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**ENGINEERING DEVELOPMENT OF ADVANCED
COAL-FIRED LOW-EMISSIONS BOILER SYSTEMS**

Project Technical Status Report

QUARTERLY REPORT

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I. Project Management

I.1 Summary of Activities

Proposal efforts to the Ohio Coal Development Office (OCDO), the North Dakota Lignite Council, and the State of Illinois to gain their funding participation in the B&W LEBS Phase IV proof-of-concept demonstration continued. Proposals were completed and submitted to the North Dakota Lignite Council (August 29, 1996 - requesting \$3 million dollars) and the State of Illinois (September 30, 1996 - requesting \$5 million dollars). A visit to some North Dakota Utilities and the Lignite Research Council Director, Clifford Porter, to promote the project is scheduled for early October.

A paper entitled, "B&W's Advanced Coal-Fired Low-Emission Boiler System; An Update on Phase II Developments," was presented at the First Joint Power and Fuel Systems Contractors Conference on July 10, 1996 in Pittsburgh, PA.

A technical paper entitled, "The Worldwide Applicability of B&W's Advanced Coal-Fired Low-Emission Boiler System," was presented at the 13th Annual International Pittsburgh Coal Conference.

The 1996 AFRC Fall International Symposium was attended where a paper entitled, "A Low-NO_x Burner Prototype Developed for B&W's Advanced Coal-Fired Low-Emission Boiler System," was presented.

A technical paper entitled, "Status of Phase II Subsystem Testing in Support of B&W's Advanced Coal-Fired Low-Emission Boiler System," was submitted for presentation at the International Joint Power Generation Conference in Huston October 14-16, 1996.

II. NO_x Subsystem

The goal of the NO_x Subsystem is to achieve continuous operation of the Low-Emissions Boiler System (LEBS) at NO_x emissions at or below 0.20 lb/MBtu through combustion techniques only, with a further target of 0.1 lb NO_x/MBtu using supplementary advanced flue gas cleanup technologies if necessary. These goals place practical constraints that must be considered on the NO_x Subsystem design. Not only must the boiler be designed to achieve time-temperature mixing histories that minimize NO_x, but it must also be designed to operate that way throughout its working lifetime. Therefore, NO_x minimization strategies must be integrated into the control systems for every boiler component from the pulverizers to the stack. Furthermore, these goals must be met without increases in carbon loss and CO emissions from the levels achieved with current low-NO_x combustion systems. Therefore, the NO_x Subsystem requires not only sound mechanical designs of burners, furnace surface, and staging air/fuel injectors, but also sensors and software to allow control of their operation. Through engineering analysis, experimental testing, and numerical modeling in Phase II, an advanced low-NO_x control system is being developed. The progress of these activities is presented in this report.

II.1 Summary of Activities

The 1996 AFRC Fall International Symposium was attended where a paper entitled, "A Low-NO_x Burner Prototype Developed for B&W's Advanced Coal-Fired Low-Emission Boiler System," was presented. A lot of interest in the DRB-4ZTM burner was generated, especially in the burner's ability to fire coals with a range of fixed carbon-to-volatile matter ratio of 1.16 to 1.57 with little effect on NO_x emissions.

The third and fourth rounds of burner development subsystem tests were completed this quarter. A number of hardware configurations were tested that changed the air flow distribution of the burner for improved NO_x, CO, and unburned carbon control.

Combustion modeling of the DRB-4ZTM burner continued at the subsystem scale for both unstaged and staged burner operation. This modeling will provide information to aid in evaluating burner performance, as well as providing input to both the commercial generating unit and proof-of-concept design activities.

II.2 Key Accomplishments

II.2.1 Subsystem Test Unit

B&W's 100 MBtu/hr Clean Environment Development Facility (CEDF) is being used as the Combustion 2000 burner development Subsystem Test Facility. The advantage of using the CEDF for Subsystem scale testing is in the ability to test a near-full size burner in an environment which closely simulates a utility boiler.

Hardware changes and various mixing devices were tested during the third and fourth rounds of subsystem testing. Parametric testing was performed for each burner configuration. Tests were performed by varying the air distribution, primary air-to-coal ratio, furnace stoichiometry and load. The data collected were averaged over the time frame of the test and were plotted for each configuration separately, while the optimum conditions were compared collectively.

Baseline testing was performed in the CEDF utilizing the DRB-4Z™ low-NO_x burner firing the LEBS Illinois #6 design coal in a previously tested configuration. The baseline tests were found to be repeatable during each round of testing.

Two coals were fired during the third and fourth rounds of burner testing, the Illinois #6 design coal and an Ohio/Mahoning 7. A Mahoning 7A coal was previously utilized during the initial round of burner development tests. It was determined that the Mahoning 7A coal showed the most sensitivity with respect to NO_x, CO, and UBC values, therefore, it was decided to utilize this coal for the third and fourth series of tests. However, the coal supply company was mining at a different location of the seam, obtaining a coal (Ohio #7) with a higher fixed carbon-to-volatile matter ratio. Consequently, the Ohio #7 coal was utilized for the third and fourth rounds of testing. Table II.2.1.1 gives the coal analysis for the test coals utilized during the all of the subsystem tests thus far.

Results from the parametric tests involving changes in air distribution tended to show the same preferences for the burner configuration. By changing the air flow pattern, definite changes were noted in the emissions performance. This information corresponded to the modeling case studies, where different mixing patterns of the coal and air could be detected. Based on these results, hardware pieces were fabricated to physically change the mixing patterns which would simulate the positive influences previously seen in the experimental tests and modeling cases.

The furnace stoichiometry was varied by changing the amount of excess air to the burner through adjusting the secondary air flow. By increasing the furnace stoichiometry, more O₂ was available causing more complete combustion thus resulting in lower CO and LOI values, while increasing the fuel-N transformation to NO_x. This trend was observed consistently through the test series.

Load variations were tested to simulate furnace turn-down. The visual stability of the flame was noted along with emission performance. The DRB-4Z™ burner did not display any problems while operating at 60% and 35% load conditions.

Figures II.2.1.1 - II.2.1.3 illustrate the NO_x, CO, and LOI comparison for the two test burners (the benchmark DRB-XCL® and the DRB-4Z™) firing the five different coals utilized throughout the test series. The values shown in the graphs correspond to the optimum burner configuration for the DRB-4Z™ and the DRB-XCL® burners. Figure II.2.1.1 shows the reduction in NO_x achieved by the DRB-4Z™ burner. NO_x reductions for the Illinois coal range between 20-25%, for the Mahoning coal between 40-50%, and for the Horizon coal between 50-55%. The Kentucky #9 and the Ohio #7 coal were not fired with the DRB-XCL® burner, therefore, no comparison can be made for these coals between the DRB-4Z™ and the DRB-XCL® burners.

The test coals ranged in fixed carbon-to-volatile matter ratios from 1.16 to 1.57, as shown in Table II.2.1.1. It is evident from Figure II.2.1.1, that the effect of firing the various coals on NO_x emission for the DRB-4ZTM burner is relatively flat across the entire range.

The effect on the CO emissions is illustrated in Figure II.2.1.2. The CO emissions while firing the Mahoning coal were greatly increased for the DRB-4ZTM burner, as could be expected due to the significant NO_x reduction. However, looking at the Ohio Horizon coal results, although the NO_x was significantly reduced with the DRB-4ZTM burner, the CO emissions were not as greatly affected, with the average remaining around 50 ppm. CO emissions for the Kentucky #9 and Ohio #7 coals remained in the same general range as the Illinois #6 and Ohio Horizon coals. Again, it should be noted that the values reported on the graphs are for the optimum burner configurations for that particular test series, firing the various coals. These graphs do not necessarily represent the average values obtained over the wide variety of test configurations.

Table II.2.1.1: Chemical Analysis of Test Coals

	Illinois #6		Mahoning 7A		Kentucky #9		Ohio #7		Ohio Horizon	
	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry
Proximate Analysis, %										
Moisture	14.25	—	5.70	—	9.82	—	3.90	—	5.51	—
Volatile Matter	36.14	42.15	37.85	40.14	35.07	38.89	34.49	35.89	38.25	40.48
Fixed Carbon	41.81	48.75	49.98	53.00	44.41	49.24	54.32	56.52	46.27	48.97
Ash	7.80	9.10	6.47	6.86	10.70	11.87	7.29	7.59	9.97	10.55
Gross Heating Value	10980	12805	13120	13913	1129	12452	13292	13831	12221	12934
Btu/lb (M&A Free)	—	14087	—	14938	—	14129	—	14967	—	14459
FC/VM	1.16		1.32		1.27		1.57		1.21	
Ultimate Analysis, %										
Moisture	14.25	—	5.70	—	9.82	—	3.90	—	5.51	—
Carbon	60.56	70.62	73.63	78.08	61.74	68.46	74.10	77.11	66.69	70.58
Hydrogen	4.54	5.29	4.98	5.28	4.42	4.90	5.21	5.42	5.05	5.34
Nitrogen	1.13	1.32	1.56	1.66	1.42	1.57	1.30	1.35	1.38	1.46
Sulfur	3.50	4.08	0.93	0.99	4.5	5.05	1.22	1.27	3.88	4.11
Ash	7.80	9.10	6.47	6.86	10.70	11.87	7.29	7.59	9.97	10.55
Oxygen (by difference)	8.22	9.59	6.73	7.13	7.35	8.15	6.98	7.26	7.52	7.96

Figure IL2.1.1 NO_x Emission Comparison to Test Burner Firing Five Test Coals

Figure IL2.1.2 CO Emission Comparison to Test Burner Firing Five Test Coals

Figure IL2.1.3 LOI Comparison to Test Burner Firing Five Test Coals

The LOI values, shown in Figure II.2.1.3 correspond to the CO emissions. The cases where lower CO emissions were obtained, lower LOI values were also measured. LOI data was not collected while firing the Ohio Horizon coal for either test burner. All fly ash samples collected were measured for loss on ignition at 1380°F. A few random samples were also measured for unburned carbon determined by an ASTM method. A comparison between the two measurements showed that the LOI measurements were on the average 7% higher than the UBC measurements.

Additional coals will be tested during the fifth round of Subsystem Testing scheduled for late October. An eastern bituminous with a higher fixed carbon-to-volatile matter ratio and a western sub-bituminous coal will be fired with the DRB-4Z™ burner.

Numerical modeling continued to be used to provide insight into unstaged and staged performance of the DRB-4Z™ burner, and to evaluate NOx reduction for deeply staged burner operation. A series of burner models were begun this quarter to compare unstaged combustion characteristics of the burner with staged combustion at a burner stoichiometry of 0.85 and 0.75. These models are also being used to compare carbon monoxide concentrations and carbon burnout, both in the burner near-field and in the overfire air zone. This information will be compared with measured trends obtained during subsystem testing to provide information for the deep-staging designs for the commercial generating unit and the proof-of-concept facility.

III. SO₂/Particulate/Air Toxics/Solid By-Product Subsystem

The scope of the SO₂ subsystem comprises the control of SO₂, particulate matter, hazardous air pollutants (commonly called "air toxics"), and solid byproducts from the B&W LEBS plant. The specific minimum performance requirements for the SO₂ subsystem are:

- SO_x -- Less than 0.20 lb (SO₂ equivalent)/MBtu for coals with sulfur levels of 3 lb of sulfur per MBtu and no more than 0.067 times the sulfur content (lb/MBtu) for coals with less than 3 lb of sulfur per MBtu.
- Particulate -- Less than 0.015 lb particulate/MBtu
- Potential to comply with possible emissions control regulations for targeted air toxics.
- Produce environmentally benign solid byproduct.
- Integrate with other plant subsystems to yield optimal overall performance and cost.

In addition, the following performance targets have been established:

- SO_x -- Less than 0.10 lb (SO₂ equivalent)/MBtu for coals with sulfur levels of 3 lb of sulfur per MBtu and no more than 0.0333 times the sulfur content (lb/MBtu) for coals with less than 3 lb of sulfur per MBtu.
- Particulate -- Less than 0.01 lb particulate/MBtu (B&W plans to achieve 0.005 lb/MBtu)

On the basis of the results compiled during the concept selection process completed in Phase I, the Limestone Injection Dry Scrubbing (LIDS) process was selected for further development and evaluation in B&W's LEBS project. The LIDS process is a cost-effective integration of three commercially proven flue gas cleanup technologies: furnace limestone injection, dry scrubbing, and pulse-jet fabric filtration. Through engineering analysis, experimental testing, and numerical modeling, a LIDS process is being developed that is capable of ultra-high SO₂ removal and superior particulate control while addressing the potential issues of air toxic emissions and solid byproduct utilization. The progress of the LIDS activities follows.

III.1 Summary of Activities

The solid by-product cognizance effort continued. B&W is aggressively pursuing ways to reduce or utilize the solid waste produced by its various clean coal and FGD processes through a variety of in-house and externally-funded development programs. Specific plans for E-LIDS™ solid by-product utilization tests were completed. The Energy and Environmental Research Center (EERC - University of North Dakota) will be completing utilization tests and economics on the E-LIDS™ by-product. Solids were collected during the September E-LIDS™ test series for analysis and use in demonstrating the utilization methods. (Task 7.1)

The air toxics cognizance effort continued. B&W is conducting a wide variety of air toxics-related research projects, and is closely following the regulatory process. The effort will continue throughout the project. (Task 7.1)

Numerical flow modeling of the commercial dry scrubber model was completed. The model was used to evaluate design variations, with predictions for impact on pressure drop, wall impingement, and mixing. Two alternate outlet geometries were modeled to evaluate the impact of the outlet configuration on the vessel flow patterns and sorbent particle distribution. (Task 7.3)

Data reduction and analysis for the second round of Phase II 100 MBtu/hr E-LIDS testing (June 1996) was completed. The test series focused on achieving ultra-high SO₂ capture, obtaining SO₂ performance curves with a fine limestone, and observing system operability. This effort is covered under the key accomplishment section. (Task 11.2)

The third and final round of Phase II E-LIDS testing was successfully completed September 16 - 25, 1996, at 100 MBtu/hr in the Clean Environment Development Facility. The test series focused on repeating the ultra-high SO₂ removal achieved in the June 1996 test series, obtaining SO₂ performance curves using a coarser limestone, completing air toxic measurements, and addressing the effect of low-load operation on furnace limestone injection performance. This effort is covered under the key accomplishment section (Task 11.1 & 11.2)

III.2 Key Accomplishments

III.2.1 - E-LIDS Subsystem Test Series #2 Data Reduction Completed

Data reduction and analysis for the second round of Phase II 100 MBtu/hr E-LIDS testing (June 1996) was completed. The test series focused on achieving ultra-high SO₂ capture, obtaining SO₂ performance curves with a fine limestone, and observing system operability.

The LEBS goal of 0.10 lb SO₂/MBtu (98% SO₂ removal) was achieved with the E-LIDS system. Figure III.2.1.1 shows the total SO₂ removal that was achieved at the outlet of each of the E-LIDS unit operations. At the outlet of the furnace limestone injection system, 38% SO₂ removal was achieved. At the outlet of the dry scrubber, 77% SO₂ removal was achieved. At the outlet of the baghouse (or the E-LIDS system outlet) 99% SO₂ removal was achieved. The operating conditions for this test included: 1) furnace stoichiometric ratio (Ca/S); 1.35 mol Ca/mol S, 2) approach to flue gas saturation temperature; 10°F, 3) slurry percent solids concentration; 30-35%, and 4) limestone grind; 6 microns mass mean diameter.

**Figure III.2.1.1 - 10 MW, E-LIDS Total SO₂ Removal
June test series - 6 micron limestone**

Another way to express E-LIDS SO₂ capture is by the percentage of the total SO₂ (created from the coal) that is removed with each unit operation or that goes up the stack. Figure III.2.1.2 shows that for 2578 ppm produced from the coal, SO₂ capture occurred as follows (for the same conditions as the data shown in Figure III.2.1.1): 38.0% (967 ppm) in the furnace, 38.8% (989 ppm) in the dry scrubber, 22.6% (575 ppm) in the baghouse, and 0.7% (17 ppm) went up the stack.

Figure III.2.1.3 shows the furnace SO₂ removals achieved as a function of furnace calcium stoichiometry (Ca/S). The furnace SO₂ removal ranged from 32 to 39%. A range of removals may occur at a given Ca/S due to sootblowing frequency and the resulting swings in convection pass temperature.

Figure III.2.1.4 shows the SO₂ removals obtained versus approach to saturation temperature (T_{as}) for the dry scrubber, baghouse and total E-LIDS systems. The figure clearly shows that low operating temperatures enhance SO₂ capture in the dry scrubber, baghouse, and therefore, the overall E-LIDS systems. The high baghouse SO₂ removal achieved at low dry scrubber/baghouse operating temperatures is a necessary ingredient for the E-LIDS final SO₂ emissions trim.

**Figure III.2.1.2 10 MWe E-LIDS SO₂ Removal by Unit Operation
June test series - 6 micron limestone**

**Figure III.2.1.3 - 10 MWe E-LIDS Furnace SO₂ Removal versus Ca/S
June test series - 6 micron limestone**

Figure III.2.1.4 - 10 MWe E-LIDS SO₂ Removal versus Tas
June test series - 6 micron limestone

III.2.2 - E-LIDS Subsystem Test Series #3 Completed

The third round of 100 MBtu/hr E-LIDS tests were completed in late September 1996. Goals of the test series included: 1) achieve 98% SO₂ removal while using a limestone with a grind between 15 and 20 microns mass mean diameter, 2) quantify the effects of low-load operation on furnace limestone injection performance, and 3) make air toxics measurements.

Coarser limestone grind. All of the 100 MBtu/hr E-LIDS test during the first and second E-LIDS test series had used a limestone with a grind of less than 10 microns mass mean diameter (MMD). In the third round of tests coarser limestone was tested to prove that ultra-high SO₂ removal (98%) should be achieved while using a limestone between 15 and 20 microns MMD. This goal is important to the process in order to improve the E-LIDS system economics and operability. A coarser limestone will do the following: 1) decrease the auxiliary power necessary to grind the limestone, hence, increase the cost-effectiveness of the E-LIDS system and 2) decrease the amount of convection pass fouling associated with limestone adhering to the tubes.

Low load-operation. The effects of low-load operation on the furnace limestone injection process was investigated. This information will be used to determine operating procedures covering the entire load range.

Air toxics measurements. Air toxics measurements were made at the inlet to the dry scrubber, inlet to the baghouse, and at the stack during E-LIDS operation. Measurements of total mercury, speciated mercury, trace metals, and acid gases were collected to confirm the systems capability

to achieve greater than 90% mercury removal and to further characterize the E-LIDS system's air toxics removal capabilities.

Data reduction and analysis will occur during the next quarter of the project. Results from the September 1996 E-LIDS tests will be presented in the next quarterly report.

IV. Boiler Subsystem

At the heart of the LEBS is the boiler. Within this advanced B&W boiler, all of the low emission technologies are integrated. To meet the net plant efficiency goal of 42%, the boiler must be designed not only to achieve the proper conditions for low NO_x combustion with air staging and accommodate the in-furnace injection of the limestone for the LIDS process, but it must also efficiently capture the heat to produce high temperature steam at well above critical pressure. The steam conditions selected for the boiler are 4500 psi, 1100°F/1100°F/1100°F.

Since the steam-side pressure and main and reheat steam temperatures are higher than conventional cycles and operation of low NO_x burners creates sub-stoichiometric conditions in portions the furnace, additional challenges are presented. Higher alloy materials must be used in the outlet portions of the superheater and reheater banks to obtain acceptable surface metal temperatures. In addition, materials must be selected that will resist corrosion since the surface of these outlet tubes will operate at temperatures which will allow the coal ash to remain molten on their surfaces. Consideration must also be given to furnace wall corrosion in the combustion zone. Thus, boiler design work has been identified to address the integration of the NO_x and SO₂ subsystems while applying B&W's advanced supercritical boiler technology.

IV.1 Summary of Activities

IV.1.1 CGU Boiler Development

Surface for the boiler was reset after receiving reheat control load from Raytheon. Reheat control load has been defined as 60% MCR. Other modifications were also added to compensate for the low furnace exit gas temperature and the integration of the LIDS system.

IV.2 Key Accomplishments

IV.2.1 CGU Boiler Development

After receiving the reheat control load from Raytheon, work began to finalize the boiler design. In order to maintain steam temperature at control load, the surface for reheat 2 was over surfaced for full load in order to achieve control load steam temperature. Originally our concept was to control reheat 1 temperature by gas biasing and allow spray to control reheat 2 temperature at full load. After setting surface it was discovered that the amount of spray required for reheat 2 at full load would have a significant impact on cycle efficiency. Several options were investigated for reducing the spray required. The method finally settled on was to use steam bypassing on the second stage reheater at full load. In this control method, more than half of the reheat 2 steam flow bypasses the surface in the horizontal down pass and is remixed before the pendant surface. It is believed this method will be economical and easily controlled while eliminating the need for any reheat spray for temperature control.

Efforts continue on the circulation analysis for a vertical tube furnace. This furnace arrangement would significantly reduce the pressure drop for the main steam through the boiler. However, tube overheat problems are being encountered as well as stability. We are uncertain at this point if this type of furnace is feasible. In parallel, a spiral wound furnace is also being analyzed.

Due to the furnace size and overfire air for NO_x reduction, the Furnace Exit Gas Temperature (FEGT) is lower than desired. At this time we are designing for refractory being applied in the upper furnace area to increase the FEGT. Other methods are being sought to overcome this problem, but thus far refractory seems to be our only alternative.

IV.2.2 Corrosion Evaluation

The two expanded laboratory tests have been commenced during the last quarter. The first test involves exposure of candidate furnace-wall alloys and coatings to a simulated low-NO_x combustion gas for 5000 hours at 1300°F, and the second test is performed under the same environment but at 1500°F. The tests will be completed in January and February 1997, respectively.

Fabrication of a corrosion test panel for Unit #2 of Allegheny Power Systems at the Hatfield's Ferry Power Station is also underway. The 20-tube x 20-foot panel will consist of eight different commercial coatings and bare T2 sections. The panel fabrication is expected to complete in February 1997, and the installation will follow during the Unit #2 Spring outage. Following the installation, B&W will monitor and analyze the corrosion performance of this panel during the next three scheduled outages. The cost for the analysis will be paid for by the Electric Power Research Institute under a separate contract.

V. Balance of Plant Subsystem

In order to develop an overall plant design and to evaluate plant efficiency and cost, B&W subcontracted with Raytheon Engineers and Constructors of Denver, Colorado. Together a Phase I concept was developed that achieved the initial LEBS goal of 38% net plant efficiency. That design resulted in identification of a number of potential improvements to the turbine cycle and auxiliary equipment needed to meet the Phase II goal of 42% net plant efficiency.

V.1 Summary of Activities

Turbine heat balances for full load and reheat control load have been issued for HARP and non-HARP cycles. An economic analysis has also been performed comparing the two.

The economic analysis to compare on sight limestone grinding against purchasing prepared limestone has been completed.

V.2 Key Accomplishments

Heat balances for full and reheat control (60%) loads for both the HARP and non-HARP cycles were completed. The HARP cycle had a better heat rate by only eleven Btu/kWh. An economic analysis was performed to evaluate both cycles on a cost of electricity basis. The non-HARP cycle was the clear economic choice for plant design because the higher equipment costs associated with the HARP configuration outweighed the small heat rate improvement. Consequently, the non-HARP cycle has been selected for the CGU design.

The evaluation for grinding limestone or purchasing prepared limestone is now completed. Based on this evaluation, the CGU will be designed based on prepared limestone being purchased in lieu of on site grinding. This option saves plant space, maintenance cost, and auxiliary power for grinding equipment.

VI. Controls & Sensors Subsystem

In order to maintain low stack emissions and optimum boiler performance throughout the operating range and lifetime of the LEBS, a state-of-the-art integrated control system must be developed. This control system must include new sensors as well as old sensors used in new ways. It must make sense out of the data provided while initiating or directing the operator to take appropriate action. The control system that will help assure that the LEBS will meet its stack emission, efficiency, availability, and cost of electricity goals.

The overall philosophy of the LEBS control system is to use conventional, state-of-the-art solutions to satisfy new control requirements. Existing sensors, hardware, and software are specified whenever possible and new measurements or advanced equipment are recommended for development only where necessary to assure the success of the project. The progress of the Controls & Sensors Subsystem is contained in this report.

VI.1 Summary of Activities

PC network problems on the use of the X-terminal connection between Barberton and Alliance were resolved permitting the SPEEDUP process model in Alliance to be run from Barberton. A simplified control scheme was applied to the process model which identified discrepancies in both SPEEDUP and the process model which were resolved. A test matrix was established for a parametric evaluation of the combustion/NO_x portion of the POC process model and initial tests were conducted.

VI.2 Key Accomplishments

Work started on control system design using the preliminary simulator of the POC facility developed using the SPEEDUP dynamic modeling package. Secondary and overfire air flow controllers were implemented using a parallel type PID algorithm which is widely used by control vendors in the utility industry.

An open loop parametric study was conducted based on a matrix containing important input parameters - coal flow, primary and secondary air flows. The study was conducted at the condition which represents full load of the POC facility to determine the relationship between emissions parameters and input parameters. Emissions parameters monitored were excess oxygen (O₂), carbon monoxide (CO), nitrous oxide (NO), sulfur dioxide (SO₂), Economizer outlet gas temperature, and unburned carbon (UBC).

Table VI.2.1 shows the matrix of tests performed on first group of burners:

Table VI.2.1: Parametric Study Test Matrix

Parametric Study Test Matrix			
	Coal Flow	Primary Air Flow	Secondary Air Flow
TEST01			1 - 10% Step Decrease 2 - 10% Step Increase
TEST02		1 - 10% Step Decrease 2 - 10% Step Increase	
TEST03		1 - 10% Step Decrease 2 - 10% Step Increase	1 - 10% Step Decrease 2 - 10% Step Increase
TEST04	1 - 10% Step Decrease 2 - 10% Step Increase		
TEST05	1 - 10% Step Decrease 2 - 10% Step Increase		1 - 10% Step Decrease 2 - 10% Step Increase
TEST06	1 - 10% Step Decrease 2 - 10% Step Increase	1 - 10% Step Decrease 2 - 10% Step Increase	
TEST07	1 - 10% Step Decrease 2 - 10% Step Increase	1 - 10% Step Decrease 2 - 10% Step Increase	1 - 10% Step Decrease 2 - 10% Step Increase

Following is the description of coordinated control test involving a simultaneous step change in all three parameters (TEST07). Figure VI.2.1 shows changes in the input parameters and Figure VI.2.2 shows the response in the gas emissions parameters.

Figure VI.2.1 - Gas Input Parameters

Figure VI.2.2 - Gas Emission Parameters