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EVALUATION OF GAS-REBURNING AND LOW NO_x
BURNERS ON A WALL FIRED BOILER

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Technical Progress Report No. 14
For the Period
January 1 through March 31, 1994

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Clean Coal Technology (CCT) implies the use of coal in an environmentally acceptable manner. Coal combustion results in the emission of oxides of nitrogen (NO_x), which are precursors of both acid rain and ozone formation. The primary objective of this CCT project is to evaluate the use of Gas Reburning and Low NO_x Burners (GR-LNB) for NO_x emission control from a wall fired boiler. It is anticipated that, if the demonstration is successful, the GR-LNB technology could become commercialized during the 1990's and will be capable of (1) achieving significant reduction in the emissions of nitrogen oxides and sulfur dioxide (another acid rain precursor) from existing facilities to minimize environmental impacts such as transboundary and interstate pollution and/or (2) providing for future energy needs in an environmentally acceptable manner.

Low NO_x burners are designed to delay the mixing of the coal fuel with combustion air to minimize the NO_x formation. Typically, one may obtain up to 50% reduction in NO_x emissions through the use of LNB. For LNB applications, the technology is developed and a number of LNB designs are commercially available.

With GR, about 80-85 percent of the coal fuel is fired in the main combustion zone. The balance of the fuel is added downstream as natural gas to create a slightly fuel rich environment in which NO_x is converted to N_2 . The combustion process is completed by over-fire air addition. SO_x emissions are reduced to the extent that natural gas replaces sulfur-containing coal. The level of NO_x reduction achievable with 15-20% natural gas is on the order of 50-60 %. Thus the emission reduction target of the combination of these two developed technologies is about 70%.

Specifically, the technical objectives of this project are to:

1. Demonstrate the full effectiveness of GR-LNB for NO_x emission control. This includes the performance of the separate technologies and of the integrated GR-LNB technology.

2. Demonstrate the compatibility of GR-LNB with existing wall fired boilers.
3. Demonstrate the additional reductions in SO₂, particulate and CO₂ achievable with GR-LNB.
4. Demonstrate the synergism of GR-LNB with sorbent injection for SO₂ control if a sorbent injection system is installed outside the scope of this project.
5. Develop a data base which can be used to establish the commercial viability of GR-LNB to meet existing and projected emission control regulations.
6. Transfer the project results to industry to ensure that GR-LNB is a recognized cost effective competitor for utility boiler emission control.

This project is being conducted in three phases at the host site, a 172 MW_e wall fired boiler of Public Service Company of Colorado (PSCo), Cherokee Unit 3 in Denver, Colorado: Phase I - Design and Permitting, Phase II - Construction and Start-up, and Phase III - Operation, Data Collection, Reporting and Disposition. Technology transfer to industry is accomplished through the formation of an industry panel.

Phase I of the project commenced on October 13, 1990 and was completed June 30, 1992.

Phase II of the project commenced on June 13, 1991, and was completed on September 2, 1992.

Phase III of the project was approved and commenced on April 15, 1992. Phase III activities during this reporting period involved the continuation of long term testing and the extension of the program through 6-30-95. Additional funds were also allocated and changes in the workscope of Phase III were made to include Gas Reburning System Enhancements.

Key Words

SO _x	Ash	Emission
SO ₂	Coal	Control
NO _x	Gas	Boiler

NO

Burners

Start-up

CEMS

Reburning

BPMS

Low NO_x Burners

Construction

Instrumentation

Industry Panel

Injection

Precipitator

Flue Gas

Contracts

Baghouse

Ducts

2.0 INTRODUCTION

The specific goal of this project is to demonstrate NO_x emission reductions of 70 percent or more as a result of combining LNB and GR on a utility boiler having the design characteristics mentioned above. A Host Site Agreement has been signed by EER and a utility company in the State of Colorado: Public Service Company of Colorado (Cherokee Unit No. 3, 172 MW_e) front wall fired boiler near Denver.

To achieve the objectives of the project, it is being conducted in the following three phases at the host site.

- Phase I: Design and Permitting
- Phase II: Construction and Start-up
- Phase III: Operation, Data Collection, Reporting and Disposition

Phase I is complete.

Phase II is complete.

Phase III of the project (Operation, Data Collection, Reporting and Disposition) officially began on April 15, 1992 with Task 1, Project Management work. Due to delays such as the rebuilding of pulverizers, Task 2, Optimization commenced mid-September, 1992. Planned and unplanned boiler shutdowns delayed completion of Task 2 until late April 1993. Task 3, Long Term Testing began on April 27, 1993 with Gas Reburn controls configured in automatic to provide a load following test condition. Long term testing continued through January 20, 1994. The six week Cherokee Unit #3 outage followed, concluding on March 6, 1994. After completion of the outage, during which EER made a number of enhancements to the Gas Reburn (GR) system, the Low NO_x Burners were started up and optimized. No further long term testing was performed during the reporting period.

Major work performed during this past quarter was as follows:

1. Continued Long Term Load Following testing through January 20, 1994.
2. Continued data analysis of long term test results.
3. Installed modifications to improve economics of the Gas Reburn (GR) system:
 - Modified Overfire Air (OFA) nozzles.
 - Eliminated Flue Gas Recirculation (FGR) from the natural gas injection system.
 - Modified natural gas injection system for high pressure injection.

3.0 PROJECT DESCRIPTION

Within the final phase of the project, the following tasks will be performed to demonstrate the cost effective control of NO_x and SO_x emissions from pre-NSPS coal fired utility boilers:

Phase III: OPERATION, DATA COLLECTION, REPORTING AND DISPOSITION

Task 1 - Project Management

- Continuation of Phases I and II project management activities.
- Conducting final project review at conclusion of project.

Task 2 - Optimization Testing

- Optimization of LNB installation.
- Optimization of GR-LNB technology
- Evaluation of effects of process variables on emission control performance.
- Determination of operating conditions for optimum overall performance.

Task 3 - Long Term Tests

- Operation of GR-LNB equipment under optimized conditions for approximately one-year duration.
- Measurement of emission control system performance.
- Determination of boiler impacts.

Task 4 - Evaluation of Field Test Results

- Analysis of test data.

- Preparation of guideline manuals for application of GR-LNB technology, including design recommendations, cost projection and comparisons with competing technologies.

Task 5 - Restoration

- Disposition of GR-LNB equipment installation:
To be retained by host site or removal and restoration work.

Task 6 - Technology Transfer

- Continuation of technology transfer activities from Phases I and II.
- Meeting with Industry Panel to review results obtained.

Task 7 - Gas Reburning Enhancements

- Modification of OFA and Natural Gas injectors.
- Elimination of FGR system.
- Parametric and Long Term Testing of GR Enhancements.

4.0 PROJECT STATUS

4.1 Phase I Design and Permitting Phase I is Complete.

4.2 Phase II Construction and Startup Phase II is Complete.

4.3 Phase III Operation, Data Collection, Reporting and Disposition

4.3.1 Task 1 - Project Management

Project management activities this reporting period consisted of coordinating and planning, long term load following testing, data analysis and issuance of reports as required by the cooperative agreement.

Also, occurring during this reporting was the preparation of the continuation application for additional funds and extension of the project to include the GR Enhancements.

4.3.2 Task 2 - Optimization Testing

Optimization testing is completed.

4.3.3 Task 3 - Long Term Testing

Long term testing continued this quarter. The Gas Reburn (GR) system was on load following operation this quarter through January 20, 1994. Long term testing was interrupted by the 6 week Cherokee Unit #3 outage, which was followed by the Low NO_x Burners startup and optimization.

4.3.4 Task 4 - Evaluation of Results

Data evaluation will be done throughout the entire test program. The attached figures 1 - 8 provide up to date performance of Gas Reburn-Low NO_x Burner (GR-LNB) tests. Figures 1 - 3 show the AVERAGE NO_x reduction along with percent O₂, figures 4 - 6 show AVERAGE NO_x reduction -vs- MW_e load. Figures 1 - 6 also show varying levels of natural gas utilization ranging from 5% to 18% total fuel input. Finally, figures 7 - 8 show AVERAGE NO_x reduction along with percent O₂ and MW_e load with only the Low NO_x Burners in service.

4.3.5 Restoration

With testing now scheduled to be completed in September 1994, a preliminary estimate and schedule is being prepared should the host utility request restoration.

4.3.6 Technology Transfer

None to report.

4.3.7 Gas Reburning Enhancements

The participants recommended and agreed to fund modifications to enhance the Gas Reburning (GR) system at Cherokee Unit #3. The enhancements will reduce the GR capital installation and operating costs by eliminating the Flue Gas Recirculation (FGR) system. In addition, the Overfire Air (OFA) and Natural Gas injection systems were resized for lesser quantities of gas and modified for better mixing in the GR and OFA zones.

In May, upon completion of the tuning and guarantee testing of the Low NO_x Burners, parametric and long term testing of the reconfigured GR system will begin.

Long Term GR-LNB Test Performance at Cherokee

Average NOx Reduction = 63.8%. Average CEMS O2% = 3.87. Average Load = 136 MWe Net

Figure 1

Long Term GR-LNB Test Performance at Cherokee

Average NOx Reduction = 65.5%. Average CEMS O2% = 4.23. Average Load = 137 MWe Net

Long Term GR-LNB Test Performance at Cherokee

Figure 3

Long Term GR-LNB Test Performance at Cherokee

Average NOx Reduction = 63.8%. Average CEMS O2% = 3.87. Average Load = 136 MWe Net.

Long Term GR-LNB Test Performance at Cherokee

Figure 5

Long Term GR-LNB Test Performance at Cherokee

Figure 6

Long Term LNB Test Performance at Cherokee

Figure 7

Long Term LNB Test Performance at Cherokee

Average NOx Reduction = 42.4%. Average CEMS O2% = 4.40. Average Load = 125 MWc Net

Figure 8

5.0 PLANNED ACTIVITIES

During the next quarter (April through June, 1994) the following work is planned:

1. Project Management continues into the next quarter concentrating on successful operation of the Parametric and Long Term Tests associated with Gas Reburning Enhancements.
2. Data evaluation will continue throughout the Testing period.
3. Demonstrate the effectiveness of the modifications made to the Gas Reburning and Overfire Air systems on overall GR performance, and economics.
4. Gas Reburn equipment will be serviced as per maintenance schedules.

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