TOXECON™ RETROFIT FOR MERCURY AND MULTI-POLLUTANT CONTROL ON THREE 90-MW COAL-FIRED BOILERS

Quarterly Technical Progress Report
Reporting Period: October 1, 2007–December 31, 2007
Report No. 41766R15

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DISCLAIMER

ABSTRACT

With the Nation's coal-burning utilities facing tighter controls on mercury pollutants, the U.S. Department of Energy is supporting projects that could offer power plant operators better ways to reduce these emissions at much lower costs. Sorbent injection technology represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers. It involves injecting a solid material such as powdered activated carbon into the flue gas. The gas-phase mercury in the flue gas contacts the sorbent and attaches to its surface. The sorbent with the mercury attached is then collected by a particulate control device along with the other solid material, primarily fly ash.

We Energies has over 3,200 MW of coal-fired generating capacity and supports an integrated multi-emission control strategy for SO_2, NO_x, and mercury emissions while maintaining a varied fuel mix for electric supply. The primary goal of this project is to reduce mercury emissions from three 90-MW units that burn Powder River Basin coal at the We Energies Presque Isle Power Plant. Additional goals are to reduce nitrogen oxide (NO_x), sulfur dioxide (SO_2), and particulate matter (PM) emissions, allow for reuse and sale of fly ash, demonstrate a reliable mercury continuous emission monitor (CEM) suitable for use in the power plant environment, and demonstrate a process to recover mercury captured in the sorbent. To achieve these goals, We Energies (the Participant) will design, install, and operate a TOXECON™ system designed to clean the combined flue gases of Units 7, 8, and 9 at the Presque Isle Power Plant.

TOXECON™ is a patented process in which a fabric filter system (baghouse) installed downstream of an existing particulate control device is used in conjunction with sorbent injection for removal of pollutants from combustion flue gas. For this project, the flue gas emissions will be controlled from the three units using a single baghouse. Mercury will be controlled by injection of activated carbon or other novel sorbents, while NO_x and SO_2 will be controlled by injection of sodium-based or other novel sorbents. Addition of the TOXECON™ baghouse will provide enhanced particulate control. Sorbents will be injected downstream of the existing particulate control device to allow for continued sale and reuse of captured fly ash from the existing particulate control device, uncontaminated by activated carbon or sodium sorbents.

Methods for sorbent regeneration, i.e., mercury recovery from the sorbent, will be explored and evaluated. For mercury concentration monitoring in the flue gas streams, components available for use will be evaluated and the best available will be integrated into a mercury CEM suitable for use in the power plant environment. This project will provide for the use of a control system to reduce emissions of mercury while minimizing waste from a coal-fired power generation system.

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EXECUTIVE SUMMARY

Wisconsin Electric Power Company (We Energies) signed a Cooperative Agreement with the U.S. Department of Energy (DOE) in March 2004 to fully demonstrate TOXECON™ for mercury control at the We Energies Presque Isle Power Plant. The primary goal of this project is to reduce mercury emissions from three 90-MW units (Units 7, 8, and 9) that burn Powder River Basin (PRB) coal. Additional goals are to reduce nitrogen oxide (NO_x), sulfur dioxide (SO_2), and particulate matter (PM) emissions, allow for reuse and sale of fly ash, demonstrate a reliable mercury continuous emission monitor (CEM) suitable for use in the power plant environment, and demonstrate a process to recover mercury captured in the sorbent.

We Energies teamed with ADA-ES, Inc., (ADA-ES) and Cummins & Barnard, Inc., (C&B) to execute this project. ADA-ES is providing engineering and management on the mercury measurement and control systems. Cummins & Barnard is the engineer of record and was responsible for construction, management, and startup of the TOXECON™ equipment.

This project was selected for negotiating an award in January 2003. Preliminary activities covered under the "Pre-Award" provision in the Cooperative Agreement began in March 2003. This Quarterly Technical Progress Report summarizes progress made on the project from October 1, 2007, through December 31, 2007. During this reporting period, work was conducted on the following tasks:

- Task 15. Operate, Test, Data Analysis, and Optimize TOXECON™ for Mercury Control
- Task 16. Operate, Test, Data Analysis, and Optimize TOXECON™ for SO_2/NO_x Control
- Task 17. Carbon-Ash Management System
- Task 18. Revise Design Specifications/O&M Manuals
- Task 19. Reporting, Management, Subcontracts, Technology Transfer

INTRODUCTION

DOE awarded Cooperative Agreement Number DE-FC26-04NT41766 to We Energies to demonstrate TOXECON™ for mercury and multi-pollutant control, a reliable mercury continuous emission monitor (CEM), and a process to recover mercury captured in the sorbent. Under this agreement, We Energies is working in partnership with the DOE.

Quarterly Technical Progress Reports will provide project progress, results from technology demonstrations, and technology transfer information.

Project Objectives

The specific objectives of this project are to demonstrate the operation of the TOXECON™ multi-pollutant control system and accessories, and

- Achieve 90% mercury removal from flue gas through activated carbon injection
- Evaluate the potential for 70% SO_2 control and trim control of NO_x from flue gas through sodium-based or other novel sorbent injection
- Reduce PM emission through collection by the TOXECON™ baghouse
- Recover 90% of the mercury captured in the sorbent
- Utilize 100% of fly ash collected in the existing electrostatic precipitator
- Demonstrate a reliable, accurate mercury CEM suitable for use in the power plant environment
- Successfully integrate and optimize TOXECON™ system operation for mercury and multi-pollutant control

Scope of Project

The "TOXECON™ Retrofit for Mercury and Multi-Pollutant Control on Three 90-MW Coal-Fired Boilers" project will be completed in two Budget Periods. These two Budget Periods are:

Budget Period 1: Project Definition, Design and Engineering, Prototype Testing, Major Equipment Procurement, and Foundation Installation. Budget Period 1 initiated the project with project definition activities including NEPA, followed by design, which included specification and procurement of long lead-time major equipment, and installation of foundations. In addition, testing of prototype mercury CEMs was conducted. Activities under Budget Period 1 were completed during 1Q05.

Budget Period 2: CEM Demonstration, TOXECON™ Erection, TOXECON™ Operation, and Carbon Ash Management Demonstration. In Budget Period 2, the TOXECON™ system was constructed and will be operated. Operation will include optimization for mercury control, parametric testing for SO_2 and NO_x control, and long-term testing for mercury control. The mercury CEM and sorbent regeneration processes will be demonstrated in conjunction with the TOXECON™ system operation.

The project continues to move through Budget Period 2 as of the current reporting period. Each task is described in the Statement of Project Objectives (SOPO) that is part of the Cooperative Agreement.

EXPERIMENTAL

None to report.

RESULTS AND DISCUSSION

Following are descriptions of the work performed on project tasks during this reporting period.

Task 1 – Design Review Meeting

Work associated with this task was previously completed.

Task 2 – Project Management Plan

Work associated with this task was previously completed.

Task 3 – Provide NEPA Documentation, Environmental Approvals Documentation, and Regulatory Approval Documentation

Work associated with this task was previously completed.

Task 4 – Balance-of-Plant (BOP) Engineering

Work associated with this task was completed during 1Q05 in Budget Period 1.

Task 5 – Process Equipment Design and Major Equipment Procurement

Work associated with this task was completed during 1Q05 in Budget Period 1.

Task 6 – Prepare Construction Plan

Work associated with this task was completed during 1Q05 in Budget Period 1. The Construction Plan was issued on January 26, 2005.

Task 7 – Procure Mercury Continuous Emission Monitor (CEM) Package and Perform Engineering and Performance Assessment

The overall goal of this task was to have a compliance-grade, reliable, certified mercury CEM installed and operational for use in the TOXECON™ evaluation. Installation and checkout of two CEMs at the inlet and at the outlet of the baghouse was completed in 1Q06. The long-term evaluation of the mercury CEMs is described in Task 15 for the remainder of the project.

Task 8 – Mobilize Contractors

Primary work associated with this task was completed in 1Q06.

Task 9 – Foundation Erection

All major foundation work was completed during 1Q05.

Task 10 – Erect Structural Steel, Baghouse, and Ductwork

Primary work associated with this task was completed in 4Q05.

Task 11 – Balance-of-Plant Mechanical and Civil/Structural Installations

Primary work associated with this task was completed in 4Q05.

Task 12 – Balance-of-Plant Electrical Installations

Primary work associated with this task was completed in 4Q05.

Task 13 – Equipment Pre-Operational Testing

Pre-operational testing was completed in 4Q05.

Task 14 – Startup and Operator Training

Startup of all major equipment was completed in 4Q05. Final O&M manuals were received for most major equipment in 2005. Startup of the PAC system occurred in 1Q06.

The operator-training program was completed during 4Q05 to train the plant operations personnel.

The baghouse was initially brought into operation on December 17, 2005, with flue gas from Unit 7. Initial operation with Unit 8 occurred on January 5, 2006, and Unit 9 on January 27, 2006.

Task 15 – Operate, Test, Data Analysis, and Optimize TOXECON™ for Mercury Control

CEM Update

During 4Q07, the mercury Continuous Emissions Monitors (CEMs) located at the inlet and outlet of the baghouse were monitored for long-term operation. A summary of the operation of each system including any maintenance is presented below:

Inlet

At the beginning of October, daily zero and span checks on the inlet system indicate that the drift is higher than desirable. The nitrogen generator and hydrator were installed October 11-13, and performance improved greatly. Critical calibration failures for total mercury occurred 7 of the 31 days in October, none of 30 days in November, and 3 of the 31 days in December. There was increasing cal response drift during the week of December 9, possibly related to low lamp intensity pending the lamp upgrade conducted on December 12, also there was a solenoid valve malfunction. Other than poor calibrations at the beginning of October, availability of the system is improved over previous quarters with 70.2% in October, 96.7% in November, and 91.3% in December. Note that these systems are operated remotely and it is often several hours before a critical calibration failure is noticed and corrected. If a failure occurs on a Saturday, the system is out of "compliance" from the most recent successful calibration (typically Friday morning) until Monday.

Maintenance:

- October: The nitrogen generator and hydrator were installed on October 11-13. This had a significant positive impact on data as well as calibrations. The carbon scrubber blew out on October 24 and was replaced.
- November: No service was required.
- December: Lamp and lamp heater were replaced. Solenoid valve was repaired.

Outlet

Daily zero and span checks on the outlet system from October through December show very good performance with no critical calibration failures during this time. On December 13 the calibration failed due to lamp and heater upgrades being performed. The availability of the system was 100% in October, 100% in November, and 99.1% in December.

Maintenance:

- October: Replaced a lamp on the 1st.
- November: No service was required.
- December: New lamp and lamp heater were installed on December 13.
- Pending maintenance: oxidized mercury calibration source installation.

Ash Silo

During 4Q07, there continued to be problems with excessive dusting during unloading of the ash silo using the wet unloader, primarily during startup of the pin mixer. United Conveyer

Corporation (UCC) and We Energies continued to work on modifications to the mixer and optimizing its operation to reduce dusting.

The excessive dusting is due to the short material retention time in the mixer that occurs until the material bed height is established. In December three atomizing nozzles were installed near the exit of the pin mixer. This reduced dust emissions during start up of ash unloading.

Also in 4Q07, a remote operator shelter was installed to allow the operator to see into the truck bed during wet unloading. Figure 1 is a picture of the installed shelter.

Figure 1. Operator Enclosure for Ash Unloading

The filter separator in the ash silo performed well during the month of October. During November there was a failure of the filter separator bags which resulted in excessive dust emissions. The bags were changed out at the end of November and an inspection performed on the source of the dust. The inside of the bags was clean, indicating that the dust emissions were not due to bag failure. The connection between the bag and the tube sheet was considered the most likely source of the leak. New bags were installed in December using a double clamp above the cage groove. The system performed well for the remainder of the quarter.

Other Operational Issues

A continuing problem has been maintaining proper temperatures in the fan building. This has been a problem in the winter when there are freezing temperatures in the lower level and excessive hot temperatures at the top of the fan room. Based upon the design recommendations from the previous quarter, new louvers and control dampers were ordered in October. These were shipped and installed in December.

The plant EDS system was down for several days during the quarter for software upgrades. Data on baghouse and boiler performance was not available for downloading or archiving during this time.

Carbon Monoxide Detectors

We Energies has been working with Forney Corporation to install a carbon monoxide detector on Compartment #4 hopper. Carbon monoxide is produced during overheating and auto-ignition of activated carbon so detection of an increase in this gas may be an early indicator of overheating in a hopper.

As described in the 2Q07 Quarterly Report, four ports at varying levels in the hopper wall were installed to accommodate the probes for the detector. During 4Q07 there were issues with startup and the system was not successfully operated. Forney shipped the analyzer back to their facility and performed upgrades to the system and it should be operational early in the next quarter.

Long-Term Mercury Control Results

DARCO® Hg, a non-brominated carbon, was injected for the majority of 4Q07. PAC injection was controlled on coal feed rate for the entire quarter. The trim control which is based on a mercury removal was not used. Figure 2 shows TOXECON™ data for October 2007. Mercury removal was over 90% for the majority of the month using 1.6 lb/MMacf PAC. The air-to-cloth ratio was around 5 ft/min when all three units were at full load. The baghouse cleaning frequency was steady at 0.18 p/b/hr. The tube sheet pressure drop was around 2.0 inches of water when all units were at full load.

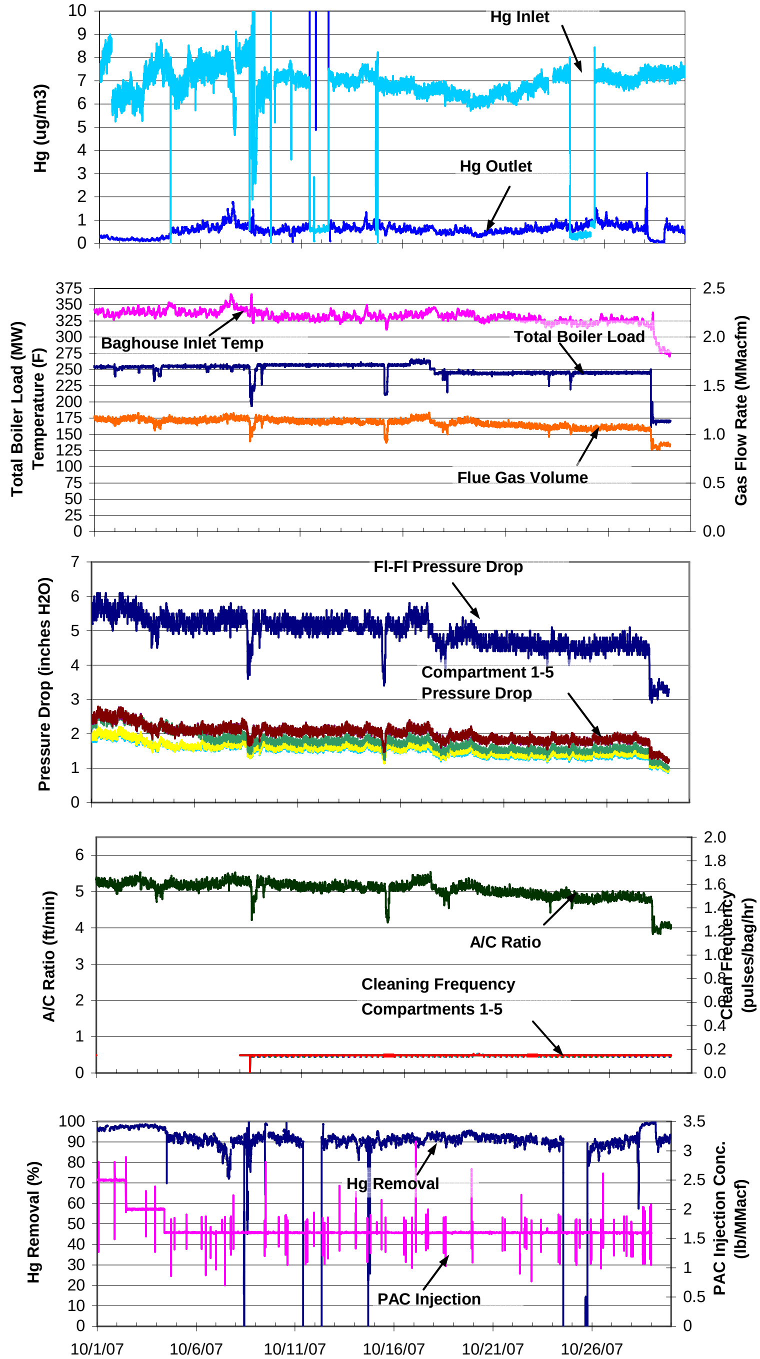

Figure 2. TOXECON™ Performance Data for October 2007.

Figure 3 shows TOXECON™ data for November 2007. Mercury removal was over 90% for the majority of the month using 1.7 lb/MMacf PAC. The air-to-cloth ratio was around 5 ft/min when all three units were at full load. The baghouse cleaning frequency was steady at 0.18 p/b/hr. The tube sheet pressure drop was around 2.0 inches of water when all units were at full load. There were 3 unit outages during the month. There was a brief outage of PAC injection on November 4 related to a failure of the ash system vent filters.

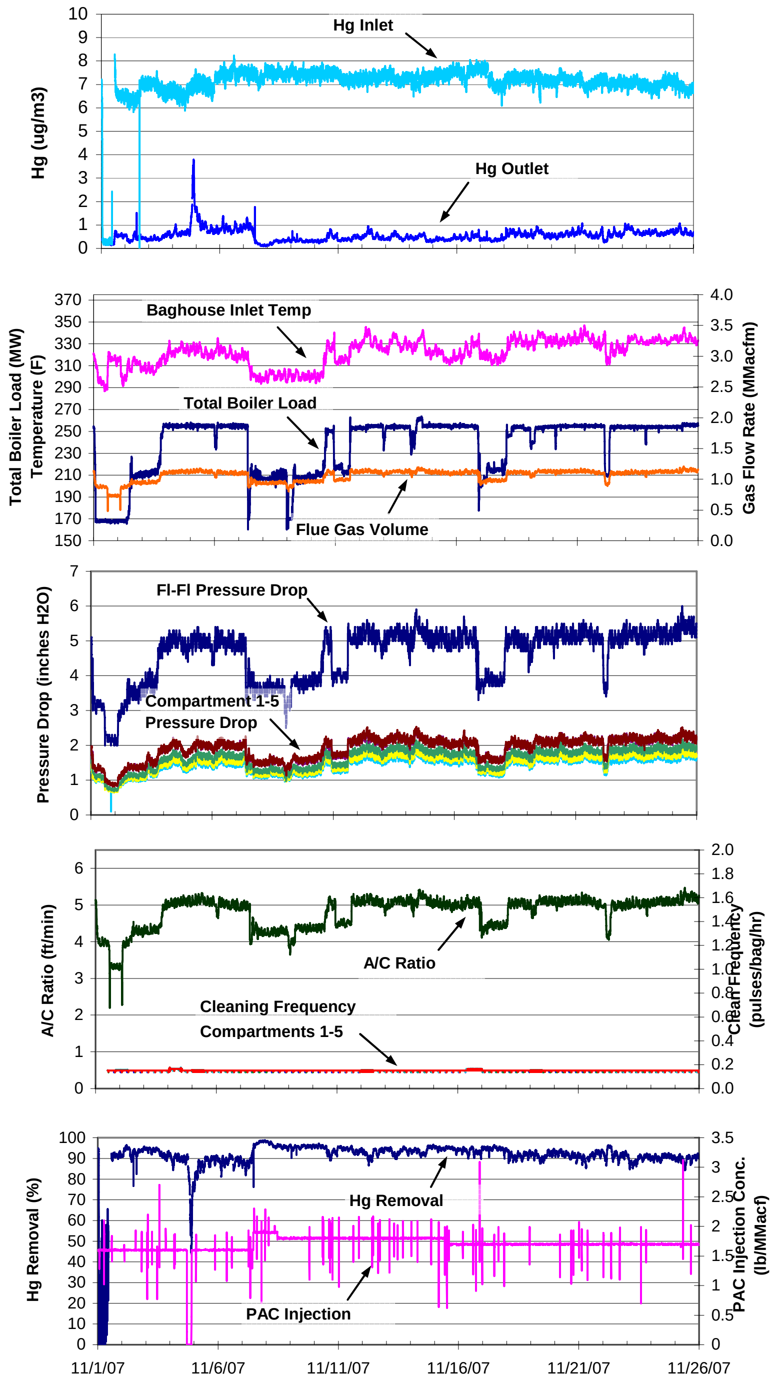

Figure 3. TOXECON™ Performance Data for November 2007.

Figure 4 shows TOXECON™ data for December 2007. Mercury removal was over 90% for the majority of the month using 1.6 lb/MMacf PAC. The air-to-cloth ratio was around 5 ft/min when all three units were at full load. The baghouse cleaning frequency was steady at 0.18 p/b/hr. The tube sheet pressure drop was around 2.0 inches of water when all units were at full load.

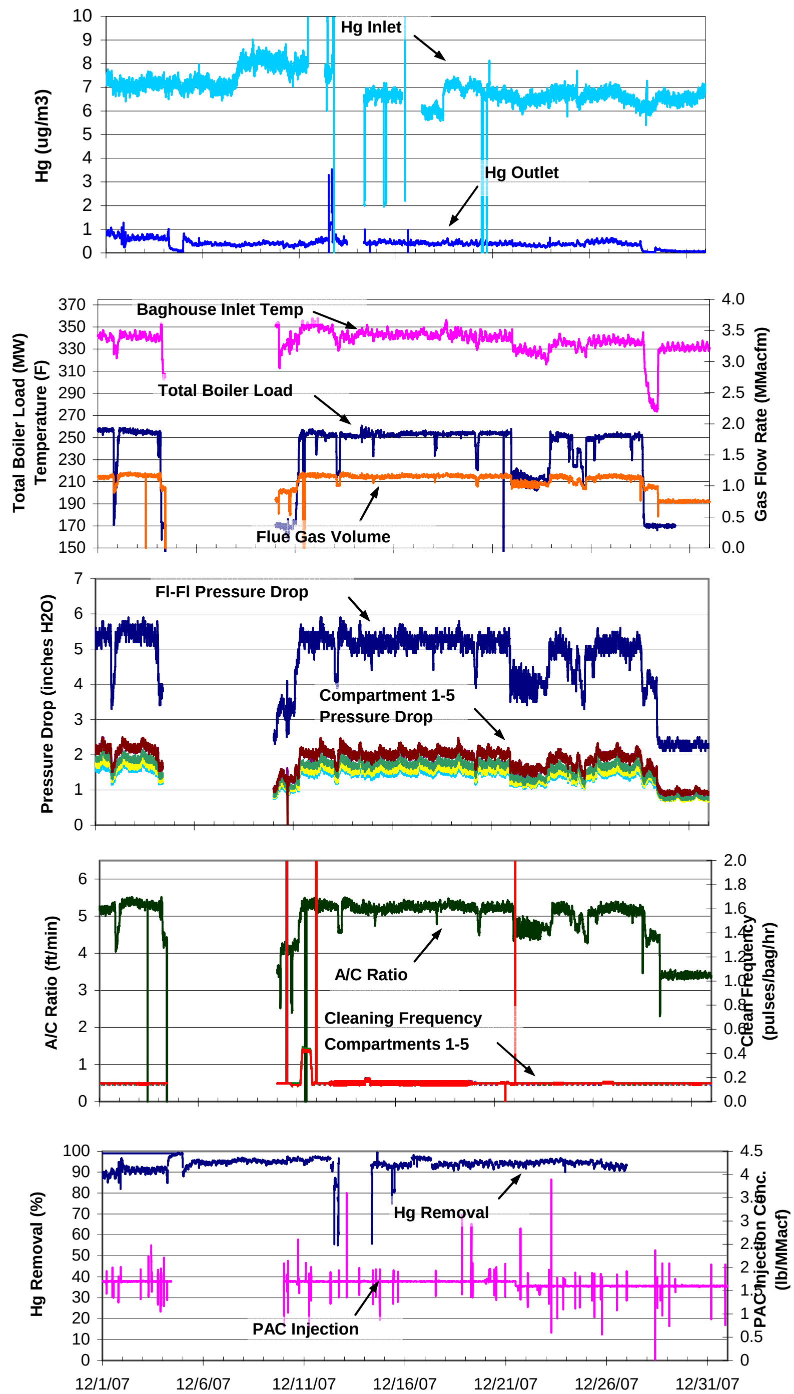

Figure 4. TOXECON™ Performance Data for December 2007.

Mercury Loading on PAC/Ash Mixtures

Additional samples of PAC/ash mixture from the baghouse were analyzed this quarter for mercury content and Loss on Ignition (LOI). The ash at Presque Isle has a measured LOI of less than 1%, so the LOI in the PAC/ash mixture from the baghouse hoppers is primarily due to the PAC contribution. Figure 5 shows the mercury loading in the mixture during several injection periods over the last year. The mercury loading increased as the LOI (PAC fraction) increased, which is expected. Typically the loading fluctuates between 35–80 ppm. The loading on the DARCO® Hg carbon used in 4Q07 seemed to perform much better than earlier in the year or in 2007. This was during the ESP detuning tests. The mechanism of increased mercury removal and loading is not understood at this time.

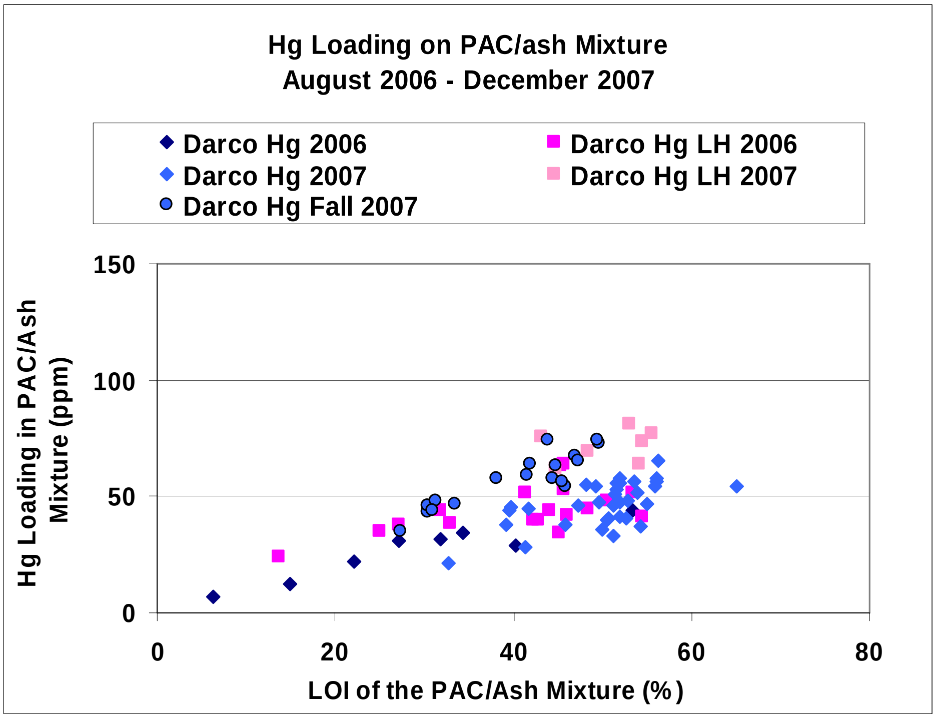

Figure 5. Mercury Loading on the PAC/Ash Mixture.

Figure 6 shows the mercury loading on just the PAC fraction in the mixture. This was back-calculated using a PAC LOI of 75% for DARCO® Hg and 74% for DARCO® Hg-LH (measured) and assuming that the ash contribution to the LOI was nominal. This assumption may not be accurate during the ESP detuning tests, due to a change in the ESP performance.

At low injection rates, the loading on the halogenated carbon was higher than the non-halogenated, although except for two data points, this was not a large difference. At higher injection rates, the loading for all of the test periods was similar, with the halogenated averaging slightly higher. The loading on the halogenated carbon during 2007 and non-halogenated in 4Q07 was consistently higher than the previous year. In fact, the loading on the non-halogenated carbon in 4Q07 was very similar to the halogenated carbon used during the summer in 2007.

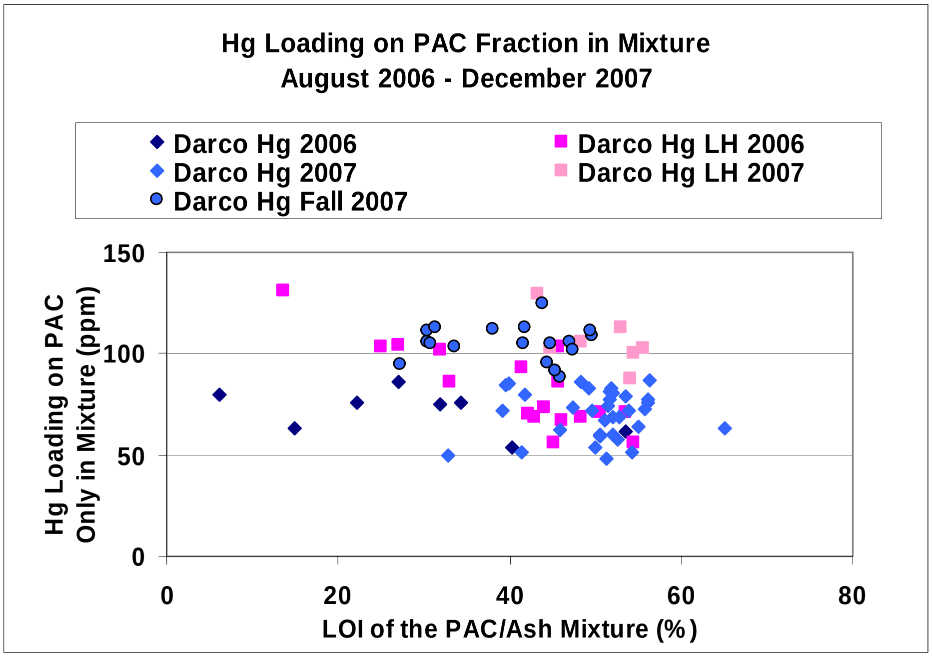

Figure 6. Mercury Loading on the PAC Fraction of the Baghouse Mixture.

Overheating of PAC/Ash

Investigations continued this quarter into the development of a model describing the factors that contribute to auto-ignition and resulting overheating of the ash mixture in the baghouse hoppers. Tests were conducted in the laboratory to determine the effect of bed size, PAC fraction, and ambient temperature on overheating.

During this quarter, laboratory oven tests continued using square containers filled with DARCO® Hg PAC/ash mixtures. Thermocouples were placed in the oven and inserted into the center of the bed of material at different levels to track temperature profiles over time.

The Frank-Kamenetskii model predicts that larger bed sizes require lower temperatures and longer times to ignite when compared to smaller bed sizes. Laboratory results confirm this behavior. Figure 7 shows results to date for DARCO® Hg PAC and PAC/ash mixtures. Larger beds auto-ignite at lower temperatures for all mixtures. Also the effect of LOI or PAC fraction in the bed has an effect on auto-ignition temperatures. These data indicate that lower LOI requires higher temperatures to auto-ignite. There is no data point for the 4-inch bed of either 21% or 26% LOI mixture. The auto-ignition temperature of these beds is above the maximum temperature of the oven used for the tests.

Using an 8-inch bed at the maximum oven temperature of 527 F, PAC/ash mixtures auto-ignited until the LOI level went below 9%. This is much lower than previously expected and this value may be lower using larger bed sizes. Next quarter, a 12-inch bed will be tested at all LOI levels.

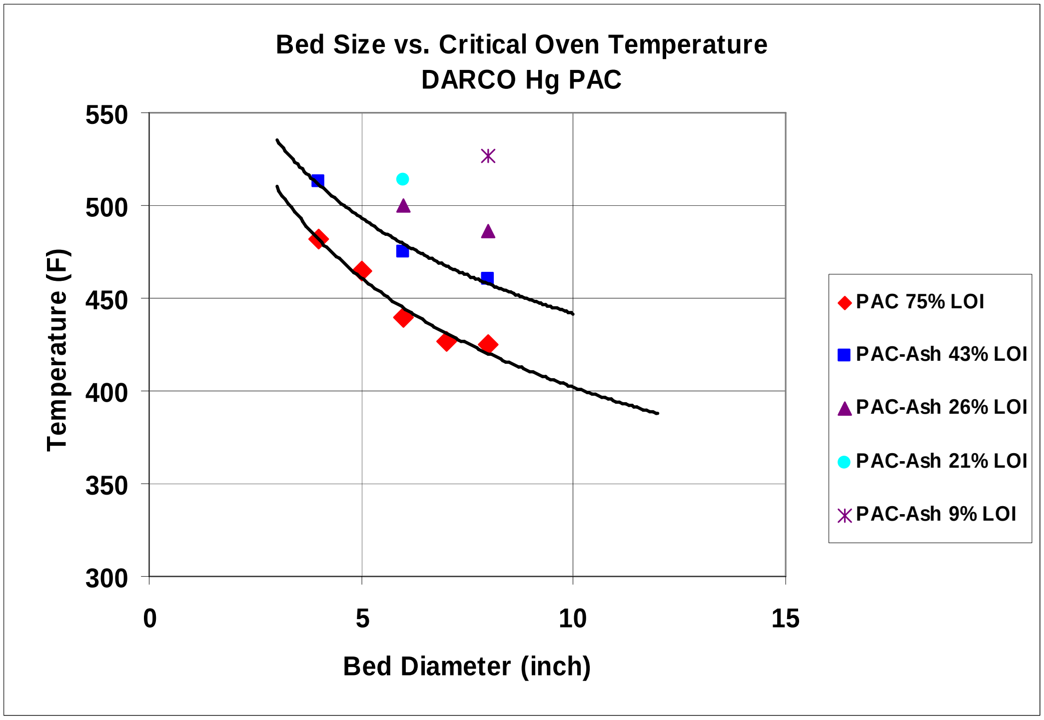

Figure 7. Correlation Between Bed Size and Critical Oven Temperature Required for Auto-Ignition.

When the critical temperature and bed dimensions are used in the model calculations, the result should be a linear correlation. Figure 8 shows the results of this correlation.

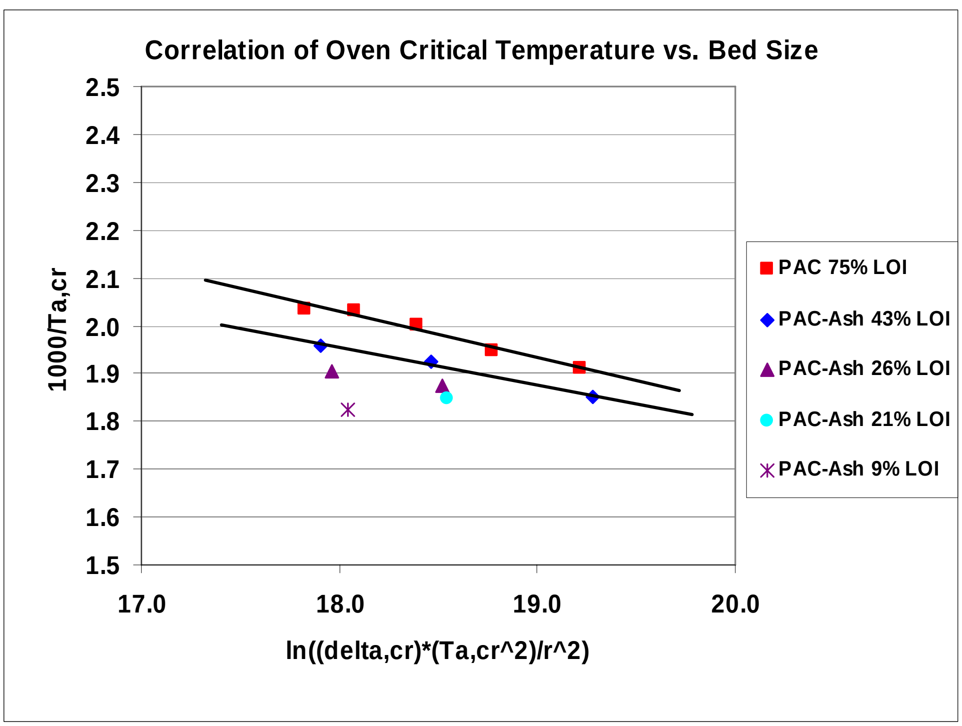

Figure 8. Auto-Ignition Correlation using DARCO® Hg PAC and PAC/Ash Mixtures.

ESP Detuning Tests

Background

The goals of this series of tests were to determine how the ash loading to the baghouse could be increased above base levels to:

- Improve collection efficiency of mercury
- Improve collection efficiency of particulate matter
- Protect the fabric of the filter bags and ensure normal life
- Eliminate dusting problems with the ash unloader operation.
- Reduce potential for auto-ignition in the baghouse hoppers.

Figure 9 outlines the layout of the ESPs for Units 7-9.

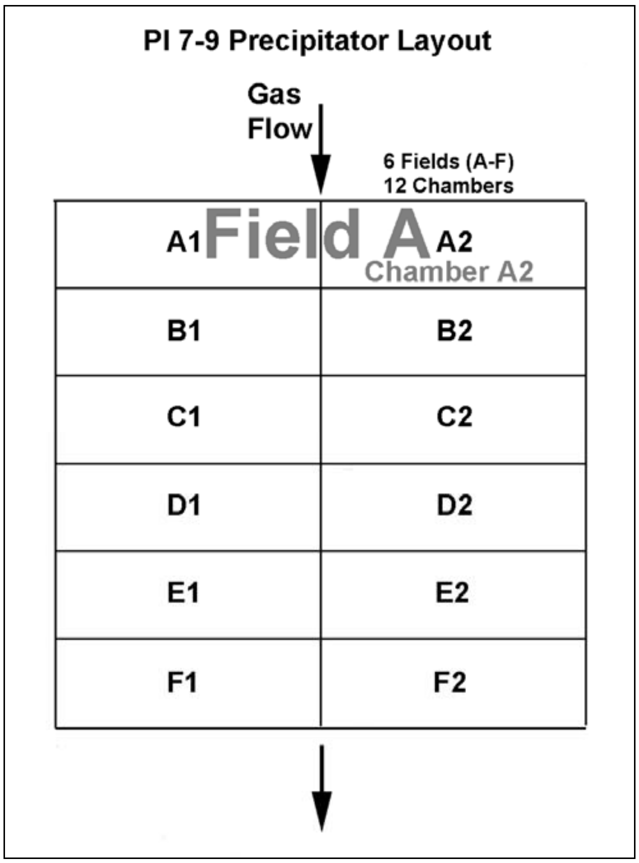

Figure 9. ESP Layout.

ESP Detuning Test Results

Stack opacity is monitored throughout the course of this project. Figure 10 below shows opacity data during the detuning tests. There was no noticeable change in opacity while the chambers were out of service. The Unit 9 CEM baseline was re-established on October 11.

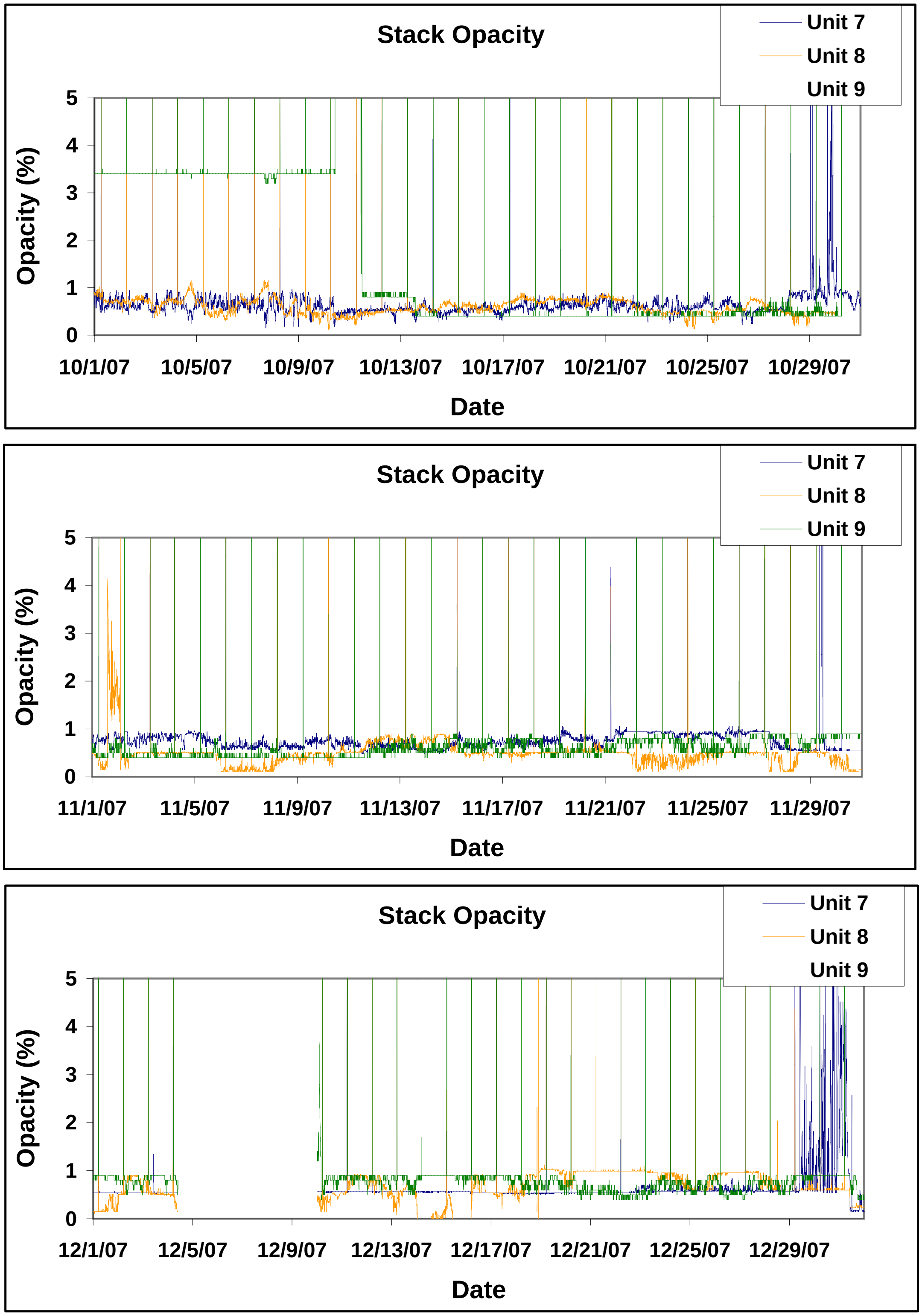

Figure 10. Stack Opacity During ESP Detuning Tests.

Figure 11 shows the LOI data for the whole test period. The LOI did not significantly drop until one of the front chambers (7A1) was taken out of service, then the LOI dropped from 40-50% to around 30%.

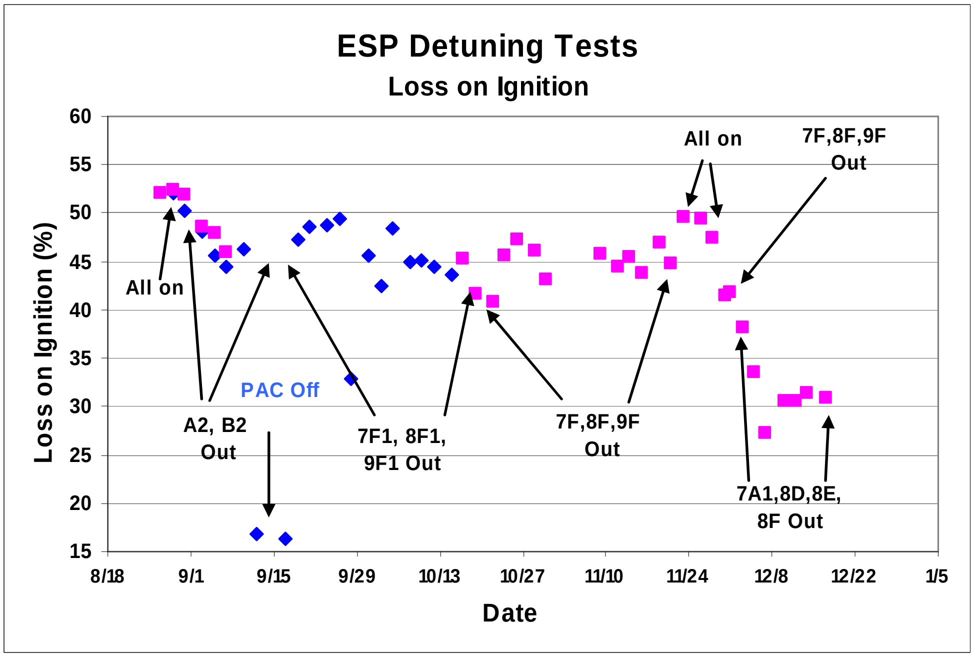

Figure 11. LOI During ESP Detuning Tests.

These tests will continue into the next quarter using DARCO® Hg-LH PAC in order to reduce the amount of PAC in the ash mixture. This should aid ash unloading and help to minimize dusting.

Task 16 – Operate, Test, Data Analysis, and Optimize TOXECON™ for NO_x and SO_2 Control

This test effort was designed to support the overall objectives of the TOXECON™ retrofit at Presque Isle as well as to further the technical understanding of the TOXECON™ technology for both We Energies and the greater industry. Parametric tests were performed in August to assess the capability of trona (sodium sesquicarbonate) injection upstream of the TOXECON™ baghouse to control SO_2 and NO_x. Injection equipment and measurement instrumentation were installed specifically for these tests. The following were the objectives of the testing program:

1. Quantify the trona injection rate versus SO_2/NO_x removal.
2. Record baghouse performance over the test period, showing how pressure drop, cleaning frequency and mercury removal change.
3. Determine if there is any negative effect of trona injection on emissions (NO_2).
4. Evaluate the technical and economic performance of trona.

Data and results from the testing in August were presented in the previous quarterly report. A draft technical report was prepared and submitted and the majority of the economics were prepared. A topical report including technical results and economic assessment will be submitted in early 1Q08.

Task 17 – Carbon/Ash Management System

During 4Q07 a review on current technologies concerning mercury removal from high carbon ash was completed. Several thermal treatment technologies were identified as having potential for a pilot scale test in 2008.

One of the original project goals includes recovery of mercury from the sorbent. During discussions regarding this phase of the project, concern was raised that this might not be desirable because it potentially would allow mercury to be re-introduced to the environment. The suggestion was made that a preferable goal might be to lock up mercury in a more innocuous, concentrated form (such as cinnabar) and to minimize mercury's environmental effects for the long term as well as the short term.

An alternative use for the PAC/ash mixture from the TOXECON™ baghouse was identified during a conference call with the project team. High carbon fly ash has been used successfully as an additive to create electrically conductive concrete. This could potentially create a demand for the untreated PAC/ash mixture. Further study on this application as a treatment option for the PAC/ash mixture will be addressed in early 1Q08.

Task 18 – Revise Design Specifications, Prepare O&M Manuals

Work began this quarter to develop a detailed training program and supplement to the Thermo Manual for the CEMs. This work was performed by ADA-ES and involved detailing background, startup, and operation of the CEMs. In 1Q08 further work will be done on developing a troubleshooting and maintenance guide. This will be presented to the plant in 1Q08.

Task 19 – Reporting, Management, Subcontracts, Technology Transfer

Reports as required in the Financial Assistance Reporting Requirements Checklist and the Statement of Project Objectives are prepared and submitted under this task. Subcontract management, communications, outreach, and technology transfer functions are also performed under this task.

Activity during this Reporting Quarter:

- Quarterly Technical Progress Report delivered
- Quarterly Financial Status Report delivered
- Quarterly Federal Assistance Program/Project Status Report delivered
- Gave a tour of the facility to representatives from the following:
    - Avondale Partners
    - Lazard Capital Markets
    - Perella Weinberg Partners

- Pritchard Capital Partners
  - Sidoti & Co.
  - Wedbush Morgan Securities
  - Strategic Energy
  - RBC Dain Rausher
  - Canaccord Adams
  - Thomas Weisel
  - Hopewell Capital
  - White Pine Power
  - Otter Tail Power
  - Marquette Range Engineering Club
- Participated in a McIlvaine webcast
- Participated in an EPA training session on Method 30A and the experiences at Presque Isle
- Attended the Emissions Marketing Association Meeting in November
- Presented at the NETL Mercury Control Technology Conference in December
- Technical papers and presentations for future meetings include:
  - EUEC (January 2008)
  - AWMA (June 2008)
  - MEGA Symposium (August 2008)

CONCLUSION

This is the fifteenth Quarterly Technical Progress Report under Cooperative Agreement Number DE-FC26-04NT41766. All major construction efforts were completed during 4Q05, and only punch list items remained during the current quarter. Operational issues that were addressed included evaluating options to the HVAC system in the fan building, and modifying and repairing the ash silo wet unloading system to prevent dusting. The filter separator continued to have problems as far as dust emissions during operation. A new installation clamping method improved the emissions. A remote operator shelter was installed for ash unloading. The carbon monoxide detector was still not operational during this quarter but should be ready in 1Q08.

Lamp and lamp heater upgrades were made to the CEMs along with routine maintenance. A nitrogen generator and humidifier were installed at the inlet, which resulted in much better performance. CEM availability was much improved this quarter.

Laboratory tests on PAC auto-ignition continued this quarter, and a good correlation between bed size and ignition temperature using the Frank-Kamenetskii Model was completed. An effect on the level of LOI in the PAC/ash mixture was measured for all bed sizes tested. Lower LOI mixtures required higher temperatures for auto-ignition. Test beds with an LOI of 9% auto-ignited and tests will continue next quarter using larger beds to see if this is the minimum LOI required for auto-ignition.

The project team is actively involved in a number of reporting and technology transfer activities, including tours of the facility at Presque Isle.