ACHIEVING NEW SOURCE PERFORMANCE STANDARDS (NSPS) EMISSION STANDARDS THROUGH INTEGRATION OF LOW-NOx BURNERS WITH AN OPTIMIZATION PLAN FOR BOILER COMBUSTION

Quarterly Technical Progress Report

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Disclaimer

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Abstract

The objective of this project is to demonstrate the use of an Integrated Combustion Optimization System to achieve NO_X emissions levels in the range of 0.15 to 0.22 lb/MMBtu while simultaneously enabling increased power output. The project consists of the integration of low-NO_X burners and advanced overfire air technology with various process measurement and control devices on the Holcomb Station Unit 1 boiler. The project includes the use of sophisticated neural networks or other artificial intelligence technologies and complex software that can optimize several operating parameters, including NO_X emissions, boiler efficiency, and CO emissions.

The program is being performed in three phases. In Phase I, the boiler is being equipped with sensors that can be used to monitor furnace conditions and coal flow to permit improvements in boiler operation. In Phase II, the boiler will be equipped with burner modifications designed to reduce NO_X emissions and automated coal flow dampers to permit on-line fuel balancing. In Phase III, the boiler will be equipped with an overfire air system to permit deep reductions in NO_X emissions to be achieved. Integration of the overfire air system with the improvements made in Phases I and II will permit optimization of the boiler performance, output, and emissions.

During this reporting period, efforts were focused on Phase I and Phase II activities. The furnace sensors were procured and installed in February 2003. Baseline testing was performed following the sensor installation. The low-NO_X burner modifications, the coal flow dampers, and the coal flow monitoring system were procured and installed during a boiler outage in March 2003. Process design activities were performed to support design of the equipment installed and to develop specifications for the overfire air system. The overfire air system preliminary engineering design was initiated.

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1.0   Introduction

The objective of this project is to demonstrate the use of an Integrated Combustion Optimization System to achieve NO_X emissions levels in the range of 0.15 to 0.22 lb/MMBtu while simultaneously enabling increased power output. The project consists of the integration of low-NO_X burners and advanced overfire air technology with various process measurement and control devices on the Holcomb Station Unit 1 boiler. The project includes the use of sophisticated neural networks or other artificial intelligence technologies and complex software that can optimize several operating parameters, including NO_X emissions, boiler efficiency, and CO emissions.

The Integrated Combustion Optimization System will be installed in three phases to demonstrate the synergistic effect of layering NO_X control technologies. The three phases are:

- Phase I – Advanced Sensors Upgrade
- Phase II – Low-NO_X Burner Modifications
- Phase III – Advanced Overfire Air System

Phase I – Advanced Sensors Upgrade will demonstrate the effectiveness of novel measuring sensors with respect to the control of factors leading to reduced NO_X emissions and improved thermal efficiency with minimal physical modifications to the boiler.

Phase II – Low-NO_X Burner Modifications will demonstrate the effectiveness of low-cost modifications to the existing, first generation low-NO_X burners to reduce NO_X emissions. The modifications will consist of new burner tips and other parts designed to lower NO_X emissions. This phase will also include modifications to the existing pulverized coal (PC) piping to permit automated fuel balancing among all burners.

Phase III – Advanced Separated Overfire Air (SOFA) will demonstrate deeper NO_X control competitive to SCR installation with the addition of an overfire air system coupled with the existing Phase I and II modifications to optimize overall system performance. The integration of

all three phases of these improvements will provide the opportunity to reduce NO_X emissions and permit improvements in power plant performance and output.

This report summarizes the technical progress during the referenced reporting period.

2.0 Technical Progress

During this reporting period, work continued on Phase I and Phase II of the project. Due to delays in completion of all agreements needed to fully initiate all tasks, efforts were focused on completion of the critical elements needed to support the plant outage in March 2003. This focus ensured that the outage schedule could be met, but had an impact on the scheduled completion date for several of the tasks. The schedule for the project is shown in Appendix A – Gantt Chart. The technical progress made during this reporting period is summarized in the following.

2.1 Task 1.0 – Phase I – Advanced Sensors Upgrade

The objective of Phase I is to demonstrate the effectiveness of novel measuring sensors with respect to the control of factors leading to reduced NO_X emissions and improved thermal efficiency with minimal physical modifications to the boiler. The scope of work for the Advanced Sensors Upgrade Phase is being performed in the following six tasks.

2.1.1 Task 1.1 – Process Design and Performance Analysis

In this task, analytical tools and methods are being used to evaluate existing process engineering systems and to prepare material/energy balances for the low-NO_X burner modifications and overfire air system.

The demonstration for the project will be performed at Holcomb Station located in Holcomb, Kansas. Unit 1 at the station has a generating capacity of approximately 380 MW. The boiler was manufactured by Babcock and Wilcox and uses an opposed wall fired design. The burner configuration features three rows on the front wall and two rows on the rear wall. Each row is equipped with five burners, for a total of twenty-five burners on the unit. The boiler typically fires Power River Basin (PRB) coal from several mines. The design basis for the unit is a full load heat input of 3,389 x 10^6 Btu/hr, and an excess air level of approximately 18 percent. Based upon this design basis, a material balance was developed for use in the design of the low-NO_X burner modifications and overfire air system.

During this reporting period, a physical model of the Unit 1 boiler was fabricated and used to characterize the furnace flow field and to evaluate preliminary overfire air system designs. The physical model was constructed of acrylic sheet. Studies performed included smoke and bubble tracer visualization, velocity measurements at selected planes in the model, and tracer dispersion measurements performed to evaluate overfire air system mixing effectiveness. Final process specifications for the OFA system were developed.

To support the design of the low-NO_X burner modifications, a physical model of the current first-generation low-NO_X burner was designed and fabricated. This model was used to evaluate the proposed burner modifications and to determine optimum settings for start up of the modified burners. Transfer functions were developed to enable estimates of the air flow split based upon damper settings and windbox pressure.

2.1.2 Task 1.2 – Design and Fabrication/Construction Documents

In this task, design and fabrication drawings for new equipment and other similar detailed information are being developed to enable the receipt of contractor proposals for equipment supply and installation.

During this reporting period, design engineers developed the designs for the automated coal balancing dampers and the low-NO_X burner modifications. The designs were approved by the plant and the components were procured. A bid package was developed to support installation of the components and was provided to several construction contractors. A pre-bid meeting was held with the plant and selected construction contractors to walk down the affected areas and to answer questions. Bids were received and the most qualified contractor was selected for installation.

2.1.3 Task 1.3 – Boiler Combustion Optimization Sensors

In this task, the boiler will be equipped with furnace sensors to monitor the balance among burner columns and between the front and rear firing walls, and with sensors to monitor coal flow in each coal pipe.

During this reporting period, a sensors package was procured and installed on the boiler. The sensors package consists of burner flame scanner sensors (Burner Profiler), LOI/FEGT Sensors, and in-situ CO sensors. Five LOI/FEGT sensors are located on the front wall at Elevation 3074′-2″. One sensor is located above each burner column. Fifteen CO sensors are located in the backpass between two sections of the primary superheater. A burner flame scanner sensor has been installed on each burner. Electrical wiring specifications were developed and provided to electrical contractors to obtain installation quotes. A vendor was selected and the wiring was completed in February 2003. The system commissioning was completed prior to the baseline tests.

To assist in the selection of a coal flow measurement technology, a review of available systems for monitoring coal flow was performed. Five products (four commercial, one developmental) were evaluated against a set of performance criteria. A final review of the systems was performed and a system selected for the project. The selected system is based upon the use of microwave signals to detect the bulk density of the solids flowing in each coal pipe. The coal flow monitoring system was procured and installed on the boiler during the March 2003 outage. The system commissioning was completed at the end of March 2003.

The output from the furnace sensors and the coal flow monitoring system was interfaced into the plant data historian to permit capture of data from the new systems along with other plant performance data.

2.1.4   Task 1.4 – Sensor Integration/Testing

In this task, tests will be performed to evaluate the information obtained from the sensors. Data were collected from the furnace sensors during the baseline tests and following start up of the boiler. These data are being analyzed.

2.1.5 Task 1.5 – Baseline Testing

In this task, tests will be performed on Holcomb Station Unit 1 to gather baseline performance and emissions data prior to retrofit of the emissions control equipment. This data set will serve as a comparison for the results of optimization tests performed on the unit.

In February 2003, baseline tests were performed on the unit. The primary information collected during the tests consisted of:

- Boiler operating and performance data
- Economizer outlet gaseous emissions data
- Coal and flyash samples

The tests characterized boiler operation and performance under normal operating conditions at full and low loads and at various operating conditions at full load. The various conditions evaluated included variations in the boiler excess air setting and coal flow distribution. Mill biasing tests were also conducted to evaluate the impact of mill operation on spatial combustion performance as well as to provide a relative indication of the burner balance within a mill. The test data are being analyzed.

2.1.6 Task 1.6 – PSD Review

In this task, a regulatory review will be performed to assure that the project will not impact the ambient air quality of the region.

During this reporting period, modeling necessary to determine the impact of increased emissions arising from the increased energy production from the unit was completed. While NO_X emissions will decrease greatly as a result of this project, a PSD review, of which this modeling effort is a part, is necessary to evaluate the potential increases in SO_2 and CO that can occur following the completion of Phase III of the project. Some additional minor revisions to the models may be required pending evaluation of various boundary conditions and assumptions. However, the preliminary results show that there are no impacts on ambient air quality brought about by the proposed changes in operating conditions.

To support the PSD analysis, a BACT evaluation was performed. This evaluation is being reviewed and will thereafter be submitted to the Kansas Department of Health and Environment for regulatory review and approval. A draft permit revision to accompany the BACT review and the PSD permit application is being prepared.

2.2 Task 2.0 – Phase II – Low-NOx Burner Modifications

The objective of Phase II is to demonstrate the effectiveness of low-cost modifications to the existing, first generation low-NO_X burners to reduce NO_X emissions. This phase will also include modifications to the existing pulverized coal (PC) piping to permit automated fuel balancing among all burners. The scope of work for the Low-NO_X Burner Modifications Phase is being performed in the following three tasks.

2.2.1 Task 2.1 – Low-NOx Burner Modifications

In this task, the existing twenty-five B&W dual-register burners installed on Holcomb Station Unit 1 are being modified to reduce NO_X emissions, particularly when operated in conjunction with the overfire air system installed in Phase III.

The design of the low-NO_X burner modifications was completed and approved by the plant. The components were fabricated and installed during the plant outage in March 2003. The modifications consist of the addition of a coal pipe expander and flame stabilizing ring to the coal pipe, extension of the secondary air sleeve, and the addition of a sliding sleeve over the tertiary air register to control the combustion air split to the burner. During installation, it was found that some field modifications to the components were necessary to permit the ignitors to be inserted past the flame-stabilizing ring. These modifications were most significant with the "E" row of burners as the existing coal nozzles on these burners were tilted upwards. During start up, it was necessary to insert the ignitor scanners further forward and to adjust the position of the main flame scanners in order to get an acceptable signal. Overall, the burner modifications appear to generate a stable flame over a wide range of burner settings and over the normal boiler load and mill operation.

2.2.2   Task 2.2 – PC Piping Coal Flow Control and Balancing System/Testing

In this task, the five pulverizers will be equipped with a coal-flow control system consisting of an automated coal-flow balancing damper. The automated coal damper will be integrated with the coal-flow monitoring system to provide for automatic balancing of all the burners over the boiler load range.

The detailed design of the automated coal-balancing damper was completed and approved by the plant. Twenty-five dampers were fabricated and installed during the plant outage in March 2003. One damper was installed on each coal pipe exiting the five coal mills. Each damper is equipped with a control drive. The drives will be brought into service in the next reporting period. During start up, the drives functioned as designed. However, several of the drives needed to have coal dust blown out of the guide vanes. The build up may have been primarily due to the wet coal that was fired during the initial start up following the outage. The build up may be preventable once the drives are automated, however, the installation of a purge air system to periodically clean the guide vanes is being evaluated. Following the outage, the dampers were manually adjusted to balance the coal flow based upon the coal flow monitoring system output.

2.2.3   Task 2.3 – Design of OFA Penetrations

To support implementation of Phase III, this task will consist of the detailed design of an optimum overfire air system for this unit.

During this reporting period, a preliminary layout for the OFA ductwork was completed. Engineers walked down the preliminary routing and identified several interferences. A revised layout is being prepared. The design of the OFA injector is in progress.

2.3   Task 3.0 – Phase III – Advanced Overfire Air System

The objective of this phase of the project will be to demonstrate deep NO_X control competitive with SCR installations with the addition of an overfire air system coupled with the existing Phase I and II modifications to optimize overall system performance. The integration of all three phases of these improvements will provide the opportunity to reduce NO_X emissions permit
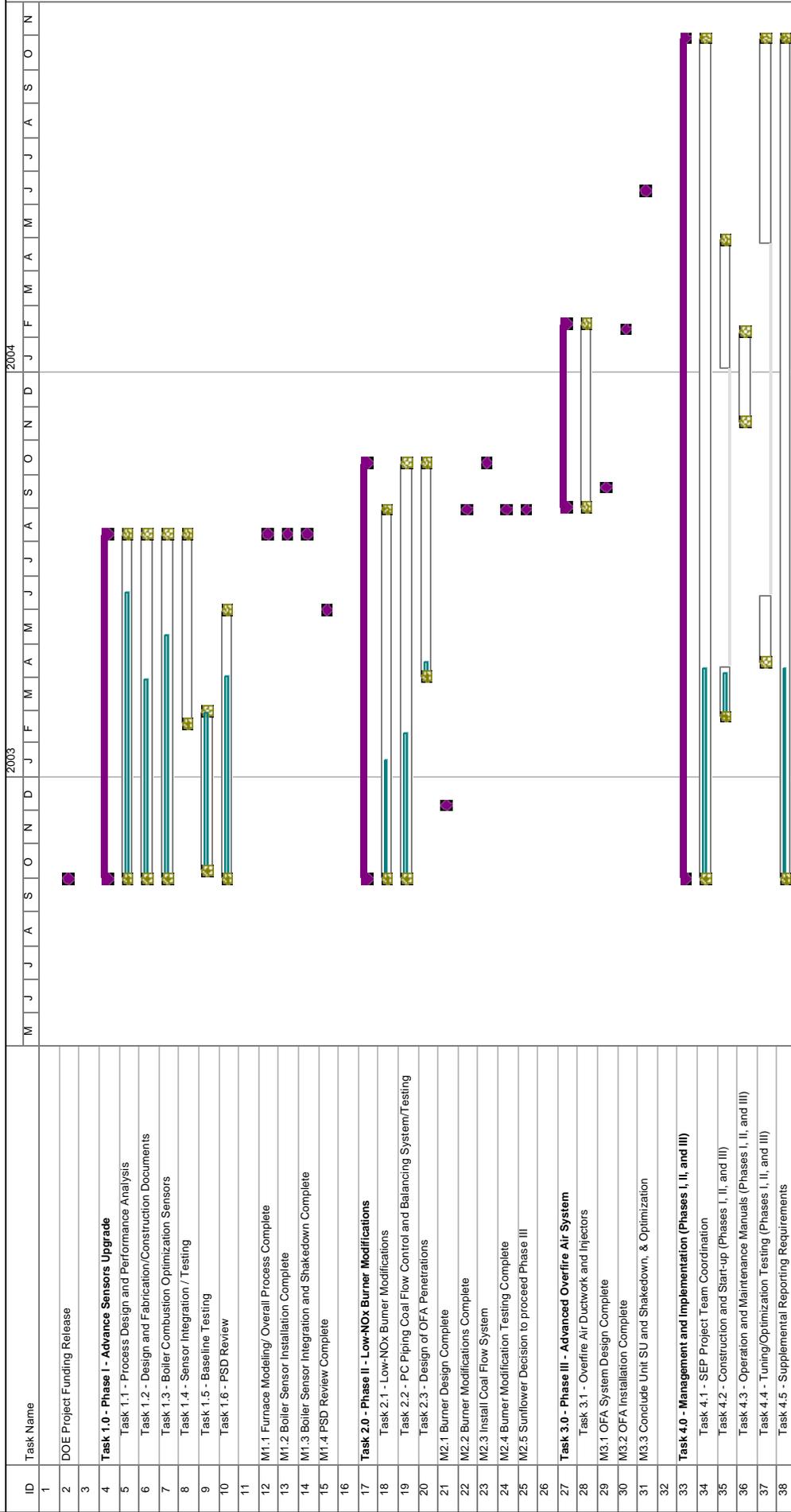
improvements in power plant performance and output. This phase of the project has not been initiated.

Appendix A – Gantt Chart

ID	Task Name
1	
2	DOE Project Funding Release
3	
4	**Task 1.0 - Phase I - Advance Sensors Upgrade**
5	Task 1.1 - Process Design and Performance Analysis
6	Task 1.2 - Design and Fabrication/Construction Documents
7	Task 1.3 - Boiler Combustion Optimization Sensors
8	Task 1.4 - Sensor Integration / Testing
9	Task 1.5 - Baseline Testing
10	Task 1.6 - PSD Review
11	
12	M1.1 Furnace Modeling/ Overall Process Complete
13	M1.2 Boiler Sensor Installation Complete
14	M1.3 Boiler Sensor Integration and Shakedown Complete
15	M1.4 PSD Review Complete
16	
17	**Task 2.0 - Phase II - Low-NOx Burner Modifications**
18	Task 2.1 - Low-NOx Burner Modifications
19	Task 2.2 - PC Piping Coal Flow Control and Balancing System/Testing
20	Task 2.3 - Design of OFA Penetrations
21	M2.1 Burner Design Complete
22	M2.2 Burner Modifications Complete
23	M2.3 Install Coal Flow System
24	M2.4 Burner Modification Testing Complete
25	M2.5 Sunflower Decision to proceed Phase III
26	
27	**Task 3.0 - Phase III - Advanced Overfire Air System**
28	Task 3.1 - Overfire Air Ductwork and Injectors
29	M3.1 OFA System Design Complete
30	M3.2 OFA Installation Complete
31	M3.3 Conclude Unit SU and Shakedown, & Optimization
32	
33	**Task 4.0 - Management and Implementation (Phases I, II, and III)**
34	Task 4.1 - SEP Project Team Coordination
35	Task 4.2 - Construction and Start-up (Phases I, II, and III)
36	Task 4.3 - Operation and Maintenance Manuals (Phases I, II, and III)
37	Task 4.4 - Tuning/Optimization Testing (Phases I, II, and III)
38	Task 4.5 - Supplemental Reporting Requirements

Task		Summary		Rolled Up Progress		Project Summary		Deadline	
Progress		Rolled Up Task		Split		External Milestone			
Milestone		Rolled Up Milestone		External Tasks		External Milestone			