Period	g	
4. Other Information		
Console Meter Correction Coefficient	-	1.0060
Pitot Tube Coefficient	-	0.84
5. Hg Analysis Information		
Hg Concentration in Particulate	ppb	
Oxidiation Hg Concentration in Solution (500 ml)	ppb	2.930
Elemental Hg Concentration in Solution (500 ml)	ppb	6.145

Table 5. OHM data summary (Feb 28- Mar 02, 2006 for 1st period of long term test)

Feb 28, Miami Fort, ADASorbent injection In 3% O_2 correction

	Hg(0) ug/NM^3	Hg(2+) ug/NM^3	Hg(P) ug/NM^3	Hg(VT) ug/NM^3	Hg(T) ug/NM^3	Hg(0)/Hg(VT) %	Net removal e %
ESP Inlet	2.58	4.89	Inertial probe	7.47		34.5	
ESP outlet	1.1	5		6.1	6.1	18.0	18.3

March 01, Miami Fort, ADA Sorbent injection In 3% O_2 correction

	Hg(0) ug/NM^3	Hg(2+) ug/NM^3	Hg(P) ug/NM^3	Hg(VT) ug/NM^3	Hg(T) ug/NM^3	Hg(0)/Hg(VT) %	Removal effi %
NO.1 ESP Inlet	3.44	4.81	Inertial probe	8.25		41.7	
NO.1 ESP outlet	1.9	4.96		6.86	6.86	27.7	16.8
NO.2 ESP Inlet	2.04	5.19	Inertial probe	7.23		28.2	
NO.2 ESP outlet	1.36	5.01		6.37	6.37	21.4	11.9
NO.2 ESP Inlet	2.48	4.31	Inertial probe	6.79		36.5	
NO.1 ESP outlet	1.33	5.12		6.45	6.45	20.6	5.0

March 02, Miami Fort, ADA Sorbent injection In 3% O_2 correction

	Hg(0) ug/NM^3	Hg(2+) ug/NM^3	Hg(P) ug/NM^3	Hg(VT) ug/NM^3	Hg(T) ug/NM^3	Hg(0)/Hg(VT) %	Removal effi %
NO.1 ESP Inlet	2.55	4.2	Inertial probe	6.75		37.8	
NO.1 ESP outlet	1.47	4.83		6.3	6.3	23.3	6.7
NO.2 ESP Inlet	3.08	5.2	Inertial probe	8.28		37.2	
NO.2 ESP outlet	2.26	4.95		7.21	7.21	31.3	12.9
NO.2 ESP Inlet	3.05	6.19	Inertial probe	9.24		33.0	
NO.1 ESP outlet	2.31	5.19		7.5	7.5	30.8	18.8

Table 6-1 Sampling parameters and analysis results on Feb 28, 2006

Reset/Clean

Sample ID		**Miami FortESP InletFEB282006OHM#1**
Date		FEB282006
Start Time		2:30:00 PM
Run #	Unit	
Time	(minutes)	96
1. Flue Gas Parameters		
Flue Gas Temperature at Sampling Location (Ts)	°C	143
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-11.5
Temperature at Console Meter (Tm)	°C	39.7
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.0
CO_2 Concentration in Flue Gas	%	13.9
O_2 Concentration in Flue Gas	%	5.1
2. Ambient Conditions and Nozzle Information		
Barometer Pressure (Pbaro)	mm-Hg	745.00
Nozzle Size	in	0.1875
3. Sampling Information		
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1017
Flue Gas Velocity Head at Sampling Location	mm-WC	15
H_2O Amount Collected from Sampling Period	g	63.50
Ash (Dust) Weight Collected From Sampling Period	g	
4. Other Information		
Console Meter Correction Coefficient	-	1.0060
Pitot Tube Coefficient	-	0.84
5. Hg Analysis Information		Inertial probe
Hg Concentration in Particulate	ppb	
Oxidiation Hg Concentration in Solution (500 ml)	ppb	8.100
Elemental Hg Concentration in Solution (500 ml)	ppb	4.280

Reset/Clean

Sample ID		**MIAMIESP outletFeb, 28,2006OHM#1**
Date		Feb, 28,2006
Start Time		2:30pm
Run #	Unit	
Time	(minutes)	85
1. Flue Gas Parameters		
Flue Gas Temperature at Sampling Location (Ts)	°C	140
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14
Temperature at Console Meter (Tm)	°C	37.5
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	17.7
CO_2 Concentration in Flue Gas	%	12.5
O_2 Concentration in Flue Gas	%	6.5
2. Ambient Conditions and Nozzle Information		
Barometer Pressure (Pbaro)	mm-Hg	745.00
Nozzle Size	in	0.1875
3. Sampling Information		
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1252
Flue Gas Velocity Head at Sampling Location	mm-WC	24.7
H_2O Amount Collected from Sampling Period	g	69.90
Ash (Dust) Weight Collected From Sampling Period	g	
4. Other Information		
Console Meter Correction Coefficient	-	1.0060
Pitot Tube Coefficient	-	0.84
5. Hg Analysis Information		
Hg Concentration in Particulate	ppb	
Oxidiation Hg Concentration in Solution (500 ml)	ppb	9.420
Elemental Hg Concentration in Solution (500 ml)	ppb	2.060

Table 6-2 Sampling parameters and analysis results on March 1, 2006

Reset/Clean

Sample ID	Unit	Miami FortESP InletMarch012006OHM#1	Miami FortESP InletMarch012006OHM#2	Miami FortESP InletMarch012006OHM#3
Date		March012006	March012006	March012006
Start Time		8:30:00 AM	11:30:00 AM	15:00:00 PM
Run #				
Time	(minutes)	99	99	96
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	143	144	145
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-12	-12	-12
Temperature at Console Meter (Tm)	°C	39.8	40.1	42.4
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.0	11.0	12.0
CO_2 Concentration in Flue Gas	%	14.0	14.0	13.9
O_2 Concentration in Flue Gas	%	5.0	5.0	5.1
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1010	1004	1014
Flue Gas Velocity Head at Sampling Location	mm-WC	15	15	15
H_2O Amount Collected from Sampling Period	g	71.00	64.30	67.50
Ash (Dust) Weight Collected From Sampling Period	g			
4. Other Information				
Console Meter Correction Coefficient	-	1.0060	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information		Inertial probe	Inertial probe	Inertial probe
Hg Concentration in Particulate	ppb			
Oxidiation Hg Concentration in Solution (500 ml)	ppb	7.970	8.540	7.070
Elemental Hg Concentration in Solution (500 ml)	ppb	5.690	3.350	4.060

Reset/Clean Sample ID		**MIAMIESP outletMarch, 1,2006OHM#1**	**MIAMIESP outletMarch, 1,2006OHM#2**	**MIAMIESP outletMarch, 1,2006OHM#3**
Date		March, 1,2006	March, 1,2006	March, 1,2006
Start Time		8:20am	11:32am	3:00pm
Run #	Unit			
Time	(minutes)	80	85	85
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	140	141	143
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14	-14	-14
Temperature at Console Meter (Tm)	°C	23.5	30.4	33.2
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	18.0	17.2	17.5
CO_2 Concentration in Flue Gas	%	12.6	12.5	12.6
O_2 Concentration in Flue Gas	%	6.5	6.5	6.4
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1109	1209	1228
Flue Gas Velocity Head at Sampling Location	mm-WC	25.0	23.9	24
H_2O Amount Collected from Sampling Period	g	73.60	74.50	72.80
Ash (Dust) Weight Collected From Sampling Period	g			
4. Other Information				
Console Meter Correction Coefficient	-	1.0060	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb			
Oxidiation Hg Concentration in Solution (500 ml)	ppb	8.680	9.320	9.640
Elemental Hg Concentration in Solution (500 ml)	ppb	3.320	2.540	2.500

Table 6-3 Sampling parameters and analysis results on March 2, 2006

Reset/Clean

Sample ID		**Miami FortESP InletMarch022006OHM#1**	**Miami FortESP InletMarch022006OHM#2**	**Miami FortESP InletMarch022006OHM#3**
Date		March022006	March022006	March022006
Start Time		8:14:00 AM	11:00:00 AM	2:00:00 PM
Run #	Unit			
Time	(minutes)	88	98	99
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	145	145	144
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-12	-12	-12
Temperature at Console Meter (Tm)	°C	41.5	41.7	41.6
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	12.0	12.0	11.0
CO_2 Concentration in Flue Gas	%	13.5	13.5	13.7
O_2 Concentration in Flue Gas	%	5.5	5.5	5.3
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1019	1019	1006
Flue Gas Velocity Head at Sampling Location	mm-WC	15	15	15
H_2O Amount Collected from Sampling Period	g	67.00	62.90	64.10
Ash (Dust) Weight Collected From Sampling Period	g			
4. Other Information		Inertial probe	Inertial probe	Inertial probe
Console Meter Correction Coefficient	-	1.0060	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb			
Oxidiation Hg Concentration in Solution (500 ml)	ppb	6.770	8.370	9.990
Elemental Hg Concentration in Solution (500 ml)	ppb	4.100	4.950	4.920

Reset/Clean

Sample ID		MIAMI FORT ESP outletMarch, 2,2006OHM #1	MIAMI FORT ESP outletMarch, 2,2006OHM#2	MIAMI FORT ESP outletMarch, 2,2006OHM#3
Date		March, 2,2006	March, 2,2006	March, 2,2006
Start Time		8:30am	11:00am	2:00pm
Run #	Unit			
Time	(minutes)	76	85	85
1. Flue Gas Parameters				
Flue Gas Temperature at Sampling Location (Ts)	°C	139	140	138
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14	-14	-14
Temperature at Console Meter (Tm)	°C	16.8	17.4	14.5
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	17.9	17.6	17.6
CO_2 Concentration in Flue Gas	%	12.5	12.5	12.5
O_2 Concentration in Flue Gas	%	6.5	6.6	6.5
2. Ambient Conditions and Nozzle Information				
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875
3. Sampling Information				
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1019	1151	1175
Flue Gas Velocity Head at Sampling Location	mm-WC	24.8	24.5	24
H_2O Amount Collected from Sampling Period	g	72.10	69.90	77.60
Ash (Dust) Weight Collected From Sampling Period	g			
4. Other Information				
Console Meter Correction Coefficient	-	1.0060	1.0060	1.0060
Pitot Tube Coefficient	-	0.84	0.84	0.84
5. Hg Analysis Information				
Hg Concentration in Particulate	ppb			
Oxidiation Hg Concentration in Solution (500 ml)	ppb	7.930	9.110	9.870
Elemental Hg Concentration in Solution (500 ml)	ppb	2.410	4.170	4.410

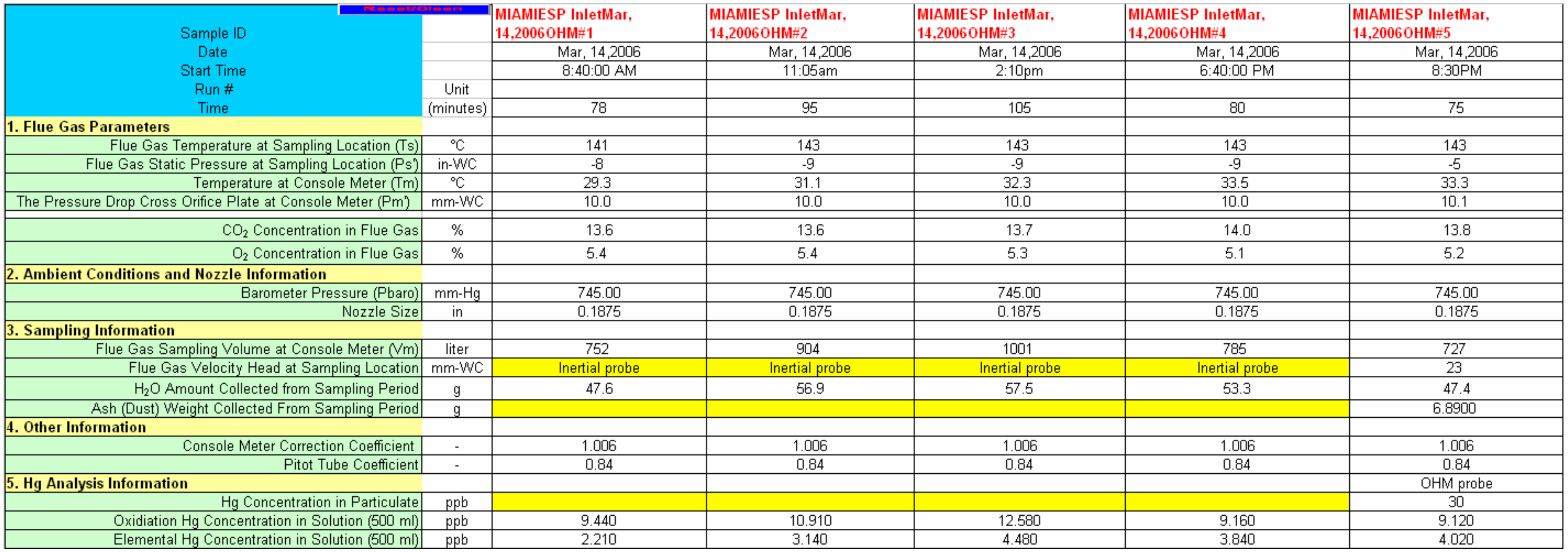
Table 7 OHM data summary (Mar 14 , 2006 for 2nd period of long term test)

March 14, Miami Fort, ADA Sorbent injection		**Time**	In 3% O_2 correction							
OHM probe at ESP inlet and outlet				Hg(0) ug/NM^3	Hg(2+) ug/NM^3	Hg(P) ug/NM^3	Hg(VT) ug/NM^3	Hg(T) ug/NM^3	Hg(0)/Hg(VT) %	Removal efficiency %
	NO.1	8:30PM	ESP Inlet	3.44	7.49	0.24	10.93	11.17	31.5	

March 14, Miami Fort, ADA Sorbent injection			In 3% O_2 correction							
Inertial probe at ESP inlet, OHM probe at ESP outlet				Hg(0) ug/NM^3	Hg(2+) ug/NM^3	Hg(P) ug/NM^3	Hg(VT) ug/NM^3	Hg(T) ug/NM^3	Hg(0)/Hg(VT) %	Removal efficiency %
	NO.1	8:40AM	ESP Inlet	1.78	7.59		9.37		19.0	
	NO.1	8:35AM	ESP outlet	1.46	4.96		6.42	6.42	22.7	31.5
	NO.2	11:05AM	ESP Inlet	2.11	7.32		9.43		22.4	
	NO.2	11:00AM	ESP outlet	1.59	6.62		8.21	8.21	19.4	12.9
	NO.3	2:10PM	ESP Inlet	2.71	7.63		10.34		26.2	
	NO.3	1:00PM	ESP outlet	1.63	6.13		7.76	7.76	21.0	25.0
	NO.4	6:40PM	ESP Inlet	2.93	6.97		9.9		29.6	
	NO.4	5:00PM	ESP outlet	0.83	8.54		9.37	9.37	8.9	5.4

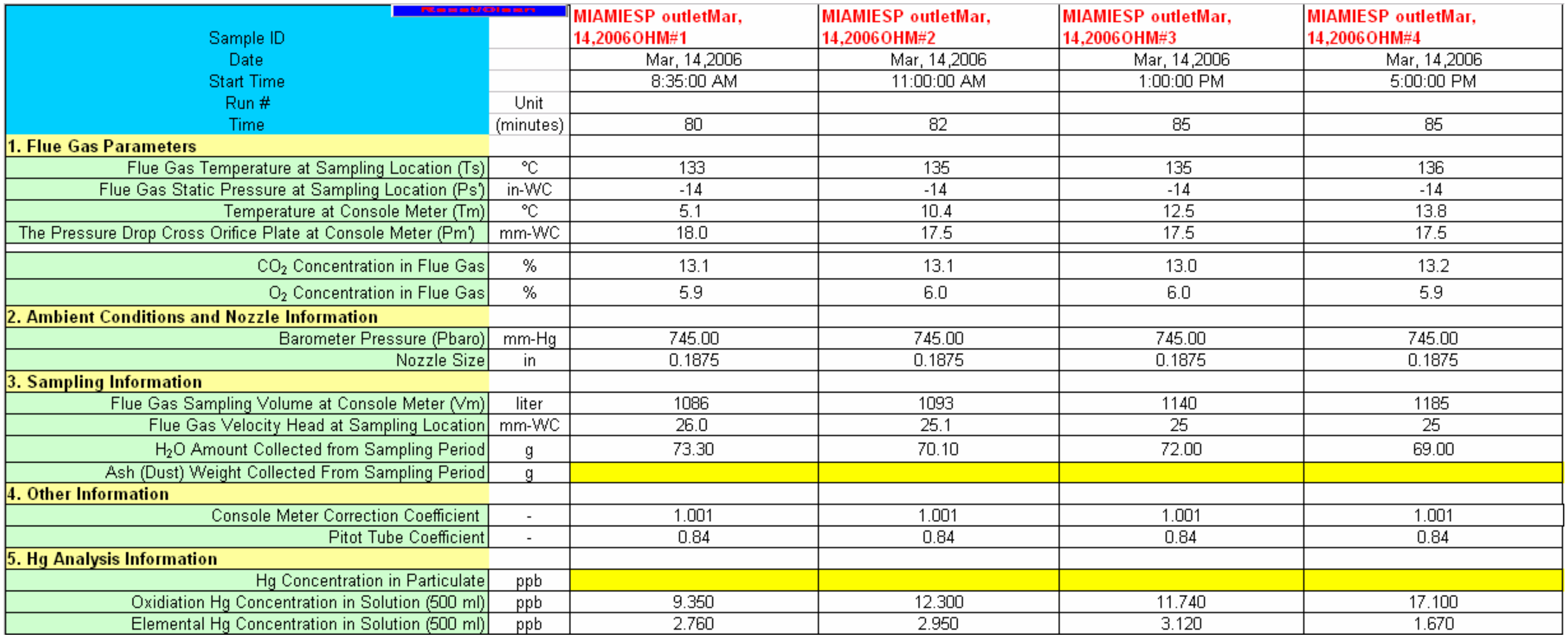
Note: 1, The sample collected at ESP inlet location by OHM probe can be used to calculate the mercury removal efficiency, which is contributed by both fly ash and sorben
2, The samples collected at ESP inlet location by inertial probe can be used to calculate the mercury removal efficiency, which is contributed solely by sorbent injecti

Table 8-1. Sampling parameters and analysis results for OHM tests at ESP inlet



Sample ID		MIAMIESP InletMar, 14,2006OHM#1	MIAMIESP InletMar, 14,2006OHM#2	MIAMIESP InletMar, 14,2006OHM#3	MIAMIESP InletMar, 14,2006OHM#4	MIAMIESP InletMar, 14,2006OHM#5
Date		Mar, 14,2006	Mar, 14,2006	Mar, 14,2006	Mar, 14,2006	Mar, 14,2006
Start Time		8:40:00 AM	11:05am	2:10pm	6:40:00 PM	8:30PM
Run #	Unit					
Time	(minutes)	78	95	105	80	75
1. Flue Gas Parameters						
Flue Gas Temperature at Sampling Location (Ts)	℃	141	143	143	143	143
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-8	-9	-9	-9	-5
Temperature at Console Meter (Tm)	℃	29.3	31.1	32.3	33.5	33.3
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	10.0	10.0	10.0	10.0	10.1
CO_2 Concentration in Flue Gas	%	13.6	13.6	13.7	14.0	13.8
O_2 Concentration in Flue Gas	%	5.4	5.4	5.3	5.1	5.2
2. Ambient Conditions and Nozzle Information						
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875	0.1875	0.1875
3. Sampling Information						
Flue Gas Sampling Volume at Console Meter (Vm)	liter	752	904	1001	785	727
Flue Gas Velocity Head at Sampling Location	mm-WC	Inertial probe	Inertial probe	Inertial probe	Inertial probe	23
H_2O Amount Collected from Sampling Period	g	47.6	56.9	57.5	53.3	47.4
Ash (Dust) Weight Collected From Sampling Period	g					6.8900
4. Other Information						
Console Meter Correction Coefficient	-	1.006	1.006	1.006	1.006	1.006
Pitot Tube Coefficient	-	0.84	0.84	0.84	0.84	0.84
5. Hg Analysis Information						OHM probe
Hg Concentration in Particulate	ppb					30
Oxidiation Hg Concentration in Solution (500 ml)	ppb	9.440	10.910	12.580	9.160	9.120
Elemental Hg Concentration in Solution (500 ml)	ppb	2.210	3.140	4.480	3.840	4.020

Table 8-2. Sampling parameters and analysis results for OHM tests at ESP outlet



Sample ID		MIAMIESP outletMar, 14,2006OHM#1	MIAMIESP outletMar, 14,2006OHM#2	MIAMIESP outletMar, 14,2006OHM#3	MIAMIESP outletMar, 14,2006OHM#4
Date		Mar, 14,2006	Mar, 14,2006	Mar, 14,2006	Mar, 14,2006
Start Time		8:35:00 AM	11:00:00 AM	1:00:00 PM	5:00:00 PM
Run #	Unit				
Time	(minutes)	80	82	85	85
1. Flue Gas Parameters					
Flue Gas Temperature at Sampling Location (Ts)	°C	133	135	135	136
Flue Gas Static Pressure at Sampling Location (Ps')	in-WC	-14	-14	-14	-14
Temperature at Console Meter (Tm)	°C	5.1	10.4	12.5	13.8
The Pressure Drop Cross Orifice Plate at Console Meter (Pm')	mm-WC	18.0	17.5	17.5	17.5
CO_2 Concentration in Flue Gas	%	13.1	13.1	13.0	13.2
O_2 Concentration in Flue Gas	%	5.9	6.0	6.0	5.9
2. Ambient Conditions and Nozzle Information					
Barometer Pressure (Pbaro)	mm-Hg	745.00	745.00	745.00	745.00
Nozzle Size	in	0.1875	0.1875	0.1875	0.1875
3. Sampling Information					
Flue Gas Sampling Volume at Console Meter (Vm)	liter	1086	1093	1140	1185
Flue Gas Velocity Head at Sampling Location	mm-WC	26.0	25.1	25	25
H_2O Amount Collected from Sampling Period	g	73.30	70.10	72.00	69.00
Ash (Dust) Weight Collected From Sampling Period	g				
4. Other Information					
Console Meter Correction Coefficient	-	1.001	1.001	1.001	1.001
Pitot Tube Coefficient	-	0.84	0.84	0.84	0.84
5. Hg Analysis Information					
Hg Concentration in Particulate	ppb				
Oxidiation Hg Concentration in Solution (500 ml)	ppb	9.350	12.300	11.740	17.100
Elemental Hg Concentration in Solution (500 ml)	ppb	2.760	2.950	3.120	1.670

4 Test QA/QC

Table 9. OHM QA/QC report (Reagent Blanks, Field Blanks and Spike)

Field Spike: KCl = 5.0 ppb, H_2O_2= 0.5 ppb, $KMnO_4$= 5.0ppb

Jan 17-19 2006	KCl	Percent Error (%)	H_2O_2	Percent Error (%)	$KMnO_4$	Percent Error (%)
Reagent Blank	0.00		0.03		0.03	
OHM-ESP-In-Blank-011706	0.13		0.00		0.03	
OHM-ESP-In-Spike-0117006	5.58	11.56	0.53	6.32	4.97	0.67
OHM-ESP-Out-Blank-011706	0.00		0.00		0.03	
OHM-ESP-Out-Spike-011706	5.65	13.04	0.52	4.96	5.08	1.67
Feb 1-3 2006	KCl	Percent Error (%)	H_2O_2	Percent Error (%)	$KMnO_4$	Percent Error (%)
Reagent Blank	0.08		0.14		0.00	
ESP In-Blank-020106	0.02		0.08		0.46	
ESP Out-Blank-020106	0.11		0.16		0.39	
Field Spike-020206	5.13	2.56	0.58	15.93	5.27	5.50
Feb 28-March 2 2006	KCl	Percent Error (%)	H_2O_2	Percent Error (%)	$KMnO_4$	Percent Error (%)
Reagent Blank	0.01		0.22		0.00	
ESP In-Blank-022806	0.12		0.23		0.01	
ESP Out-Blank-030106	0.00		0.22		0.05	
Field Spike-030206	4.77	4.70	0.46	8.16	4.35	12.98
March 14 2006	KCl	Percent Error (%)	H_2O_2	Percent Error (%)	$KMnO_4$	Percent Error (%)
Reagent Blank	0.03		0.10		0.02	
ESP In-Blank-031406	0.05		0.08		0.04	
ESP Out-Blank-031406	0.08		0.03		0.06	
Field Spike-031406	5.33	6.58	0.47	6.15	4.79	4.11

Table 10 presents data quality objectives for flue gas mercury analysis for the Ontario Hydro Method. As shown in Table 10, one field blank and one field spike were taken at each location for each test condition and for every day of testing. The field blank and spikes consist of a sample train that was assembled, and taken to the same location as a test sample, leak-checked, broken down and recovered exactly like the impingers used for the actual sampling. It is also required that WKU analyze one blank as a sample from every batch of solution prepared for each reagent. The quality objective for a field blank is less than 10% of the typical sample mercury concentration and 15% of the true spiked value for the field spike. If the field blank does not meet this criteria, the data must be flagged and corrective action be taken to discover the source of the contamination or any other problems.

For this project, all field blanks were within acceptable range which is less than 0.5 μg/L and within 10% of sampled mercury concentration (See Table 9). Meanwhile, almost all the field spikes are within 15% of true value. Also, most all of the reagent blanks were less than 0.1 μg/L. But there were two reagent blanks and one field spike of hydrogen peroxide samples that were slightly out of the acceptable range. Contamination of samples sometimes occurs when dealing with ultra-low mercury concentrations on the ppb level. However, this low-level contamination will not affect the QA/QC of the project.

Table 10. Data Quality Objectives for Flue Gas Mercury Analysis by the Ontario Hydro Method

MEASURE	SAMPLE TYPE	OBJECTIVE	APPROACH
Accuracy	Reagent Blank	0.1 μg/L	Analyze one blank per batch of each reagent
Accuracy	Field Blank	Maximum of 0.5 μg/L and < 10% of sampled mercury concentration	Collect and analyze one field blank for each unit per day of testing (analysis must be done on each solution)
Accuracy	Field Spike	< 15% of true value	Collect and analyze one field spike for each unit per day of testing (analysis must be done on each solution)
Precision	Triplicate Analysis	The standard deviation < 0.5 μg/L	Doing analysis for each solution one for each set of 10 samples. A second set of triplicate analysis is done for each succeeding 10th set of solutions Every sample
Precision	Duplicate Analysis	RPD < 15%	

F. Operation Logs

Demonstration Activity Log

Baseline Activities

University of North Dakota Environmental and Energy Corportation (UNDEERC) installed two Sir Galahad continuous mercury monitors (CMM) on Unit 6 (Miami Fort Station) the week of January 2nd. Data from the inlet and outlet mercury monitors were recorded as of Jan 9th. The units operated for several days prior to the baseline phase of the project to assess operability of the equipment.

ADA personnel arrived at Miami Fort Station on January 10, 2006. Safety training presentations were made to the Cinergy plant operators outlining the scope of the sorbent injection demonstration, duties of operators to support the demonstration effort, and reviewing the Materials Safety Data Sheets (MSDS's) for sorbent materials and chemicals brought on site for Ontario-Hydro analytical procedure.

January 14th – Start Baseline Phase of project. During this phase data UNDEERC operated their CMMs to establish typical inlet and outlet mercury levels in the flue gas. Several times during the day, ADA personnel recorded current and voltages levels for the 12 T/R sets on the ESP. In addition, coal and flyash samples were pulled daily to assess mercury, trace metal and LOI levels in the samples. The daily coal sample was a composite sample consisting of coal taken from each of the operating mills (total of five mills). The daily flyash sample was a composite formed by grab samples from the middle two hoppers in the first two rows of hoppers (Hoppers: 6, 7, 10, and 11).

A 55-gallon drum of Amended Silicates sorbent arrived January 16th. This material was used to calibrate the Norit sorbent feeder. A calibration curve was prepared which correlated pounds per hour of sorbent as a function of feeder RPMs. A steam signal (kilo-pounds steam per hour) from the plant was connected to the feeder controller to adjust sorbent injection rate as plant load varied. After several discussions with the Norit representative, the proper parameters were entered into the feeder controller which enabled the feeder to follow plant load.

The feeder system was operated with no sorbent in the hopper during the baseline tests. A Campbell data logger accompanied by a laptop computer was set up to display and record the steam load signal and the feed motor RPMs in real time. Data were recorded for January 17, 18, and 19th.

A crew from Western Kentucky University (WKU) arrived on Monday January 16th to perform the baseline Ontario-Hydro (O-H) sampling campaign. During this campaign, WKU analyzed the O-H liquids on-site. A cold vapor atomic absorption instrument was set up in engineering office (Boiler Inspection Room). A smaller room outside of the engineering office was used for chemical solutions preparation and assembling the glassware for the sampling trains. ADA prepared a test plan that identified the inlet and outlet sample port locations to use for O-H tests. WKU performed a flue gas velocity profile at the ESP outlet sample port to determine the proper insertion depth for their sampling probe.

January 17th –Two inlet and two outlet O-H tests were preformed by WKU on this day. The purpose was to run through the sampling and analytical procedures to assess the functionality of the instrumentation.

January 18th – WKU simultaneously sampled the inlet and outlet sample ports three times during the day. No problems noted.

Per ADA's request, Cinergy pulled ash samples from all 30 ESP flyash hoppers. Four 55-gallon drums of flyash were also taken to provide Boreal materials for their testing efforts.

January 19th – WKU simultaneously sampled the inlet and outlet sample ports in triplicates.

January 20th – WKU demobilized their equipment and left Miami Fort Station.

January 21st through 25th – ADA and Cinergy continued to pull daily coal and flyash samples and recorded ESP data.

Parametric Activities

January 26th – ADA started parametric sorbent injection phase of project to investigate incremental mercury removal as a function of sorbent injection rate. Amended Silicates sorbent was injected at a rate of 1 lb/MMACF for 5 hours. No problems were noted with the sorbent injection system. Coal and flyash samples were taken. ESP data with also recorded.

January 27th – Amended Silicates sorbent was injected at a rate of 2 lb/MMACF for ten hours. Experience some plugging of sorbent material in the number 2 injection lance piping. Hit the distribution tee with hammer to dislodge plug. Outlet CMM reported several mercury spikes (~25 $\mu g/m^3$) atypical of majority of mercury data.

January 28th – No mercury spikes at the outlet were noted overnight, increased the hot line temperature from 280 to 300F; troubleshot the outlet CMM and hotline. ADA injected Amended Silicates sorbent at a rate of 3 lb/MMACF from 10:30 to 19:00. No problems with sorbent feed system.

January 29th – No sorbent was injected today. Unit 6 was at low load.

January 30th – ADA injected Amended Silicates sorbent at a rate of 5 lb/MMACF. Super sacks have a 12" diameter chute and have a tendency to choke off flow as the sack empties. Sorbent injection rate was reduced at one point during the day. There were no sorbent feed problems noted. Sorbent was injected from 9:00 to 18:00.

January 31st – ADA started high sorbent injection rate tests. At an injection rate of 8 lb/MMACF, consistent sorbent feed rate was difficult to maintain. Sorbent material would start to back up in the feed system and blow out of the eductor injection port. Sorbent feed rate had to be reduced to 5-6 lb/MMACF to maintain consistent sorbent flow.

February 1st – ADA and Cinergy engineers worked together to identify cause of the sorbent plugs in the feed system. Piping network reduces from a 2" diameter line to four 1" diameter lines leading to the four injection lances. The 2"x 1" transition pieces were quite sharp and abrupt. These fittings were replaced with bell-reducers which provided a smoother transition. System functioned for about an hour until sorbent started to puff out of the eductor. Flow to lance No. 2 was plugged. There was significant accumulation in the lance. Lance was pulled, cleaned out and reassembled. Sorbent feed rate was set at 4.5 lb/MMACF. Lances plugged throughout the afternoon. Sorbent system had to be taken off-line for cleaning.

A reddish residue was found in the tubing of the chemical conversion system at the outlet CMM. Modifications to the conversion system plumbing were made to eliminate this issue. The reddish residue is thought to be a selenium compound.

WKU returned to site to do parametric Ontario-Hydro tests. Two sets of inlet and outlet O-H tests were performed.

February 2nd – Prior to testing, the end caps on the sorbent injection lances were removed. Sorbent injection started at 8:45. Evidence of plugging was noted around 12:00. Disassembled injection piping and found "clinkers" in several hose lines and fittings. System was cleaned and reassembled. Sorbent injection resumed at 13:30. At 16:50, found ¼" diameter nodules bridged in the 1" diameter line leading to lance No.1. Similar problems were encountered throughout the day and into the night. Sorbent injection was stopped at 20:00.

WKU performed two inlet and outlet O-H tests.

February 3rd – Sorbent feed system piping was cleaned at the start of the day. Several clinkers found and saved for analysis. Sorbent feed started at 10:00. At 14:00, the No. 1 lance had plugged. More nodules discovered in the lines. A screen will be placed in the eductor throat to prevent nodules from entering the sorbent feed lines before the 30-day trial starts.

WKU performed only one inlet and outlet O-H tests. Sorbent flow was too erratic for consistent mercury concentrations to be established.

February 4th through 8th – No sorbent injection activity.

February 9th – ADA and UNDEERC returned to resume parametric tests. At the start of the day, a screen with ¼" openings was installed in the throat of the eductor. Sorbent injection started at 9:00 at 2 lb/MMACF and was gradually increased to a maximum of 9 lb/MMACF. There were no feed problems over this range of injection rates. There was significant buildup of material on the eductor screen by noon. System was shutdown so that the screen could be removed and cleared of sorbent nodules. Screen was inspected every hour thereafter for buildup.

UNDEERC installed new sample probe at the outlet port. Not able to keep the temperature consistent along the length of probe.

February 10th – Sorbent feeder was recalibrated today, to better set the operating parameters of the feeder. Sorbent was feed from 10:00 til18:30. Sorbent feed was suspended at 15:00 due to super sack choking off chute. Weight in sack was adjusted to resume sorbent flow. Sorbent rates ranged between 4 and 6 lb/MMACF.

February 11th – Sorbent was injected from 10:00 til 19:00 at a rate of 5.5 lb/MMACF. At 12:00, UNDEERC found that the new probe installed February 9th had developed a short in the heater and had to be replaced with the old probe. UNDEERC requested a third probe to be set to Miami Fort Station.

February 12th – This was the last day of the parametric tests. Sorbent was fed from 13:00 until 17:00 at 5 lb/MMACF.

30-Day Amended Silicates Sorbent Injection Activities

February 13th – The 30-day trial with Amended Silicates sorbent started at 10:30 this morning. The plan was to maintain an injection rate of 5 lb/MACF throughout the trial.

February 14th – There was a significant amount of sorbent pebbles captured on the eductor screen at 11:30. System was shutdown to clean pebbles off of screen. At 20:00, plastic sheeting was found on the eductor screen, presumably from the plastic liner inside the super sack.

February 15th – Eductor screen was cleaned at 8:30 and 14:30. Sorbent injected at 4.6 lb/MMACF.

February 16th – Problems developed with the inlet CMM at about 02:00. Occasionally, the inlet to the chemical conversion system plugged off due to the evaporation of the chemical solution (sodium hydroxide and stannous chloride). Temperature in this area of the plant (air preheater section) is quite warm (110F). As a result, gas flow to the inlet CMM gradually shut off as the residue builds up and the response of the instrument dropped to zero. UNDEERC came back to the plant to cleanout the residue in the chemical conversion system. Inlet CMM was back online at 5:00. Plastic sheeting was again found on the eductor screen at 17:00. It rained hard this night. Door to the outlet CMM shack was found open at 22:30. Door to shack was closed.

The new probe/heater from UNDEERC arrived at the hotel this evening.

February 17th – Heater on the outlet probe is full-on with a reported temperature of 305F, set point is 310F. Heater is undersized for this application. Weather is quite cold, expected to chill into the teens in the coming days. John Henderson with Engelhard made a trip to Miami Fort for a look at the sorbent injection system.

Difficulties were reported with a particular super sack of sorbent that had problems with sorbent flowing out of bag.

February 18th – Eductor screen was cleaned at 18:30. Cleaned chemical converter tees at inlet CMM around 20:00.

February 19th – Inlet chemical converter ran out of chemical at 3:00. Weather was quite cold tonight. Compressed air supply to the outlet CMM shack froze. A second air supply line was run to the CMM shack. The outlet CMM was online at 19:00. There were some difficulties feeding sorbent material out of the super sack and into the feed hopper. The super sacks are larger than the original super sacks. These bags hold 1,800 pounds of material versus 1,200 pounds. Sometimes the inner plastic chute is quite long. We are now cutting off the excess plastic chute material to prevent plastic from being entangled in the sorbent feed hopper.

February 20th – Cleaned the eductor screen at 6:30 and 23:00. Inlet chemical converter plugged off until 9:30 this morning.

February 21st – Cleaned the eductor screen at 0:00. At 9:00 UNDEERC replaced the outlet sample probe that arrived February 16th. The inlet CMM chemical converter plumbing was cleaned at 22:00.

February 22nd - Inlet chemical converter plugged off until 8:30 this morning. Eductor screen was cleaned at 8:45. Bags are starting to feed well. Cleaned the inlet chemical converter tees at 21:30.

February 23rd – Inlet chemical converter plugged off until 10:00 this morning. Cleaned the inlet chemical converter plumbing at 16:00, 18:00 and 22:00. The eductor screen was only cleaned once today, at 21:30.

February 24th – Bindicator on sorbent feed hopper was replaced today. Sorbent feed was suspended from 13:45 until 14:20.

UNDEERC moved the inlet chemical conversion system inside the CMM shack to eliminate residue formation in the chemical converter. The CMM shack is temperature controller to 70F.

February 25th – There is a strong sulfur dioxide smell in the inlet CMM shack; possible gas leak in the CMM plumbing – UNDEERC to investigate. Eductor screen cleaned only once today at 21:00.

February 26th – Unit 5 came online this evening (actual time not recorded). Sorbent feed hopper ran empty at 18:50 to 19:25. Outlet CMM spiked to around 12 micrograms per cubic meter at 19:45.

February 27th – From 11:30 to 20:00 UNDEERC was trouble shooting the outlet CMM, problems with outlet sampling probe.

February 28th – At 12:00 the QSIS probe was installed at the outlet. UNDEERC's probe removed and stored. WKU was onsite to perform another series of O-H tests. One inlet and one outlet O-H test was performed today. The eductor screen was cleaned once at 18:45. At 21:00 the sorbent feeder was turned off so that the Bindicator could be removed.

March 1st – WKU pulled three simultaneous inlet and outlet O-H samples. In addition, ADA sampled the outlet for total mercury using iodated carbon (IC) traps. Two IC traps were taken today. Sorbent injection rate was 6 lb/MMACF for the first two O-H tests and 4 lb/MMACF for the third O-H test.

March 2nd – WKU pulled three simultaneous inlet and outlet O-H samples. ADA sampled the outlet for total mercury three times with IC traps. Sorbent injection rate was 4 lb/MMACF.

March 3rd – Sorbent feeder turned off at 04:00, plant is conducting stack particulate test until midnight tonight.

March 4th – Sorbent feed restarted at 00:30. UNDEERC had installed their probe at the outlet on March 3rd. The QSIS probe was reinstalled by noon. Physical work being done on Mill #5 (Unit 6) – subsequently load is lower.

March 5th – All coal mills are back online. Cleaned the eductor screen at 16:00. Found something that looks like mattress fiber. Sorbent feed rate adjusted to 6 lb/MMACF.

March 6th – Switched to the EERC probe, QSIS probe needed maintenance (12:30). G. Anderson cleaned the QSIS eductor; also found that the filter heater wiring had come loose. Wires were twisted together to solve problem. Apogee Scientific to send new heater as back-up.

Sorbent hopper allowed to run low so that the new Bindicator switch can be installed (15:30).

March 7th – At 10:00 the QSIS probe was reinstalled at the outlet sample port. Sorbent feed was shut off at 10:30 to wire the new Bindicator switch. Sorbent feed back online at 10:50.

March 8th – No operational news to report.

March 9th – A pin-hole leak has developed in the 2”diameter sorbent feed line just downstream of the eductor. At 15:00, pipe fitters shut off sorbent feed to cut out the worn section of hose. The sampling system used for pulling IC traps was reworked to improve temperature controllability. The sorbent eductor screen was cleaned at 20:00. Some rubbery pieces of material were found. (high-temperature RTV?).

March 10th – The QSIS probe heaters shut down around 03:00. Weather was quite stormy last night with thunderstorms passing through the area. The GFI circuit that powered the QSIS probe heater tripped during the night. The outlet sample line leading to the CMM was completely plugged with a gooey condensate. UNDEERC technician reinstalled their sampling probe, cleaned out the hot line and rebuilt the sampling pump to resume outlet mercury measurements.

Distribution of sorbent through the different lance could be improved. During the parametric tests the end-cap on the sorbent injection lances were removed to improve flowability of sorbent through lances. Holes were drilled in two of the end-caps and screwed back on the two rightmost lances. These lances have greater sorbent flow compared to the leftmost lances. The end-cap for the No. 1 lance (rightmost) had a ½” hole; the end-cap for the No.2 lance had a ¾” hole. Sorbent flow through the four lances is more evenly distributed.

March 11th – No problems with sorbent injection system overnight. Assembled the IC trap sampling train and performed dry-run test. All equipment functioned properly. Mill #3 offline for maintenance – load between 80 and 130 MW.

March 12th – Upped the sorbent injection feed rate to get a performance data point at 10 lb/MMACF. Load was increased in late afternoon. Injection rate was more on the order of 7 lb/MMACF. On three of the recently delivered super sack, the plastic inner chute is inside the second drawstring. Super sacks have to be laid on its side and rolled over in order to open the second drawstring and pull out the inner plastic chute. Bags with this problem were not used.

March 13th – Prepare for the O-H tests scheduled for March 14th. WKU is on-site.

March 14th – Lot of activity today – last day of Amended Silicates sorbent injection. WKU performed four simultaneous inlet and outlet O-H tests from 8:00 to 19:00. ADA also sampled gas through IC traps at similar times to the O-H tests for comparison. Flyash samples were taken from each of the ESP hoppers, along with four 55-gallon drums of flyash for Boreal, and several 5-gallon buckets of flyash for others. Sorbent feed system was ran overnight to clean system out.

Activated Carbon Sorbent Injection Activities

March 15th – Start of the Activated Carbon (AC) parametric tests. First bag was loaded at 13:00. Injection rate was set for ~2 lb/MMACF. Sorbent injected at this rate from 14:30 until 23:00. Sorbent injection reduced to 1 lb/MMACF for overnight.

March 16th – Injection rate was set for ~5 lb/MMACF. Sorbent injected at this rate from 15:00 to 20:00. Sorbent injection reduced to 1 lb/MMACF for overnight.

March 17th - Injection rate was set for ~7 lb/MMACF. Sorbent injected at this rate from 11:00 to 17:00. Sorbent injection reduced to 1 lb/MMACF for overnight.

March 18th – Load no consistent today. Injection rate was set for ~6 lb/MMACF. Sorbent injected at this rate from 14:00 to 19:00. Sorbent injection reduced to 1 lb/MMACF for overnight.

March 19th – Plant operating at low-load. Injection rate was set for ~9 lb/MMACF. Sorbent injected at this rate from 12:00 to 17:00. Plant went to high-load at 17:00. Sorbent rate is now 5 lb/MMACF; ran this way until 23:00. Sorbent injection rate reduced to 4 lb/MMACF for overnight.

March 20th - Injection rate was set for ~6 lb/MMACF. Sorbent injected at this rate from 16:00 to 23:00. Sorbent injection rate reduced to 4 lb/MMACF for overnight.

March 21th – Last day of AC injection. Injection rate was set for ~6 lb/MMACF. Sorbent injected at this rate from 8:00 to 18:00. Sorbent feed system allowed to run overnight to clean out the feed system.

Summary of Sorbent Bag Changes

Amended Silicates Sorbent Bag Identification and Feed Time during 30-day Run

Sorbent Bag ID	Start	Finish	Bag Weight (lbs)	Calc'd lbs/Mmacf	Run Time (hours)
EL00004-6	2/13/06 10:37	2/13/06 18:41	1800	5.6	8.1
EL00004-5	2/13/06 19:23	2/14/06 23:50	1800	6.1	4.5
EL00004-5	2/14/06 1:25	2/14/06 7:00	1800	3.2	5.6
EL00004-2	2/14/06 7:43	2/14/06 15:15	1800	5.3	7.5
EL00004-4	2/14/06 16:48	2/15/06 3:30	1800	4.9	10.7
EL00004-Not Labeled	2/15/06 4:10	2/15/06 13:30	1800	5.4	9.3
EL00002-1	2/15/06 14:18	2/15/06 20:00	1250	5	5.7
EL00002-4	2/16/2006 5:28	2/16/2006 12:30	1250	5	7.0
EL00002-11	2/16/2006 14:45	2/16/2006 18:12	1250	7	3.5
EL00002-2	2/16/2006 19:35	2/17/2006 1:40	1250	6	6.1
EL00002-13	2/17/2006 1:40	2/17/2006 9:00	1250	4.5	7.3
EL00002-9	2/17/2006 9:25	2/17/2006 15:48	1250	6.5	6.4
EL00002-6	2/17/2006 15:48	2/17/2006 20:23	1250	6.8	4.6
EL00002-16	2/17/2006 20:23	2/18/2006 2:35	1250	7.3	6.2
EL00004-7	2/18/06 2:35	2/18/06 12:06	1800	5	9.5
EL00004-10	2/18/06 12:06	2/18/06 21:30	1800	7	9.4
EL00004-8	2/18/06 21:30	2/19/2006 17:15	1800	erratic	19.8
EL00002-15	2/19/2006 19:15	2/19/2006 23:30	1250	6.3	4.3
EL00002-5	2/19/2006 23:30	2/20/2006 8:20	1250	1.4	8.8
EL00002-14	2/20/2006 8:20	2/20/2006 12:30	1250	4	4.2
EL00002-12	2/20/2006 12:30	2/20/2006 17:15	1250	4.4	4.8
EL00002-7	2/20/2006 17:15	2/20/2006 22:21	1250	6.3	5.1
EL00002-8	2/20/2006 22:45	2/21/2006 7:00	1250	7	8.3
EL00004-Not labeled	2/21/2006 7:00	2/21/2006 18:41	1800	erratic	11.7
EL00005-2	2/21/06 22:20	2/22/06 8:45	1800	5	10.4
EL00005-1	2/22/06 8:45	2/22/06 17:00	1800	5.5	8.3
EL00005-6	2/22/06 17:50	2/23/06 1:15	1800	7	7.4
EL00005-3	2/23/06 1:15	2/23/06 12:30	1800	5	11.3
EL00005-7	2/23/06 13:01	2/23/09 19:00	1800	6.6	6.0
EL00003-10	2/23/2006 19:45	2/24/06 1:45	1250	6.2	6.0
EL00003-7	2/24/2006 1:45	2/24/06 9:45	1250	5.3	8.0
EL00003-9	2/24/06 9:45	2/24/2006 15:00	1250	6.3	5.3
EL00003-8	2/24/2006 16:00	2/24/2006 21:00	1250	6.3	5.0
EL00005-5	2/24/06 21:25	2/25/06 10:45	1800	erratic	
EL00006-3	2/25/06 11:00	2/25/06 19:30	1800	8	8.5
EL00006-4	2/25/06 19:30	2/26/06 8:00	1800	5-8	12.5
EL00006-9	2/26/06 8:00	2/26/2006 19:25	1800	5	11.4
EL00006-10	2/26/2006 19:45	2/27/2006 11:30	1800	5-6	15.8
EL00006-6	2/27/2006 11:30	2/27/2006 20:00	1800	6.8	8.5
EL00006-11	2/27/2006 20:00	2/28/2006 7:00	1800	6	11.0
EL00006-1	2/28/2006 7:00	2/28/06 14:43	1800	6	7.7
EL00006-5	2/28/06 14:43	3/1/06 1:00	1800	5-7	10.3

Sorbent Bag ID	Start	Finish	Bag Weight (lbs)	Calc'd lbs/MMACF	Run Time (hours)
EL00006-7	3/1/06 1:00	3/1/06 10:35	1800	5-7	9.6
EL00006-2	3/1/06 10:35	3/1/06 19:00	1800		8.4
EL00006-8	3/1/06 19:00	3/2/2006 11:30	1800	4	16.5
EL00006-12	3/2/2006 11:30		1250		
EL00007-6	3/3/2006 0:30	3/3/2006 4:00	1250	6	3.5
EL00007-2	3/4/2006 0:53	3/4/06 13:24	1127	4	12.5
EL00007-8 (special)	3/4/2006 13:24	3/4/2006 21:10	1250	4	7.8
EL00007-9 (special)	3/4/2006 21:25	3/5/2006 6:00	1250	4	8.6
EL00007-14	3/5/2006 8:15	3/5/2006 15:33	1250	4	7.3
EL00007-1	3/5/2006 15:50	3/5/2006 22:33		4 and 6	6.7
EL00007-16	3/5/2006 22:33	3/6/2006 5:10	1250		6.6
EL00007-7	3/6/2006 5:10	3/6/2006	1250	6	4.8
EL00008-2	3/6/2006 10:00	3/6/2006 15:29	1250	6	5.5
EL00007-5	3/6/2006 15:55	3/6/2006 19:37	1250	6	3.7
EL00007-3	3/6/2006 19:52	3/7/2006 1:30	1250	6	5.6
EL00007-18	3/7/2006 1:33	3/7/2006 8:45	1250	6	7.2
EL00007-10	3/7/2006 8:45	3/7/2006 13:00	1250	6	4.3
EL00007-11	3/7/2006 13:45	3/7/2006 18:17	1250	6	4.5
EL00007-12	3/7/2006 18:36	3/8/2006 0:00	1250	6	5.4
EL00007-13	3/8/2006 0:30	3/8/2006 7:50	1250	6	7.3
EL00007-15	3/8/2006 13:32	3/8/2006 18:15	1250	6	4.7
EL00007-4	3/8/2006 18:49	3/8/2006 23:00	1250	6	4.2
El00008-1	3/8/2006 23:30	3/9/2006 7:00	1250	6	7.5
EL00008-3	3/9/2006 7:25	3/9/2006 12:00	1250	6	4.6
EL00008-4	3/9/2006 13:00	3/9/2006 17:09	1250	6	4.2
EL00008-8	3/9/2006 18:00	3/9/2006 23:00	1250	6	5.0
EL00008-6	3/9/2006 23:00	3/10/2006 8:10	1250	6	9.2
EL00008-5	3/10/2006 8:10	3/10/2006 13:05	1250	6	4.9
EL00008-7	3/10/2006 14:10	3/10/2006 19:14	1250	6	5.1
EL00008-16	3/10/2006 20:18	3/11/2006 4:00	1250	6	7.7
EL00008-13	3/11/2006 4:00	3/11/2006 13:00	1250	6	9.0
EL00008-11	3/11/2006 13:45	3/11/2006 21:36	1250	6	7.9
EL00008-18	3/11/2006 21:50	3/12/2006 8:00	1250	6	10.2
EL00008-10	3/12/2006 8:48	3/12/2006 16:24	1250	6	7.6
EL00008-17	3/12/2006 17:21	3/12/2006 21:48	1250	6	4.5
EL00008-14	3/12/2006 20:48	3/13/2006 6:00	1250	6	9.2
EL00009-1	3/13/2006 6:45	3/13/2006 11:30	1250	6	4.8
EL00009-2	3/13/2006 11:45	3/13/2006 16:39	1250	6	4.9
EL00009-3	3/13/2006 17:51	3/14/2006 0:10	1250	6	6.3
EL00009-5	3/14/2006 0:10	3/14/2006 8:00	1250	6	7.8
EL00009-6	3/14/2006 8:28	3/14/2006 11:30	1250	10	3.0
EL00009-4	3/14/2006 11:32	3/14/2006 15:00	1250	10	3.5
EL00008-9	3/14/2006 15:08	3/14/2006 18:14	1250	10	3.1
EL00008-12	3/14/2006 18:26	3/14/2006 21:30	1250	10	3.1

G. Plant Operational Data

Miami Fort Station Unit 6 Operational and CEM Data

Baseline Tests **Date/Time**	**U6 unit load (MW)**	**U6 coal flow (klb/hr)**	**U6 boiler O2 (vol %)**	**U6 AH out temp (deg F)**	**U6 Steam Flow (klb/hr)**	**U5/U6 Stack Flow (MMscfh)**	**U5/U6 Stack Opacity (%)**	**U5/U6 Stack SO2 (ppm)**	**U5/U6 Stack NOx (ppm)**	**U5/U6 Stack CO2 (vol %)**	**Injection Ratio (lb/MMACF)**
Baseline Test 1											
1/17/06 9:00	168.9	120.7	3.2	289.5	1168.4	29.2	7.2	816.4		8.92	
1/17/06 10:00	168.9	120.6	3.1	289.2	1168.1	29.2	7.2	767.8		8.95	
1/17/06 11:00						29.1	6.8	753.3		8.94	
1/17/06 12:00						29.1	6.9	760.0		8.94	
1/17/06 13:00	169.1	124.4	2.9	289.4	1168.7	29.0	6.5	753.2		9.01	
1/17/06 14:00	169.3	124.9	2.9	288.1	1168.7	29.0	6.2	759.9		9.05	
1/17/06 15:00	169.2	124.1	3.0	287.8	1168.8	29.1	5.7	762.3		9.00	
1/17/06 16:00	169.6	123.4	3.0	287.1	1167.9	29.1	5.7	771.9		9.04	
1/17/06 17:00	169.1	121.6	3.1	286.7	1168.4	29.1	5.6	795.4		8.99	
Test Averages	**169.2**	**122.8**	**3.0**	**288.3**	**1168.4**	**29.1**	**6.4**	**771.1**		**8.98**	
Baseline Test 2											
1/18/06 9:00	175.0	122.0	2.9	280.7	1213.6	30.3	4.6	769.1		9.10	
1/18/06 10:00	175.2	122.3	2.9	280.7	1213.7	30.3	4.3	748.4		9.11	
1/18/06 11:00	174.1	120.8	3.1	279.9	1213.6	30.4	4.3	754.3		9.04	
1/18/06 12:00	174.7	120.6	3.0	280.3	1213.2	30.2	4.3	762.7		9.10	
1/18/06 13:00	175.3	121.9	2.9	280.6	1213.6	30.3	4.3	744.5		9.12	
1/18/06 14:00	175.2	121.2	2.9	281.2	1213.6	30.2	4.7	746.7		9.11	
1/18/06 15:00	176.0	120.6	2.9	281.4	1213.7	30.3	4.4	772.8		9.17	
1/18/06 16:00	176.9	121.4	2.8	282.5	1213.7	30.2	4.5	775.3		9.22	
1/18/06 17:00	166.1	113.7	3.4	283.4	1145.0	29.3	4.7	741.6		8.87	
Test Averages	**174.3**	**120.5**	**3.0**	**281.2**	**1206.0**	**30.2**	**4.5**	**757.3**		**9.09**	
Baseline Test 3											
1/19/06 9:00	170.7	119.0	3.3	284.6	1181.5	27.9	5.8	1194.7		9.39	
1/19/06 10:00	170.9	118.8	3.4	284.9	1182.3	27.7	5.8	1204.5		9.43	
1/19/06 11:00	170.8	118.8	3.3	284.6	1183.1	27.5	5.8	1214.8		9.45	
1/19/06 12:00	170.7	119.2	3.3	285.4	1182.5	27.2	5.6	1228.0		9.47	
1/19/06 13:00	170.5	117.2	3.3	286.1	1182.5	27.2	5.7	1238.1		9.49	
1/19/06 14:00	170.7	117.9	3.3	286.4	1182.3	27.1	5.9	1253.2	243.94	9.51	
1/19/06 15:00	170.4	118.4	3.2	286.5	1182.6	27.1	5.8	1253.7	243.27	9.50	
1/19/06 16:00	170.8	117.9	3.3	287.3	1182.4	27.1	5.9	1248.7	252.42	9.54	
1/19/06 17:00	171.7	119.1	3.2	288.5	1187.7	27.2	5.9	1192.3	240.66	9.58	
Test Averages	**170.8**	**118.5**	**3.3**	**286.1**	**1183.0**	**27.3**	**5.8**	**1225.3**	**245.07**	**9.48**	

Miami Fort Station Unit 6 Operational and CEM Data

Parametric Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
Parametric Test 1											
1/26/06 13:00	168.0	115.9	3.5	286.3	1161.9	27.7	5.0	878.7	278.60	9.90	1.2
1/26/06 14:00	168.0	115.5	3.6	286.6	1161.8	27.6	5.0	886.8	276.00	9.80	1.2
1/26/06 15:00	167.8	115.8	3.5	286.8	1161.5	27.4	5.0	893.4	280.00	9.90	1.2
1/26/06 16:00	168.1	115.2	3.6	286.6	1161.3	27.5	5.0	886.9	284.60	9.90	1.2
1/26/06 17:00	168.0	115.1	3.5	285.7	1161.8	27.5	5.0	879.4	285.80	9.90	1.2
1/26/06 18:00	169.8	117.3	3.4	286.0	1175.5	28.0	5.0	884.8	282.90	9.90	1.2
Test Averages	**168.3**	**115.8**	**3.5**	**286.3**	**1164.0**	**27.6**	**5.0**	**885.0**	**281.32**	**9.88**	
Parametric Test 2											
1/27/06 8:00	171.6	120.3	2.9	283.2	1187.0	27.9	5.0	881.1	258.10	9.90	2.4
1/27/06 9:00	171.6	119.8	2.9	283.9	1187.7	27.7	5.0	921.3	248.90	9.90	2.4
1/27/06 10:00	171.4	118.6	2.9	284.7	1187.0	27.6	5.0	966.7	248.60	10.00	2.4
1/27/06 11:00	171.6	118.3	3.0	285.3	1187.2	27.5	5.0	1008.4	242.40	9.90	2.4
1/27/06 12:00	171.5	117.6	2.9	285.9	1187.5	27.4	5.0	1060.5	243.90	9.90	2.4
1/27/06 13:00	171.3	116.5	3.0	286.5	1188.0	27.6	5.0	1124.2	258.90	9.80	2.4
1/27/06 14:00	171.3	116.9	3.0	287.7	1187.1	27.4	5.0	1194.6	263.70	9.90	2.4
1/27/06 15:00	171.7	116.9	3.0	287.1	1188.3	27.3	5.0	1223.0	256.80	9.90	2.4
1/27/06 16:00	171.5	117.1	3.0	286.8	1188.6	27.5	5.0	1179.4	258.60	10.00	2.4
1/27/06 17:00	170.4	117.1	3.0	286.5	1178.3	27.2	5.0	1173.3	240.70	9.80	2.4
1/27/06 18:00	168.6	116.3	3.0	285.3	1166.4	26.8	5.0	1089.3	245.90	9.70	2.4
Test Averages	**171.1**	**117.8**	**3.0**	**285.7**	**1184.8**	**27.4**	**5.0**	**1074.7**	**251.50**	**9.88**	
Parametric Test 3											
1/28/06 10:00	166.9	117.8	3.0	288.8	1153.0	26.9	5.0	913.3	252.30	9.90	3.5
1/28/06 11:00	166.8	118.8	3.0	289.6	1153.5	26.9	6.0	875.8	249.20	9.90	3.5
1/28/06 12:00	166.9	118.9	3.0	290.1	1154.0	26.7	6.0	886.1	249.30	9.90	3.5
1/28/06 13:00	166.8	118.7	3.0	290.6	1153.6	26.8	6.0	906.2	237.00	9.90	3.5
1/28/06 14:00	166.8	118.8	3.0	291.2	1154.2	26.6	6.0	926.1	237.50	9.90	3.5
1/28/06 15:00	166.9	119.1	2.9	291.5	1154.9	26.8	6.0	902.3	235.70	9.90	3.5
1/28/06 16:00	167.1	118.9	2.9	292.0	1155.4	26.6	6.0	904.5	233.10	9.90	3.5
1/28/06 17:00	167.3	118.4	2.9	292.6	1154.9	26.8	6.0	986.6	237.00	9.80	3.5
1/28/06 18:00	167.0	118.4	2.8	292.2	1155.1	27.0	6.0	1009.8	234.20	9.80	3.5
1/28/06 19:00	166.1	116.9	2.9	291.9	1144.9	24.3	6.0	947.9	253.20	8.90	3.5
Test Averages	**166.8**	**118.5**	**2.9**	**291.0**	**1153.3**	**26.5**	**5.9**	**925.8**	**241.85**	**9.78**	
Parametric Test 4											
1/30/06 9:00	165.3	119.7	2.8	284.4	1140.9	26.7	5.0	935.3	218.10	9.60	4.5
1/30/06 10:00	165.3	119.5	2.9	284.9	1140.9	26.6	5.0	939.8	216.00	9.70	4.5

Miami Fort Station Unit 6 Operational and CEM Data

Parametric Tests **Date/Time**	**U6 unit load (MW)**	**U6 coal flow (klb/hr)**	**U6 boiler O2 (vol %)**	**U6 AH out temp (deg F)**	**U6 Steam Flow (klb/hr)**	**U5/U6 Stack Flow (MMscfh)**	**U5/U6 Stack Opacity (%)**	**U5/U6 Stack SO2 (ppm)**	**U5/U6 Stack NOx (ppm)**	**U5/U6 Stack CO2 (vol %)**	**Injection Ratio (lb/MMACF)**
1/30/06 11:00	165.5	120.3	2.8	285.3	1141.2	26.7	5.0	949.9	216.10	9.70	4.5
1/30/06 12:00	165.2	120.2	2.8	285.7	1140.9	26.6	5.0	969.5	220.10	9.80	4.5
1/30/06 13:00	165.4	119.9	2.8	285.2	1141.0	26.7	5.0	948.8	219.30	9.80	4.5
1/30/06 14:00	165.3	120.8	2.8	284.5	1140.9	26.6	6.0	955.7	224.20	9.80	4.5
1/30/06 15:00	165.3	120.0	2.9	283.8	1141.0	26.8	5.0	967.7	227.80	9.80	4.5
1/30/06 16:00	165.0	119.5	2.9	284.5	1141.1	26.7	5.0	960.8	238.30	9.80	4.5
1/30/06 17:00	166.5	121.3	2.9	284.8	1150.4	27.7	5.0	973.2	231.00	10.00	4.5
1/30/06 18:00	174.7	128.1	2.7	283.4	1211.3	27.9	5.0	992.9	228.90	10.10	4.5
Test Averages	**166.3**	**120.9**	**2.8**	**284.6**	**1149.0**	**26.9**	**5.1**	**959.4**	**223.98**	**9.81**	
Parametric Test 5											
1/31/06 9:00	168.3	124.7	2.9	281.8	1164.7	27.3	5.0	865.6	249.00	10.00	7.6
1/31/06 10:00	168.3	124.4	2.9	281.7	1165.3	27.4	5.0	866.3	244.80	10.00	7.6
1/31/06 11:00	168.3	124.6	2.9	281.6	1165.6	27.4	5.0	828.2	248.20	10.00	7.6
1/31/06 12:00	168.2	124.9	2.9	281.6	1165.0	27.3	5.0	832.9	241.80	10.00	6.1
1/31/06 13:00	168.3	123.9	2.9	281.9	1165.4	27.2	5.0	844.1	243.20	10.00	5.8
1/31/06 14:00	168.1	123.6	3.0	283.3	1165.6	27.2	5.0	868.9	254.30	10.10	5.4
Test Averages	**168.3**	**124.4**	**2.9**	**282.0**	**1165.3**	**27.3**	**5.0**	**851.0**	**246.88**	**10.02**	
Parametric Test 6											
2/1/06 9:00	165.9	122.1	2.9	283.1	1151.6	27.1	5.2	894.3	247.69	9.50	4.2
2/1/06 10:00	166.4	122.9	2.9	282.7	1152.6	27.0	5.0	877.1	246.15	9.53	4.2
2/1/06 11:00	166.7	121.4	2.9	283.4	1153.9	27.1	4.7	885.5	246.11	9.55	4.2
2/1/06 12:00	167.0	121.8	2.8	284.3	1153.7	27.0	4.7	1002.6	245.94	9.52	4.2
2/1/06 13:00	166.9	122.2	2.9	284.4	1153.7	27.1	4.8	1033.1	244.44	9.52	4.2
2/1/06 14:00	166.8	122.5	3.0	285.1	1153.3	27.0	5.2	1061.5	238.20	9.51	4.2
2/1/06 15:00	166.7	122.8	3.0	285.2	1152.9	27.1	5.2	1043.5	241.20	9.47	4.2
2/1/06 16:00	166.6	122.4	3.0	285.7	1152.8	27.1	5.2	1088.6	236.08	9.52	4.2
2/1/06 17:00	166.8	123.6	3.0	285.5	1152.9	27.1	5.4	1055.3	230.18	9.48	4.2
Test Averages	**166.7**	**122.4**	**3.0**	**284.4**	**1153.1**	**27.0**	**5.0**	**993.5**	**241.78**	**9.51**	
Parametric Test 7											
2/2/06 10:00	169.2	124.4	3.1	284.3	1174.9	27.6	5.0	978.9	254.70	9.51	3.4
2/2/06 11:00	169.3	124.5	3.1	284.5	1174.8	27.2	5.1	1065.3	252.83	9.58	3.4
2/2/06 12:00	169.2	123.9	3.1	284.4	1174.7	27.2	5.3	1111.4	249.26	9.55	3.4
2/2/06 13:00	169.0	123.8	3.1	284.2	1175.0	27.3	5.4	1135.5	248.08	9.56	3.4
2/2/06 14:00	168.9	123.7	3.1	285.4	1173.7	27.3	5.5	1127.7	248.01	9.54	3.4
2/2/06 15:00	169.6	124.0	3.0	285.3	1173.9	27.2	5.3	1113.7	251.57	9.53	3.4
2/2/06 16:00	169.2	123.8	3.0	285.0	1174.2	27.0	5.3	1135.1	247.60	9.58	3.4

Miami Fort Station Unit 6 Operational and CEM Data

Parametric Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/2/06 17:00	169.2	124.4	3.0	285.4	1174.6	27.1	5.3	1123.6	243.03	9.55	3.4
Test Averages	**169.2**	**124.1**	**3.1**	**284.8**	**1174.5**	**27.2**	**5.3**	**1098.9**	**249.38**	**9.55**	
Parametric Test 8											
2/3/06 8:00	174.0	125.3	2.9	285.4	1208.3	30.1	6.0	987.8	235.64	8.94	3.5
2/3/06 9:00	167.9	119.6	3.3	286.4	1162.2	30.3	5.9	1018.7	233.17	9.05	3.5
2/3/06 10:00	166.0	119.3	3.2	285.7	1144.4	29.6	6.0	1033.9	238.16	8.86	3.5
2/3/06 11:00	165.7	119.7	3.1	284.9	1144.6	29.4	5.9	985.4	229.35	8.88	3.5
2/3/06 12:00	165.7	120.4	3.1	285.1	1144.2	29.4	5.8	954.5	225.36	8.89	3.5
2/3/06 13:00	166.0	121.1	3.0	284.6	1143.8	29.3	5.7	930.3	225.04	8.90	4.7
2/3/06 14:00	165.5	119.8	3.1	285.8	1143.8	29.2	6.0	884.1	220.12	9.00	4.7
2/3/06 15:00	165.4	119.8	3.1	287.2	1144.1	27.1	5.5	989.1	240.51	9.66	4.7
Test Averages	**167.0**	**120.6**	**3.1**	**285.6**	**1154.4**	**29.3**	**5.8**	**973.0**	**230.92**	**9.02**	
Parametric Test 9											
2/9/06 8:00	166.7	122.8	3.1	282.4	1149.6	29.9	7.4	1009.3	209.87	8.81	2.4
2/9/06 9:00	166.8	122.6	3.1	283.4	1149.9	29.9	7.5	1006.3	208.22	8.81	4.7
2/9/06 10:00	165.7	121.4	3.3	284.1	1149.8	29.9	6.7	1005.4	211.85	8.80	5.5
2/9/06 11:00	166.6	122.4	3.2	283.9	1149.8	29.8	6.6	1003.2	216.43	8.78	5.5
2/9/06 12:00	165.8	121.4	3.3	284.0	1145.3	29.9	6.9	1011.0	227.50	8.80	6.3
2/9/06 13:00	163.1	120.2	3.5	284.8	1127.5	29.8	6.4	1004.9	228.61	8.73	6.8
2/9/06 14:00	163.6	119.6	3.5	284.4	1126.9	29.6	6.5	986.6	238.24	8.66	8.1
2/9/06 15:00	163.4	121.1	3.5	283.5	1127.8	29.7	6.0	986.0	237.53	8.69	9.1
2/9/06 16:00	163.7	121.4	3.4	284.2	1127.0	29.7	6.0	980.3	239.47	8.66	9.1
Test Averages	**165.0**	**121.5**	**3.3**	**283.9**	**1139.3**	**29.8**	**6.7**	**999.2**	**224.19**	**8.75**	
Parametric Test 10											
2/10/06 10:00	169.1	120.8	3.5	285.8	1172.5	30.0	6.6	845.3	241.32	8.68	4.1
2/10/06 11:00	166.0	118.6	3.6	285.8	1144.9	30.4	6.4	935.6	245.06	8.66	4.1
2/10/06 12:00	166.0	117.5	3.6	285.5	1144.4	30.0	6.7	986.0	246.12	8.58	4.1
2/10/06 13:00	165.3	116.8	3.7	285.8	1143.9	30.1	6.8	1019.0	245.00	8.55	4.1
2/10/06 15:00	164.8	116.3	3.8	285.5	1141.9	30.0	7.2	1025.8	247.50	8.48	4.8
2/10/06 16:00	165.1	115.7	3.7	284.9	1142.1	30.1	6.7	1033.1	249.19	8.49	5.5
2/10/06 17:00	165.2	115.5	3.7	285.1	1142.0	30.1	6.8	1042.8	248.28	8.48	5.5
2/10/06 18:00	165.3	115.2	3.7	285.7	1142.5	30.1	7.0	1057.6	249.77	8.52	5.5
Test Averages	**165.8**	**117.1**	**3.7**	**285.5**	**1146.8**	**30.1**	**6.8**	**993.2**	**246.53**	**8.56**	
Parametric Test 11											
2/11/06 10:00	168.8	121.5	3.4	285.7	1170.0	30.2	7.4	866.7	239.42	8.73	5.4

Miami Fort Station Unit 6 Operational and CEM Data

Parametric Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/11/06 12:00	168.8	121.9	3.5	284.6	1168.6	30.2	7.0	905.4	241.67	8.69	5.4
2/11/06 13:00	167.1	120.5	3.5	284.4	1155.1	30.2	6.9	914.6	241.72	8.69	5.4
2/11/06 15:00	166.9	120.7	3.5	283.1	1155.0	30.1	6.6	1013.8	236.19	8.66	5.4
Test Averages	**167.9**	**121.2**	**3.5**	**284.5**	**1162.2**	**30.2**	**7.0**	**925.1**	**239.75**	**8.69**	
Parametric Test 12											
2/12/06 11:00	146.6	104.3	3.8	272.6	987.0	27.8	6.0	1000.7	242.13	8.09	4.0
2/12/06 12:00	147.0	103.8	3.7	273.0	988.7	27.8	5.7	1024.9	241.92	8.26	4.0
2/12/06 13:00	146.7	103.6	3.8	272.6	990.7	28.0	5.6	1034.5	238.98	8.26	4.4
2/12/06 14:00	146.3	103.3	3.8	272.2	990.3	27.8	5.5	1037.9	238.11	8.26	5.3
2/12/06 15:00	146.4	102.9	3.8	272.2	990.2	27.8	5.7	1036.0	238.68	8.23	5.3
2/12/06 16:00	147.1	103.5	3.9	275.6	1000.3	27.8	5.5	1039.5	238.12	8.22	5.2
2/12/06 17:00	160.5	115.8	4.0	281.1	1109.1	27.9	5.7	1044.0	239.11	8.23	5.0
Test Averages	**148.6**	**105.3**	**3.8**	**274.2**	**1008.1**	**27.8**	**5.7**	**1031.1**	**239.58**	**8.22**	

Miami Fort Station Unit 6 Operational and CEM Data

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/13/06 10:00	166.8	118.2	3.4	282.1	1151.4	30.3	6.7	517.2	174.49	7.24	4.1
2/13/06 11:00	166.7	117.7	3.4	282.0	1152.2	30.4	6.4	869.2	282.34	8.88	4.1
2/13/06 12:00	166.5	118.1	3.5	281.9	1152.0	30.1	5.9	785.2	291.06	9.18	4.1
2/13/06 13:00	166.7	118.3	3.5	283.8	1151.4	30.3	5.9	779.7	288.60	9.22	4.8
2/13/06 14:00	166.5	117.4	3.4	284.1	1151.4	30.3	6.0	572.5	223.04	6.91	5.0
2/13/06 15:00	166.4	117.8	3.5	283.9	1151.4	30.2	6.4	753.9	179.86	6.18	5.1
2/13/06 16:00	166.4	118.0	3.4	285.0	1151.3	30.3	6.3	934.6	203.12	7.53	5.2
2/13/06 17:00	166.8	117.8	3.5	284.5	1151.5	30.3	6.3	937.4	212.70	7.60	5.3
2/13/06 18:00	166.8	117.1	3.5	284.2	1152.6	30.2	6.2	968.0	216.84	7.59	5.6
2/13/06 19:00	166.7	117.6	3.5	284.4	1152.4	30.3	6.2	983.1	214.20	7.58	6.1
2/13/06 20:00	166.5	117.6	3.5	284.5	1151.8	30.2	6.1	1028.1	220.18	7.90	6.7
2/13/06 21:00	166.5	117.2	3.5	284.5	1151.5	30.2	6.2	1035.5	215.95	7.94	6.7
2/13/06 22:00	157.2	108.6	3.8	285.5	1073.2	30.3	6.3	1022.8	211.10	7.92	6.6
2/14/06 7:00	166.3	120.3	3.5	284.0	1153.3	29.0	6.6	1029.2	235.15	8.18	4.1
2/14/06 8:00	167.2	121.1	3.5	284.5	1155.7	30.3	6.5	1051.8	234.15	8.38	5.1
2/14/06 9:00	173.5	126.8	3.4	284.2	1206.0	30.4	6.4	1063.6	231.77	8.44	5.6
2/14/06 10:00	165.0	121.1	3.6	284.9	1139.9	31.0	6.4	1080.0	230.91	8.56	5.7
2/14/06 11:00	165.4	122.4	3.5	285.5	1142.3	30.2	6.7	1062.2	231.56	8.43	5.5
2/14/06 12:00	165.3	123.0	3.5	285.8	1142.3	30.1	7.0	1068.6	232.67	8.45	5.2
2/14/06 13:00	165.5	123.1	3.5	285.2	1141.2	30.0	6.8	1068.8	229.77	8.45	5.2
2/14/06 14:00	139.8	103.7	4.8	286.2	937.2	30.0	6.8	1070.0	229.21	8.44	5.2
2/14/06 15:00	130.7	97.4	5.4	285.2	877.6	27.7	7.9	964.4	243.66	7.67	5.2
2/14/06 16:00	130.7	97.2	5.3	284.5	877.0	27.1	8.1	925.9	251.85	7.37	5.0
2/14/06 17:00	157.1	118.0	4.1	285.2	1094.9	27.1	8.3	929.5	254.57	7.39	4.5
2/14/06 18:00	163.0	121.3	3.6	286.7	1136.6	29.5	7.9	1036.6	243.89	8.17	4.0
2/14/06 19:00	164.0	121.1	3.6	287.5	1135.4	29.9	7.7	1075.9	242.71	8.45	3.5
2/14/06 20:00	163.9	120.5	3.6	286.9	1135.8	29.9	8.0	1069.8	240.61	8.43	3.7
2/14/06 21:00	163.8	119.6	3.7	288.1	1136.4	30.0	7.7	1063.8	238.27	8.44	4.1
2/15/06 7:00	162.1	114.5	3.5	283.9	1126.9	25.8	7.9	918.5	258.17	7.25	3.5
2/15/06 8:00	164.2	115.0	3.4	285.9	1135.6	29.6	7.6	1009.6	239.55	8.44	3.8
2/15/06 9:00	164.9	114.5	3.3	285.5	1136.4	29.7	7.6	915.6	241.80	8.51	4.2
2/15/06 10:00	164.6	114.0	3.4	287.4	1138.1	29.6	7.4	877.0	237.01	8.56	4.4
2/15/06 11:00	165.0	114.0	3.3	288.8	1137.9	29.6	7.4	884.5	238.50	8.55	4.6
2/15/06 12:00	164.8	113.5	3.4	288.6	1138.9	29.6	7.2	842.9	239.14	8.57	4.7
2/15/06 13:00	165.1	113.4	3.3	289.7	1138.6	29.5	7.2	792.2	237.46	8.57	4.6
2/15/06 14:00	164.9	112.9	3.4	289.7	1138.2	29.6	7.1	776.7	237.24	8.59	4.5

Miami Fort Station Unit 6 Operational and CEM Data

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/15/06 16:00	164.7	112.0	3.4	289.1	1137.6	29.5	6.8	674.6	227.77	8.62	4.6
2/15/06 17:00	164.8	112.0	3.4	290.1	1137.8	29.5	6.6	709.6	228.24	8.61	4.6
2/15/06 18:00	164.6	112.5	3.4	290.7	1138.9	29.4	6.6	737.8	238.84	8.63	4.4
2/15/06 19:00	164.9	113.2	3.4	291.0	1138.3	29.6	6.6	798.5	241.49	8.60	4.1
2/15/06 20:00	165.1	113.1	3.3	290.5	1138.0	29.5	6.6	868.9	244.22	8.60	4.3
2/16/06 10:00	165.8	120.0	3.2	287.8	1160.7	26.9	7.8	975.2	238.93	7.91	3.6
2/16/06 11:00	166.3	119.6	3.0	289.0	1150.8	29.7	7.9	1082.3	230.44	8.64	3.6
2/16/06 12:00	165.4	119.9	3.0	289.4	1142.9	29.4	7.7	1083.9	226.41	8.66	3.9
2/16/06 13:00	165.5	120.5	3.0	287.9	1142.8	29.3	7.5	1072.9	220.62	8.64	4.2
2/16/06 14:00	165.3	121.3	3.0	286.9	1142.6	29.3	13.6	1073.9	214.61	8.63	4.6
2/16/06 15:00	165.2	121.2	3.1	288.0	1142.8	29.3	7.6	1071.4	204.35	8.64	5.1
2/16/06 16:00	165.3	121.9	3.1	289.3	1142.6	29.4	7.1	1071.1	199.93	8.63	5.6
2/16/06 17:00	165.3	121.2	3.1	290.0	1142.8	29.2	7.1	1074.1	199.02	8.67	5.8
2/16/06 18:00	165.1	121.0	3.1	291.0	1142.1	29.4	7.3	1061.4	200.19	8.65	5.7
2/16/06 19:00	164.9	121.4	3.1	291.8	1141.9	29.3	7.1	1061.2	201.18	8.63	5.6
2/16/06 20:00	165.2	119.7	3.2	291.7	1142.8	29.3	7.0	1064.0	205.52	8.65	5.4
2/16/06 21:00	165.0	118.9	3.1	292.6	1142.4	29.3	6.8	1066.9	204.49	8.58	5.5
2/17/06 6:00	164.6	122.4	3.4	280.4	1140.3	24.5	6.5	768.1	266.37	6.97	3.6
2/17/06 7:00	166.0	123.5	3.6	282.5	1148.9	29.9	6.5	874.1	237.51	8.63	4.2
2/17/06 8:00	164.0	122.6	3.7	282.7	1133.4	30.3	5.8	840.3	237.70	8.60	4.8
2/17/06 9:00	164.1	123.4	3.7	282.8	1132.7	30.3	5.7	811.9	242.76	8.57	5.2
2/17/06 10:00	164.5	125.1	3.6	282.9	1133.4	30.2	5.6	785.2	245.40	8.61	5.5
2/17/06 11:00	164.3	126.0	3.5	283.0	1133.9	30.1	7.1	721.3	242.11	8.66	5.7
2/17/06 12:00	164.0	125.5	3.5	283.4	1133.8	30.0	5.5	663.5	238.83	8.73	5.7
2/17/06 13:00	164.1	123.9	3.4	283.9	1133.3	29.9	5.4	678.8	247.03	8.70	5.8
2/17/06 14:00	164.4	122.5	3.4	284.6	1134.1	29.9	5.3	705.3	246.13	8.74	5.5
2/17/06 15:00	164.4	119.8	3.4	285.4	1134.1	29.9	5.4	740.7	240.31	8.72	5.2
2/17/06 16:00	164.4	118.4	3.5	285.7	1134.0	30.0	5.5	836.5	240.58	8.68	4.7
2/17/06 17:00	164.4	117.8	3.5	286.4	1134.1	29.9	5.5	909.7	240.34	8.65	5.4
2/17/06 18:00	164.3	116.5	3.6	286.6	1133.6	29.8	5.6	926.4	237.51	8.64	5.7
2/17/06 19:00	164.2	115.8	3.6	286.9	1133.6	29.9	5.8	953.1	237.08	8.64	5.9
2/17/06 20:00	164.3	115.4	3.6	288.5	1133.3	30.0	5.9	992.0	235.47	8.61	5.9
2/17/06 21:00	164.1	115.1	3.5	288.2	1134.4	29.9	6.0	1021.2	237.80	8.61	6.1
2/17/06 22:00	164.6	114.8	3.4	285.8	1133.9	29.9	6.1	999.7	236.29	8.60	6.4
2/18/06 11:00	163.2	124.2	3.5	278.7	1130.7	26.3	4.4	588.7	273.42	8.72	4.8
2/18/06 12:00	166.5	124.4	3.3	279.9	1150.7	27.7	4.4	625.1	262.64	9.31	6.5

2/18/06 13:00	166.7	122.3	3.3	280.8	1151.4	27.7	4.4	660.5	260.91	9.38	9.8

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/18/06 15:00	166.9	119.9	3.3	280.6	1153.3	27.8	4.7	881.4	260.59	9.35	10.3
2/18/06 16:00	166.8	118.8	3.3	279.4	1153.9	27.9	4.7	999.6	257.67	9.30	8.1
2/18/06 17:00	166.7	117.3	3.3	278.0	1153.8	27.9	4.4	1093.3	251.94	9.25	6.3
2/18/06 19:00	166.6	118.5	3.3	278.6	1153.2	27.8	4.4	1144.0	249.95	9.34	6.6
2/18/06 20:00	166.4	118.3	3.3	278.5	1153.4	27.8	4.3	1147.5	246.53	9.32	7.5
2/18/06 21:00	166.7	119.0	3.2	277.3	1152.5	28.0	4.3	1156.8	241.50	9.25	8.7
2/18/06 22:00	166.6	118.1	3.2	277.0	1152.9	28.0	4.3	1162.0	248.74	9.26	9.0
2/18/06 23:00	166.2	118.2	3.2	277.6	1152.6	27.9	4.3	1175.6	240.86	9.27	8.1
2/19/06 0:00	166.5	118.8	3.2	277.3	1151.8	27.9	4.3	1159.5	230.80	9.26	6.6
2/19/06 1:00	166.3	119.9	3.3	277.1	1151.4	27.6	4.2	1110.7	241.30	9.30	4.0
2/19/06 2:00	166.6	123.5	3.2	277.4	1151.1	27.9	4.4	1028.8	234.14	9.31	2.8
2/19/06 3:00	166.1	124.4	3.2	276.8	1152.2	27.8	4.5	881.6	230.85	9.38	2.1
2/19/06 4:00	166.5	126.1	3.3	277.6	1151.1	27.9	4.5	784.3	231.23	9.45	1.9
2/19/06 5:00	166.4	126.0	3.2	277.4	1152.2	26.9	4.5	565.2	176.84	6.72	1.7
2/19/06 6:00	166.4	125.6	3.2	278.2	1152.3	28.1	4.5	722.7	241.86	9.31	1.5
2/19/06 7:00	166.7	125.8	3.2	277.3	1152.8	27.7	4.9	777.1	256.04	9.39	1.4
2/19/06 8:00	166.6	125.6	3.2	277.0	1152.5	27.6	4.5	764.7	258.89	9.47	1.5
2/19/06 9:00	166.5	125.3	3.2	277.7	1152.1	27.7	4.5	722.9	253.32	9.43	1.7
2/19/06 10:00	166.3	125.1	3.3	278.3	1151.3	27.7	4.5	757.2	249.99	9.43	2.0
2/19/06 11:00	166.4	124.4	3.3	278.7	1151.7	27.6	4.4	762.5	250.27	9.43	2.1
2/19/06 12:00	166.1	122.2	3.3	279.4	1152.2	27.4	4.5	751.7	238.71	9.43	2.0
2/19/06 13:00	166.6	120.9	3.4	280.5	1151.1	27.4	4.8	836.0	241.93	9.45	2.0
2/19/06 14:00	166.4	120.8	3.3	280.9	1151.1	27.4	4.9	902.7	262.19	9.39	2.1
2/19/06 15:00	166.5	120.1	3.3	280.0	1151.3	27.4	5.2	955.0	259.56	9.40	2.1
2/19/06 16:00	166.4	120.6	3.2	280.9	1151.1	27.2	4.9	985.8	256.78	9.42	2.2
2/19/06 17:00	166.4	121.0	3.1	280.2	1151.7	27.2	4.8	1033.6	242.01	9.43	2.3
2/19/06 18:00	166.5	120.1	3.1	279.9	1150.6	27.3	4.7	1112.1	238.85	9.50	2.6
2/19/06 19:00	166.3	121.2	3.2	280.3	1151.3	27.2	4.9	1162.6	239.94	9.49	3.4
2/19/06 20:00	166.2	121.5	3.2	279.5	1151.6	27.2	4.8	1163.9	233.39	9.47	4.7
2/19/06 21:00	166.5	121.6	3.2	279.0	1151.7	27.4	4.7	1177.2	231.14	9.45	5.4
2/19/06 22:00	166.2	122.2	3.2	279.8	1152.0	27.4	4.7	1171.7	227.61	9.40	5.9
2/19/06 23:00	165.4	120.7	3.2	279.3	1143.8	27.6	4.7	1176.2	234.66	9.39	6.3
2/20/06 6:00	165.8	121.7	3.3	277.4	1152.4	26.6	4.7	1155.9	257.27	9.05	1.6
2/20/06 7:00	166.1	122.0	3.3	277.7	1153.8	27.6	5.2	1208.0	253.28	9.41	2.5
2/20/06 8:00	165.7	121.5	3.4	277.7	1153.5	27.6	4.8	1218.3	255.28	9.42	4.4
2/20/06 9:00	165.4	121.9	3.5	278.5	1153.5	27.6	4.8	1217.1	255.91	9.41	5.5
2/20/06 10:00	173.0	127.1	3.0	280.7	1202.0	27.6	4.8	1215.0	257.75	9.42	5.7

2/20/06 11:00	174.3	127.1	3.3	282.1	1212.0	28.0	4.8	1242.6	264.52	9.64	6.0
2/20/06 12:00	174.1	127.4	3.2	283.3	1212.2	28.3	4.9	1112.6	276.84	9.61	6.8

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O_2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO_2 (ppm)	U5/U6 Stack NO_x (ppm)	U5/U6 Stack CO_2 (vol %)	Injection Ratio (lb/MMACF)
2/20/06 14:00	174.4	128.1	3.1	286.8	1212.0	27.8	4.9	864.6	271.63	9.75	6.6
2/20/06 15:00	174.2	126.9	3.2	287.2	1211.7	27.8	5.0	758.2	263.01	9.73	6.0
2/20/06 17:00	172.3	121.4	3.3	285.8	1195.6	27.9	5.2	659.1	245.83	9.76	5.7
2/20/06 18:00	167.9	118.3	3.3	285.5	1163.7	27.8	5.2	607.7	253.32	9.64	5.6
2/20/06 19:00	165.9	115.4	3.4	286.2	1148.9	27.3	5.1	600.3	251.82	9.56	5.5
2/20/06 20:00	165.5	114.9	3.3	285.8	1145.3	27.3	5.1	558.9	259.49	9.47	5.5
2/20/06 21:00	165.1	114.5	3.2	284.8	1145.5	27.1	5.1	552.1	258.15	9.49	5.5
2/21/06 7:00	164.0	123.0	3.6	282.2	1147.3	27.6	5.6	1107.1	265.17	9.08	2.3
2/21/06 8:00	164.9	122.7	3.6	283.6	1147.0	28.1	5.3	1130.3	262.94	9.19	2.1
2/21/06 9:00	165.1	123.0	3.6	283.3	1147.4	28.0	5.3	1151.9	263.56	9.26	2.0
2/21/06 10:00	165.2	123.4	3.6	284.2	1147.0	27.8	5.6	1161.2	264.41	9.31	2.1
2/21/06 11:00	165.7	123.2	3.6	285.5	1147.3	27.7	5.6	1174.0	264.68	9.37	2.2
2/21/06 12:00	165.8	122.7	3.6	285.5	1147.5	27.4	5.7	1178.1	264.37	9.40	2.3
2/21/06 13:00	164.9	122.3	3.7	284.9	1148.3	27.3	5.7	1191.2	265.46	9.46	2.4
2/21/06 14:00	165.1	123.1	3.5	286.0	1146.8	27.4	5.8	1178.7	262.69	9.38	2.7
2/21/06 15:00	165.7	122.9	3.5	286.1	1146.6	27.3	6.0	1192.1	267.89	9.45	2.8
2/21/06 16:00	165.4	122.5	3.5	287.0	1147.2	27.2	6.0	1194.7	264.21	9.47	2.9
2/21/06 17:00	165.0	122.3	3.5	287.9	1147.0	27.1	6.2	1203.6	263.84	9.53	3.1
2/21/06 18:00	165.0	122.2	3.5	288.0	1146.9	26.8	6.3	1213.0	259.61	9.57	3.3
2/21/06 19:00	165.1	122.0	3.5	286.9	1147.3	27.2	6.1	1199.1	249.11	9.46	3.4
2/21/06 20:00	165.1	121.9	3.5	286.9	1146.8	27.4	5.9	1199.2	243.46	9.47	3.3
2/21/06 21:00	165.0	121.5	3.6	287.3	1147.5	27.3	6.2	1195.3	241.51	9.45	3.3
2/22/06 6:00	162.3	122.1	3.5	285.7	1131.7	26.1	6.0	1123.8	255.26	9.01	4.4
2/22/06 7:00	162.6	122.4	3.5	286.0	1131.6	26.9	5.8	1188.1	267.70	9.47	4.0
2/22/06 8:00	165.2	123.2	3.4	286.3	1148.5	26.9	5.5	1187.5	271.58	9.48	3.7
2/22/06 9:00	173.8	129.4	3.1	285.8	1214.0	27.1	5.4	1212.7	263.57	9.65	3.4
2/22/06 10:00	173.9	129.1	3.0	287.2	1214.0	27.5	5.6	1236.7	260.34	9.81	3.4
2/22/06 11:00	173.6	128.6	3.0	288.1	1214.4	27.7	5.7	1233.1	256.63	9.82	3.7
2/22/06 12:00	173.5	128.2	3.0	288.1	1213.7	27.4	5.9	1240.0	253.72	9.88	3.8
2/22/06 13:00	166.3	123.1	3.1	287.6	1157.7	27.3	6.0	1235.0	246.80	9.83	4.2
2/22/06 14:00	166.5	123.5	3.0	288.4	1161.0	26.5	5.8	1224.8	233.94	9.77	4.5
2/22/06 15:00	166.8	124.1	3.1	289.1	1160.6	26.6	5.9	1228.5	229.63	9.78	4.6
2/22/06 16:00	166.7	124.0	3.1	290.0	1160.6	26.6	6.1	1231.3	232.31	9.79	4.7
2/22/06 17:00	166.8	123.0	3.0	290.1	1160.8	26.5	6.0	1228.4	226.28	9.77	4.9
2/22/06 18:00	166.4	123.5	3.0	289.5	1161.6	26.6	6.0	1223.4	222.68	9.71	5.4

2/22/06 19:00	167.0	123.4	3.0	289.9	1162.3	26.6	5.9	1226.3	235.46	9.71	5.7
2/22/06 20:00	166.7	123.3	3.1	289.1	1162.6	26.7	5.9	1223.1	231.47	9.72	6.0
2/22/06 21:00	167.1	122.9	3.0	288.7	1162.7	26.9	5.8	1213.0	236.22	9.64	6.2

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/23/06 7:00	166.1	120.6	3.4	286.0	1164.2	26.0	6.9	1167.2	270.09	9.14	3.3
2/23/06 9:00	170.2	120.6	3.2	288.5	1184.1	27.4	5.7	1236.0	262.51	9.62	4.4
2/23/06 10:00	166.4	118.7	3.3	288.8	1153.7	27.1	5.8	1240.1	262.82	9.66	4.7
2/23/06 11:00	173.9	124.0	3.0	290.4	1211.1	27.0	5.9	1231.5	260.40	9.62	4.6
2/23/06 12:00	169.5	120.1	3.2	291.0	1177.3	27.6	6.2	1253.2	259.15	9.78	4.5
2/23/06 13:00	163.4	116.4	3.4	290.4	1129.9	27.3	6.3	1219.3	253.31	9.55	4.5
2/23/06 14:00	163.3	116.0	3.5	290.6	1130.4	26.9	6.2	1206.3	247.68	9.45	4.8
2/23/06 15:00	163.3	116.0	3.5	290.9	1130.1	26.8	6.3	1204.2	238.23	9.44	5.3
2/23/06 16:00	163.2	116.2	3.5	291.6	1130.9	26.7	6.4	1208.4	236.10	9.47	5.6
2/23/06 17:00	163.5	115.9	3.5	291.2	1130.8	26.7	6.5	1207.0	252.61	9.51	5.7
2/23/06 18:00	163.6	116.6	3.4	291.4	1131.3	26.8	6.5	1197.4	254.39	9.48	5.6
2/23/06 19:00	163.6	116.5	3.4	292.0	1131.4	26.7	6.4	1192.4	247.81	9.48	5.5
2/23/06 20:00	163.6	116.0	3.5	291.5	1131.5	26.9	6.4	1184.6	239.21	9.48	5.2
2/23/06 21:00	163.4	115.5	3.5	291.5	1131.3	26.9	6.2	1173.7	236.93	9.43	5.2
2/23/06 22:00	163.3	115.7	3.5	291.4	1130.8	27.0	6.2	1163.3	235.19	9.41	5.4
2/24/06 7:00	164.7	119.0	3.3	285.6	1148.0	26.9	6.4	1171.4	263.34	9.38	4.9
2/24/06 8:00	165.4	119.3	3.3	285.6	1146.9	26.8	6.0	1215.6	257.79	9.63	5.3
2/24/06 9:00	165.8	119.9	3.3	286.9	1146.8	27.0	6.1	1210.7	257.49	9.57	5.6
2/24/06 10:00	165.8	119.9	3.3	286.9	1147.1	26.9	6.2	1222.8	257.23	9.65	5.5
2/24/06 11:00	165.2	120.2	3.4	287.5	1146.5	26.9	6.3	1214.1	252.41	9.61	5.4
2/24/06 12:00	165.6	120.6	3.3	287.7	1145.9	26.0	6.2	1181.8	255.63	9.36	5.3
2/24/06 13:00	165.8	120.7	3.3	289.2	1147.1	27.0	6.3	1198.8	251.95	9.47	5.4
2/24/06 14:00	165.8	121.6	3.2	288.9	1147.3	27.2	6.2	1139.9	250.25	9.57	5.5
2/24/06 15:00	165.7	120.7	3.3	289.2	1148.0	27.3	6.1	929.0	254.23	9.56	5.7
2/24/06 16:00	158.6	114.6	3.4	289.6	1089.9	27.5	6.0	858.3	242.47	9.47	5.9
2/24/06 17:00	161.2	116.7	3.4	289.6	1111.4	27.3	6.0	706.5	254.83	9.39	6.0
2/24/06 18:00	166.0	121.5	3.2	292.5	1157.4	23.4	6.1	567.2	287.95	8.00	5.8
2/24/06 19:00	166.9	121.7	3.2	290.2	1156.6	21.1	6.3	583.6	305.08	7.12	5.5
2/24/06 20:00	167.0	121.1	3.2	290.6	1156.9	21.0	6.4	528.8	305.87	7.17	5.4
2/24/06 21:00	166.4	121.1	3.2	291.1	1156.2	21.0	6.5	533.2	305.00	7.15	5.3
2/25/06 8:00	166.1	123.7	2.8	288.1	1176.0	26.5	5.8	1090.9	258.77	9.76	1.1
2/25/06 9:00	166.7	122.5	2.8	289.0	1174.2	26.5	5.9	1092.7	264.49	9.68	1.9
2/25/06 10:00	167.1	120.2	2.8	290.0	1174.2	25.7	5.8	1069.5	267.85	9.26	2.8
2/25/06 11:00	166.1	119.2	2.9	289.0	1164.8	23.5	5.9	969.6	284.69	8.58	4.1

2/25/06 12:00	164.2	117.6	2.9	289.6	1144.9	23.9	6.1	993.0	283.41	8.52	5.1
2/25/06 13:00	164.3	117.3	2.9	290.6	1145.3	23.9	6.2	1005.0	283.02	8.50	6.2
2/25/06 14:00	161.3	114.0	3.0	289.1	1118.1	24.1	6.1	970.0	283.78	8.47	6.7

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/26/06 11:00	166.6	123.4	3.2	282.5	1165.1	27.2	7.4	711.5	207.11	6.10	3.4
2/26/06 12:00	125.3	93.6	5.3	279.7	840.3	27.4	7.4	731.2	205.48	6.22	3.9
2/26/06 13:00	100.4	75.0	6.1	270.1	669.2	29.5	7.0	819.6	205.37	6.95	4.6
2/26/06 14:00	99.9	73.9	6.2	271.7	667.2	33.9	7.2	954.1	210.45	7.97	4.6
2/26/06 15:00	99.6	73.5	6.2	271.8	665.3	33.8	8.8	952.6	209.05	7.99	4.6
2/26/06 16:00	99.8	73.2	6.2	272.3	666.1	33.8	10.6	952.9	213.19	8.03	4.4
2/26/06 17:00	113.8	83.3	5.4	273.8	763.8	30.7	10.6	805.9	210.66	6.91	4.2
2/26/06 18:00	160.0	115.7	3.5	284.5	1127.2	26.9	10.6	675.4	208.33	5.99	3.9
2/26/06 19:00	165.4	118.5	3.5	286.7	1168.8	27.2	9.5	643.7	208.26	6.13	4.0
2/26/06 20:00	166.9	119.0	3.4	287.2	1169.3	27.3	8.5	576.9	209.41	6.03	4.6
2/27/06 6:00	167.1	122.2	3.0	288.2	1160.9	38.2	8.2	1004.6	293.71	9.73	1.8
2/27/06 7:00	167.7	122.5	2.9	288.6	1161.9	40.1	7.0	1136.9	334.90	10.10	1.8
2/27/06 8:00	167.7	122.9	2.9	289.8	1162.5	40.2	7.0	1161.5	331.90	10.10	2.0
2/27/06 9:00	167.3	122.4	3.0	290.1	1163.4	40.1	6.0	1203.2	328.00	10.10	2.1
2/27/06 10:00	167.6	121.4	2.9	290.4	1163.7	40.1	6.0	1195.7	329.40	10.10	2.3
2/27/06 11:00	167.7	120.6	2.9	291.2	1163.6	40.3	6.0	1225.4	339.10	10.10	2.5
2/27/06 12:00	167.7	121.2	2.8	289.9	1164.1	40.3	6.0	1256.8	349.70	10.20	3.0
2/27/06 13:00	168.2	119.9	2.8	289.7	1165.1	40.3	16.0	1322.2	330.60	10.50	4.0
2/27/06 14:00	168.1	120.2	2.8	290.8	1164.6	40.8	17.0	1331.8	340.90	10.60	5.3
2/27/06 15:00	168.1	120.3	2.8	292.7	1165.1	40.8	11.0	1306.6	339.10	10.50	5.8
2/27/06 16:00	167.9	119.7	2.9	293.6	1165.4	40.3	8.0	1279.0	334.70	10.30	5.9
2/27/06 17:00	168.3	118.3	2.9	294.0	1165.4	36.8	7.0	1195.6	353.00	9.70	5.8
2/27/06 18:00	168.1	118.8	2.8	293.9	1165.7	31.5	7.0	1056.9	380.70	8.70	5.7
2/27/06 19:00	168.4	118.7	2.8	293.9	1166.3	31.5	7.0	1054.9	384.00	8.60	5.5
2/27/06 20:00	168.2	119.4	2.8	294.1	1166.8	31.6	6.0	1057.2	398.20	8.60	5.6
2/27/06 21:00	168.0	118.7	2.8	293.1	1165.2	31.5	6.0	1059.6	401.10	8.70	5.7
2/28/06 6:00	163.2	116.6	3.2	286.1	1152.8	41.5	14.0	1363.6	329.20	10.70	3.0
2/28/06 7:00	166.8	117.7	3.2	286.3	1171.9	41.3	15.0	1364.9	328.60	10.70	3.6
2/28/06 8:00	167.5	117.3	3.1	286.4	1172.5	41.1	20.0	1343.2	333.30	10.60	4.3
2/28/06 9:00	168.1	117.2	3.2	287.2	1173.2	41.1	17.0	1328.4	333.30	10.50	4.7
2/28/06 10:00	168.0	116.3	3.2	288.1	1173.6	40.9	12.0	1327.2	332.70	10.50	5.0
2/28/06 11:00	168.4	116.0	3.1	289.0	1173.6	41.3	8.0	1315.5	340.50	10.50	5.2
2/28/06 12:00	168.5	115.9	3.1	289.9	1174.3	41.8	7.0	1321.3	340.10	10.50	5.4

2/28/06 13:00	168.4	115.7	3.1	290.9	1174.5	42.0	7.0	1321.7	333.00	10.50	5.4
2/28/06 14:00	168.3	116.8	3.1	291.7	1173.8	42.1	7.0	1328.4	335.90	10.50	5.1
2/28/06 15:00	168.3	116.7	3.0	292.0	1173.6	40.0	6.0	1258.5	345.50	10.00	5.0
2/28/06 16:00	169.2	117.2	3.0	291.8	1180.8	36.2	6.0	1180.7	355.80	9.50	5.0
2/28/06 17:00	174.5	121.0	3.1	292.8	1214.1	32.4	6.0	1041.3	376.20	8.50	5.8

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
2/28/06 19:00	174.3	120.7	3.2	293.3	1213.6	31.7	6.0	1050.1	383.80	8.60	5.5
3/1/06 4:00	172.9	120.7	2.8	290.0	1213.1	38.5	5.0	1252.8	293.80	10.10	4.0
3/1/06 5:00	173.3	120.7	2.8	291.3	1212.4	37.2	6.0	1252.8	272.60	10.10	4.0
3/1/06 6:00	168.7	116.9	3.0	291.7	1176.1	37.3	6.0	1254.2	272.60	10.10	4.3
3/1/06 7:00	166.2	115.4	2.9	291.4	1155.8	37.1	6.0	1250.4	273.60	10.10	4.9
3/1/06 8:00	166.5	115.8	2.9	291.4	1155.8	37.2	6.0	1240.9	273.60	10.10	5.7
3/1/06 9:00	166.3	115.0	2.9	291.5	1156.0	37.0	6.0	1244.1	281.00	10.10	5.8
3/1/06 10:00	166.3	115.1	3.0	291.4	1156.2	36.7	6.0	1244.7	276.60	10.10	5.6
3/1/06 11:00	166.5	115.1	2.9	293.1	1155.8	36.8	7.0	1246.6	277.40	10.10	5.1
3/1/06 12:00	167.0	114.6	2.9	293.9	1155.6	36.7	6.0	1241.6	271.60	10.10	5.1
3/1/06 13:00	166.5	113.9	2.9	294.8	1154.8	36.8	9.0	1262.8	277.70	10.10	5.1
3/1/06 14:00	165.7	113.9	3.0	295.9	1153.8	37.8	11.0	1316.7	294.60	10.40	5.1
3/1/06 15:00	165.2	113.6	2.9	296.5	1152.7	39.6	14.0	1383.8	304.30	10.70	5.0
3/1/06 16:00	166.1	114.7	3.0	296.4	1152.3	39.9	13.0	1378.0	312.30	10.70	4.9
3/1/06 17:00	166.0	114.4	3.0	296.8	1152.9	37.6	7.0	1285.8	337.90	10.20	4.5
3/1/06 18:00	166.0	115.0	3.0	296.7	1153.7	32.5	6.0	1120.5	378.80	9.10	4.0
3/1/06 19:00	166.1	115.1	3.0	295.8	1152.8	30.8	7.0	1077.2	385.70	8.80	3.1
3/1/06 20:00	166.0	115.7	3.0	295.9	1153.0	30.8	6.0	1076.3	381.70	8.80	2.4
3/1/06 21:00	166.2	116.2	3.0	293.9	1153.1	30.9	6.0	1065.1	381.60	8.70	1.5
3/2/06 7:00	164.3	117.5	2.9	292.0	1149.2	38.8	6.0	968.8	325.70	10.20	2.0
3/2/06 8:00	165.5	117.6	3.0	291.3	1149.7	38.8	6.0	999.6	325.30	10.20	2.1
3/2/06 9:00	165.6	117.3	3.1	291.8	1150.3	38.6	6.0	1063.7	321.80	10.30	2.3
3/2/06 10:00	165.8	118.0	3.0	292.0	1150.4	37.9	9.0	1065.7	294.50	10.20	2.6
3/2/06 11:00	165.9	117.9	3.1	291.9	1150.8	38.3	5.9	1079.6	317.92	10.34	3.0
3/2/06 12:00	165.7	118.5	3.0	291.5	1150.5	37.8	11.4	1013.1	248.82	9.74	3.6
3/2/06 13:00	165.6	119.5	3.0	291.6	1151.0	38.4	9.6	1022.4	247.56	9.73	4.2
3/2/06 14:00	165.6	121.2	3.0	290.8	1151.2	38.2	6.1	992.1	266.06	9.78	4.7
3/2/06 15:00	166.1	121.6	3.0	289.1	1155.9	39.1	6.1	996.1	304.13	10.27	4.7
3/2/06 16:00	167.8	123.0	3.0	289.0	1169.3	39.5	9.9	1003.9	305.42	10.46	4.6
3/2/06 17:00	164.9	121.7	3.1	288.0	1145.1	39.5	8.1	1021.2	313.11	10.36	4.4
3/2/06 18:00	164.9	120.4	3.1	288.1	1144.6	39.2	6.8	973.8	314.91	10.14	4.2
3/2/06 19:00	164.7	120.6	3.1	288.0	1144.1	36.9	6.2	848.6	320.63	9.42	4.0

3/2/06 20:00	165.0	121.8	3.0	287.5	1144.2	33.2	6.4	694.3	333.76	8.74	3.8
3/2/06 21:00	165.0	121.3	3.1	287.0	1144.4	29.9	8.0	709.2	333.57	8.35	3.9
3/3/06 6:00	169.1	122.1	3.8	283.5	1194.7	42.0	12.8	1143.1	341.29	10.13	0.4
3/3/06 7:00	167.3	119.3	3.8	285.1	1172.7	41.9	8.0	1088.1	341.16	10.08	0.0
3/3/06 8:00	165.3	118.4	3.7	285.8	1154.7	41.9	9.4	1067.0	341.59	10.12	0.0

Amended Silicates Tests **Date/Time**	**U6 unit load (MW)**	**U6 coal flow (klb/hr)**	**U6 boiler O2 (vol %)**	**U6 AH out temp (deg F)**	**U6 Steam Flow (klb/hr)**	**U5/U6 Stack Flow (MMscfh)**	**U5/U6 Stack Opacity (%)**	**U5/U6 Stack SO2 (ppm)**	**U5/U6 Stack NOx (ppm)**	**U5/U6 Stack CO2 (vol %)**	**Injection Ratio (lb/MMACF)**
3/3/06 10:00	164.8	118.1	3.7	286.0	1155.6	39.9	6.0	873.2	293.13	9.38	0.0
3/3/06 11:00	165.1	119.5	3.7	286.7	1155.3	38.1	6.5	641.9	206.47	7.37	0.0
3/3/06 12:00	166.0	121.0	3.6	287.0	1156.3	38.7	8.5	636.1	189.78	6.81	0.0
3/3/06 13:00	166.1	122.1	3.6	284.3	1156.5	39.5	7.7	649.6	185.08	6.68	0.0
3/3/06 14:00	166.4	121.3	3.5	284.9	1156.7	29.3	7.7	958.4	258.43	9.32	0.0
3/3/06 15:00	166.4	120.4	3.6	285.7	1156.0	28.5	7.4	973.0	263.30	9.43	0.0
3/3/06 16:00	166.5	119.3	3.7	286.4	1156.0	28.8	7.3	978.1	255.55	9.38	0.0
3/3/06 17:00	172.5	123.2	3.5	286.5	1202.0	28.7	6.7	1019.8	252.27	9.40	0.0
3/3/06 18:00	173.6	122.5	3.5	286.6	1209.1	28.6	6.7	1042.4	249.22	9.35	0.0
3/3/06 19:00	173.2	121.9	3.4	286.7	1208.3	28.5	6.9	1076.2	260.56	9.41	0.0
3/3/06 20:00	173.2	121.7	3.4	286.8	1208.0	28.7	7.1	1060.4	249.56	9.38	0.0
3/3/06 21:00	173.1	121.3	3.4	286.9	1208.2	26.2	8.5	977.1	228.25	8.78	0.0
3/3/06 22:00	173.2	121.7	3.4	286.2	1208.0	25.4	6.9	940.7	218.27	8.64	0.3
3/3/06 23:00	173.1	121.5	3.3	286.5	1207.8	25.4	6.4	899.8	223.89	8.50	0.9
3/5/06 12:00	166.7	120.4	3.3	286.4	1159.6	26.8	6.9	1241.8	244.45	9.71	2.4
3/5/06 13:00	166.8	121.4	3.2	286.5	1160.9	27.2	6.9	1216.6	251.77	9.61	2.4
3/5/06 14:00	167.0	121.2	3.2	286.8	1160.7	27.4	7.2	1194.9	245.01	9.51	2.6
3/5/06 15:00	167.1	121.6	3.2	287.3	1161.6	27.0	6.5	1198.7	240.04	9.65	3.0
3/5/06 16:00	167.2	122.6	3.1	287.6	1162.0	27.1	6.5	1187.6	238.68	9.63	3.3
3/5/06 17:00	167.5	121.9	3.0	287.4	1161.9	27.1	6.4	1189.6	247.24	9.62	3.7
3/5/06 18:00	167.4	122.3	3.0	287.4	1161.7	26.9	6.4	1220.0	249.72	9.63	4.0
3/5/06 19:00	167.1	121.6	3.1	287.5	1162.2	27.1	6.2	1233.2	241.45	9.64	4.1
3/5/06 20:00	167.2	122.6	3.1	286.7	1161.8	27.1	6.2	1233.9	236.41	9.59	4.1
3/5/06 21:00	167.4	122.3	3.1	286.7	1161.6	26.1	6.5	1178.5	229.15	9.14	3.8
3/5/06 22:00	167.3	122.7	3.0	286.9	1161.4	21.8	7.9	911.1	253.94	7.18	3.1
3/5/06 23:00	167.3	122.7	3.0	287.2	1161.2	21.4	7.7	899.2	258.66	7.05	2.3
3/6/06 5:00	163.0	122.1	3.4	283.5	1145.3	27.3	6.4	1226.2	229.32	9.71	3.0
3/6/06 6:00	168.9	123.7	3.3	287.3	1178.5	27.4	6.4	1230.5	228.68	9.68	4.0
3/6/06 7:00	169.2	123.8	3.2	287.3	1179.5	27.3	6.5	1243.7	237.03	9.73	5.1
3/6/06 8:00	169.2	124.3	3.1	287.2	1178.5	27.3	6.6	1247.2	238.28	9.77	5.6
3/6/06 9:00	169.0	123.9	3.2	287.4	1179.3	27.4	6.5	1240.5	244.08	9.71	5.7

3/6/06 10:00	169.2	124.8	3.2	286.4	1179.9	27.5	6.5	1239.9	260.40	9.69	5.6
3/6/06 11:00	169.2	123.9	3.3	287.7	1180.2	27.7	6.8	1228.6	249.25	9.64	5.5
3/6/06 12:00	169.0	123.9	3.3	288.4	1180.6	27.8	6.8	1162.5	245.46	9.64	5.4
3/6/06 13:00	169.1	124.5	3.3	286.8	1180.1	28.0	6.4	1075.0	235.30	9.63	5.3
3/6/06 14:00	169.6	124.5	3.2	288.1	1180.1	27.9	6.3	967.0	237.61	9.66	5.2
3/6/06 15:00	169.2	125.3	3.2	288.2	1180.2	27.8	6.2	889.6	235.21	9.65	5.2
3/6/06 16:00	169.4	126.5	3.2	288.2	1180.2	27.5	6.2	854.6	240.93	9.73	5.3

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/6/06 18:00	169.0	128.0	3.3	288.2	1177.0	27.9	5.9	693.3	238.33	9.67	5.8
3/6/06 19:00	167.6	127.6	3.3	288.2	1167.3	26.9	5.9	651.3	241.25	9.05	5.8
3/6/06 20:00	167.5	128.4	3.3	288.3	1167.3	24.1	6.4	612.8	273.38	7.61	5.9
3/6/06 21:00	167.9	129.7	3.3	287.9	1167.4	22.1	6.6	693.2	296.61	7.14	6.1
3/7/06 5:00	166.7	125.0	3.4	283.4	1175.2	27.8	5.9	1168.9	258.54	9.64	3.2
3/7/06 6:00	167.8	124.3	3.3	284.9	1175.2	27.7	6.0	1201.0	260.36	9.71	3.3
3/7/06 7:00	168.6	125.1	3.3	286.2	1175.2	27.6	6.2	1207.9	253.95	9.82	3.6
3/7/06 8:00	168.5	124.0	3.3	286.7	1176.7	27.7	6.5	1206.5	254.04	9.88	4.3
3/7/06 9:00	169.0	124.7	3.3	286.6	1176.2	27.1	6.6	1178.9	247.43	9.70	4.8
3/7/06 10:00	171.6	126.7	3.1	287.0	1194.4	27.0	6.9	1218.4	245.51	9.73	5.3
3/7/06 11:00	174.0	127.8	3.1	287.4	1213.6	27.1	7.1	1235.3	241.73	9.76	5.3
3/7/06 12:00	167.3	123.0	3.3	288.0	1163.5	26.9	7.4	1258.9	241.91	9.80	5.5
3/7/06 13:00	167.2	122.6	3.3	288.7	1162.6	26.8	7.5	1253.4	252.58	9.79	5.6
3/7/06 14:00	167.1	122.3	3.3	289.8	1162.3	26.9	7.4	1251.8	260.19	9.77	5.9
3/7/06 15:00	167.2	122.0	3.3	290.8	1162.7	26.9	7.4	1261.5	264.81	9.75	6.3
3/7/06 16:00	167.0	122.6	3.3	290.9	1162.9	27.2	7.1	1255.6	261.18	9.65	6.4
3/7/06 17:00	167.0	122.5	3.3	291.1	1162.1	27.4	7.0	1252.6	259.54	9.57	6.2
3/7/06 18:00	167.0	121.8	3.3	291.6	1162.4	27.2	7.0	1227.3	258.78	9.40	6.0
3/7/06 19:00	167.3	122.3	3.2	292.1	1162.3	22.8	8.4	966.6	269.46	7.54	6.0
3/7/06 20:00	167.2	121.7	3.2	290.7	1162.6	21.9	8.1	903.0	264.85	7.08	6.3
3/7/06 21:00	165.0	119.8	3.3	290.2	1142.8	21.9	8.2	914.7	257.89	7.09	6.5
3/8/06 5:00	161.3	119.2	3.5	286.9	1128.0	27.5	7.4	1310.4	242.61	9.83	3.4
3/8/06 6:00	165.6	120.9	3.4	289.1	1153.7	27.4	7.2	1247.3	242.36	9.54	3.5
3/8/06 7:00	165.5	120.9	3.4	288.3	1154.1	27.3	7.1	1218.5	230.71	9.45	3.6
3/8/06 8:00	171.0	124.6	3.2	289.8	1199.6	27.3	7.7	1213.4	228.02	9.40	3.9
3/8/06 9:00	167.6	121.6	3.3	289.7	1170.6	27.5	7.6	1202.2	230.78	9.36	4.3
3/8/06 10:00	164.0	119.4	3.4	289.4	1142.1	27.7	7.5	1188.9	227.61	9.31	4.8
3/8/06 11:00	164.2	119.7	3.4	289.2	1141.4	27.6	7.6	1209.2	247.60	9.37	5.3
3/8/06 12:00	164.0	120.8	3.3	288.7	1141.6	27.7	7.3	1210.4	236.91	9.35	5.7
3/8/06 13:00	163.9	120.9	3.3	287.6	1142.1	27.5	7.2	1219.9	229.75	9.43	6.1

3/8/06 14:00	164.5	121.4	3.3	288.2	1142.1	27.1	7.0	1234.4	251.59	9.53	6.1
3/8/06 15:00	164.8	121.6	3.3	287.3	1142.5	27.2	7.0	1233.5	253.23	9.51	6.2
3/8/06 16:00	164.7	121.4	3.2	287.8	1142.1	27.4	7.0	1220.5	242.67	9.46	6.0
3/8/06 17:00	164.2	121.6	3.3	288.7	1141.7	27.4	7.0	1208.0	236.15	9.41	5.9
3/8/06 18:00	164.6	121.6	3.3	287.9	1141.0	27.1	7.2	1209.4	238.79	9.33	6.0
3/8/06 19:00	164.7	121.3	3.2	288.4	1140.7	24.5	8.2	1027.9	243.29	8.00	6.3
3/8/06 20:00	164.4	120.8	3.2	289.5	1140.9	22.2	8.5	913.3	255.88	7.16	6.8
3/8/06 21:00	162.7	119.1	3.3	289.5	1125.5	22.1	8.7	884.5	262.20	7.01	7.0

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/9/06 6:00	160.5	119.9	3.6	288.5	1129.4	27.5	7.8	1248.0	257.07	9.48	4.0
3/9/06 7:00	165.1	122.0	3.5	290.8	1158.6	27.5	7.8	1251.7	256.37	9.48	4.5
3/9/06 8:00	165.0	122.3	3.5	291.4	1158.4	27.6	7.8	1256.1	256.12	9.46	5.7
3/9/06 9:00	164.8	122.4	3.5	290.5	1159.5	27.3	7.8	1271.9	256.07	9.50	5.8
3/9/06 10:00	165.0	122.6	3.5	289.9	1158.5	27.4	7.7	1269.9	256.05	9.47	5.8
3/9/06 11:00	164.4	122.7	3.4	290.0	1158.7	27.2	7.7	1277.4	257.16	9.51	5.6
3/9/06 12:00	165.0	122.8	3.4	290.0	1158.8	27.2	7.9	1283.8	259.95	9.56	5.3
3/9/06 13:00	164.9	122.7	3.3	288.8	1159.9	27.2	7.9	1272.5	257.43	9.51	5.2
3/9/06 14:00	165.1	122.3	3.4	289.9	1160.5	27.2	7.9	1283.0	256.41	9.59	5.3
3/9/06 15:00	165.3	122.5	3.3	289.3	1160.1	26.8	7.9	1303.7	261.11	9.75	5.4
3/9/06 16:00	165.8	122.8	3.4	290.0	1160.2	26.8	7.8	1290.5	256.80	9.73	5.5
3/9/06 17:00	165.5	122.4	3.2	290.8	1161.9	27.2	7.4	1270.0	256.70	9.63	5.5
3/9/06 18:00	166.6	123.2	3.3	289.7	1161.3	27.5	7.2	1248.6	252.73	9.51	5.4
3/9/06 19:00	167.1	122.7	3.2	288.2	1162.0	26.8	7.2	1188.8	246.04	9.18	5.4
3/9/06 20:00	166.8	122.7	3.3	287.0	1162.0	22.4	7.9	913.9	242.11	7.25	5.4
3/9/06 21:00	167.0	123.3	3.2	287.6	1161.1	21.7	7.7	887.5	239.61	7.06	5.5
3/9/06 22:00	165.4	121.6	3.3	287.8	1149.3	21.6	7.9	890.5	242.34	7.06	5.7
3/10/06 7:00	168.9	125.7	3.7	288.8	1183.2	27.6	72.9	838.9	274.45	9.42	3.2
3/10/06 8:00	163.2	121.2	3.7	288.8	1134.3	27.2	7.3	844.2	271.53	9.42	3.4
3/10/06 9:00	162.9	120.7	3.8	288.2	1129.4	27.1	7.3	880.6	271.47	9.49	4.2
3/10/06 10:00	162.4	120.0	3.8	288.7	1128.9	27.0	7.5	897.6	271.96	9.51	4.9
3/10/06 11:00	159.3	118.0	3.8	289.3	1102.3	26.9	7.5	970.3	266.25	9.56	5.4
3/10/06 12:00	159.4	117.5	3.7	289.5	1102.9	26.9	7.4	1007.2	264.87	9.62	5.6
3/10/06 13:00	159.5	118.5	3.7	288.5	1102.3	26.6	7.6	1068.1	262.61	9.76	5.6
3/10/06 14:00	159.4	117.7	3.7	290.1	1103.4	26.9	7.9	1087.8	258.86	9.82	5.4
3/10/06 15:00	159.2	117.4	3.5	288.1	1103.5	26.8	8.0	1127.6	267.65	9.90	5.0
3/10/06 16:00	159.9	118.1	3.5	289.4	1104.1	26.7	8.0	1150.6	262.82	9.88	4.6
3/10/06 17:00	163.9	120.6	3.4	288.7	1137.4	26.9	7.8	1164.1	260.11	9.85	4.5
3/10/06 18:00	163.8	120.6	3.4	288.5	1137.7	27.0	7.6	1163.5	254.12	9.81	4.6
3/10/06 19:00	164.1	120.4	3.4	290.0	1138.2	23.5	7.8	938.9	252.28	8.06	4.8

3/10/06 20:00	164.1	120.0	3.4	288.7	1137.9	20.7	8.2	792.8	269.71	7.00	4.9
3/10/06 21:00	164.1	119.9	3.4	288.9	1137.3	20.9	7.9	784.5	265.73	6.90	5.0
3/13/06 7:00	168.1	122.4	3.0	289.0	1173.3	27.5	8.2	1227.6	233.07	9.72	5.3
3/13/06 8:00	168.7	123.2	2.9	290.0	1175.1	27.5	7.6	1237.2	234.64	9.69	5.7
3/13/06 9:00	168.4	122.8	2.9	290.7	1175.5	27.6	7.6	1251.4	229.84	9.67	5.7
3/13/06 10:00	168.5	122.8	2.9	289.8	1176.1	27.4	7.7	1251.8	228.94	9.68	5.5
3/13/06 11:00	168.3	122.1	2.9	288.2	1175.9	27.3	7.8	1264.6	223.31	9.71	5.1
3/13/06 12:00	168.3	121.9	2.9	288.3	1175.7	27.3	7.8	1266.8	221.31	9.73	5.1

Amended Silicates Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/13/06 14:00	168.6	122.1	2.8	288.9	1175.2	27.4	7.5	1277.7	222.94	9.70	5.9
3/13/06 15:00	168.5	122.0	2.7	289.1	1175.6	27.6	7.5	1268.0	234.14	9.67	6.0
3/13/06 16:00	168.9	122.5	2.6	289.2	1175.9	27.9	7.3	1257.0	239.11	9.62	5.8
3/13/06 17:00	168.6	122.2	2.6	288.7	1177.0	28.1	7.0	1224.9	239.43	9.56	5.6
3/13/06 18:00	168.5	121.9	2.8	287.2	1177.0	28.3	6.7	1183.1	233.08	9.48	5.5
3/13/06 19:00	168.6	120.9	3.0	287.5	1176.6	24.5	6.9	950.1	231.94	7.92	5.2
3/13/06 20:00	168.4	120.7	3.1	286.7	1176.0	21.3	7.0	746.8	241.42	6.64	5.1
3/13/06 21:00	168.6	120.8	3.1	286.2	1175.9	21.2	6.8	722.5	239.47	6.61	5.3
3/14/06 7:00	166.9	122.0	3.1	282.2	1164.5	28.5	6.2	1031.2	238.67	9.64	8.2
3/14/06 8:00	168.4	122.4	3.1	283.0	1172.1	28.3	6.0	1077.2	235.57	9.66	11.9
3/14/06 9:00	168.0	122.5	3.1	283.7	1172.1	28.3	6.1	1074.5	234.04	9.67	11.8
3/14/06 10:00	168.2	121.7	3.2	284.4	1172.2	28.2	6.2	1129.2	244.40	9.71	11.0
3/14/06 11:00	168.2	121.4	3.1	285.0	1172.2	28.2	6.3	1121.1	233.46	9.73	9.8
3/14/06 12:00	168.2	121.5	3.0	285.7	1172.1	28.3	6.3	1182.7	230.53	9.68	9.4
3/14/06 13:00	168.1	121.5	3.1	286.0	1172.0	28.2	6.3	1242.6	230.44	9.75	9.3
3/14/06 14:00	168.5	121.9	3.0	287.1	1172.2	28.2	6.3	1290.0	232.62	9.78	9.2
3/14/06 15:00	168.6	121.8	3.0	287.0	1172.3	28.4	6.2	1264.9	233.61	9.67	8.9
3/14/06 16:00	168.2	121.6	3.0	287.8	1172.9	28.4	6.1	1285.4	235.07	9.68	8.2
3/14/06 17:00	168.7	122.3	2.9	288.1	1172.4	28.4	6.2	1302.7	245.63	9.72	8.0
3/14/06 18:00	168.8	122.3	2.9	288.4	1172.8	28.2	6.1	1333.2	246.64	9.75	7.2
3/14/06 19:00	167.8	121.6	2.9	287.2	1172.2	28.4	6.7	1321.2	241.76	9.74	5.8
3/14/06 20:00	168.1	121.9	3.0	288.8	1172.0	28.3	7.2	1320.9	239.70	9.75	
3/14/06 21:00	168.5	121.9	2.9	289.1	1172.9	25.6	8.3	1155.8	242.41	8.55	
3/14/06 22:00	168.4	121.6	3.0	288.9	1173.2	21.6	8.6	888.0	263.99	6.88	
3/14/06 23:00	168.7	122.3	2.9	288.5	1173.3	21.6	8.3	883.6	269.69	6.80	

Miami Fort Station Unit 6 Operational and CEM Data

Activated Carbon Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/15/06 6:00	169.2	123.8	3.2	284.3	1180.6	28.2	7.9	1245.5	250.19	9.67	
3/15/06 7:00	168.9	124.5	3.2	284.4	1178.8	28.1	7.8	1207.8	256.44	9.64	
3/15/06 8:00	169.1	125.4	3.2	284.7	1178.5	28.1	7.7	1189.1	258.21	9.67	
3/15/06 9:00	169.0	125.7	3.2	284.6	1178.8	28.0	7.3	1172.8	256.17	9.70	
3/15/06 10:00	168.1	125.2	3.3	284.3	1179.2	27.8	6.8	1168.5	259.98	9.75	
3/15/06 11:00	168.4	125.9	3.2	285.6	1178.2	28.0	6.9	1156.1	260.99	9.69	
3/15/06 12:00	169.3	124.8	3.2	286.9	1178.6	27.7	6.9	1166.7	261.15	9.75	
3/15/06 13:00	168.9	124.9	3.2	286.3	1179.0	27.6	7.0	1182.1	265.13	9.79	1.4
3/15/06 14:00	169.1	124.5	3.2	286.6	1178.5	27.7	6.9	1169.5	262.68	9.80	1.4
3/15/06 15:00	167.7	123.6	3.3	286.7	1179.1	27.4	7.0	1178.9	263.95	9.88	1.4
3/15/06 16:00	168.5	124.5	3.2	287.5	1177.6	27.4	6.7	1168.0	258.12	9.86	1.5
3/15/06 17:00	169.2	124.1	3.2	287.4	1178.8	27.8	6.5	1152.3	249.03	9.83	1.6
3/15/06 18:00	168.9	125.3	3.2	287.7	1178.7	27.5	6.5	1141.6	239.09	9.85	1.6
3/15/06 19:00	169.2	125.2	3.2	288.4	1178.5	27.6	6.6	1196.0	243.61	9.85	1.6
3/15/06 20:00	169.5	125.9	3.1	287.4	1179.6	27.7	6.4	1234.6	233.68	9.84	1.7
3/15/06 21:00	169.2	125.9	3.0	287.6	1179.8	26.9	6.8	1220.8	234.66	9.42	1.7
3/15/06 22:00	169.0	125.4	3.1	288.2	1179.3	21.9	8.9	927.6	273.20	7.12	1.7
3/15/06 23:00	169.2	125.5	3.0	287.3	1179.1	21.0	8.5	891.1	275.35	6.72	0.8
3/16/06 0:00	168.4	123.6	3.2	286.5	1170.6	21.1	8.3	737.1	219.46	5.69	0.8
3/16/06 6:00	164.7	122.2	3.1	284.0	1150.2	27.3	7.1	1361.4	238.69	9.68	1.1
3/16/06 7:00	165.3	121.8	3.1	285.3	1153.3	27.3	7.1	1348.5	237.87	9.60	1.4
3/16/06 8:00	165.6	122.3	2.9	286.6	1153.1	27.2	6.8	1330.4	250.67	9.68	2.1
3/16/06 9:00	165.7	121.3	2.9	287.2	1153.7	27.0	6.8	1306.7	244.64	9.75	2.0
3/16/06 10:00	166.2	120.5	2.8	287.7	1153.4	27.0	6.8	1281.1	244.53	9.71	1.7
3/16/06 11:00	164.7	120.0	3.0	288.4	1155.2	27.1	6.7	1278.6	248.74	9.69	1.7
3/16/06 12:00	166.3	119.6	3.0	288.3	1155.0	26.9	6.8	1273.9	255.02	9.72	1.9
3/16/06 13:00	166.2	118.5	2.9	288.3	1155.6	26.9	6.8	1264.2	255.11	9.68	1.8
3/16/06 14:00	165.9	119.7	2.9	288.0	1155.2	27.0	6.6	1260.7	251.36	9.72	2.5
3/16/06 15:00	166.0	119.1	3.0	288.0	1155.0	27.2	6.3	1252.3	250.45	9.63	3.3
3/16/06 16:00	165.5	118.9	3.0	287.8	1155.9	27.5	6.3	1239.4	252.04	9.57	4.1
3/16/06 17:00	165.8	121.0	3.0	287.6	1154.9	27.5	6.3	1124.0	252.47	9.60	4.3
3/16/06 18:00	166.2	120.4	3.0	288.0	1155.1	27.7	6.0	1002.0	237.28	9.57	4.6
3/16/06 19:00	166.1	120.7	2.9	287.1	1155.8	27.6	5.8	893.1	238.27	9.57	4.8
3/16/06 20:00	165.5	119.6	3.0	287.6	1155.7	23.4	6.4	649.8	257.70	7.76	1.9
3/16/06 21:00	166.3	121.4	2.9	287.2	1154.1	20.8	6.7	566.1	266.03	6.71	1.9
3/16/06 22:00	166.6	123.4	2.7	286.3	1153.3	21.1	6.5	570.5	269.11	6.71	1.0

Miami Fort Station Unit 6 Operational and CEM Data

Activated Carbon Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/17/06 7:00	167.2	125.2	3.2	283.1	1165.4	28.2	5.7	1029.2	228.42	9.62	1.1
3/17/06 8:00	167.5	125.8	3.2	284.2	1166.5	28.2	5.4	978.6	228.54	9.68	1.6
3/17/06 9:00	167.5	126.7	3.2	283.3	1167.2	27.9	5.5	932.8	231.70	9.74	4.2
3/17/06 10:00	167.4	128.2	3.2	282.6	1167.1	27.9	5.6	861.3	229.21	9.75	6.1
3/17/06 11:00	167.6	128.6	3.2	282.7	1167.1	28.0	5.5	816.7	230.72	9.74	6.3
3/17/06 13:00	167.6	130.0	3.2	284.5	1167.5	28.2	5.7	847.9	255.07	9.75	7.0
3/17/06 14:00	167.8	129.6	3.2	284.3	1167.4	28.0	5.8	905.6	244.60	9.77	6.3
3/17/06 15:00	167.5	129.1	3.2	284.0	1167.3	28.0	5.7	937.6	235.52	9.71	6.3
3/17/06 16:00	167.4	129.2	3.3	284.8	1167.9	28.3	5.8	1036.7	247.53	9.65	6.2
3/17/06 17:00	167.8	128.7	3.1	285.2	1167.9	28.2	6.0	1315.4	253.22	9.70	1.9
3/17/06 18:00	167.9	128.7	3.2	284.9	1168.1	27.8	6.0	1465.0	245.51	9.68	1.9
3/17/06 19:00	167.6	127.4	3.2	285.1	1168.5	23.7	7.8	1201.3	264.46	7.95	1.9
3/17/06 20:00	167.9	125.1	3.2	287.3	1167.7	21.7	7.7	995.6	274.69	6.98	1.9
3/17/06 21:00	167.9	125.3	3.2	286.3	1168.8	22.0	7.3	975.0	272.06	6.90	1.9
3/18/06 19:00	169.0	127.0	3.5	283.4	1190.4	28.3	7.1	1367.0	261.69	9.66	1.5
3/18/06 20:00	171.8	127.5	3.5	286.3	1198.9	23.3	8.8	1040.0	271.78	7.55	1.4
3/18/06 21:00	171.8	126.4	3.4	286.0	1199.8	21.8	8.2	899.9	274.37	6.79	1.4
3/18/06 22:00	172.1	125.8	3.4	285.4	1199.5	21.9	7.8	877.7	289.44	6.77	1.4
3/19/06 19:00	171.4	128.8	3.0	282.8	1200.5	26.5	5.5	894.1	241.75	9.16	5.1
3/19/06 20:00	164.6	123.7	3.1	283.1	1145.8	22.0	6.2	597.6	288.38	7.11	5.1
3/19/06 21:00	164.6	123.7	3.0	283.1	1146.2	21.7	6.1	611.5	298.09	6.97	5.2
3/19/06 22:00	162.8	121.6	3.2	283.2	1129.8	21.6	6.0	646.1	298.69	6.95	4.9
3/19/06 23:00	107.7	80.0	5.8	279.1	701.5	21.4	5.9	665.3	297.09	6.98	5.8
3/20/06 7:00	159.3	119.5	3.3	279.5	1103.6	27.8	5.6	1271.2	252.27	9.58	3.0
3/20/06 8:00	166.1	123.7	3.3	281.5	1153.9	27.7	5.3	1278.1	255.06	9.59	4.1
3/20/06 9:00	166.2	123.5	3.2	280.9	1155.0	27.7	5.4	1260.7	251.33	9.58	4.3
3/20/06 10:00	166.1	122.8	3.4	280.9	1155.1	27.8	5.4	1254.2	251.94	9.53	4.1
3/20/06 11:00	166.2	123.6	3.2	280.0	1155.1	27.7	5.5	1272.4	264.22	9.55	3.7
3/20/06 12:00	166.0	123.4	3.3	281.2	1155.7	27.6	5.5	1313.6	270.66	9.56	4.1
3/20/06 13:00	166.2	123.2	3.4	282.1	1155.6	27.9	5.5	1323.7	268.24	9.52	4.4
3/20/06 14:00	166.1	123.0	3.3	283.0	1155.8	28.0	5.4	1390.7	263.97	9.46	5.0
3/20/06 15:00	165.9	122.7	3.3	283.4	1156.6	28.0	5.5	1435.5	252.39	9.45	7.4
3/20/06 16:00	166.4	122.7	3.4	284.6	1156.1	28.1	5.5	1444.4	265.71	9.43	7.8
3/20/06 17:00	166.2	122.8	3.3	285.1	1156.5	28.0	5.5	1364.1	266.56	9.48	5.5
3/20/06 18:00	166.5	122.8	3.2	285.4	1156.2	28.1	5.4	1220.4	254.45	9.43	5.4
3/20/06 19:00	166.2	121.8	3.3	284.3	1157.0	27.8	5.5	1106.6	245.70	9.33	5.3

3/20/06 20:00	166.4	122.3	3.3	285.7	1156.8	22.8	5.9	815.4	277.25	7.26	6.2

Activated Carbon Tests Date/Time	U6 unit load (MW)	U6 coal flow (klb/hr)	U6 boiler O2 (vol %)	U6 AH out temp (deg F)	U6 Steam Flow (klb/hr)	U5/U6 Stack Flow (MMscfh)	U5/U6 Stack Opacity (%)	U5/U6 Stack SO2 (ppm)	U5/U6 Stack NOx (ppm)	U5/U6 Stack CO2 (vol %)	Injection Ratio (lb/MMACF)
3/20/06 21:00	166.5	122.9	3.2	285.6	1157.4	21.5	5.7	709.9	283.24	6.88	6.0
3/20/06 22:00	166.2	123.2	3.3	284.9	1157.3	21.6	5.6	686.4	276.81	6.83	5.8
3/21/06 6:00	166.4	123.0	3.2	281.7	1157.4	28.1	5.2	1190.4	244.72	9.52	4.3
3/21/06 7:00	166.8	122.8	3.1	282.0	1161.5	28.1	4.9	1189.0	238.05	9.54	5.7
3/21/06 9:00	167.0	123.0	3.1	281.2	1162.1	28.2	4.8	1183.5	248.70	9.48	5.7
3/21/06 10:00	167.0	121.4	3.1	281.5	1162.7	28.2	4.8	1168.4	246.39	9.46	6.3
3/21/06 11:00	167.0	120.5	3.1	282.1	1162.6	28.3	4.8	1160.3	243.97	9.45	6.6
3/21/06 12:00	166.9	118.7	3.2	282.7	1161.7	28.3	4.9	1151.5	249.24	9.41	5.8
3/21/06 13:00	167.1	119.0	3.1	282.6	1161.9	28.7	4.8	1183.4	253.67	9.64	5.4
3/21/06 14:00	166.9	118.0	3.1	282.8	1161.7	29.0	4.8	1176.9	244.30	9.60	5.3
3/21/06 15:00	167.0	118.1	3.1	283.5	1161.6	28.9	4.8	1179.3	239.09	9.64	5.3
3/21/06 16:00	166.8	117.5	3.2	283.7	1162.3	28.4	4.8	1193.2	235.23	9.81	5.3
3/21/06 17:00	172.4	122.2	2.9	283.5	1204.1	28.5	4.9	1189.0	236.05	9.73	5.2
3/21/06 18:00	173.7	122.8	2.9	283.6	1212.5	27.8	4.9	1143.2	247.63	9.39	
3/21/06 19:00	173.3	122.4	2.9	283.6	1212.3	23.6	6.1	900.9	276.84	7.57	
3/21/06 20:00	173.4	122.6	2.9	284.6	1212.2	22.5	6.0	862.5	288.61	7.30	
3/21/06 21:00	173.2	121.0	2.9	284.5	1212.0	22.6	6.3	837.5	282.91	7.30	
3/21/06 22:00	165.5	115.1	3.3	284.4	1150.1	22.4	6.2	706.7	274.11	7.36	