

**Cost-Effective Control of NO_x with Integrated Ultra
Low-NO_x Burners and SNCR**

Technical Progress Report

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INTRODUCTION

Coal-fired electric utilities are facing a serious challenge with regards to curbing their NO_x emissions. At issue are the NO_x contributions to the acid rain, ground level ozone, and particulate matter formation. Substantial NO_x control requirements could be imposed under the proposed Ozone Transport Rule, National Ambient Air Quality Standards, and New Source Performance Standards.

McDermott Technology, Inc. (MTI), Babcock & Wilcox (B&W), and Fuel Tech are teaming to provide an integrated solution for NO_x control. The system will be comprised of an ultra low-NO_x pulverized coal (PC) burner technology plus a urea-based, selective non-catalytic reduction (SNCR) system. This system will be capable of meeting a target emission limit of 0.15 lb NO_x/10⁶ Btu and target ammonia (NH₃) slip level targeted below 5 ppmV for commercial units. Our approach combines the best available combustion and post-combustion NO_x control technologies. More specifically, B&W's DRB-4ZTM ultra low-NO_x PC burner technology will be combined with Fuel Tech's NO_xOUT (SNCR) and NO_xOUT Cascade (SNCR/SCR hybrid) systems and jointly evaluated and optimized in a state-of-the-art test facility at MTI. Although the NO_xOUT Cascade (SNCR/SCR hybrid) system will not be tested directly in this program, its potential application for situations that require greater NO_x reductions will be inferred from other measurements (i.e., SNCR NO_x removal efficiency plus projected NO_x reduction by the catalyst based on controlled ammonia slip). Our preliminary analysis shows that the integrated ultra low-NO_x burner and SNCR system has the lowest cost when the burner emissions are 0.25 lb NO_x/10⁶ Btu or less. At burner NO_x emission level of 0.20 lb NO_x/10⁶ Btu, the levelized cost per ton of NO_x removed is 52% lower than the SCR cost.

Large-scale testing has been conducted in B&W's Clean Environment Development Facility (CEDF). Testing in the CEDF provides the premise for the evaluation and optimization of the integrated NO_x control system at conditions representative of pulverized coal-burning utilities. Past experience has shown that a large prototype, 100 million Btu/hr burner design can be readily scaled with minimal risk for commercial retrofit where a typical burner size is about 150 to 200 million Btu/hr. It is anticipated that a commercial offer can be made around the 2001-2002 timeframe.

A wide range of commercially available utility coals including Powder River Basin (PRB) subbituminous, high-volatile bituminous, and medium-volatile bituminous with respective baseline NO_x levels of 0.20, 0.30, and 0.45 lb NO_x/10⁶ Btu will be tested with the DRB-4ZTM ultra low-NO_x PC burner at different loads and excess air levels. It was expected that NO_x emissions in some commercial units could be higher than in the CEDF due to flame interactions, hotter furnaces, coal property value variations, imperfect mixing of NO_x reducing reagent with flue gas, etc. Therefore, to ensure that NO_x emissions of 0.15 lb NO_x/10⁶ Btu or lower can be attained in the field, the CEDF target level was set at 0.125 lb NO_x/10⁶ Btu or less. However, after refractory maintenance was performed in the CEDF, the furnace became very hot, and resulted in higher NO_x emissions. A new target of 0.15 lb NO_x/10⁶ Btu was established. The estimated market size for the integrated system is approximately 86,000 MW_e.

OBJECTIVES

The objective of this project is to develop an environmentally acceptable and cost-effective NO_x control system that can achieve less than 0.15 lb NO_x/10⁶ Btu for a wide range of coal-burning commercial boilers.

The system will be comprised of an ultra low-NO_x PC burner technology plus a urea-based, selective non-catalytic reduction (SNCR) system. In addition to the above stated NO_x limit of 0.15 lb NO_x/10⁶ Btu, ammonia (NH₃) slip levels will be targeted below 5 ppmV for commercial units. Testing will be performed in the 100 million Btu/hr Clean Environment Development Facility (CEDF) in Alliance, Ohio.

Finally, by amendment action, a limited mercury measurement campaign was conducted to determine if the partitioning and speciation of mercury in the flue gas from a Powder River Basin coal is affected by the addition of Chlorides to the combustion zone.

WORK PERFORMED

Task 1: Project Planning and Deliverables

Subtask 1.1 – Planning & Coordination

The purpose of this activity is to account for those project management and tracking activities and associated costs necessary to carry out the project in a timely, cost-effective manner. Coordination of different tasks has been accomplished by discussions between combustion and SNCR task leaders.

As a part of this task we prepared for a progress meeting in early October between DOE, MTI, B&W and Fuel Tech. Attached is a copy of the presentation.

Subtask 1.2 – Management Plan Preparation

Management Plan - MTI had prepared and submitted a Management Plan for the project. No activity in this reporting period.

Subtask 1.3 – Quarterly Reports

Project Status Report – The quarterly report covering July through September 2001 was prepared.

Quarterly Financial Report – The report is attached.

Subtask 1.4 – Data Analysis & Report Preparation

Final Report – We have been performing comprehensive data reduction and analysis. Burner optimization data and in-furnace HVT and gaseous species data have been reduced and are being plotted for inclusion into the final report. Data from mercury tests have been reduced, tabulated and are currently being analyzed.

Task 2: Modeling Application for Ultra Low-NO_x PC Burner and NO_xOUT™

Performance Optimization

Subtask 2.1 – Burner and Furnace Simulations

The objective of the subtask is to generate data sets for the determination of the optimum location for SNCR urea injection in the CEDF. B&W's proprietary flow and combustion modeling code, COMO, was used to model the plug-in DRB-4Z™ burner firing three coals. Each coal has been modeled at three loads: 40, 60 and 100 million Btu/hr. The single-burner CEDF furnace and convection pass shown was modeled based on as-built furnace dimensions and refractory specifications. The modeling study, as well as in-furnace temperature and gaseous measurements, has been used at Fuel Tech, Inc. (FTI) to assist in the design of the SNCR system.

This modeling work is completed for now. We are looking to see if revisions are needed to assist with analysis of the experimental results.

Subtask 2.2 – Additive Injector and SNCR Performance Simulations

The purpose of this subtask is to determine the optimum SNCR port locations. Fuel Tech has developed procedures for extracting and visualizing data from B&W's modeling of the test unit. During the period covered by this report, Fuel Tech performed SNCR performance calculations, using MTI's data sets that provided input to Fuel Tech's Chemical Kinetics Model (CKM), to predict SNCR performance and explain the results obtained in the CEDF.

Task 3: Ultra Low-NO_x DRB-4Z™ PC Burner Performance Evaluation at 100 million Btu/hr

Subtask 3.1 – Coal Procurement

No activity was performed in this quarter.

Subtask 3.2 – Ultra Low-NO_x PC Burner Hardware Selection

It has already been decided to use a plug-in DRB-4ZTM PC-fired burner for this project. This task is completed.

Subtask 3.3 – Coal Rank Variations Effects on Ultra Low-NO_x PC Burner Performance

Burner optimization tests have been completed.

Subtask 3.4 – Gas Species and Temperature Mappings

This task has been completed.

Task 4: Integrated NO_xOUTTM and Ultra Low-NO_x PC Burner Performance Evaluation at 100 Million Btu/hr**Subtask 4.1 – SNCR Process Optimization**

No activity.

Subtask 4.2 – Coal Rank Variations Effects on the Combined Ultra Low-NO_x PC Burner and NO_xOUT^â Performance

There was no testing performed in this quarter.

Task 5: Commercial Assessment

No activity.

SCHEDULE AND MILESTONE PLAN

All planned experimental tasks have been completed. After these tests we identified additional scope to DOE for their consideration. The proposed scope is described below.

1- Testing a water-cooled SNCR lance in front of superheater tubes - This technique has the following advantages:

- improved mixing between urea and boiler gases
- achieves very fine urea particles that evaporate quickly and engage in reducing NO_x

This technique has a good potential to achieve the OTR limit with PRB coal.

2- A hybrid SCR/SNCR technology can be commercialized to take advantage of the strength of both technologies. The full-load conditions of utility boilers are very challenging environments for SNCR technology, since temperatures are high and residence time is low for reaction. SNCR performs very well in low load conditions, since temperature is reduced and residence time is increased. SCR, on the other hand, can achieve over 90% reduction in full load, but there are concerns about catalyst poisoning at low loads due to ammonia bisulfate deposits on the catalyst. If we use SNCR in low load and SCR in full load, the hybrid system will use the strength of both technologies.

3- Burner Modifications – The DRB 4Z burner has been developed to the point that very low-NO_x emissions have been obtained with this burner. As an alternative to SNCR, we can perform burner modification tests to reduce the NO_x by only the burner itself.

Preliminary results are positive, but improved performance may be possible with additional testing. Currently, analysis of the test data is underway. The project schedule has been extended through March 2002.