Coal Reburning for Cyclone
Boiler NO\textsubscript{x} Control Demonstration

Quarterly Report No. 13
April, May and June 1993

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B&W CRD Agreement No.: CRD-1229

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Prepared by:
Babcock & Wilcox
a McDermott Company

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1.0 EXECUTIVE SUMMARY

The Coal Reburning for Cyclone Boiler NO\textsubscript{x} Control Demonstration project (DOE Agreement No. DE-FC22-90PC89659) progress for April, May, and June 1993 is identified in this 13th quarterly report and pertains to the on-going activities of draft Final Report Preparation. The project involves retrofitting/testing the reburning technology at Wisconsin Power & Light’s 100 MWe Nelson Dewey Unit #2 in Cassville, Wisconsin to determine the commercial applicability of this technology to reduce NO\textsubscript{x} emission levels.

Phase III - Operation and Disposition activities emphasized preparation of the final report. A draft has been completed and it will be provided to DOE/PETC in August for review and comment. The preliminary results of the hazardous air pollutant (HAP) testing indicate no major impact of reburn on volatile organics emissions. HAP results will be completed and reported by Acurex in July, 1993.
2.0 INTRODUCTION

As per the Cooperative Agreement No. DE-FC22-90PC89659 dated April 2, 1990, the following quarterly report has been prepared for the Coal Reburning for Cyclone Boiler NO\textsubscript{x} Control Demonstration Project. The period covered by this quarterly report is April through July 1993. This report represents the 13th three-month period of the project.

The subject of this report identifies progress during the quarter for Phase III - Operation and Disposition.

Under Phase III - Operation and Disposition, preparation of the final report continues. The final emissions and boiler performance results will be part of the final report.
3.0 PROJECT DESCRIPTION

3.1 PROJECT OVERVIEW

The current energy policy of the United States includes the expanded use of coal in utility and industrial applications. However, the increased use of coal must not conflict with environmental goals and thus requires development of cost-effective technology to control the pollutants resulting from coal combustion. Of major concern is the problem of oxides of nitrogen in the Northeastern United States and portions of Canada.

The reduction of NO\textsubscript{x} and SO\textsubscript{2} emissions from fossil fired boilers has been a major objective of the DOE, the EPA, and all of the major boiler and burner manufacturers for many years. This is demonstrated by a number of concurrent efforts that have been and are being conducted to develop lower NO\textsubscript{x} burners for pulverized coal applications. Reduction of NO\textsubscript{x} emissions via combustion modifications presents many options for most coal-fired utility boilers, but not for the 26,000 MWe of cyclone boiler generating capacity. The operating characteristics of a cyclone boiler do not lend themselves to delayed mixing or staged combustion which are the two major low-NO\textsubscript{x} alternatives for coal-fired boilers. The reburning process is the best known technically and economically feasible low-NO\textsubscript{x} alternative via combustion modification for cyclone boilers. Back-end NO\textsubscript{x} removal systems, such as Selective Catalytic Reduction (SCR) technology offers promise of NO\textsubscript{x} control for cyclones but at high capital and operating costs.

B&W engineering studies followed by pilot-scale testing has developed/confirmed the potential of utilizing gas, oil or coal reburning as a viable NO\textsubscript{x} reduction technology. To date, two U.S. sponsored programs promote natural gas/oil as a reburning fuel because it was believed that gas/oil will provide significantly higher combustion efficiency than using coal at the reburn zone. Although B&W has shown that gas/oil reburning will play a role in reducing NO\textsubscript{x} emissions from cyclone boilers, B&W coal reburning research has also shown that coal as a reburning fuel performs nearly as well as gas/oil without deleterious effects on combustion efficiency. This means that boilers using reburning for NO\textsubscript{x} control can maintain 100\% coal usage instead of switching to 20\% gas/oil for reburning. As a result of the B&W performed coal reburning research, the technology has advanced to the point which it is now ready for demonstration on a commercial scale.

The coal reburning equipment is to be installed in the furnace of the boiler, downstream of the cyclone burners. The equipment consists of coal reburning burners and overfire air ports and associated control systems. Outside of the boiler, a coal pulverizer will be installed as well as coal piping to the reburn burners. The reburn system will inject 20\% to 30\% of the coal feed.
directly into the boiler, bypassing the cyclones and reducing cyclone load to 80% to 70% of normal. An increase in ash particulate, which is substantially removed in the cyclones will occur within the boiler, increasing ash collection requirements at the precipitator. The majority of plant's precipitators should be capable of handling the increased ash loading.

The coal reburning for cyclone boiler NO\textsubscript{x} control system consists of commercially available equipment, such as a pulverizer, burners, a pneumatic coal transfer system, overfire air ports and a control system, all of which are well proven, reliable equipment that can be readily installed. Extensive power plant modification is not required to implement the reburn technology which will increase the potential for commercialization.

The coal reburning technology will be a desirable alternative for cyclone boiler NO\textsubscript{x} control by offering:

- A technically and economically feasible low-NO\textsubscript{x} alternative for cyclone boilers to achieve a 50% to 60% NO\textsubscript{x} reduction where one currently does not exist.

- Significant reductions in emission-levels of oxides of nitrogen achieved at a low capital cost and very low operating costs (compared to the SCR technology).

- No need for a supplemental fuel. Reburn will be carried out using the present boiler fuel which is coal.

- A system that will maintain boiler reliability, operability, and steam production performance after retrofit.

The coal reburning for cyclone boiler NO\textsubscript{x} control demonstration project will be carried out at the Nelson Dewey Station Unit No. 2 of Wisconsin Power and Light in Cassville, Wisconsin. Unit No. 2 is small enough (100 MWe) to limit project costs, but large enough to assure that the reburning technology can be successfully applied to the cyclone-fired utility boiler population. As part of the project, B&W's 6 million Btu/hr SBS pilot facility will be utilized to duplicate the operating practices of WP&L's Nelson Dewey Unit #2. The coal which is fired at Nelson Dewey will be fired in the SBS cyclone and will also be utilized as the reburn fuel. During the field test phase at Nelson Dewey Station, emission and performance data will be acquired and analyzed before and after the coal reburn conversion to determine the NO\textsubscript{x} reduction and impact on boiler performance. Combining these combustion test results with physical and numerical flow modeling of the technology as applied to Dewey Unit #2, will provide a comprehensive test program not only for successful application of WP&L's Unit, but for the cyclone population as a whole.
3.2 OBJECTIVES

It is the objective of the Coal Reburning for Cyclone Boiler NO$_x$ Control Project to fully establish that the coal reburning clean coal technology offers cost-effective alternatives to cyclone operating electric utilities for overall oxides of nitrogen control. The project will evaluate the applicability of the reburning technology for reducing NO$_x$ emissions in full scale cyclone-fired boilers which use coal as a primary fuel. The performance goals while burning coal are:

- Greater than 50 percent reduction in NO$_x$ emissions, as referenced to the uncontrolled (baseline) conditions at full load.
- No serious impact on cyclone combustor operation, boiler efficiency or boiler fireside performance (corrosion and deposition), or boiler ash removal system performance.

3.3 BACKGROUND

Boilers equipped with cyclone furnaces have many important advantages over conventional pulverized-coal-fired boilers, such as the capability to burn a range of low-grade fuels and simpler, more economical coal preparation and feeding system. However, cyclone units utilize extremely fast mixing between the coal and combustion air and, therefore, inherently promote well mixed combustion and elevated NO$_x$ emissions. It is estimated that 21% of the total NO$_x$ emissions from coal fired power stations in the U.S. come from cyclone fired boilers. The majority of the existing 26,000 MW of cyclone boiler generating capacity will probably continue to operate for the next 20 years. Thus, cyclone boilers are prime candidates for mandated reduction in the emissions of oxides of nitrogen. Currently there is no proven retrofit low NO$_x$ combustion control technology for cyclone boilers. The previous attempts to apply staged combustion have not been successful due to operational problems (cyclone corrosion).

The use of Selected Catalytic Reduction (SCR) technology offers promise of controlling NO$_x$ from these units, but at high capital and operating cost. Reburning is therefore a promising alternative NO$_x$ reduction approach for cyclone equipped units at a more reasonable operating cost.

Reburning is a process by which NO$_x$ produced in the cyclone is reduced (decomposed to molecular nitrogen) in the main furnace by injection of a secondary fuel. The secondary (or reburning) fuel creates an oxygen deficient (reducing) region which accomplishes decomposition of the NO$_x$. Since reburning can be applied while the cyclone operates under its normal oxidizing condition, it effects
on cyclone performance can be minimized. Sometime ago, B&W performed a feasibility analysis for applying reburn technology to utility cyclone-fired boilers, and the results were very encouraging. Based on the results of the feasibility analysis, pilot scale evaluation of cyclone reburn was undertaken. B&W's 6 million Btu/hr Small Boiler Simulator (SBS) was utilized to perform the pilot-scale cyclone reburning tests. Three different reburning fuels, natural gas, #6 oil, and pulverized coal were utilized. The results indicate that 50 to 80% NO\textsubscript{x} reduction from baseline conditions can be achieved while utilizing 15 to 25% reburning fuel. Additionally, the tests revealed that the potential side effects of the technology (e.g., changes in combustion efficiency, deposition, and corrosion) would not adversely affect boiler performance.

3.4 HOST SITE BOILER

The host site is Wisconsin Power and Light's Nelson Dewey Unit No. 2. The following is a summary of pertinent information.

- **UTILITY:** Wisconsin Power & Light
- **UNIT ID:** Nelson Dewey Unit No. 2
- **LOCATION:** County Trunk VV, Cassville, Grant County, Wisconsin 53806
- **NAME PLATE RATE:** 100 MWe
- **TYPE:** Steam Turbine
- **PRIMARY FUEL:** Bituminous Coal
- **OPERATION DATE:** October 1962 - Unit No. 2
- **BOILER ID:** B&W RB-369
- **BOILER CAPACITY:** Nominal 110 MWe
- **BOILER GENERAL CONDITION:** Good
- **BOILER MANUFACTURER:** Babcock & Wilcox
- **BOILER TYPE:** Cyclone Fired RB Boiler
- **REBURNING DEMONSTRATION FUEL:** Indiana (Lamar) Bituminous Coal, Medium Sulfur (1.87%)
- **BURNERS:** Three B&W Vortex-Type Burners, Single-wall fired
- **PARTICULATE CONTROL:** Research Cottrell ESP
- **BOILER AVAILABILITY:** 90% Availability
3.5 PROJECT TEAM


Major subcontractors are Acurex and Sargent & Lundy. Acurex has been designated to perform continuous emissions monitoring activities as well as various analytical requirements during the testing program. Sargent & Lundy will perform those activities pertaining to the coal handling system supplying coal to the coal pulverizer in addition to various structural steel and electrical design specification activities.

A summary of the overall project organization is as follows:

Project Organization
- Department of Energy - 50% funding co-sponsor
- Babcock & Wilcox - Prime contractor and project manager
- Wisconsin Power & Light - Host site utility and funding co-sponsor
- EPRI - Technical advisor and funding co-sponsor
- State of Illinois - funding co-sponsor
- Utility funding co-sponsors
- Acurex Corporation - testing subcontractor
- Sargent & Lundy - architect engineer subcontractor

3.6 PROJECT PHASES

The coal reburn project, which is a $13.64 million project, consists of four separate phases which are planned to occur over a 49 month period. These are:

- Phase I - Design and Permitting

During this phase, collection of baseline emissions and performance data, along with performance of general boiler system assessment, will be completed at WP&L's Nelson Dewey Unit #2 prior to the coal reburning retrofit. The coal reburn
system will be designed based upon B&W's pilot-scale combustion tests, physical and numerical flow modeling tests, and experience/knowledge of full-scale burner/OFA port/control system retrofits.

• Phase IIA - Long Lead-Time Item Procurement

In order to meet the construction schedule, long lead-time equipment will be ordered during the design and permitting phase. To facilitate the funding of this procurement activity, Phase II is divided into two parts, Phase IIA and Phase IIB.

• Phase IIB - Construction and Start-up

The coal reburn system will be fabricated and installed at Nelson Dewey No. 2 and started up to provide a fully operational system prior to testing.

• Phase III - Operation and Disposition

Parametric/optimization and performance tests will assess the potential of the technology from both the resulting emission reductions and boiler performance capability aspects. Both full load and reduced load operations will be evaluated for the cyclone reburn technology. Finally, readiness for commercialization will be determined from both a technical and economic viewpoint.
4.0 PROJECT STATUS

The time period covered by this Quarterly Report No. 13 is April, May, and June 1993. Progress will be discussed on a task basis for Phase III activities.

4.1 PHASE I - DESIGN AND PERMITTING

All major activities in Phase I are complete.

4.2 PHASE IIA - LONG LEAD-TIME ITEM PROCUREMENT

The long lead-time item procurement process is complete.

4.3 PHASE IIB - FABRICATION, INSTALLATION, START-UP AND SHAKEDOWN

All major activities of Phase IIB are complete.

4.4 PHASE III: OPERATION AND DISPOSITION

Activities in Phase III include Management and Reporting Parametric Optimization Testing, Long-Term Performance Testing, Performance, Economic and Application Studies, the Final Report and Disposition. A description of activities expected in each task is provided followed by reported activity.

4.4.1 Task 1 - Project Management and Report

The purpose of this task is to account for the management and reporting activities and cost monitoring that apply to all tasks collectively in Phase III.

This task provides for overall project coordination, reporting, and supervision for Phase III of the Coal Reburning project. Additionally, this task includes a single point contact within B&W for DOE on the Coal Reburning project for reporting and resolution of technical and cost issues.

Monthly reports for the period of April, May, and June 1993 were completed and issued to DOE/PETC.

4.4.2 Task 2 - Parametric Optimization Tests of the Reburn System

Parametric optimization testing is complete.

4.4.3 Task 3 - Long Term Performance Testing

Long-term testing is complete. A summary of emissions and boiler performance testing results for both Lamar bituminous coal and western sub-bituminous coal was presented in Quarterly Report #12.
4.4.4 Task 4 - Performance, Economic, and Application Studies

As part of the economic analysis, EPRI has provided an updated version of its Technical Assessment Guide for use in evaluation of the reburn technology. Capital costs (dollars/installed KW) and levelized cost for NO<sub>x</sub> removal (dollars/ton of NO<sub>x</sub> removed) are being developed for the 110 MW size as well as a hypothetical 600 MW size. This information will be summarized in the project final report.

4.4.5 Task 5 - Final Report

The draft final report is in preparation and will be submitted in August.

4.4.6 Task 6 - Disposition

The title to the reburn system now resides with WP&L as one of the conditions of their involvement. The reburn system continues to be operated on Unit No. 2 in a load following manner. This task is complete.
5.0 PLANNED ACTIVITIES

Planned activities for the next quarter, July, August, and September 1993 will focus on completion of the final report. This final task of the project will be complete in October 1993.
6.0 SUMMARY

The coal reburning for cyclone boiler NOx control demonstration project's 13th Quarterly Report covering the time period of April, May, and June 1993 involves the work performed in Phase III - Operation and Disposition.

Phase III activities consisted of evaluation of performance data and preparation of the final report.
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