U.S. Power Plant Laboratories

Project Status Report for: February 2001

Project Title: Ultra Low NOx Integrated System for Coal-Fired Power Plants

Project Number: 91890460 **Project Manager:** John Marion

Customer Name: U.S. DOE / Performance Projects **Project Leader:** Charles Maney

GOALS AND OBJECTIVES:

Develop low cost, retrofit NO_x control technologies to address current and anticipated, near term emissions control legislation for existing coal fired utility boilers. Specific goals include:

- Achieve < 0.15 lb/MMBtu NO_x for eastern bituminous coals
- Achieve < 0.10 lb/MMBtu NO_x for western sub-bituminous or lignitic coals
- Achieve economics at least 25% less than SCR-only technology
- Validate NOx control technology through large (15 MWt) pilot scale demonstration
- Evaluate the engineering feasibility and economics for representative plant cases
- Provide input to develop commercial guidelines for specified equipment
- Provide input to develop a commercialization plan for the resultant technologies

WORK PLANNED FROM PREVIOUS REPORT:

Task 2.4 – Advanced Control System Design

- Complete preparations for the calibration / testing of coal mass flow meters.
- Begin analysis of the advanced flame scanner data.

Task 3.1 – Test Planning & Facility Preparation

- Purchase fuels for 2nd BSF test week.
- Begin general BSF facility prep.
- Finalize selection of additional NOx reduction concepts and begin engineering / procurement.

ACCOMPLISHMENTS FOR REPORTING PERIOD:

Task 2.4 – Advanced Control System Design

- *Complete preparations for the calibration / testing of coal mass flow meters.*

A set of 12 mass flow meters was used in the recent BSF testing to measure, and allow for control over the coal flow rate to each of the 12 coal nozzles (3 elevations x 4 corners). As these devices were received immediately prior to the BSF testing, no attempt was made to calibrate them prior to their use. As a result, a set of 12 barrels with bag filters were fabricated for connection to each coal line to allow the coal flow rates to be determined by weighing the barrels. All hoses and fittings have been procured and prepared. The pulverized coal was transported to the feed silo and the coal piping aligned for firing in the BSF. The verification testing of the coal flow meters will occur early in March.

- *Begin analysis of the advanced flame scanner data.*

A quick review of the flame scanner data obtained during the first combustion test period in the BSF identified problems with the sampling procedure. Decreases in the signal amplitude were observed with time due to ash deposition in the sight pipe. Due to the relatively large size of the flame scanner sight pipe (2" diameter) in comparison with the coal nozzles (2.5" x 2.75"), a continuous air purge of a significant velocity was not possible without impacting the local stoichiometry. Hence, it was decided to purge intermittently in between actual tests.

As the sight pipes were not purged before each test, it is now difficult to separate decreases in signal intensity due to changes in furnace conditions from decreases due to a change in the effective area of the pipe.

Although there may be useful frequency data in the signals that were collected in the first week of combustion testing in the BSF, it was decided to save the analysis dollars for review of data from the second combustion test period in the BSF where both frequency and amplitude information should be available. At that time, additional care will be taken to minimize the impact of ash deposition on the signal amplitude via more frequent monitoring and cleaning and / or the use of continuous purge air.

Task 3.1 – Test Planning & Facility Preparation

- *Purchase fuels for 2nd BSF test week.*

A sub-bituminous coal from the Powder River Basin will be fired during the second test period in the BSF. The Kennecott Energy Company has agreed to donate 300 tons of their Cordero Rojo Complex coal, including transportation to our Windsor site, in support of the test campaign. Due to the increased volatile content and high char reactivity of the Cordero Rojo coal, more of the fuel nitrogen is released in the sub-stoichiometric region of the boiler where it can be reduced to N_2. As a result, it is expected that the NOx emissions from the Cordero Rojo coal will be the lowest of this test campaign. The interest of Kennecott Energy in our low NOx project and their willingness to support it are greatly appreciated. The contribution of the Burlington Northern railroad in donating part of the transportation costs is also acknowledged. The coal is scheduled to arrive by March 23.

In addition to the Cordero Rojo coal, a high volatile Eastern bituminous coal has also been selected for fire in the BSF during the 2nd test period. Arrangements have been made with the mine and a trucking company to provide the coal. An assessment is currently being made of the feasibility of separating the testing of the sub-bituminous and the high volatile bituminous coals by approximately a week. The additional time between testing will cost a little more, but should allow for a more careful review of the test results on the more reactive sub-bituminous fuel before firing the bituminous coal. This should result in a more focused test campaign on the bituminous coal to achieve the most useful results in the shortest test time possible.

Preliminary analyses of the week 2 test coals and the mVb coal fired during the week 1 work are provided in Table 1.

Table 1. BSF Test Coal Analyses

	mvb	hvBb	Cordero Rojo sub-bit
Proximate			
VM	22.5	34.5	30.7
FC	63.1	52.0	33.8
FC/VM	2.8	1.5	1.1
Ultimate			
Moisture	0.9	4.0	29.6
Hydrogen	4.0	4.7	3.4
Carbon	74.7	70.4	48.8
Sulfur	1.4	2.4	0.3
Nitrogen	1.3	1.4	0.7
Oxygen	4.2	7.6	11.5
Ash	13.6	9.5	5.7
Total	100.0	100.0	100.0
HHV, BTU/lb	13,109	12,624	8,429
lb N / MMbtu	1.0	1.1	0.9
O / N	3.2	5.4	15.8

- *Begin general facility prep.*

Work is currently underway to prepare the BSF for the week 2 testing. Repairs / maintenance of the coal transport and storage systems have been largely completed. Parts have been ordered to repair the sootblowers and the windbox air damper actuator which failed near the end of the last testing. Needed repairs will be made in March. Additional inspection and cleaning of the BSF has also been started. Some damage to the lower SOFA assemblies was discovered. Furnace de-slagging is currently underway and must be completed to reveal the extent of the SOFA damage and to allow a detailed inspection of the windbox frames.

As illustrated in Figures 1-4, the medium volatile bituminous coal fired in the BSF during the 1st test period formed significant slag deposits on the furnace walls. Figures 1-2 show the main windbox region before and after testing. There was a significant buildup of ash on the refractory walls (approx. 2 ") and even some deposits in the furnace corners where the water-cooled walls are not covered with refractory.

Figures 3-4 illustrate the deposition that occurred around the lower SOFA compartments. Even though the photos were taken from different locations due to the absence of scaffolding after the tests, the figures illustrate the significant ash buildup that occurred in the SOFA region. The high ash content (13.6%), the relatively high ash fusion temperatures (2700 °F), and the higher than normal firing rate (57 MMBtu/hr) all contributed to the slagging observed when firing the medium volatile bituminous coal. This high rate of slag buildup is not expected for the coals that will be fired in the 2nd test period as their low ash fusion temperatures should result in a thin film of running slag on the BSF walls.

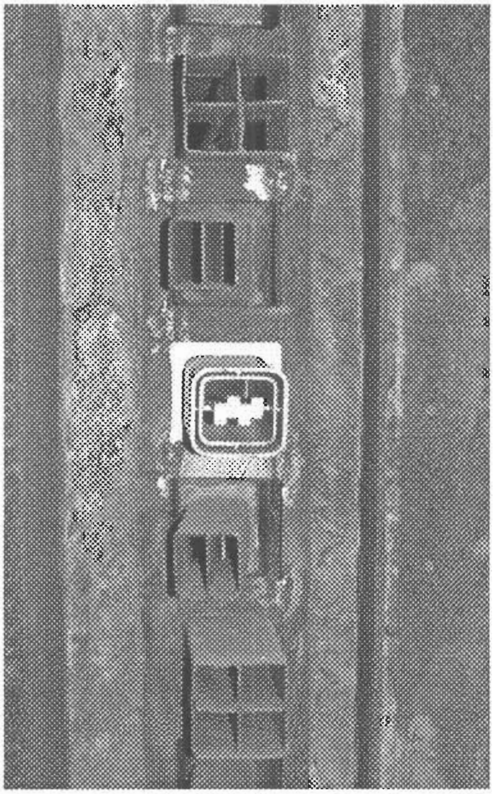

Figure 1. BSF windbox before testing.

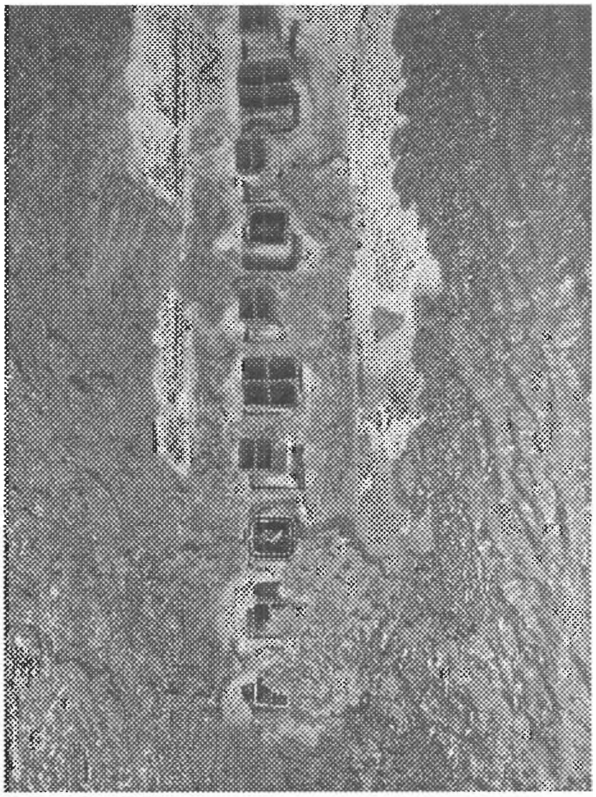

Figure 2. BSF windbox after testing.

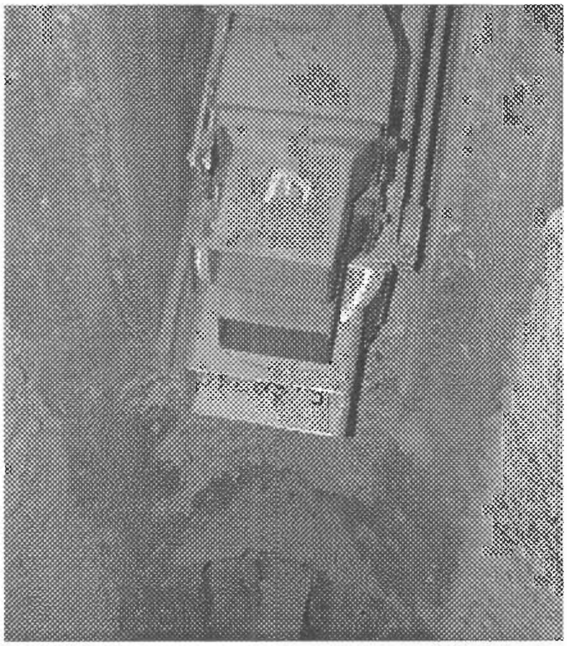

Figure 3. Lower SOFA before testing (from above).

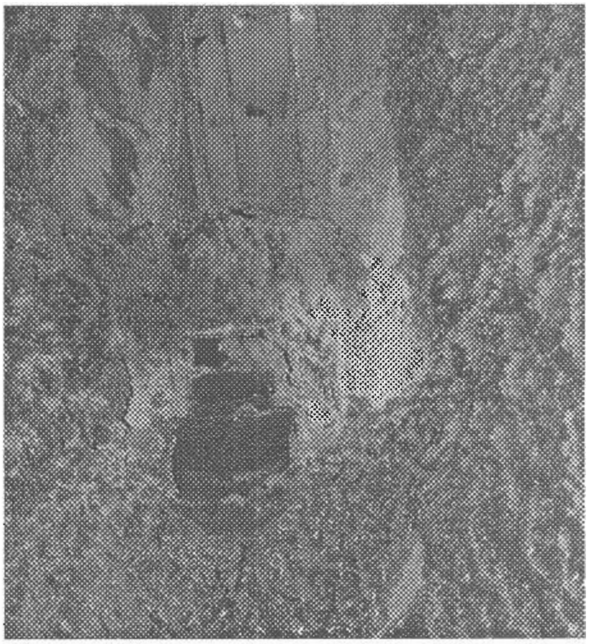

Figure 4. Lower SOFA after testing (from below).

- *Finalize selection of additional NOx reduction concepts and begin engineering / procurement.*

The main variables that will be examined in the second period of combustion testing in the BSF are listed in Table 2. The noted variables represent the extension of the test work performed in October where performance will be evaluated on a more reactive fuel, with the addition of some new parameters to attempt to achieve additional NOx reduction.

Table 2. List of variables to be tested in week 2 of BSF testing.

1 MBZ Stoichiometry
2 Staged Residence Time
3 Near Field Stoichiometry
- **a Transport air to fuel ratio**
- **b Fuel air flow**
- **c Subcompartmentalization**

4 Transport Air & Fuel Flow Balance
- **a Coal flow balancing**
- **b Vertical coal bias (*top coal %*)**

5 SOFA Elevation (*1 vs. 2*)
6 SOFA Mixing
- **a SOFA Velocity (*field equivalent*)**
- **b SOFA Yaw**
- **c *SOFA Location***

7 Boiler Load
8 Coal Fineness (*sub-bit coal*)
9 Excess Air (*USOFA flow variation*)
10 Bottom End Air
- **a Quantity**
- **b Location / separation distance**
- **c Direction (yaw / tilt)**

11 Low-set / compressed WB
12 O2 enrichment

The first new concept that will be tested in the BSF is that of a low-set, compressed windbox. Lowering the top coal elevation will result in additional staged residence time which should provide additional NOx reduction.

The second NOx reduction concept under consideration for testing in the BSF is O_2 enrichment. Increasing the O_2 concentration in the coal nozzles should increase local flame temperatures, resulting in higher volatile yields and more fuel nitrogen being released in the sub-stoichiometric region of the furnace where it can be reduced to N_2. ALSTOM Power is a subcontractor to Praxair for their DOE sponsored low NOx project to look at using oxygen to reduce NOx emissions from coal fired boilers for wall-fired applications. The addition of this scope will complement that work and extend it to tangentially-fired boiler applications.

An evaluation is currently underway to determine the additional facility preparation and testing costs to assess the viability of testing O_2 enrichment in the BSF. However, as O_2 enrichment was not originally budgeted for in this project, it is not clear if the project will be able to bear the cost.

Task 8 – Project Management

Modifications to the overall project work scope were made and agreed to with US DOE NETL with the net result that the project is now on-budget for the scope of work performed. A revised statement of work reflecting the agreed to project scope modifications was transmitted to ALSTOM Power and US DOE personnel in February.

In addition, a technical paper entitled "Ultra-Low NOx Integrated System for Coal Fired Power Plants was written and presented at the 28th International Technical Conference on Coal Utilization & Fuel Systems to be held in Clearwater, FL on March 5-8, 2001. The paper describes ALSTOM Power, Inc.'s experience implementing low-NOx retrofits of T-fired utility boilers and the development efforts of this project to further reduce NOx emissions in coal-fired utility boilers.

WORK PLANNED FOR NEXT REPORTING PERIOD:

Task 2.4 – Advanced Control System Design

- Complete calibration / testing of coal mass flow meters.

Task 3.1 – Test Planning & Facility Preparation

- Receive sub-bituminous coal and begin pulverization.
- Finalize week 2 test matrix for BSF.
- Make needed modifications / preparations for BSF week 2 testing.

BUDGET STATUS: