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ENGINEERING DEVELOPMENT OF ADVANCED
COAL-FIRED LOW-EMISSION BOILER SYSTEMS

QUARTERLY TECHNICAL PROGRESS REPORT

October - December 1993

Submitted by:

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Quarterly Technical Progress Report

Reporting Period - October 1 through December 31, 1993

Work Completed During Working Period and Work in Progress

Task 1.0 Project Planning

Project schedule and status review meetings were held throughout the period as planned and/or as needed with subsystem team leaders and key individuals to track overall and detailed project activities and schedule.

Joint NO_x and Boiler Subsystem team meetings with PSI and MIT were held in October and December to review and discuss burner testing and LEBS furnace modeling results to-date.

A project status meeting was held with the DOE at PETC on October 28, 1993. The work completed thus far in the project was reviewed and the work scheduled for Tasks 4, 5, & 6 was discussed.

During the period, technical papers on the program were presented at the Joint ASME/IEEE Power Generation Conference and the 1993 Fall American Flame Research Committee International Conference, and a paper was submitted for the Coal Utilization & Fuel System's 19th International Technical Conference. Copies of the papers presented are attached.

Task 2.0 Concept Development

Subtask 2.5 Subsystem Preliminary Design

All planned subsystem preliminary design, cost estimate and generating unit cost analysis work was completed. The Subsystem Preliminary Engineering Design Report was completed and submitted to the DOE and distributed to all team members and Advisory Board.

Preliminary subsystem designs were developed for a Low-Emission Boiler System as shown in Attachment 1. Key features of the NO_x and Boiler Subsystem includes: deep staged combustion with advanced low NO_x burners in a furnace arrangement designed to minimize NO_x emissions, advanced pulverizer design, advanced operating diagnostics and control integration of steam conditions, combustion, burner management and sootblowing. For SO₂ and particulate control, key features include; an optimized limestone furnace injection design, an advanced dry scrubber design with optimum operating conditions, subsystem integration of baghouse performance and operation, and recycle of baghouse collected sorbent material. Balance of plant subsystem design concepts were addressed as

necessary with major focus on effective integration and support of the advanced emission control systems and high efficiency. Final economical analysis showed the cost of electric for the selected LEBS generating unit to be equal to that of a current conventional coal-fired generating plant.

Task 3.0 RD&T Plan

Subtask 3.1 Design Deficiency Analysis

In addition to economical assessment, the preliminary subsystem designs developed in Subtask 2.5 were assessed with regard to new technologies or components for which design criteria or performance is uncertain or not demonstrated. This assessment was completed and documented in the Design Deficiency Analysis Report submitted to the DOE in the previous work quarter. Subsequently, review comments to the report were received from the DOE. The report has been revised accordingly and the final document will be included in the Phase I Final Report. For reference, Attachment 2 is provided as a summary list of the identified uncertainties and related R&D activities.

Subtask 3.2 RD&T Plan Formulation

In parallel with Subtask 3.1, the draft RD&T Plan for Phase I was completed and submitted to the DOE in the previous working quarter. Subsequently, review comments on the draft document were received from the DOE. Revisions addressing the comments received were completed and a Final RD&T Plan for Phase I submitted to the DOE for final approval. For reference, a diagram of major RD&T activity tasks and critical information flow within the RD&T Plan is presented in Attachment 3.

Task 4.0 Component Definition

Subtask 4.1 Engineering Analysis

Control and Sensors: PSI completed a review and provided comments on the preliminary control system design developed for the generating unit in Subtask 2.5. A joint review meeting with B&W's Electrical and Controls personnel and PSI was held to review ongoing and planned work activities and the integration of the control strategies for the LEBS design concept. Work is currently in progress to better define the overall and detailed operating strategy for the combustion system.

PSI began work on the development of a flame signature scanner which will perform direct flame diagnostics on the burner's flame frequency spectra and produce a signal(s) (Reference Attachment 4) indicative of individual burner operation. PSI visited Alabama Power to discuss testing of

PSI's flame scanner at the Gaston Plant, which has B&W DRB-XCL burners. A complete test plan has been finalized jointly by PSI, B&W and Alabama Power with actual testing scheduled for late February 1994. Gathering of flame scanner signature data for analysis was also performed by PSI during the RSFC burner testing at MIT. Analysis of data gathered is underway.

SO₂ Subsystem - LIDS System and By-Products: Work continued on LIDS solid by-product evaluation. A copy of the final report for the B&W/OCDO co-funded project entitled, "*Management of Solid Waste from the Limestone Injection Dry Scrubbing (LIDS) Clean Coal Technical*" was submitted to the DOE for their information. Work continues on compiling a reference package on dry scrubber/baghouse and furnace injection by-product utilization studies. Some of the studies in the package include those completed by B&W, Ohio State University, IEA Coal Research and EPRI. One of the uses for the package will be to assist in bringing a solid by-product consultant on board later in the program.

Work on the furnace injection SO₂ removal analysis continues. Evidence has been cited claiming that virtually all of the SO₂ is removed prior to the air heater in furnace sorbent injection processes. A list of references is being compiled. The feasibility of testing SO₂ removal in the LIDS 6MBtu/hr test on the SBS facility was evaluated. It was decided that relative furnace flue gas SO₂ removal measurements may be feasible. The EPA Method 8 will be the technique used for making the measurements.

Lower Furnace Corrosion: A literature search continues to collect information on the topic of low-NO_x corrosion to supplement the field data previously collected by B&W. Some papers have been ordered and received. These papers are currently being review.

Subtask 4.2 Experimental Testing

Burner Testing: Testing was completed at MIT on the RSFC burner in the MIT's CRF facility. An outline drawing of MIT's CRF testing facility and RSFC burner is provided in Attachments 5 and 6. Testing included both staged and unstaged conditions. Parametric data as well as detailed flame mapping was completed. Analysis of the data obtained continues. A joint subsystem team review meeting was held in early December to discuss and review results to date. Initial results show promise for meeting the NO_x emission goal, and keeping the unburned carbon at a minimum. Attachment 7, Figures 1 through 3, show some of the preliminary results illustrating the effect on NO_x emission.

Design work on adapting B&W's pilot-scale XCL burner, shown in Attachment 8, to MIT's CRF facility continues. Work has been

completed on the designs for the quartz plate and windbox. All needed materials have been ordered and should be received by the middle of January. Additional preparations include design modifications required to the CRF to allow heat-up with an XCL burner installed. Ordinarily, with the RSFC burner, gas was fired directly through the RSFC. The pilot-scale XCL burner that will be tested will not have this capability. Design modifications are being developed to allow a gas gun to be located at the current pilot light-off location on the CRF.

Work has also begun on the development of a detailed test plan and schedule for the pilot-scale XCL testing on the CRF.

LIDS Testing: Detailed planning, material procurement and set-up necessary for LIDS 6MBtu testing on B&W's SBS facility has been completed. This experimental pilot-scale testing is to demonstrate the feasibility of reaching the LEBS plant SO₂ removal goal using the Advanced LIDS system. A schematic of the SBS test facility with an integrated LIDS system is provided in Attachment 9.

An outside testing company has been subcontracted to make Mercury measurements during the LIDS feasibility demonstration testing. Sampling probe access at the appropriate sample locations in the facility is being investigated.

Subtask 4.3 Modeling

Burner Modeling: Development of numerical computer models of MIT's RSFC burner and CRF test unit continued. Initial runs to be completed were 3-D combustion solutions for the RSFC burner based on preliminary conditions provided by MIT. An illustration of the results is shown in Attachment 10. Additional runs for the RSFC burner in the CRF have been completed for unstaged conditions for which flame mapping data was recorded. Comparison between the modeling results and the data has begun.

Work was initiated and continues on development of a model of the XCL test burner in the CRF. Work is nearly complete on development of dimensions on the burner to be tested. Final set-up of the model will be completed once final design of the burner is completed. For support and use in the LEBS concept design furnace modeling effort underway, the geometry for a full-scale, staged XCL burner has also been developed.

Initially, work continued on physical flow modeling of MIT's RSFC burner. This work, however, has been stopped and will not be completed since completion of the model and testing could not be done in a timely manner as needed and anticipated results were not viewed as critical.

LEBS Furnace Concept Modeling: Modeling runs have been completed on the base LEBS furnace design concept, a comparison convectional furnace and several alternative design concepts relative to furnace sizing, burner arrangements, mid furnace arch sizing and over-fired air port arrangements. Several of the furnace design concepts modeled are illustrated in Attachment 11. Outputs from the modeling runs included flow and velocity patterns, gas temperature, major gas species and heat flux predictions. Examples of topical output are provided in Attachments 12 and 13. Review and assessment of the current results continue. A final LEBS furnace design concept for use in Subtask 5 will be selected based this assessment underway.

Dry Scrubber Modeling: The initial arrangement scoping runs using B&W's DIAN1D code were completed. Work has now begun on two and three dimensional runs. These runs will be used to determine mixing and potential for deposition in the dry scrubber. Initial runs at full load conditions have been completed and results are being analyzed. Work has begun on additional runs needed to establish the operating mode required at reduced load.

Work Plan Status

All major activities continue on schedule as planned. Some engineering analysis activities are continuing longer than originally planned to allow compliment and/or completion with related testing and/or modeling work. No delays are expected in achieving completion of any major activity or milestone.

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LEBS - Combustion 2000

Phase I Design Uncertainties and RD&T Activities

Design Uncertainties	RD&T Activities			
	Burner Testing	LIDS System Testing	Engineering Analysis	Modeling
Low NO _x Burner Performance	X		X	X
Staged Combustion	X			X
Control/Sensors	X		X	
Furnace Corrosion			X	X
High Temperature Corrosion			X	
Fuel Preparation Requirements			X	X
Furnace Design Specifications			X	X
Convection Pass Design			X	
Cycle Performance and Efficiency			X	
Furnace Sorbent Injection Performance		X	X	X
Dry Scrubber Perf.		X	X	X
Baghouse Performance		X	X	
Air Toxics		X	X	
Byproduct Disposal/Utilization		X	X	

RD&T Work Flow

A snapshot of a coal flame signature

C-3264

MIT Combustion Research Facility

Overall Geometry Configuration for Combustion 2000

Schematic of the Low-NO_x Radially Stratified Flame Core Burner

Figure 1. Effect of Stoichiometric Ratio on Exit NO_x
(All Experimental Data)

Figure 2. Effect of Exit O_2 Concentration on Exit NO_x

Figure 3. Effect of Transport Air to Coal Mass Ratio
on Exit NO_x Concentration
With OFA, SR=0.92

Pilot-Scale B&W XCL Burner

B&W's SBS and LIDS Pilot Facility

Combustion 2000 - MIT CRF Furnace 3-D Combustion Solution for RSFC Burner

Longitudinal Cross-Sections in Combustion Chamber ($x = 0$ at Burner End Wall)

Babcock & Wilcox
a McDermott company

kck/43048/1-31-93

BASE VENTURI
FURNACE DESIGN

ALTERNATE VENTURI
FURNACE DESIGN

ALTERNATE VENTURI
FURNACE DESIGN

ALTERNATE CONVENTIONAL
FURNACE DESIGN

1" (ALL) DIMENSIONS ARE TYPICAL

PRELIMINARY

FOR
BABCOCK & WILCOX
P 52-0241 - 13L 0

COMBUSTION 2000 LEBS

BABCOCK & WILCOX

Combustion 2000 Predicted Gas Temperature (F)

Middle Burner Column

PRELIMINARY

BABCOCK & WILCOX
COMBUSTION 2000
RDD: 43048-403-661
12/07/93
CONFIDENTIAL

Burner SR = 0.75

Burner SR = 0.75

Velocity Vectors

PRELIMINARY

2nd Burner Column

BABCOCK & WILCOX
COMBUSTION 2000
RDD: 43048-403-661
12/07/93
CONFIDENTIAL

DATE

FILMED

5/12/94

END