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

QUARTERLY TECHNICAL PROGRESS REPORT

Submitted by:

Babcock & Wilcox
a McDermott Company
Contract Research Division, 1562 Beeson Street
Alliance, Ohio 44601

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Quarterly Technical Progress Report

Reporting Period - January 1 through March 31, 1994

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.

A review meeting was held with the DOE, January 27, 1994, in Alliance, Ohio to discuss the progress being made on the project. Presentations were made covering the testing performed at MIT with the RSFC burner, the test matrix for the testing of the XCL burner at MIT, the LIDS testing scheduled at ARC and the modeling work completed to date.

During the period, abstracts for technical papers were submitted for inclusion in the 1994 Fall American Flame Research Committee (AFRC) International Conference to be held Maui, Hawaii, the 1994 International Joint Power Generation (IJPG) Conference to be held in Phoenix, and the Pittsburgh Coal Conference to be held in Pittsburgh. The draft manuscript for the '94 IJPG Conference has been completed and submitted for review.

During March, separate kick-off meetings were held with PSI PowerServe, Raytheon and B&W's Environmental Equipment Division to begin work on Phase I Task 5, the Commercial Plant Design. In addition, a meeting was held with MIT to discuss and review work completed and schedule work remaining on the project.

Task 4.0 Component Definition

Subtask 4.1 Engineering Analysis

Control and Sensors: PSI PowerServe used information provided by B&W on anticipated operating conditions from 25 to 100 percent load to prepare operating curves for one, two, three and four mill operation. These operating curves will be used in developing a control strategy and burner operating range for the commercial generating unit design. A final draft Operating Strategy Report has been completed and is currently undergoing final internal review by PSI PowerServe.

Preparation for flame signature testing at the E. C. Gaston, Alabama was completed with testing conducted during March. Three scanners were evaluated by PSI in a test at this commercial utility plant. The overall goal of this testing was to determine the feasibility of enhancing the combustion

control/burner management system using temporal flame frequency power spectrum scanning. Preliminary results are very promising. Not only were unique flame "signatures" obtained for various burner operating parameters, but also signals were found to be repeatable with burner setting changes. After two days of parametrically evaluating the effects of operating parameters on flame signature, the 18 burners on this commercial utility unit were manually balanced. Further analysis of the data collected continues by PSI.

Low-NO_x Corrosion: Papers from open literature on topics pertinent to low-NO_x corrosion for the LEBS system were obtained and reviewed. This information along with additional reported by PSI was incorporated into B&W's existing database. This information is currently being used for corrosion rate predictions and to make recommendations on material of construction for the LEBS Commercial Generating Unit furnace.

SO₂ Subsystem - LIDS System and By-Products: Work on the Solid By-Product Evaluation continued. Work continued on compiling a reference package on dry scrubber/baghouse and furnace injection by-product utilization studies. Three uses have been identified as having promise for the LIDS solid by-product: autoclaved cellular concrete (ACC), mine reclamation/neutralization agents, and agricultural liming agents. Work will continue on the LIDS solid by-product evaluation.

Work on the Air Toxics Evaluation began in February. B&W is conducting a wide variety of air toxics-related research projects, and is closely following the regulatory process. It has been cited frequently in the current literature that the best available control technology (BACT) for air toxics control in several countries is a spray dryer absorber followed by a fabric filter. EPRI recently said in the ECS Update (Winter 1994, Number 31), "Among the different combination of control technologies examined under the PISCES field monitoring, the best overall reduction (>95%) of trace metals was achieved with fabric filters alone or with the combination of either wet or dry scrubbers with particulate controls." The LIDS process is consistent with this information.

Evaluation and selection of a fabric filter for the LIDS baghouse was completed. In order to meet the LEBS SO₂ and particulate emissions goals, the baghouse will be required to operate closer to adverse conditions when compared to today's baghouses. The most important operating and design conditions considered for the LIDS baghouse in terms of fabric selection were: (1) the operating temperature, (2) very low emissions rate, and (3) chemical resistance, especially resistance to hydrolysis. Based on the conditions expected and design

requirements set, Ryton was selected as the preferred fabric filter material for the LIDS baghouse.

Work was begun and continues on engineering analysis of other B&W LIDS testing programs and internal development work on the LIDS process. Results from other B&W LIDS testing in March included achieving 99% SO₂ removal at the following approximate conditions: 1.5 Ca/S, 10°F (approach to saturation) and 35% slurry solids. With this information, preparations are now underway to perform the Combustion 2000 LIDS feasibility demonstration run in April 1994. This demonstration run will be run at conditions selected to better achieve the program goal of 97% removal and will be run for an extended time at the selected operating conditions.

Boiler and Convection Pass Design:

Work was begun and completed on analysis of the boiler upper furnace and convection pass design. This work was performed in conjunction with and interaction with the limestone injection modeling efforts. The objective of this activity was to assess upper furnace and convection pass arrangement modifications to establish an optimum arrangement for limestone injection with advanced steam cycle conditions. Several potential modifications including the addition of upper furnace wing-wall and/or curtain-wall surface, alternate superheat outlet bank series arrangements, and alternate sorbent injection locations were assessed. In addition, the impact of increasing the final main steam and reheat 1 steam temperatures to 1100F were assessed.

As a result, arrangement design improvements, more effective both steam performance wise and limestone injection wise, have been identified. These improvements will be incorporated into the commercial unit design in Task 5.

Thermal Efficiency Improvements: Work was begun on development and evaluation of potential steam/boiler cycle thermal efficiency improvement concepts. Potential identified improvement concepts studied include variations of the following: wet and dry scrubbing systems, partial by-passing of high pressure heaters, partial/total by-passing of low pressure heaters, additional pre and/or post scrubber heat recovery, and air preheating with extraction steam. Evaluation of identified concepts was begun by B&W using ASPEN simulation to predict a relative performance comparison. Work currently continues with performance results being forwarded to Raytheon, as available, for further analysis, including a budgetary present worth benefit assessment. Complete results are not yet available.

Subtask 4.2 Experimental Testing

Burner Testing: Design modification and fabrication of the base and staged B&W pilot-scale XCL burners, quarl plate adaptor (to the MIT furnace), gas lighter, and miscellaneous parts were finished and delivered to MIT. Installation of the base burner (unstaged) has been completed during the last week of February and preliminary firing on gas and coal started the first of March. Testing continued as scheduled with parametric testing and flame mapping of both the base and staged burners completed in March. The initial test results look promising. Some differences were noted in the pilot-scale XCL burner flame shape as a result of the MIT furnace in comparison to previous testing at the Alliance Research Facility with the burners.

Tony Mayne, DOE project manager, visited MIT to view testing on March 23, 1994.

Detailed data analysis currently continues on both the RSFC burner testing and pilot-scale XCL burner testing in MIT's CRF. Preliminary results show that both burners appear to be capable of meeting the program NO_x goal while maintaining stable flame and low carbon in the ash.

LIDS Testing: Planning for the LIDS 6 MBtu/hr testing continued. It is noted, however, that the Phase I LIDS testing in the RD&T plan was identified strictly as a feasibility demonstration. It was assumed that significant LIDS development work would not be needed. However, work in other B&W LIDS programs that preceded the demonstration run planned for Combustion 2000 showed that further development efforts were, in fact, required to achieve the LEBS 97% SO₂ removal goal in an optimum manner.

The LIDS feasibility demonstration to be performed for LEBS was therefore delayed allowing B&W to analyze observations made to date and perform additional B&W internal LIDS development testing needed prior to the demonstration for LEBS.

The bench-scale testing in B&W's Flue Gas Mixing Facility to generate baghouse SO₂ removal performance data will occur if required following the pilot-scale LIDS feasibility demonstration. The need for the work will be determined based on the baghouse SO₂ removal information acquired in the feasibility demonstration.

As noted above under Engineering Analysis, recent testing in B&W's other LIDS programs has now been successful in achieving the LEBS program SO₂ removal goal. Based on this achievement and other analysis work completed, the feasibility demonstration for LEBS is now scheduled for the week of April

25,1994. In addition to proving the feasibility of achieving 97% SO₂ removal with the LIDS process, during the demonstration test run relative SO₂ removal measurements will be made by B&W and Hg measurements will be made by Frontier GeoSciences, Inc.

Subtask 4.3 Modeling

Burner Modeling: Development efforts on the chemistry model continue through the period for the development of the COMO model. Capabilities added to COMO included the influence of turbulent fluctuations on the general pollutant NO_x formation/destruction processes.

The geometry and conditions for the modeling of the pilot-scale XCL burner in MIT's CRF were finalized. The set-up for the model was completed and the computer runs begun. Initial solutions were started based on preliminary operating condition specifications. To date, a 3-D solution for the unstaged XCL operating in the CRF has been completed based on preliminary operating conditions. A run corresponding to conditions used during the CRF testing and flow mapping have been started.

Initial comparisons of MIT flame mapping data and RSFC/CRF predictions were started based on unstaged conditions. These initial comparisons and heat loss data from MIT were used to adjust heat transfer boundary conditions for the CRF model. Sensitivity studies were also begun to assess variations of the current devolatilization and CO models.

As data became available, work was also begun on modeling the deep-staged MIT RSFC burner condition (0.82 burner stoichiometry) and final axisymmetric runs on both the unstaged and staged cases. Axisymmetric predictions for the RSFC in both the unstaged and staged modes currently continues. Exit NO_x predictions for both cases agreed qualitatively with measured data in the CRF. Additional runs are continuing, applying recent enhancements in the COMO chemistry model to improve near-burner predictions.

Final modifications to the Cartesian CRF model were completed for the full, 3-D solution of the unstaged and deep-staged RSFC burner cases previously mapped at MIT. Final runs for the unstaged RSFC using the 3-D Cartesian CRF model are currently underway, including an embedded case to provide improved resolution at the burner exit.

LEBS Furnace Concept Modeling: Work was completed on all LEBS furnace design cases needed to assess furnace configuration, burner and over-fire air port placement. Based on the computer modeling conducted, the benefits of mid furnace arches was found to be over-estimated. A furnace arrangement

with a straight wall furnace and an advanced over-fired air system was selected to begin modeling of limestone injection into the upper furnace.

Initial furnace sorbent injection mixing modeling runs were begun based on the selected LEBS furnace arrangement and preliminary design sorbent nozzle locations. Initial results indicated that the ports had insufficient momentum for adequate penetration and that the furnace temperatures at the point of injection was too high. Additional runs were made to screen and evaluate alternate sorbent nozzle designs and locations, and potential upper furnace/convection pass modifications being studied separately under convection pass design evaluation. From the results of these additional runs and evaluations a modified upper furnace/convection pass arrangement with the sorbent injection ports located within a convection pass cavity was selected and final modeling runs begun. Initial modeling results indicate that ports alone have insufficient momentum for adequate penetration. However, the gas temperature in the cavity was within the window for injection. A modeling run is currently under way to evaluate the use of both lances and ports to better distribute sorbent to a greater depth into the cavity.

PSI PowerServe developed a furnace cleaning strategy using their Slagging Advisor model. Current modeling analysis indicates that lower furnace slagging may be a problem with the current selected LEBS furnace sizing. Currently, slagging from Illinois No. 6 coal is being evaluated in furnaces for which PSI has some slagging data, and in which furnace design parameters are similar.

Dry Scrubber Modeling: Work was completed on dry scrubber reduced load modeling and analysis. The results indicate that the proposed design is feasible for both full-load and partial load. Future work (in Phase II) will be needed to examine configurations of operational atomizers for partial load operation and to model the exit configuration of the dry scrubber in more detail. A draft topical report was been completed for internal use and review and as input for the dry scrubber modeling final report.

Task 5.0 Commercial Generating Unit Design: Work has begun on the development of the commercial generating unit design. Kick-off meetings have been held to initiate work, establish work scopes and schedules. Work has begun on establishing all final design condition including changes as a result of current RD&T activities.

Work Plan Status

All major activities continue on schedule as planned except as noted. No delays are expected in achieving completion of the program as planned.

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7/27/94

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