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

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Prepared for
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Colorado Interstate Gas Company
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# 1.0 SUMMARY

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 $SO_2$, particulate and $CO_2$ achievable with GR-LNB.
4. Demonstrate the synergism of GR-LNB with sorbent injection for $SO_2$ 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 initiation of the second generation gas reburning parametric testing. This technology utilizes enhanced natural gas and overfire air injectors with elimination of the flue gas recirculation system. The objective is to demonstrate $NO_x$ reductions similar to that of long term testing but with a reduced capital cost requirement through elimination of the FGR system.

Key Words

| | | |
|---|---|---|
| $SO_x$ | Ash | Emission |
| $SO_2$ | Coal | Control |
| $NO_x$ | Gas | Boiler |
| NO | Low $NO_x$ Burners | Precipitator |
| Burners | Construction | Flue Gas |
| Start-up | Instrumentation | Contracts |
| CEMS | Industry Panel | Baghouse |
| Reburning | Injection | Ducts |
| BPMS | | |

## 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 Reburning 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 Reburning (GR) system, the Low $NO_x$ Burners were started up and optimized. Guarantee tests followed. During the last quarter, no significant coal/gas reburning was performed due to a coal mill being out of service, impacting full load operation. However, gas/gas reburning was performed.

Major work performed during this past quarter was as follows:

1. Gas/gas reburning testing.

# 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, data analysis and issuance of reports as required by the cooperative agreement.

A no-cost schedule extension to December 31, 1995 was approved. The extension will allow additional time to complete the current testing and accommodate utility optimal dates for restoration.

### 4.3.2 Task 2 - Optimization Testing

Optimization testing is completed.

### 4.3.3 Task 3 - Long Term Testing

Long term testing is completed.

### 4.3.4 Task 4 - Evaluation of Results

Due to the suspension of coal/gas reburning testing owing to the coal mill outage, no results are presented.

100% gas was burned in Cherokee's Unit 3 from November 2 thru 11, 1994. Twenty LNB and 44 GR-LNB tests were conducted at the 100% gas firing condition with a total of 71 hours of 100% gas firing tests. The test results are as follows:

| Load MW Net | % Gas Heat Input | $NO_x$, lb/MMBtu | LNB Baseline $NO_x$ | $NO_x$ Reduction |
|---|---|---|---|---|
| 150 | 6.4 | 0.173 | 0.325 | 46.8% |
| 120 | 6.8 | 0.111 | 0.211 | 49.8% |

LNB Baseline NOx was adjusted to a nominal $O_2$ of 3.6%.

### 4.3.5 Restoration

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

### 4.3.6 Technology Transfer

The Industry Panel Meeting scheduled for December 5-6, 1994 in Orlando, Florida was canceled due to lack of participation by the invited electrical utilities. The meeting has been rescheduled for the Spring of 1995 and will be held at a location in the northeast United States. Although the panel was canceled, EER conducted a reburning seminar just prior to the PowerGen Conference which was moderately attended.

### 4.3.7 Gas Reburning Enhancements

Parametric/optimization testing of the second generation gas reburning continued during October; however, no significant data was collected. The extent of the testing was limited as follows:

One of the Foster Wheeler burners failed in early October and was taken out of service. The damage consisted of burned holes in the liners separating the coal and combustion air passages. It was determined that the damage was not caused by operation of the gas reburning system. However, the gas reburning testing was curtailed during the period of time the utility assessed the damage.

PSCo placed one of the four coal mills out of service in mid-October to rebuild the unit. The mill remained out of service thru December and is expected to be back on line in mid-January, 1995. During this period, no full load operations are possible which severely limits the gas reburning parametric testing.

Although coal/gas reburning was not possible, EER was able to accomplish the planned gas/gas reburning test in its entirety.

The parametric and load-following testing of the second generation gas reburning system will be accomplished in January, 1995. A two-shift operation will allow for completion of all testing by the end of that month.

## 5.0 PLANNED ACTIVITIES

During the next quarter (October through December, 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 Reburning equipment will be serviced as per maintenance schedules.

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