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Full-Scale Demonstration

Low-NOx Cell™ Burner Retrofit

Quarterly Report No. 3

for the period - April 1, 1991 through June 30, 1991

DOE Agreement No.: DE-FC22-90PC90545

B&W CRD Agreement No.: CRD-1250

Patents Cleared by Chicago on March 12, 1992

Prepared by:

Babcock & Wilcox
a McDermott Company

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5.0 PLANNED ACTIVITIES

Planned activities for the next quarter, July, August, and September 1991 will focus on the following:

Management & Reporting will include completion of the Environmental Monitoring Plan, Baseline (Pre-Retrofit) Test Report, and the Post Retrofit Test Plan. An Advisory Committee meeting at DP&L Stuart Station during the construction phase will also be planned.

Phase IIA, Task 3 - Manufacturing and Fabrication of the ceramic coal piping will be continued towards the expected completion date of July, 1991.

Phase IIB, Task 2 - Pre-Outage Construction work will be initiated. This includes fabrication of the corrosion test panels, planning the outage work, readying the equipment for installation (uncrating, inventory, moving into location, etc.) and installing construction support equipment (monorails and scaffolding).

Phase IIB, Task 3 - Installation of LNCB™ equipment will begin with the start of Stuart Station Unit #4's outage which is scheduled to start September 22, 1991.

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1.0 EXECUTIVE SUMMARY

The Full Scale Demonstration Low-NOx Cell™ Burner (LNCB™) Project (DOE Agreement No. DE-FC22-90PC90545) progress from April 1, 1991 through June 30, 1991 identified in this, the Third Quarterly Report. The Report centers on Phase I - Design, Phase IIA - Procurement and Fabrication, and Phase IIB - Installation 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 intregal NOx port). Previous pilot-scale tests have shown such an arrangement to achieve 50% reduction in NOx emission levels. This full-scale project will determine the commercial applicability of this technology.

The Electric Power Research Institute (EPRI) still remains the only agreement to negotiate. Formal documentation for the Continuation Application, the Project Evaluation Plan, the Detailed Work Plan, the Technical Progress Quarterly Report #1, the Preliminary Public Design Report, the Procurement Plan, the Procurement Report and the QA/QC Plan were submitted to DOE PETC. Also released was the second draft of the Environmental Monitoring Plan. A prospective project testing workscope change involving DOE's insistence that trace metals & organics testing be added to the project was rejected by Dayton Power & Light (DP&L). DP&L reasoned that trace metals & organics are a function of the coal and not the burner. Therefore, the time and expense of such testing had no bearing on the LNCB™ project results.

Baseline test data analysis was completed and a draft copy of the pre-retrofit test report was submitted to DP&L for their review and comment. Laboratory Corrosion testing work continued with an expected completion date of July 1991.

Two prospective items for project workscope change were discussed with DOE and Dayton Power & Light (DP&L). These items included ... A corrosion test panel, and a second burner impeller design for evaluation of performance impact (NOx, unburned carbon, etc.). Both DOE and DP&L agreed that the addition of the corrosion test panel to the workscope would be of benefit to overall evaluation of corrosion. This workscope addition was added to the second budget period. The alternate burner impeller design was rejected as to costly & time consuming versus the relatively small improvement in NOx reduction.

All materials, except for some ceramic piping, have been manufactured and shipped to the jobsite. The balance of the ceramic piping will ship in July 1991.

B&W requested and received approval to start 2nd budget period work at B&W's risk pending Continuation Application approval. It was necessary to begin fabrication of the new corrosion test panel in order to have it on site by mid-September 1991.

Dayton Power & Light found it necessary to change to Enerfab as their maintenance contractor. Enerfab will therefore be the vendor who will install the LNCB™ equipment.

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, and IIB of the Full-Scale Demonstration of Low-NOx Cell™ Burner Project. The period covered by this quarterly report is April 1, 1991 through June 30, 1991. This report is the third quarterly prepared for the project.

Phase I - Design work accomplished during this quarter follows. Under Task 1 - Management & Reporting, formal documentation for the Project Evaluation Plan, the Detailed Work Plan, the Technical Progress Quarterly Report #2, the Preliminary Public Design Report, the Procurement Plan, the Procurement Report and the QA/QC Plan were submitted to DOE PETC. Also released was the second draft of the Environmental Monitoring Plan. A prospective project testing workscope change involving DOE's insistence on trace metals & organics testing was rejected by Dayton Power & Light (DP&L). Under Task 3 - Pre-Retrofit Testing, baseline test data analysis was completed and a draft copy of the pre-retrofit test report was submitted to DP&L. Laboratory Corrosion testing work continued with an expected completion date of July 1991. Activities in Task 2 - Test Plan Development, Task 4 - Functional Engineering, Task 5 - Detailed Design Engineering, and Task 6 - Permitting were concluded in prior quarters.

Phase IIA - Procurement and Fabrication work accomplished during this quarter for Task 1 - Management & Reporting centered around the addition of a corrosion test panel to the workscope and discussions for a workscope change to test a second impeller design. Submitted formal documentation for the Continuation Application. Work under Task 3 - Manufacturing & Fabrication shows all materials, except for some ceramic piping, completed and shipped to the jobsite.

Phase IIB - Installation work accomplished during this quarter for Task 1 - Management & Reporting involved B&W requesting and receiving approval to perform 2nd budget period work at B&W's risk pending Continuation Application approval. Dayton Power & Light found it necessary to change to Enerfab as their maintenance contractor. Enerfab will therefore be the vendor who will install the LNCB™ equipment.

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/10^6 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 $9.796 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 #3 is April 1, 1991 through June 30, 1991. Progress will be discussed on a task basis for each of the Phase I, Phase IIA, and Phase IIB activities.

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.

4.1.1 Task 1- Management and Reporting

Monthly reports covering the time period of this report were completed and issued to DOE PETC on schedule. Final copies of the Project Evaluation Plan, the Detailed Work Plan, the Technical Progress Quarterly Report #2, the Preliminary Public Design Report, the Procurement Plan, the Procurement Report and the QA/QC Plan were submitted during this period. Also released was the second draft of the Environmental Monitoring Plan.

Negotiations continued with Electric Power Research Institute (EPRI) to finalize an agreement.

A prospective project testing workscope change involving DOE's insistence on trace metals & organics testing, was discussed by DOE with both Babcock & Wilcox (B&W) and Dayton Power & Light (DP&L). DP&L rejected DOE's request for the addition of trace metals & organics testing on the basis that such items were a function of the coal and therefore had no bearing on the LNCB™ project results.

4.1.2 Task 2 - Test Plan Development

This task, which involved the identification of all test parameters, sampling instrumentation, equipment location, test data forms, test procedures, and testing matrix for both the baseline pre-retrofit tests and the Low-NOx Cell™ Burner tests, was completed prior to the period covered by this report.

4.1.3 Task 3 - Pre-Retrofit Testing

Task 3 includes planning and coordination, diagnostic testing and baseline characterization (unit condition assessment, boiler modifications for baseline testing numerical modeling, continuous emissions monitoring system (CEMS) installation, data acquisition equipment purchase and installation, baseline testing, laboratory testing), and completion of a Pre-Retrofit Test Report.

Most of the subtasks defined above were completed prior to the period covered by this report. Only those subtasks involving ongoing work are reported below.

4.1.3.2 Subtask 3.2 - Diagnostic Testing and Baseline Characterization

Laboratory Testing

The object of this subtask is to conduct retrofit tests of various candidate alloys by exposing them to simulated low NOx combustion gases at different H_2S concentrations and temperatures. The low NOx flue gas compositions were determined by theoretical calculations of coal combustion at predicted air/fuel stoichiometric ratios. These compositions are being simulated in the laboratory and used for the corrosion retrofit tests. A total of 18 materials, including carbon steel, alloy steels, stainless steels, and coating systems, are being exposed to the simulated LNCB™ mixed gases. The test conditions vary temperature (500, 700, and 900 C) and mixed gas composition (0.05, 0.25, and .5% H_2S).

Laboratory Corrosion Testing work continued thru the period covered by this report. Several of the 1000 hour retort tests have ended. All retort tests will be completed in July 1991. Results will be available at that time.

4.1.3.3 Subtask 3.3 - Pre-Retrofit Test Report

Pre-retrofit test data analysis was completed and a draft copy of the baseline testing report was submitted to Dayton Power & Light for their review and comments. The fundamental results are as reported in the last quarterly report.

In addition to incorporating DP&L's comments into the report, a QA/QC report on the baseline testing program must be added to the report before it can be stamped as complete. An Interm Baseline Test Report will be released in July 1991, minus a section concerning QA/QC results. The QA/QC section should be released in August 1991.

4.1.4 Task 4 - Functional Engineering

4.1.5 Task 5 - Detailed Design Engineering

The final version of the Preliminary Public Design Report was submitted to DOE PETC for appropriate formal document release. This completes tasks 4 and 5.

4.1.6 Task 6 - Permitting

This task 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.

4.2A.1 Task 1- Management and Reporting

Two prospective items for project workscope change were discussed with DOE and Dayton Power & Light (DP&L). These items included ... A corrosion test panel, and a second burner impeller design for evaluation of performance impact (NOx, unburned carbon, etc.). Both DOE and DP&L agreed that the addition of the corrosion test panel to the workscope would be of benefit to overall evaluation of corrosion. The formal request for workscope addition was submitted as part of the Continuation Application.

B&W proposed to test a second impeller because large scale burner laboratory testing results had indicated ten points improvement in NOx. The only reported detriment was the doubling of flame length versus that of the standard cell burner. DP&L expressed skepticism regarding the testing of a second impeller design because it would require an outage to install them. DP&L wanted to reserve judgement on testing a second impeller design until after evaluation of preliminary LNCB™ testing with its initial impeller design. B&W withdrew its request after fully reviewing the large scale testing report. B&W concluded that the results were suspect because more than one variable had been changed. B&W also concluded that impact of impeller design could be simulated by simply retracting the impeller into the coal nozzle.

Formal documentation for the Continuation Application was submitted to DOE PETC.

4.2A.2 Task 2 - Procurement

Release of all raw material and sublet fabricated material procurement orders was completed prior to the period covered by this report.

4.2A.3 Task 3 - Manufacturing and Fabrication

All but a few manufactured items have been fabricated and shipped to the job site. Since the outage was delayed until September 1991, the ceramic piping vendor requested an extension to his delivery date due to shop work overload. The vendor expects to complete shipment by July 1991.

4.2B Phase IIB - Installation

4.2B.1 Task 1- Management and Reporting

B&W requested and received approval to perform 2nd budget period work at B&W's risk pending Continuation Application approval. It was necessary to begin fabrication of the new corrosion test panel in order to have it on site by mid-September 1991.

Dayton Power & Light found it necessary to change maintenance contractors. They requested updated bid packages from the same group of vendors previously submitting proposals. As a result of the bid evaluation, DP&L selected Enerfab as their maintenance contractor. They will therefore be the vendor who will install the LNCB™ equipment.

END

DATE FILMED

7/13/92