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

Quarterly Technical Progress Report
Reporting Period: July 1, 2007–September 30, 2007
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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 July 1, 2007, through September 30, 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 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:

<u>Budget Period 1</u>: 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.

<u>Budget Period 2</u>: 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 3Q07, 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

Daily zero and span checks on the inlet system indicate that the drift is higher than desirable. Critical calibration failures for total mercury occurred 14 of the 31 days in July, 14 of 31 days in August and most of the days in September. The availability of the system was 69% in July, 80% in August, and 70% in September. 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. This significantly reduces the reported availability. It is further expected that the system operation will improve when upgrades are available from Thermo.

Maintenance:

- July: Updated software on 20th, replaced orifice pressure transducer on Unit 9 probe, and performed routine maintenance.
- September: Serviced sample pump
- Pending maintenance: hydrator upgrade, nitrogen generator installation, lamp and lamp heater installation.

Outlet

Daily zero and span checks on the outlet system from July through September show very good performance with no critical calibration failures in July and August. The last two days in September failed calibration, but this was due to the new lamp installed on the 28th changing the reference intensity (this was corrected on Monday, October 1st). The availability of the system was 97.2% in July, 100% in August, and 99.6% in September.

Maintenance:

- July: Updated software on the 20th and performed routine maintenance.
- September: New lamp installed on 28th and serviced sample pump.
- Pending maintenance: hydrator upgrade, lamp heater, oxidized mercury calibration source installation.

Ash Silo

During 3Q07, 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.

UCC recommended modifications to the pin mixer sprocket, chain and guard to increase the speed for better mixing. However, this was not done. Instead a variable speed drive was installed on the pin mixer to provide the ability to tune the pin mixer to an optimal speed and horsepower required to mix and control dust effectively. This was felt to be needed for the trona injection trial since there was uncertainty how the unloader would work with this product. Mixing at a higher speed improved the dust control during ash/PAC unloading. This also reduced the amount of time required to fill a truck.

A vacuum line was installed on the end of the pin mixer in 2Q07 to catch the dust prior to the wetted material moving out of the mixer and into the truck. The dust from this was routed back to the top of the ash silo. This system was tested this quarter and resulted in reduced dust emissions from the mixer. However, it was found to be drawing in moisture from the water sprays which is a problem since the vent goes back into the ash silo. The use of this line was discontinued to prevent moisture caused problems in either the ash silo vent filter bags or the ash silo itself.

The filter separator in the ash silo consists of two modules with 14 bags in each. This is used to filter the air leaving the ash silo during removal of ash from the hoppers. During 2Q07, a set of P84 bags were installed. They worked well initially, but needed to be replaced after approximately the same amount as the polyester bags, indicating no net benefit to using this material. During August, air leakage in the filter separation resulted in increased dust emissions during ash unloading. RTV was placed on the seams of the bags and on the sheet metal screws in the tube sheet. The pulse timer card for the filter separator was changed during August. Investigations early in the month showed that the system was performing continuous cleaning during a portion of the ash unloading process. This would result in over-cleaning of the bags and subsequent loss of filter cake on the bags, which would then allow dust to penetrate the fabric.

On September 10, both ash system exhaust blowers failed. Two new blowers were ordered and received on site September 26. PAC injection was discontinued on September 10 due to the inability to pull ash from the baghouse. PAC injection was resumed on September 14 after repairs were made to one of the blowers and to the pin mixer.

Problems with the pin mixer included a failure of the chain drive mechanism and a failure of the shaft seals. The end seals, packing and bearings on both the driven and non driven ends of the pin mixer were replaced. It was determined that this was caused by running the pin mixer backwards in an attempt to un-jam it.

A flow meter was installed on the water line to the spray nozzles in the pin mixer. This was required to determine the ratio of water to PAC/ash mixture required for dust-free mixing. This would also be necessary for the trona injection testing.

Despite all the modifications and improvements, there is still some dusting during start up. This is due to the short material retention time in the mixer that occurs until the material bed height is established. UCC is investigating ways of increasing the initial retention time including pre-charging the mixer with high expansion foam. Another change would be to sequence the water nozzles to each come on only as the ash bed builds beneath it.

Another possible change is adding fogging nozzles in the mixer and around the discharge chute. The use of these nozzles has been successful at other installations. At this time a final decision has not been made on whether or not to add these nozzles.

Another suggestion was to build a wind screen or structure that would extend around the truck so it would be totally enclosed during the unloading operation. That way, any fugitive dust during the initial startup of the unloading operation would be confined.

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. An engineering study concluded in September with recommendations to add louvers and control dampers along with changes to the HVAC logic. These changes will be implemented in the coming months.

The plant EDS system was down for several days during August 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 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 August the system was started up briefly but was showing signs of excessive condensation in the sample line. Changes were made to address the condensate issue and the system startup was scheduled for early in the next quarter.

Long Term Mercury Control Results

DARCO® Hg-LH, a brominated carbon, was injected for the majority of 3Q07. For most of the time, PAC injection was controlled on coal feed rate and the trim control was based on a mercury removal of 91%. Figure 1 shows TOXECON™ data for July 2007. Mercury removal was over 90% for the majority of the month. The air-to-cloth ratio was between 5 and 5.5 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 three unit outages of 1-2 days each during this month.

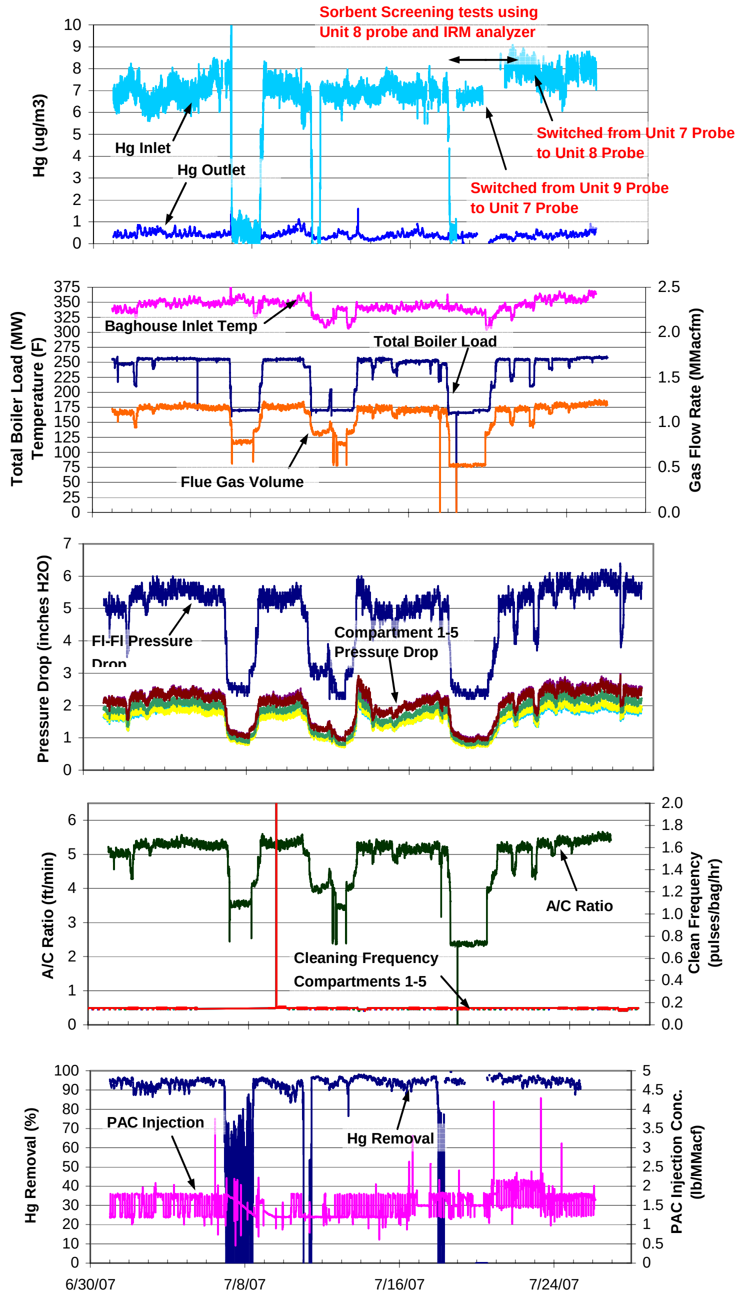

Figure 1. TOXECON™ Performance Data for July 2007.

Figure 2 shows TOXECON™ data for August 2007. During the first 10 days of the month, trona injection testing was conducted, which affected mercury removal. This will be discussed in more detail in the next section. Baghouse data was not available during the middle of the month due to the EDS system upgrades. Mercury removal on average was over 90% for the majority of the month unless there were upset conditions present.

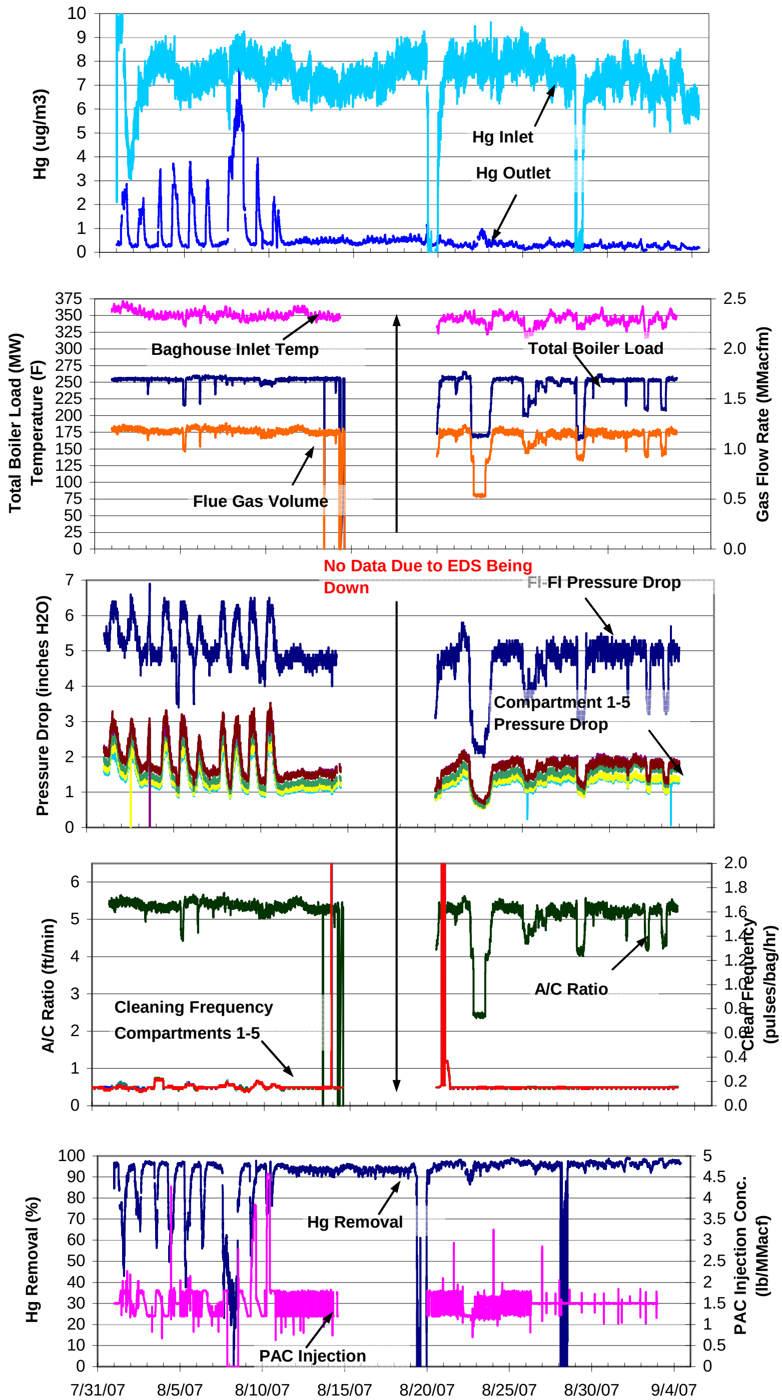

Figure 2. TOXECON™ Performance Data for August 2007.

Figure 3 shows TOXECON™ data for September 2007. There were several days of unit outages during the middle of the month. The air-to-cloth ratio and cleaning frequency were steady when the units were at full load. The PAC was switched from DARCO® Hg-LH to Hg, a non-brominated carbon, near the end of the month so PAC injection was increased accordingly.

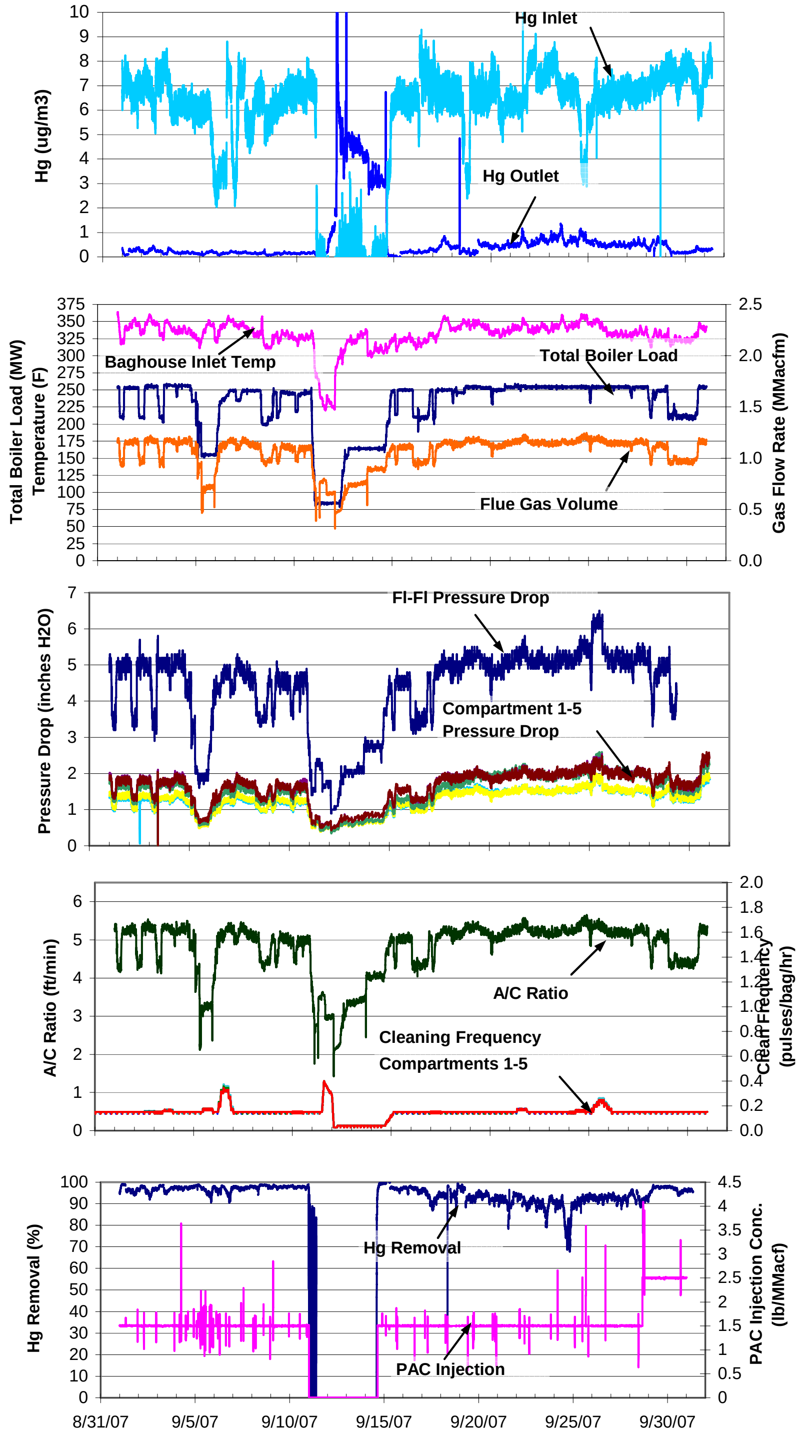

Figure 3. TOXECON™ Performance Data for September 2007.

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 4 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.

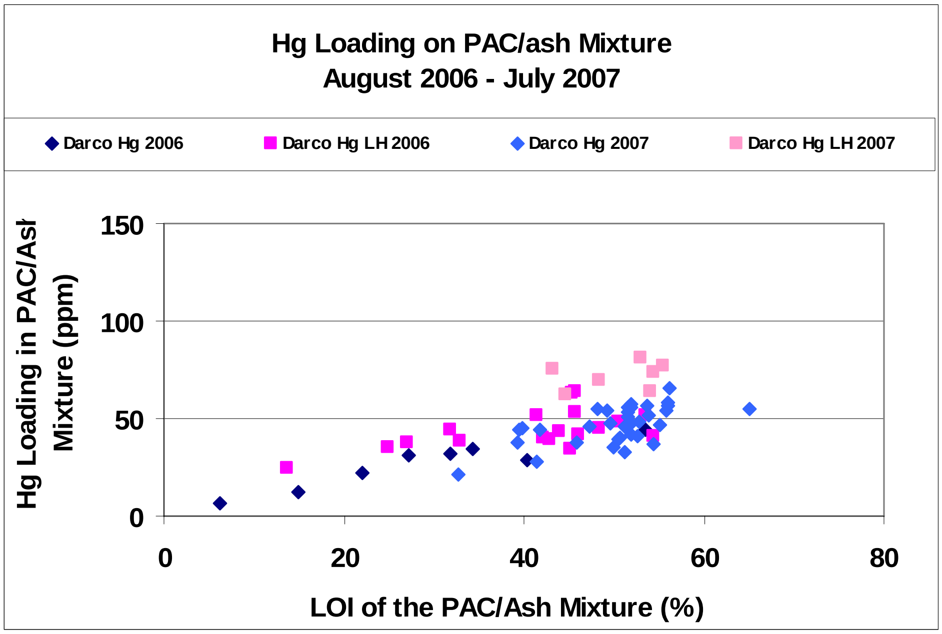

Figure 4. Mercury Loading on the PAC/Ash Mixture.

Figure 5 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. 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 is consistently higher at the high injection rates than the previous year. This could be due to a number of factors, including baghouse optimization efforts of the previous year or variations in carbon.

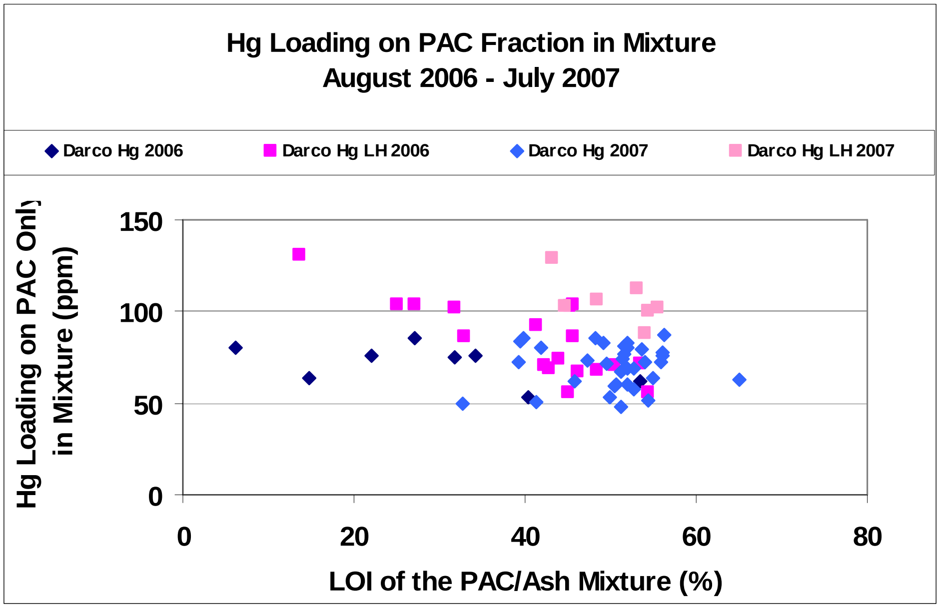

Figure 5. Mercury Loading on the PAC Fraction of the Baghouse Mixture.

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 and 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 LOI basis of 69% measured in 2006 for DARCO® Hg and LH have been revised. The LOI tests were repeated this quarter using a smaller sample size to ensure complete combustion of the PAC. Duplicate samples of each type of PAC were tested, resulting in a new LOI value of 75% for DARCO® Hg and 74% for DARCO® Hg-LH. Previous tests have had the LOI value updated to reflect this.

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 6 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.

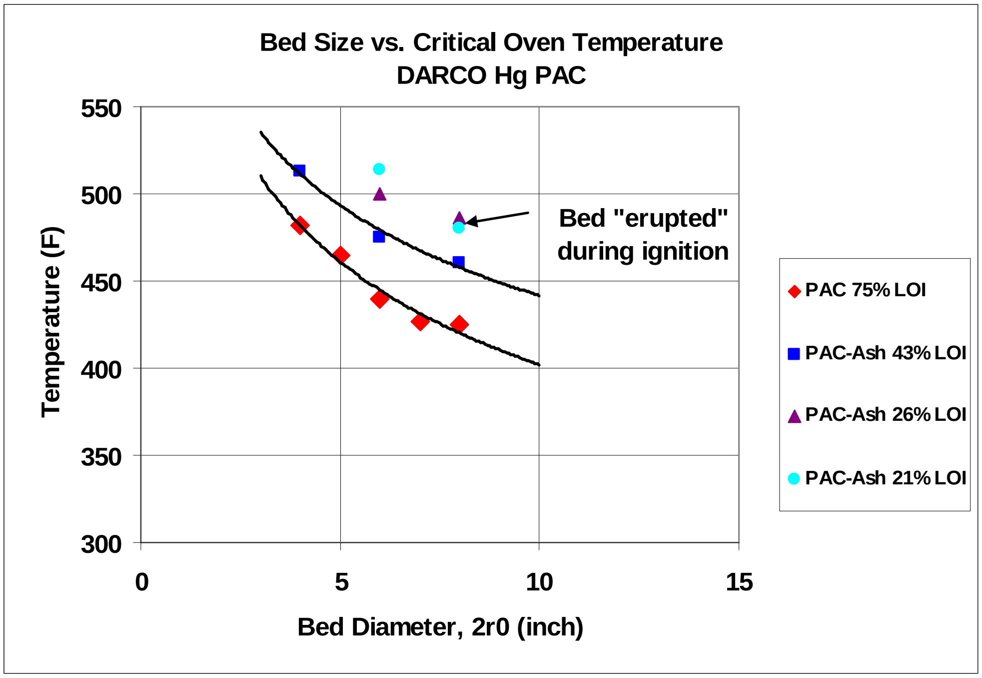

Figure 6. Correlation Between Bed Size and Critical Oven Temperature Required for Auto-Ignition.

When the critical temperature and bed dimensions are used in the model calculations, the result should be a linear correlation. Figure 7 shows the results of this correlation.

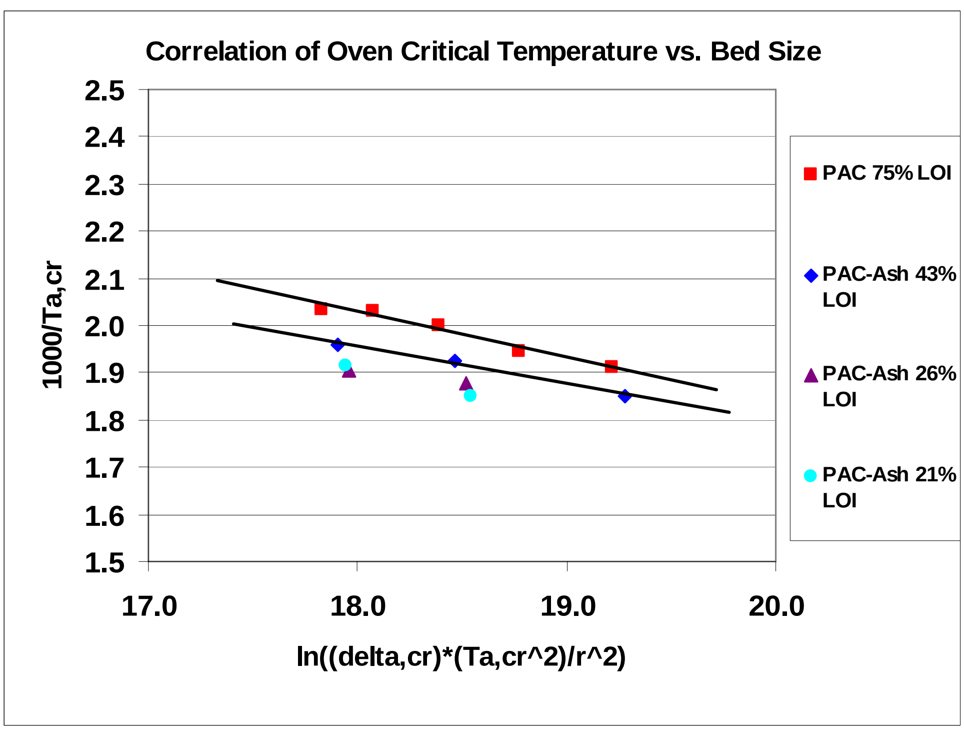

Figure 7. Auto-Ignition Correlation using DARCO® Hg PAC and PAC/Ash Mixtures.

The auto-ignition temperature for the 8-inch bed of 21% LOI is lower than expected based on the other series of tests. This bed also showed an unusual behavior during auto-ignition. The outer edges of the PAC bed looked like they had “erupted” out of the container (Figure 8). There was PAC/ash on the ceiling, walls, and bottom of the oven. This picture shows the bed after removal of the center thermocouples. The top of the bed typically has a fine layer of unburned carbon over the burned section along with an unburned edge around the bed but as seen in this picture, the edges of unburned mixture are missing from the container.

Figure 8. 8-inch Bed of 21% LOI PAC/ash Showing Loss of Edge Material.

In previous tests, the burned section looked like an inverted cone, with the peak reaching down approximately 2/3 the distance into the bed. In this test, the top looked typical except for the erupted edge material, but as the layers were removed, the normal cone shape was not there. The burned section stopped about 1.5 inches into the bed instead of almost 6 inches that would typically be seen. Figure 9 shows a side by side comparison of the ash in a previous test with 75% LOI PAC and the 21% LOI PAC/ash mixture that showed erupted material. Both the depth and shape of the lowest ash layer vary significantly between the two cases.

Tests will continue in the next quarter to determine if there is a LOI level below which the bed will not auto-ignite. The bed disturbance, or eruption, during auto-ignition of low LOI mixtures will also be investigated.

Figure 9. Comparison of Ash Depth for 75% LOI PAC and 21% LOI PAC/Ash Mixture.

ESP Detuning Tests

Background

The testing of the TOXECON™ process to date has shown a correlation between mercury removal and the amount and age of PAC on the filter bags. One of the problems with optimizing these factors is the complication of maintaining a proper filter cake on the bags.

The fabric of the filter bags is primarily used to collect dust particles upon its surface. The combination of the felted fabric and the dust cake filter particulate out of the flue gas. The dust cake builds up with time, and at some point it is necessary to clean the filter bags and remove part, but not all of the dust cake. The filter bags, with some residual dust on them continue to remove particulate matter more efficiently than if they were completely cleaned of the dust cake.

The baghouse cleaning strategy would normally be based on maintaining the ideal thickness of dust cake on the bags. First, it needs to be thick enough to be an efficient filter and protect the fabric on the filter bags. Second, it should not be too thick as to cause excessive draft loss which must be overcome with the booster fans. The thickness of the dust cake is indirectly measured by the differential pressure from the inlet to the outlet of the baghouse. One of the lessons learned so far is that there is a conflicting need to clean the baghouse so the PAC doesn't become too "old". As a result, for much of the operation of the baghouse cleaning is based on time and not differential pressure. The problem this causes is that at times the amount of filter cake on the bags is not optimal. This may lead to higher emissions because in a well maintained baghouse, the majority of the emissions occur when the bags are cleaned. It may also lead to shortened bag life from more frequent pulsing.

Another problem which is ongoing involves operation of the ash unloader. There is a high ratio of carbon to ash in the material collected in the baghouse. The ash unloader system has not been successful dealing with this mixture when the carbon to ash ratio is greater than 1 to 1. If this ratio could be reduced to 0.5 to 1, we believe the ash unloader would be better able to provide dustless unloading under most conditions.

An additional concern is the susceptibility of high concentrations of PAC to auto-ignition. Lowering the overall LOI of the PAC/ash mixture by adding more ash should reduce the risk of auto-ignition.

In summary, the goals of this test were to determine how the ash loading to the baghouse could be increased above current 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.

Test Description

The following test program objectives were initially pursued:

1. Operate the ESPs at varying levels of detuning.
    a. Baseline data collection. All fields in service.
    b. Power down one chamber of a single unit's ESP (Figure 10). All other fields at normal operating conditions.
    c. Power down one chamber on 2 units', ESPs. All other fields at normal operating conditions.
    d. Power down one chamber on 3 units' ESPs. All other fields at normal operating conditions. If less than 3 units are operating, then power down two chambers on 1 unit and one chamber on the other.
2. Determine the carbon to ash ratio by sampling from the baghouse hoppers and measuring the LOI.
3. Record baghouse performance over the test period, showing how pressure drop, cleaning frequency and mercury removal change.
4. Record opacity monitor and PM monitor readings to ensure there is no increase in emissions. Monitor stack visibility during daylight hours to verify there is no detectable change.
5. Evaluate the technical and economic performance of tested operating modes.

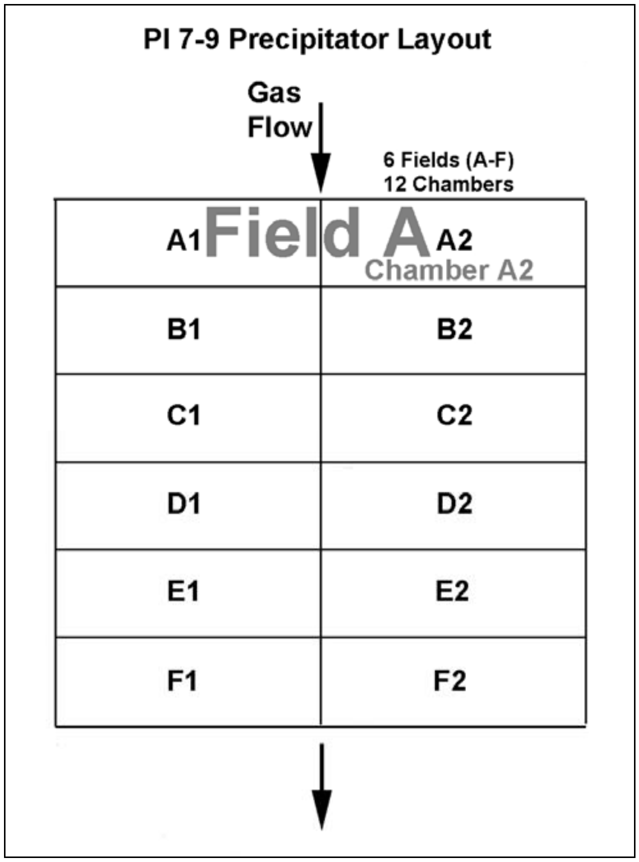

Figure 10. ESP Layout.

ESP Detuning Test Results

Stack opacity is monitored throughout the course of this project. Figure 11 below shows the data from the three stack monitors (one per flue). There was some offset on the Unit 9 monitor, and there is a small (<0.5%) change from day to day.

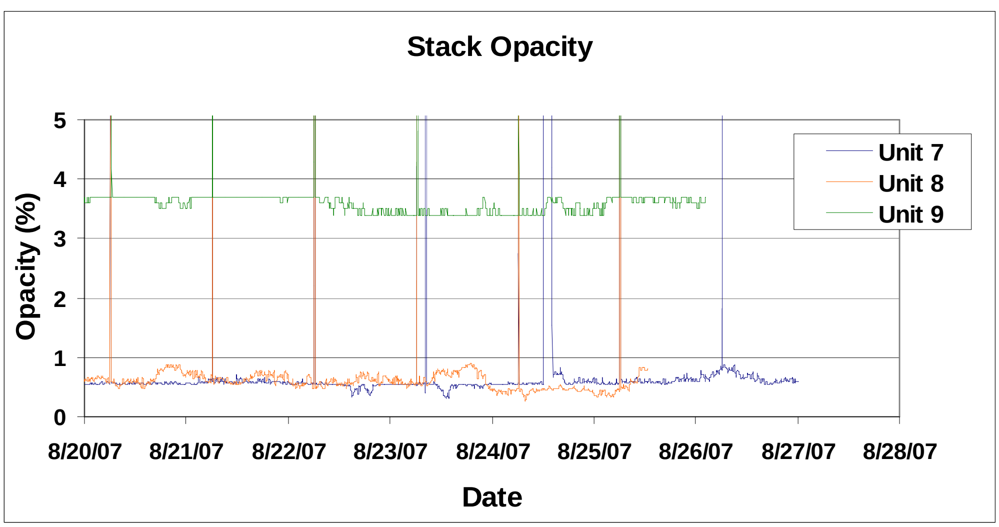

Figure 11. Baseline Opacity Data.

Figure 12 shows the opacity data during the detuning tests. There was no noticeable change in opacity while the chambers were out of service.

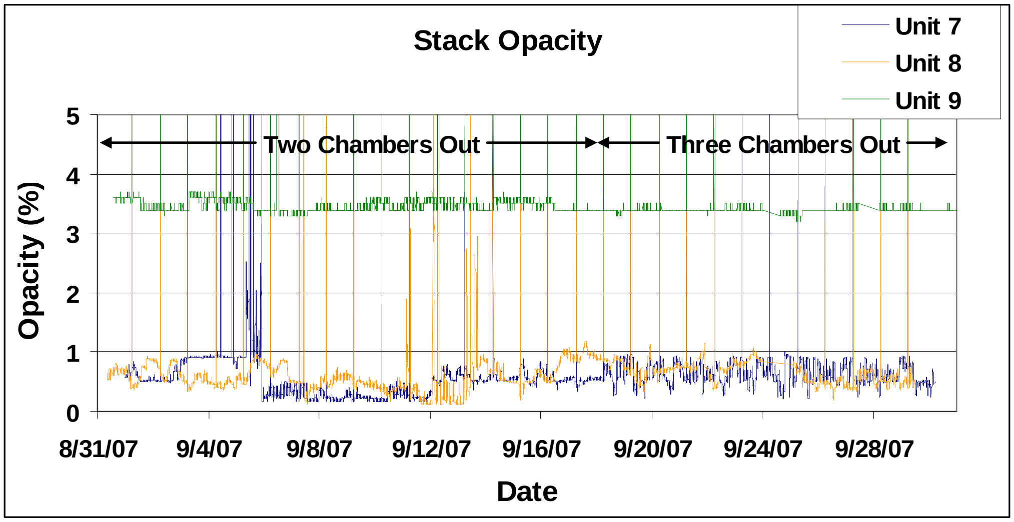

Figure 12. Stack Opacity with Two and Three Chambers Out of Service.

Figure 13 shows the LOI levels in the ash from each compartment during baseline testing and the first part of September. The individual compartment tests were run to determine if there was any variation in ash loading throughout the baghouse. This figure shows that there is some minor variation from compartment to compartment, and that with two chambers out of service, the LOI was reduced when compared to baseline values.

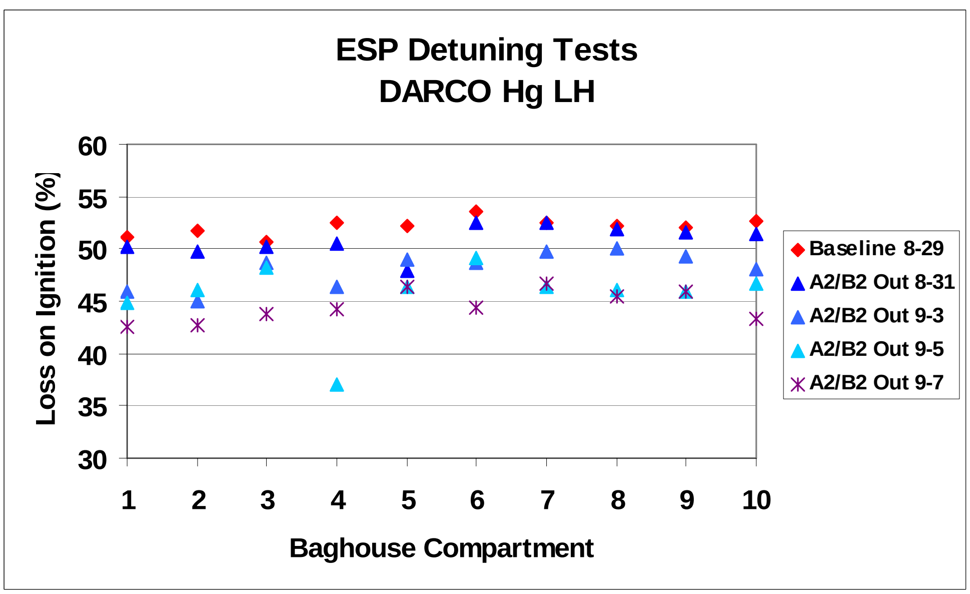

Figure 13. Baghouse Ash LOI for Each Compartment During ESP Detuning Tests.

Figure 14 shows the averaged LOI data for the first part of September when chambers A2 and B2 were out of service. These are front fields so more ash would be expected when compared to a comparable number of chambers out of service in the back fields. During the last part of

September, three of the last chambers in each ESP were out of service. There was not much difference in LOI reduction when three chambers were out of service instead of two, showing the effect of as loading when different chambers are out of service.

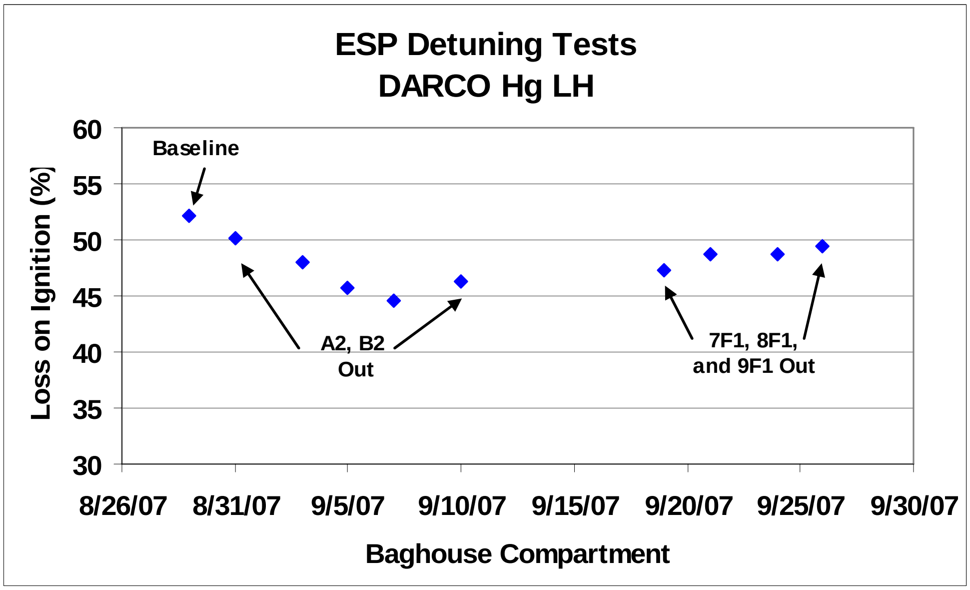

Figure 14. Average LOI with Two and Three Chambers Out of Service.

These tests will continue into the next quarter using DARCO® Hg PAC at a higher injection concentration when compared to the DARCO® Hg-LH tests above. Because there was a modest reduction in LOI with three back chambers out of service, three additional back field chambers will be taken out during October.

Mercury Quality Index Test

Background and Objective

The standard tests used for quality assurance testing of activated carbon (iodine number, etc.) are not specific to mercury. Work began in 1Q06 to develop a test method for mercury uptake in sorbents, referred to as the "Mercury Quality Index," or MQI.

Work to Date

Fabrication of the second-generation MQI apparatus neared completion during 2Q07. This design was based upon lessons learned from the original laboratory MQI. No further work was done on this unit during this quarter due to labor and time constraints.

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 and continuous tests were planned 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.

The tests for SO_2/NO_x control were conducted in two phases as shown in Table 1: Baseline and Parametric Testing. Measurements were taken during July to determine Baseline conditions. Parametric testing determined the performance of trona across a range of injection rates and at different PAC injection concentrations. Originally, a 5 day continuous test was scheduled but due to shipping and material handling issues this phase was cancelled.

Table 1. Schedule of Activities for SO_2/NO_x Control Testing.

SO_2-NO_x Control Activity	Duration (Days)	Start Date	Boiler Load
Baseline Testing	21	07/09/2007	Normal Operation
Equipment Installation and Shakedown	2	07/30/2007	Normal Operation
Parametric Testing	10	08/1/2007	Full Load 6AM–6PM

The final test plan for injecting trona to control SO_2 and NO_x was distributed to the project team in July. The plant completed the installation of SO_2 and NO_x analyzers at each of the three ducts upstream of the sorbent injection point in early July. These analyzers provided data on untreated SO_2 and NO_x levels for both baseline and injection testing.

Sorbent Information

Trona is a sodium-based, naturally occurring mineral (sodium sesquicarbonate). The trona used during this test program was obtained from Solvay Chemicals, Inc. and was mined in Green River, Wyoming. The purified SOLVAir Select 200 trona was shipped by rail to Chicago then loaded into hopper trucks for delivery to Marquette, Michigan. The hopper trucks typically carried 45,000 – 48,000 lb of trona depending on the test schedule. The particle size of the trona averaged 26 µm according to the Certificate of Analysis accompanying the material.

Trona Injection Equipment

The injection equipment for this test program was obtained from Bulk Conveyer Services, Inc. and staged near the Units 7-9 stack as shown in Figure 15. This equipment consisted of a trailer holding approximately 40 tons of trona and a separate trailer housing the blowers and controls (Figure 16). This system injected sorbent at the shipped particle size. Feed rate for the trona was from 2,200 lb/hr up to 5,900 lb/hr at full load to cover a wide range of stoichiometric ratios.

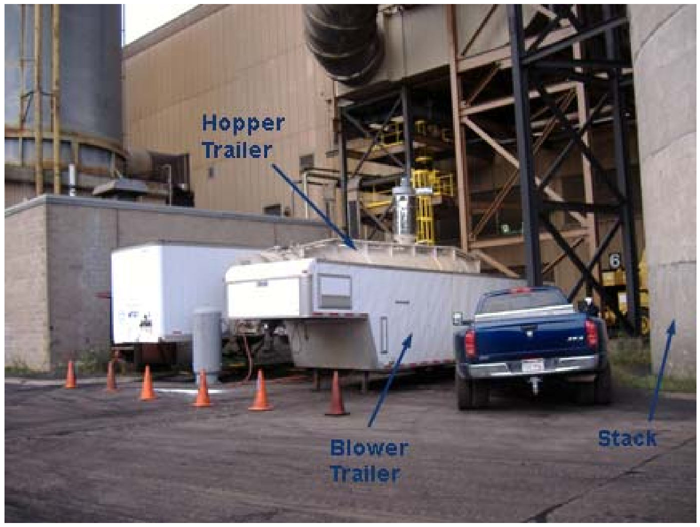

Figure 15. Staging Area for Trona Injection Equipment.

Figure 16. Trona Injection Trailer Blowers and Controls.

The trona was fed to three injection lances which were located downstream of the ID fan discharges, but upstream of the point where the ducts combine. Each lance discharged sorbent into the center of its duct. The lances were located below the current PAC injection lances (white pipe in Figure 17). This is downstream of the NO_x analyzer probe used for boiler feedback.

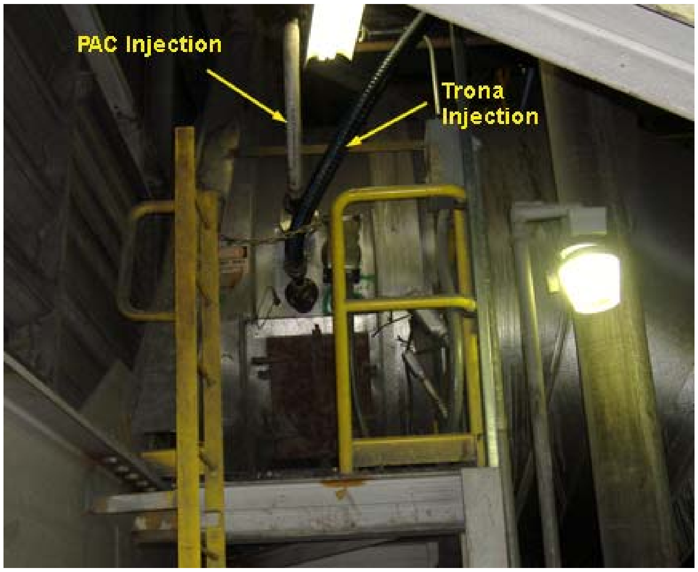

Figure 17. PAC and Trona Injection Ports.

Baseline Testing

The purpose of the baseline test was to establish the level of SO_2 and NO_X leaving the air preheater and to determine if there was any native capture across the TOXECON™ fabric filter without sorbent injection. Figure 18 shows inlet and outlet data for SO_2 and NO_x for the three ducts and flues during July. None of the three graphs show any removal across the baghouse prior to trona injection.

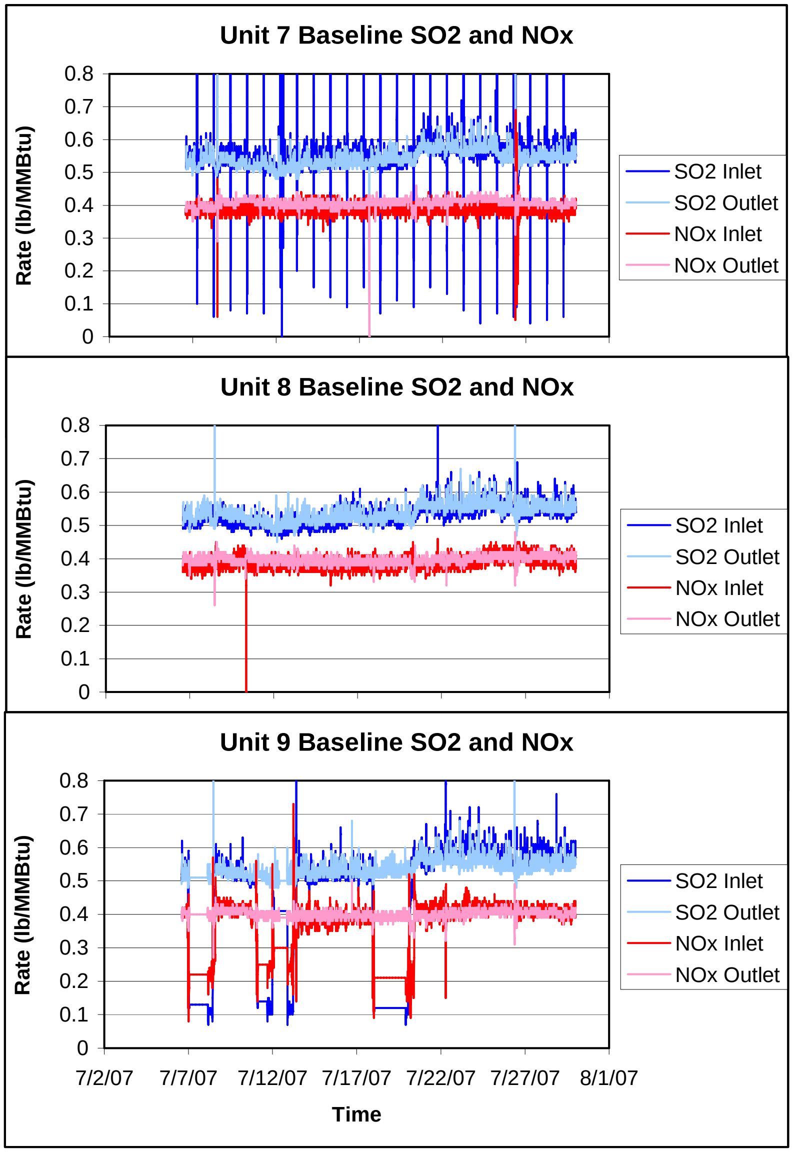

Figure 18. Baseline SO_2 and NO_x Data.

Equipment Setup and Material Handling

The trona injection equipment was set up at Presque Isle on Monday, July 30, 2007. The first truckload of trona arrived on site Tuesday morning. This truck carried 48,000 lbs, which partially filled the hopper truck. In order to test the wet unloader and the effect of the anti-setup chemical supplied by Benetech, four hours of injection at 2,200 lb/hr was performed on Tuesday, July 31. At the end of the four hours, the ash silo was unloaded using the chemical in the water feed to the pin mixer. The ash silo had been unloaded earlier in the day so the majority of the ash in the silo contained reacted trona.

There were no problems with hardening or setting up of the reacted trona/ash/PAC in the wet unloader or in the ash truck. Benetech also provided 10 gallons of a "trona release chemical" for spraying on the inside of the ash truck bed and the inside of the pin mixer. Bottom ash from Units 5 and 6 (bituminous coal) was used to line the bottom of the ash truck also since the efficacy of the release chemical or anti-setup chemical had not been tested at full scale yet. Figure 19 shows the material being unloaded at the landfill. The consistency was similar to wet sand. The next day the material still had not changed in consistency.

Figure 19. Unloading Reacted Trona/PAC/ash Mixture.

On Wednesday morning, August 1, the ash silo was unloaded to remove the accumulated material from the end of injection the previous day and overnight. This material contained significant amounts of reacted trona that had been cleaned from the bags over the course of several hours after injection had stopped. This unloading process was inadvertently performed without the anti-setup chemical, and there were no problems with the material setting up in either the mixer or the truck. Over the course of the next few days, unloading at the end of injection was done with the chemical, and in the morning without. There were no issues with setup either with or without the chemical. The wetted material showed a significant heat of reaction and was still steaming when unloaded at the landfill.

During the second week of testing, the ash silo was unloaded after injection using just water and no anti-setup chemical. There was heat associated with the mixing, but the material didn't set up in the pin mixer or in the truck. A sample was taken at the landfill and the next day it still hadn't set up. The reaction with water to form a solid hydrate may have occurred in the pin mixer but the action of the mixer may have kept the material from solidifying into a solid piece. The main risk of wetting the trona/ash/PAC without the anti-setup chemical is that if the mixer stops, the wet material in the mixer would likely solidify and would be very difficult to remove.

Parametric Testing

Parametric testing began August 1, 2007. During this test phase all three units were at full load. The original plan was to vary the sorbent injection rate from approximately 2,200 lb/hr up to

5,400 lb/hr. There was some concern that the ash system could not handle a sorbent injection rate above 5,400 lb/hr. The vacuum system used to pull ash from the hoppers and transport it to the silo was rated for 5,000 lb/hr. Adding the ash and PAC (110 lb/hr and 130 lb/hr approximately) put the highest injection rate well above the rating for the vacuum system.

Table 2 shows the injection rate and SO_2 removal for the test period. The maximum removal achieved during the testing was 74.1% when co-injecting 3.8 lb/MMacf PAC.

Table 2. Trona Injection Results.

Date	Trona Injection Rate (lb/hr)	Average NSR	SO_2 Inlet (lb/MBtu)	SO_2 Removal (%)	Comments
8/1/07	2223	0.37	0.50-0.66	46.6	
8/2/07	2223	0.41	0.48-0.63	47.6	
8/3/07	4446	0.81	0.48-0.59	65.4	
8/4/07	4446	0.79	0.50-0.58	65.5	
8/5/07	5432	0.97	0.49-0.57	69.8	
8/6/07	5926	-	-	-	Difficulty feeding trona – test stopped
8/7/07	5926	1.02	0.52-0.60	70.7	
8/8/07	5926	1.02	0.52-0.66	68.5	PAC injection turned off during am
8/9/07	5926	1.03	0.49-0.62	72.1	PAC injection ramped up to 3.8 lb/MMacf
8/10/07	5926	1.02	0.51-0.64	74.1	Started PAC injection at 3.8 lb/MMacf at start of trona injection

As seen in Table 2 and Figure 20 below, the best removal was when PAC was being injected at an unusually high level for this site (3.8 lb/MMacf). During all trona injection tests, mercury removal degraded, and then slowly recovered overnight when no trona was injected (discussed below).

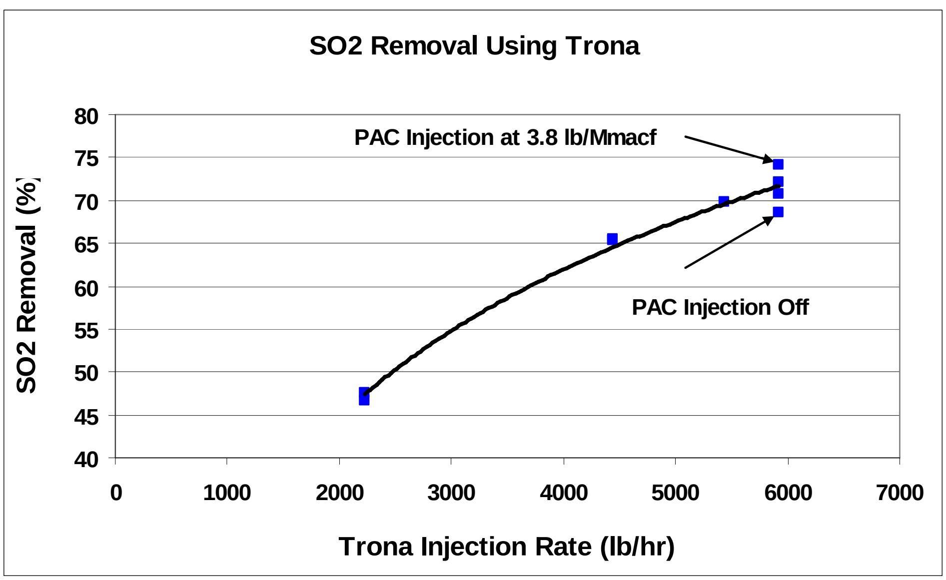

Figure 20. SO_2 Removal vs. Trona Injection Rate.

Figure 21 shows typical SO_2 removal profiles at varying trona injection rates. There was an initial rapid increase in removal but it took 3-4 hours before removal became somewhat steady. Most test periods were 8 hours, but one day was only 6 hours. When trona injection was turned off, there was an initial rapid decrease in SO_2 removal, but it doesn't come back to baseline levels for 5-6 hours, which was the time required to perform a full cleaning cycle on the baghouse.

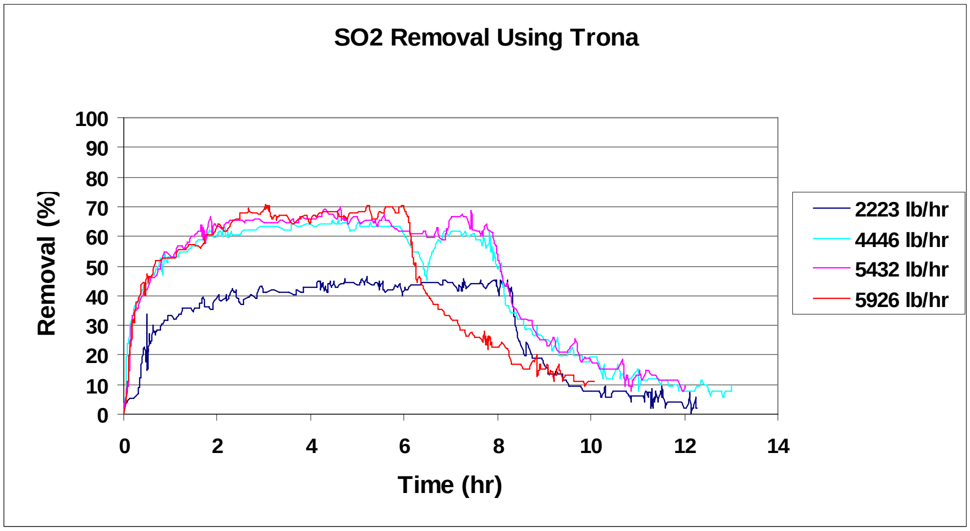

Figure 21. SO_2 Removal Profiles.

In addition to the impacts on SO_2, a small reduction in NO_x emissions was expected based upon work at other test sites. As shown in figure 22, there was no noticeable reduction in NO_x.

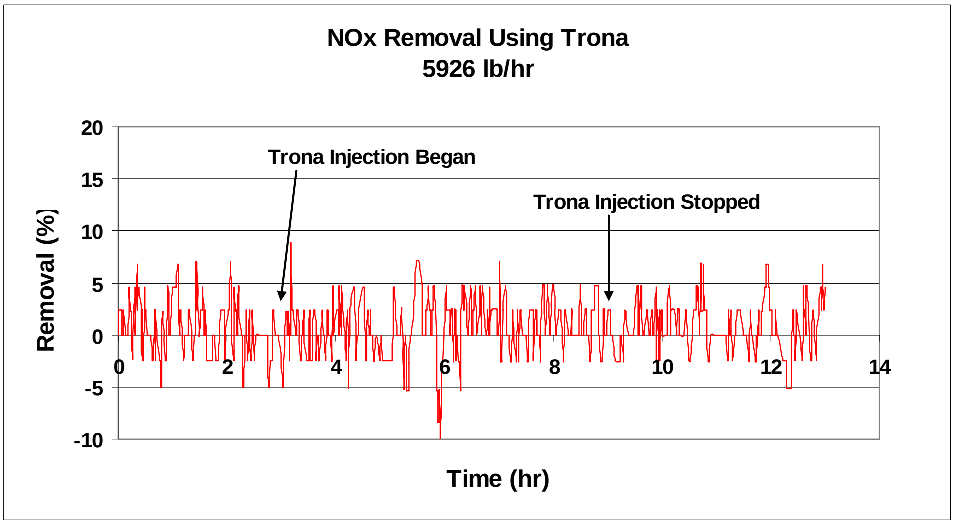

Figure 22. NOx Removal During Trona Injection.

At other test sites, a side reaction from using trona is the creation small amounts of NO_2, which results in a brownish plume and an increase in opacity. Figure 23 shows a very slight increase in the three opacity monitors during the highest injection rate used. There was no visible brown plume during this test.

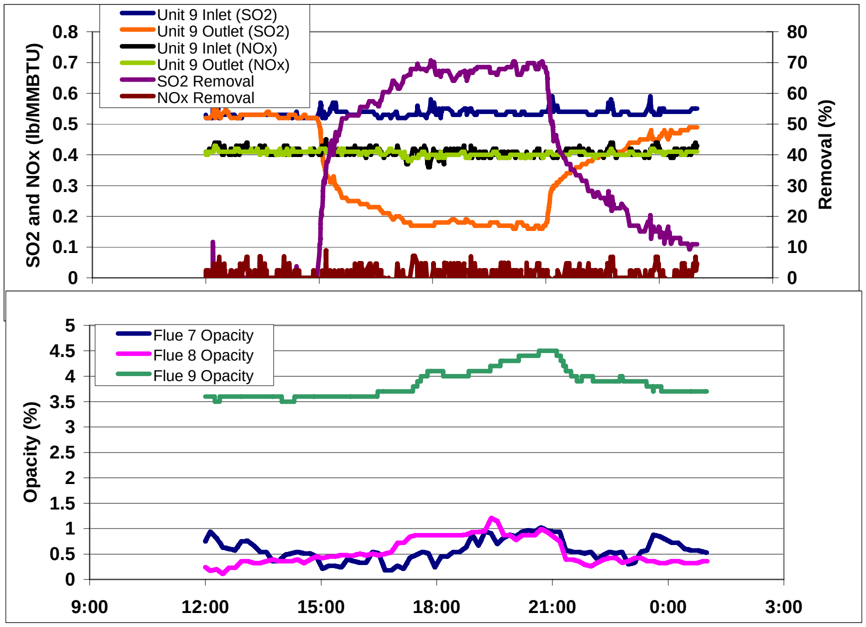

Figure 23. Effect of 5926 lb/hr Trona Injection on SO_2, NO_x, and Opacity.

At the end of the injection period on August 7, PAC injection was also turned off and kept off overnight and through the start of trona injection on August 8. At mid-day on August 8 a brownish plume was seen coming from the stack. This is the first time this had occurred. The opacity on all three monitors was also noticeably increased (Figure 24). PAC injection was turned back on at 1 pm and within 30 minutes the plume had been visibly reduced and the opacity began to go down.

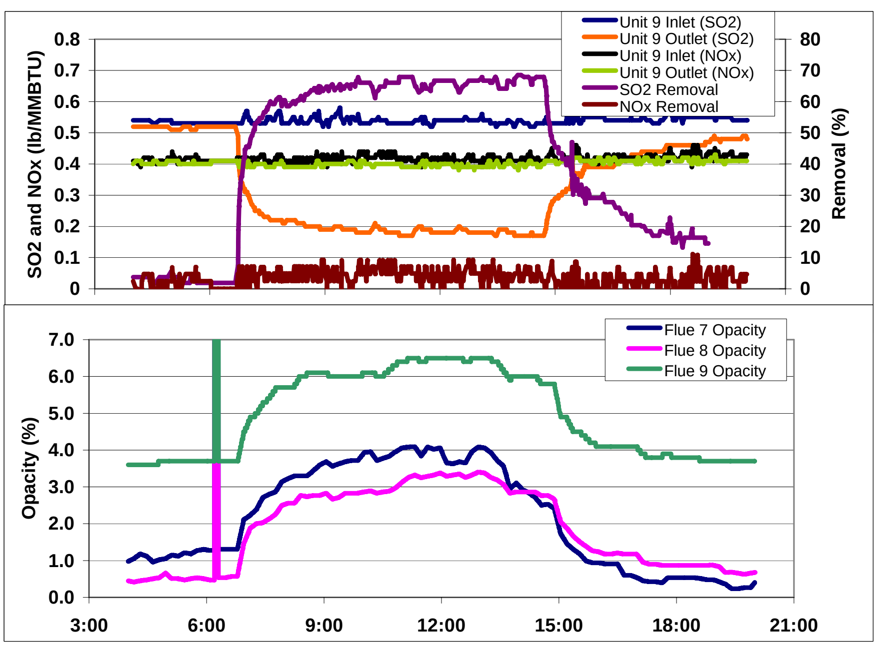

Figure 24. Effect of 5926 lb/hr Trona Injection without PAC Injection

Any impacts on the cleaning cycle and pressure drop were closely monitored. The fabric filter was cleaned in an online mode for all parametric tests. Figure 25 shows the effect of trona injection on baghouse operation during the entire injection period. As mentioned earlier, mercury removal was negatively affected during trona injection, but recovered overnight. The air-to-cloth ratio didn't change during testing. The cleaning frequency increased slightly during testing.

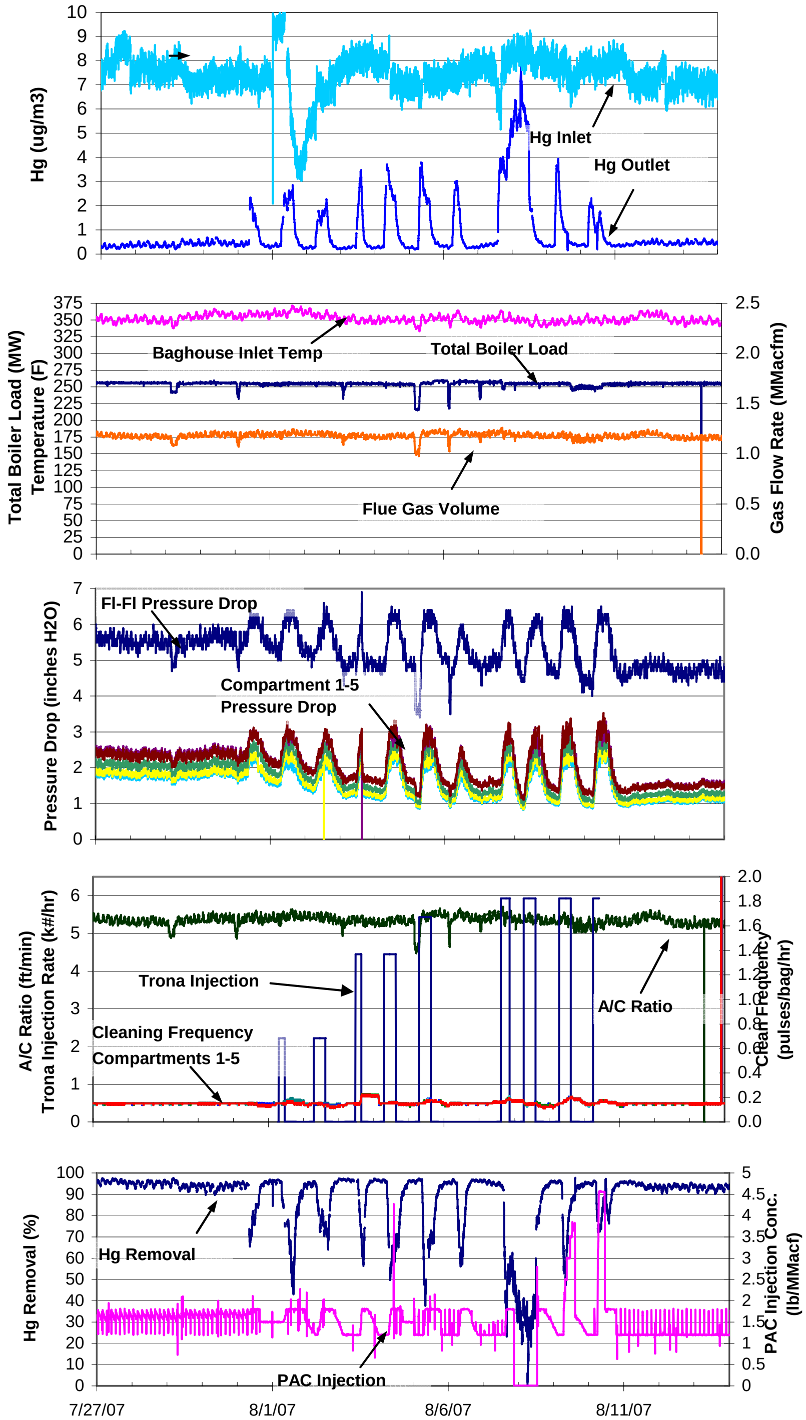

Figure 25. Baghouse Operation During Trona Injection Testing.

One unexpected side effect that was seen as soon as trona was injected into the baghouse was degradation in mercury removal. This is seen in Figure 25 above, which shows mercury levels before and during trona injection. To better understand the effect, on August 9 the PAC injection rate was increased to see if mercury removal could be increase back to the 90% level. By the end of the injection period, PAC injection was at 3.8 lb/MMacf and mercury removal was at 89%. On August 10, PAC injection was increased to 3.8 lb/MMacf at the start of trona injection and there was still a reduction in removal initially. PAC injection reached 4.5 lb/MMacf without regaining 90% mercury removal. Previous tests showed an initial drop in removal, then a partial recovery after several hours.

Task 17 – Carbon/Ash Management System

Work on this task was limited to preliminary investigations on current technologies related to carbon recycling and mercury recovery.

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

Minor work was done to update the database with as-built drawings for the project.

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:
  - Tucson Electric
  - Alliant Energy
  - Consumers Power
  - S&L
  - Gray Corp.
  - Midwest Generation
  - Norit Americas
  - NRG Energy
  - Ash Grove Cement
  - FL Smith
  - University of North Dakota EERC

    - Michigan Tech
    - ETS
    - Nebraska Public Power District
    - Southern Company
- Submitted an abstract for the EUEC in January 2008
- Submitted a paper for AQVI
- Participated in a McIlvaine webcast
- Presented an overview of mercury control technology for the Wisconsin DNR
- Presented at the Reinhold Conference in July
- Presented at the Coal Gen Conference in August
- Presented at the Thermo Super Group Meeting in September
- Presented at the American Coal Ash Conference in September
- Presented two papers at the AQVI Conference in September
- Technical papers and presentations for future meetings include:
    - NETL Mercury Control Technology Conference (December 2007)
    - EUEC (February 2008)

CONCLUSION

This is the fourteenth 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. A carbon monoxide detector was installed on Compartment #4 hopper this quarter as a possible aid in detecting incipient combustion in the hopper.

Software upgrades were made to the CEMs along with routine maintenance. An orifice pressure transducer was replaced on the Unit 9 probe and the inlet CEM pump was serviced. A new lamp was installed on the outlet CEM and the sample pump serviced.

Trona injection for SO_2/NO_x control task was completed this quarter. A removal of 74% SO_2 was achieved at an NSR of 1.02 (5926 lb/hr). NO_x level was not noticeably affected. Mercury removal was adversely affected during trona injection, but recovered over night. A brown plume was seen one day during injection when the PAC injection was turned off. Opacity also increased noticeably on this day. Baghouse pressure drop was affected during injection, but overall cleaning frequency increased by a small amount.

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. Next quarter tests will continue to study the effect of LOI on ignition temperature.

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