

DOE/PC/90545--T9

DOE/PC/90545--T9

DE93 012274

Full-Scale Demonstration

Low-NOx Cell™ Burner Retrofit

Quarterly Report No. 7

for the period - April 1, 1992 through June 30, 1992

DOE Agreement No.: DE-FC22-90PC90545

B&W CRD Agreement No.: CRD-1250

Patents Cleared by Chicago on September 28, 1992

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Prepared by:

Babcock & Wilcox
a McDermott Company

September 21, 1992

Rev. 1 March 25, 1993

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared by Babcock & Wilcox pursuant to a cooperative agreement partially funded by the U.S. Department of Energy and neither Babcock & Wilcox nor any of its subcontractors nor the U.S. Department of Energy, nor any person acting on behalf of either:

- (a) Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights; or
- (b) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

Reference herein to any specific commercial project, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Department of Energy. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Department of Energy.

Table of Contents

- 1.0 Executive Summary
- 2.0 Introduction
- 3.0 Project Description
- 4.0 Project Status
- 5.0 Planned Activities (for next quarter)

1.0 EXECUTIVE SUMMARY

The Full Scale Demonstration Low-NO_x Cell™ Burner (LNCB™) Project (DOE Agreement No. DE-FC22-90PC90545) progress from April 1, 1992 through June 30, 1992 identified in this, the Seventh Quarterly Report. The Report centers on Phase III - Operation status.

The LNCB™ project involves retrofitting the two-nozzle cell burners at Dayton Power & Light's, 605 MWe J.M. Stuart Unit #4 Boiler near Aberdeen, Ohio with LNCB™ (a burner and integral NO_x port). Previous pilot-scale tests have shown such an arrangement to achieve 50% reduction in NO_x emission levels. This full-scale project will determine the commercial applicability of this technology.

Monthly reports covering the time period of this report and final copies of the Technical Progress Reports #5 and #6 were completed and issued to DOE PETC. An LNCB™ project technical paper was presented at the 85th Annual meeting of the Air & Waste Management Association in Kansas City, Missouri the week of June 22, 1992.

Fabrication and installation of all materials for the burner inversion and impeller change was completed during this quarter. The outage work, which began April 27th and concluded with the unit returning on line May 9th, went very smoothly.

DP&L inspected the unit during the outage. They found that the pendant superheater surfaces were unusually clean (devoid of its typical slagged condition). DP&L also noted that they had a significant decrease in the quantity of bottom ash and economizer outlet ash that has to be removed.

The parametric and optimized testing plan was finalized. The plan calls for 30 parametric tests to be done over a four week period beginning May 11th. The 19 different optimized test conditions were to be taken over a four week test period beginning June 15th.

The parametric testing phase of the project actually began May 14th after correcting test equipment problems. Preliminary results show that the impeller change and burner inversion were successful. The Low NO_x Cell™ burners achieved better than 50% NO_x reduction and carbon monoxide (CO) inside the lower furnace is less than 1000 ppm. The parametric testing phase of the project was concluded on June 4, 1992.

Following a week off from testing to review parametric test results and finalize optimum burner settings, optimized testing began June 15, 1992. This phase of testing will be completed by July 3, 1992.

Long term testing via a Continuous Emissions Monitor (CEM), will begin in July, 1992. CEM testing will continue until Spring of 1993 when Unit #4 comes off line for its annual outage which at this time is scheduled for April 4, 1993.

A key item remaining to be evaluated as part of the long term testing is furnace tube wall corrosion. H₂S probing similar to optimized test probing will be repeated at intervals two more times. Come the Spring '93 outage, ultrasonic testing of the furnace wall tubes as well as destructive examination of samples from the corrosion test panel will be taken.

2.0 INTRODUCTION

As per the Cooperative Agreement No. DE-FC22-90PC90545 dated October 11, 1990, the following quarterly report has been prepared for Phases I, IIA, IIB and III of the Full-Scale Demonstration of Low-NOx Cell™ Burner Project. The period covered by this quarterly report is April 1, 1992 through June 30, 1992. This report is the sixth quarterly prepared for the project.

All Phase I - Design, Phase IIA - Procurement & Fabrication, and Phase IIB - Installation work was concluded in prior quarters.

Under Phase III Operation, Task 1 - Management & Reporting work accomplished during this quarter involved submittal of final copies of the Technical Progress Reports #5 and #6 to DOE PETC. An LNGB™ project technical paper was presented at the Air & Waste Management Association Seminar in Kansas City, Missouri the week of June 22, 1992. Task 2 - Preliminary Testing, saw completion of the fabrication and installation of the lower burner inversion and shallower angled impellers. Task 3 - Parametric and Optimization Testing work was near completion with the last of the testing to conclude July 3, 1992. Preparation work is underway to begin Task 4 - Long Term Testing.

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.

U.S.-installed steam generating units (ie. boilers) equipped with pulverized-coal-fired, cell-type burners account for approximately 26,000 MW of electric power generating capacity. Ten thousand MW of generating capacity is located in Ohio. The balance is located primarily in the Midwest and Northeast, but also in the South and West. coal-fired generating units equipped with cell-type burners produce about 20% of the Pre-New Source Performance Standards (NSPS) utility NOx emissions with an uncontrolled emission rate of approximately 1,000,000 t/yr NOx as NO2. Replacement of the standard cell burners with Low-NOx Cell™ Burners (LNCB™) can potentially reduce NOx emissions by 50% per boiler, or 500,000 - 600,000 tons per year if applied to all pre-NSPS boilers of this type.

Currently there is no other commercially-available technology that can achieve NOx emission reductions on the order of 50% in cell-fired utility boilers without resorting to pressure part modifications. The unique cell burner configuration precludes the use of commercially-available low-NOx burner designs. This is due to the proximity of the burner throats and the relatively small burner throat openings typical of the pre-NSPS cell burner design. Low-NOx burner designs operating on the principle of delayed combustion require larger throat openings, i.e., lower burner air velocities, to inhibit the formation of volatile NOx in the early stages of combustion. Furthermore, optimum NOx reduction with unit volume is minimized. The existing cell burner configuration does not lend itself to either of these requirements.

Realizing the need, Babcock & Wilcox and the Electric Power Research Institute (EPRI) have invested a large amount of resources in the research and development of an unique, "plug-in" Low-NOx Cell™ Burner for retrofitting these existing boilers equipped with standard cell burners.

3.2 PROJECT BACKGROUND

The Low-NOx Cell™ Burner operates on the principle of staged combustion. The lower burner of each two-nozzle cell is modified to accommodate all the fuel input previously handled by two nozzles. Secondary air, less than theoretically required for complete combustion, is introduced to the lower burner. The remainder of secondary air is directed to the upper "port" of each cell to complete the combustion process.

B&W/EPRI have thoroughly tested the LNCB™ at two pilot scales (6 million Btu per hour and 100 million Btu per hour), and tested a single full-scale burner in a utility boiler. Combustion tests at two scales have confirmed NOx reduction with the low-NOx cell on the order of 50% relative to the standard cell burner at optimum operating conditions. The technology is now ready for full unit, full-scale demonstration.

From the standpoint of cost-effective NOx reduction technology the Low-NOx Cell™ Burner is, by design, ideally suited for retrofit to existing two-nozzle cell burner installations. The "plug-in" design will fit existing wall tube openings eliminating outage time and material/labor expense associated with pressure part modifications and burner relocations. Potentially, this burner can be installed on all utility boilers currently equipped with two-nozzle cell burners, and can be adapted to units with three-nozzle cell burners.

Since pressure part changes are not required for the replacement, Low-NOx Cell™ Burners are the most cost-effective NOx control alternative for boilers equipped with standard cell burners. The cost effectiveness (dollars per ton NOx removal) for the Low-NOx Cell Burners™ is about one-half of that for conventional low-NOx burners, and one-tenth that for selective catalytic reduction.

The Low-NOx Cell™ Burner retrofit is expected to be compatible with all U.S. Coals currently being burned in the original cell burners. No loss to domestic coal sourcing will be recognized. Utilities representing 70% of the potential Low-NOx Cell™ Burner retrofit market (capacity basis) are participating in the project.

To accelerate commercialization of this promising technology in controlling NOx levels in pre-NSPS power plants, a full-scale retrofit of a complete boiler system is to be performed. This project at Dayton Power & Light's J.M. Stuart Unit #4, located along the Ohio River between Manchester and Aberdeen, Ohio, will permit actual full-scale NOx levels to be quantified and demonstrate the ability of the equipment to reliably meet conservative utility industry standards.

Unit No. 4 is a supercritical Universal Pressure, single-reheat, Carolina-type boiler, fired with pulverized coal. The unit is designed for a maximum continuous capacity of 4,400,000 lbs steam/hr delivered to a 3500 psig (nominal) General Electric turbine-generator for a maximum gross generating capacity of 605 MWe.

Existing combustion equipment consists of 24 two-nozzle cell burners, 6 MPS-89K pulverizers, and 6 gravimetric feeders. The burners are arranged in an opposed-fired configuration with 12 cell burners on each wall, 2 high by 6 wide. The existing burner throat openings are 38 inches in diameter.

3.3 PROJECT OBJECTIVES

The overall objectives of the full-Scale Low-NOx Cell™ Burner (LNCB™) Retrofit project is to demonstrate the cost-effective reduction of NOx generated by a large, base-loaded (70% capacity factor or greater), coal-fired utility boiler. Specific objectives include:

- At least 50% NOx reduction over standard two-nozzle cell burners, without degradation of boiler performance or life.
- Acquire and evaluate emission and boiler performance data before and after the retrofit to determine NOx reduction and impact on overall boiler performance.

- Demonstrate that the LNCB™ retrofits are the most cost-effective alternative to emerging, or commercially-available NOx control technology for units equipped with cell burners.

The focus of this demonstration is to determine maximum NOx reduction capabilities without adversely impacting plant performance, operation and maintenance. In particular, the prototype evaluations will resolve many technical issues not possible to address fully in the previous pilot-scale work and the single full-scale burner installation. These include low-NOx combustion system impact on:

- (1) boiler thermal efficiency
- (2) furnace temperature and heat absorption profiles
- (3) slagging and fouling
- (4) waterwall corrosion
- (5) gaseous and particulate emissions
- (6) boiler operation considerations

3.4 HOST SITE BOILER

The host site is an existing utility boiler owned by Dayton Power & Light Company, Cincinnati Gas & Electric Company, and Columbus Southern Power Company. The following is a summary of pertinent information.

- OPERATING UTILITY: The Dayton Power & Light Company
- UNIT ID: J.M. Stuart No. 4
- LOCATION: Route 52, P.O. Box 468
Aberdeen, Adams County, Ohio 45101
- NAME PLATE RATING: 605 MW NDC
- TYPE: Tandem Steam Turbine
- PRIMARY FUEL: Eastern Bituminous Pulverized Coal
from Ohio, West Virginia, and Kentucky
- OPERATION DATE: 1974
- BOILER ID: Babcock & Wilcox UP No. 106
- BOILER GENERAL CONDITION: Commercial Operation/Good Condition
- BOILER TYPE: Supercritical, Once-Through
- DEMONSTRATION FUEL: Eastern Bituminous Pulverized Coal
- BURNERS: 24 Two-Nozzle Cells, to be replaced with
Low-NOx Cell™ Burners
- PARTICULATE CONTROL: Electrostatic Precipitators
- PAST EMISSIONS MONITORING: Precipitators - 99+% collection
efficiency NOx (full load) -
1.2 lb/10⁶ Btu

3.5 PROJECT TEAM

The Low NOx Cell™ Burner Project Team consists of the U.S Department of Energy, The Babcock & Wilcox Company, Dayton Power & Light, the Electric Power Research Institute (EPRI).

Team members from B&W represent the Research and Development Division (R&DD), the Fossil Power Division (FPD), the Energy Services Division (ESD) and the Contract Research Division (CRD).

Major subcontractors are Acurex and Enerfab. Acurex has been designated to perform continuous emissions monitoring activities as well as various analytical requirements during the testing program. The installation subcontractor is Enerfab. They are the Dayton Power & Light - J.M. Stuart Station maintenance contractor. They will perform pre-outage, outage, and start-up work necessary to install the Low-NOx Cell™ Burners and its associated equipment.

A summary of the overall project organization is as follows:

Project Organization

- Department of Energy - 48.4% funding co-sponsor
- Babcock & Wilcox - Prime contractor, project manager, and funding co-sponsor
- Dayton Power & Light - Host site utility and funding co-sponsor
- EPRI - Technical advisor and funding co-sponsor
- Ohio Coal Development Office - Advisory committee member and funding co-sponsor
- Utility advisory committee members and funding co-sponsors

Allegheny Power System

Centerior Energy Corporation - Funding thru EPRI

Duke Power Company - Funding thru EPRI

New England Power Company - Funding thru EPRI

Tennessee Valley Authority - Funding thru EPRI

- Acurex Corporation - testing subcontractor
- DP&L Stuart Station Maintenance Contractor - LNCB™ installation

3.6 PROJECT PHASES

The LNCB™ project, which is a \$10 million project, consists of four separate phases which are planned to occur over a 38-month period. These are:

- Phase I - Design

During this phase, the Low-NOx Cell™ Burner (LNCB™) System will be designed based upon B&W's pilot-scale combustion tests, and experience/knowledge of full-scale burner/OFA port/control system retrofits. Additionally, collection of baseline emissions and performance data, along with performance of general boiler system assessment, will be completed at DP&L's J.M. Stuart Unit #4 prior to the LNCB™ retrofit.

- Phase IIA - Procurement & Fabrication

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

- Phase IIB - Installation

The LNCB™ system will be installed and started up to provide a fully operational system prior to testing.

- Phase III - Operation

Parametric/optimization and long term 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 LNCB™ 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 project quarterly report #7 is April 1, 1992 through June 30, 1992. Progress will be discussed on a task basis for Phase III activities. Phase I, Phase IIA, and Phase IIB are complete.

4.1 PHASE I - DESIGN

Activities in Phase I include the following tasks: Management and Reporting, Test Plan Development, Pre-Retrofit Testing, Functional Engineering, Detailed Design Engineering, and Permitting.

PHASE I WORK IS COMPLETE!

4.2A PHASE IIA - PROCUREMENT AND FABRICATION

Activities in Phase IIA include the following tasks: Management and Reporting, Procurement, and Manufacturing and Fabrication.

PHASE IIA WORK IS COMPLETE!

4.2B PHASE IIB - INSTALLATION

Activities in Phase IIB include the following tasks: Management & Reporting, Pre-Outage Construction, Installation of LNCB™ Equipment, and Start-up & Shakedown.

PHASE IIB WORK IS COMPLETE!

4.3 PHASE III - OPERATION

Activities in Phase III include the following tasks: Management & Reporting, Preliminary Testing, Optimization Testing, Long Term Testing, Data Analysis, Final Report, and Disposition.

4.3.1 Task 1- Management and Reporting

Monthly reports covering the time period of this report were completed and issued to DOE PETC. Final copies of the Technical Progress Reports #5 and #6 were also submitted to DOE.

An LNCB™ project technical paper was presented at the 85th Annual meeting of the Air & Waste Management Association in Kansas City, Missouri the week of June 22, 1992. B&W is to give a technical paper at an EPRI workshop in Boston Massachusetts, July 7-9, 1992. Plans call for technical presentations at the DOE Clean Coal Technology Conference, September 22-24, 1992 in Cleveland, Ohio, the Pittsburgh Coal Conference in Pittsburgh, Pennsylvania and the ASME International Joint Power Generation Conference in Atlanta, Georgia. Both the Pittsburgh Coal Conference and Joint Power Generation Conference are scheduled in October 1992.

4.3.2 Task 2 - Preliminary Testing

Fabrication and installation of all materials for the burner inversion and impeller change was completed during this quarter. The outage work, which began April 27th and concluded with the unit returning on line May 9th, went very smoothly.

DP&L inspected the unit during the outage. They found that the pendant superheater surfaces were unusually clean (devoid of its typical slagged condition). The lack of slagging indicates improved combustion efficiency of the Low NOx Cell™ burner system. DP&L also noted that they had a significant decrease in the quantity of bottom ash and economizer outlet ash that has to be removed. This could signify an increase in loading to the precipitator. This theory will not be verified until dust loading tests are performed during optimized testing.

4.3.3 Task 3 - Parametric & Optimization Testing

The parametric and optimized testing plan was finalized. The plan called for 30 parametric tests to be done over a four week period beginning May 11th. After a one week review of parametric test results, the burners will be fixed at optimum settings. Optimization testing was to begin June 15th. The 19 different optimized test conditions which duplicate baseline testing, were to be taken over a four week test period. This would mean burner optimization test completion by July 10th.

The parametric testing phase of the project actually began May 14th after correcting test equipment problems. Preliminary results show that the impeller change and burner inversion were successful. The Low NOx Cell™ burners achieved better than 50% NOx reduction and carbon monoxide (CO) inside the lower furnace is less than 1000 ppm. Under certain burner settings, the Low NOx Cell™ burners were able to achieve between 53% to 55% NOx reduction. A 55% reduction equates to 385 ppm NOx level corrected to 3% O₂. The parametric testing phase of the project was concluded on June 4, 1992.

Following a week off from testing to review parametric test results and finalize optimum burner settings, optimized testing began June 15, 1992. This phase of testing will be completed by July 3, 1992.

4.3.4 Task 4 - Long Term Testing

Results from the optimized test phase of the project will be factored into long term test results. Long term testing via a Continuous Emissions Monitor (CEM), will begin in July, 1992. CEM testing will continue until Spring of 1993 when Unit #4 comes off line for its annual outage which at this time is scheduled for April 4, 1993.

Another key item remaining to be evaluated as part of the long term testing is furnace tube wall corrosion. H₂S probing similar to optimized test probing will be repeated at intervals two more times. Come the Spring '93 outage, ultrasonic testing of the furnace wall tubes as well as destructive examination of samples from the corrosion test panel will be taken.

5.0 PLANNED ACTIVITIES

Planned activities for the next quarter, July, August, and September 1992 will focus on the following:

Management & Reporting will include technical presentations on the LNCB™ technology at the EPRI workshop in Boston on July 7th and the First Annual DOE Clean Coal Conference in Cleveland on September 24th. Technical papers for the Pittsburgh Coal Conference, October 12-15, 1992 and the ASME International Joint Power Conference, October 18-22, 1992 will be finalized during this time frame. The Fifth Advisory Committee meeting will be convened September 10, 1992 in Cincinnati, Oh.

Phase III, Task 3 - Complete optimization testing.

Phase III, Task 4 - Continue long term testing.

Phase III, Task 5 - Begin data analysis from optimized testing.

END

DATE
FILMED

5 / 20 / 93

