ABB'S LEBS ACTIVITIES - A STATUS REPORT

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ABSTRACT

ABB Combustion Engineering, Inc. is one of three contractors executing Phases I, II and III of the Department of Energy project entitled Engineering Development of Advanced Coal-Fired Low-Emission Boiler Systems (LEBS). Phase I has been completed and Phase II is scheduled for completion on September 30, 1996. The following major activities are being carried out in parallel in Phase II and this paper is a status report on this work:

- In-furnace NO_X reduction
- Catalytic filter optimization
- Add Kalina cycle to POCTF
- POCTF design and licensing

The in-furnace NO_X reduction work has been completed and, therefore, a description of this work comprises the major part of this paper.

INTRODUCTION

The primary objectives of the LEBS project are, using near-term technologies, to dramatically improve environmental performance of future coal-fired power plants while increasing their efficiency and maintaining the cost of electricity at or below current levels. The secondary objectives are to improve ash disposability, reduce waste generation and reduce airtoxics emissions. The overall objective is expedited commercialization of the technologies developed. The major deliverables are a design data base and the preliminary design of a commercial generating unit (CGU).

Since the award of contracts in September 1992 the DOE has asked the contractors to strive for ever lower emissions and higher efficiency. In addition ABB, with the addition of the Kalina cycle, has set an even higher efficiency target. Today the targets are as follows:

		DOE Minimum Performance	DOE Preferred Performance	ABB's Targeted Performance
SO_2*	lb/MM Btu	0.2	0.1	0.1
NO_X	lb/MM Btu	0.2	0.1	0.1
Particulates	lb/MM Btu	0.015	0.01	0.005
Efficiency (HHV, net),	%	42	42	45

*3 lb S/MM Btu in the coal

Phase I consisted of selection of candidate technologies, creation of a preliminary 400 MWe CGU design and preparation of an RD&T Plan for Phases II and III. The Phase II work consists of: Component Optimization, POCTF Preliminary Design and Subsystem Testing. The four major Phase II activities are listed above in the ABSTRACT and are described below. (The work on in-furnace NO_X reduction is the only one completed.)

IN-FURNACE NO_X REDUCTION

<u>Introduction</u>: The most cost-effective method of reducing nitrogen oxide emissions when burning fossil fuels, such as coal, is through in-furnace NO_X reduction processes. For the LEBS project, the DOE has specified the use of near-term technologies to provide for these overall emissions reductions. Based on technical and economic feasibility, advanced tangential firing was selected as the primary means of NO_X emissions control for the ABB LEBS boiler design [1,2]. Specifically, ABB CE's TFS 2000™ firing system, which is a proven technology and commercially available, represents the technology selected as the basis for in-furnace NO_X reduction. This firing system design has been demonstrated to provide NO_X emissions of 0.2 pounds/MM Btu in prior laboratory and full scale, retrofit, utility boiler applications [3,4]. The objective of recent development work was to reduce this value to 0.1 lb/MM Btu.

Briefly, the TFS 2000™ firing system has been developed for minimum NO_X emissions from pulverized coal fired boilers, accomplished by way of combustion techniques only. Specific features of this system include the use of concentric firing system (CFS) air nozzles, where the main windbox secondary air jets are introduced at a larger firing circle than the fuel jets; close-coupled overfire air (CCOFA) for improved carbon burnout; and multi-staged separated overfire air (SOFA) to provide for complete combustion while maintaining an optimum global stoichiometry history for NO_X control. In addition, the TFS 2000™ firing system includes flame attachment coal nozzle tips for rapid fuel ignition and a pulverizer configured with a DYNAMIC™ Classifier to produce fine coal to minimize carbon losses under these staged combustion conditions.

Potential enhancements to the TFS 2000™ firing system focused on optimizing the introduction of the air and fuel within the primary windbox zone to provide additional horizontal and vertical staging. These enhancements were based on controlling the combustion of the coal in a more local sub-stoichiometric environment. That is, in addition to the global staging currently applied, improved NO_X reduction was sought by controlling and optimizing the mixing of the fuel and air locally through vertical and horizontal staging techniques. As is the case with all in-furnace NO_X control processes, it is necessary to operate the system in a manner which does not decrease NO_X at the expense of reduced combustion efficiency. The objective of recent developmental work on the firing system was to reduce NO_X emissions levels leaving the boiler to 0.1 pounds NO_X/MM Btu while maintaining carbon in ash at acceptably low levels (<5%) for high sulfur, mid-western and eastern bituminous coals.

The approach used in the development and evaluation of the various firing system concepts included an integrated approach of kinetic and computational modeling, small scale experimental testing in a Fundamental Scale Burner Facility (FSBF), and larger scale combustion testing in a Boiler Simulation Facility (BSF). Both modeling and experimental testing were applied to better understand the mechanisms governing in-furnace NO_X reduction and to identify potential enhancements to the TFS 2000™ firing system. Results from this testing were used in the development of advanced low NO_X firing systems which were evaluated in pilot scale combustion testing [5]. The pilot scale testing and evaluation of various advanced low NO_X firing systems is described below.

<u>Pilot Scale Combustion Testing</u>: Pilot scale combustion testing of in-furnace NO_X control systems was performed in ABB Power Plant Laboratories' BSF. The objective of this testing was to evaluate enhancements to the existing NO_X control technologies for improved NO_X emissions performance, while providing the necessary information for supporting the design of the NO_X control subsystem for the LEBS Proof-of-Concept Test Facility (POCTF).

The BSF is a pilot scale test furnace, nominally rated at 50 MM Btu/hour (5 MWe) for coal firing, that reliably duplicates the combustion characteristics of a tangentially-fired utility boiler. All major aspects of a typical tangentially-fired utility boiler are duplicated in the BSF including a v-shaped hopper for bottom ash collection, the use of multiple burner elevations, and an arch with subsequent backpass convective "superheat," "reheat," and "economizer" surfaces. Selective refractory lining over atmospheric pressure "waterwalls" allows the matching of the residence time/temperature history of large scale utility boilers, including the horizontal furnace outlet plane (HFOP) gas temperature.

The BSF is fully instrumented to monitor the combustion process. Instruments for measuring coal feed rate, primary and individual secondary air mass flow rates, outlet emissions (O_2, CO_2, CO, SO_2, NO, and NO_X), and convective pass heat flux distribution are tied into a combined DCS/data acquisition system to allow for control and logging of these and other important operational parameters. For the subject testing, the BSF was operated in a tangentially-fired mode with levels of separated overfire air (SOFA). Prior laboratory test programs have shown that BSF test results can be reliably translated to the field for use in firing system design, and subsequent performance prediction[3].

Performance targets for the BSF combustion testing were consistent with those for the LEBS program; maximum NO_X emissions of 0.1 pounds/MM Btu and carbon in the fly ash <5% for high sulfur, mid-western and eastern bituminous coals. In addition, the lower furnace heat absorption profiles and convective pass heat flux distribution were to remain similar to or improved over the existing system. The coal utilized during the BSF testing was the high sulfur, medium volatile, bituminous Viking coal from Montgomery, Indiana.

Prior to the initiation of NO_X control subsystem testing, the firing system for the BSF was modified to take advantage of current and previous R&D project findings. First, ABB CE's Aerotip™ coal nozzle tip design was utilized as the base from which the BSF coal nozzles were constructed. The Aerotip™ design embodies improved aerodynamic features which support the test program need for a low NO_X coal nozzle tip through its control over near field stoichiometry.

In addition to the incorporation of an Aerotip™ based coal nozzle tip, the main windboxes of the BSF were designed to accommodate a range of vertical and horizontal air and coal staging scenarios. The design of the secondary air nozzles was based on the need to maintain proper jet momenta, while having sufficient flexibility to test variations in vertical and horizontal air staging. In addition, excess coal nozzle capacity was incorporated to allow the testing of various coal staging scenarios, including two-corner coal firing. With this foundation, each of the "base" (*i.e.*, benchmark) firing system designs tested in the BSF, including the TFS 2000™ firing system, was able to incorporate the results of the prior chemical kinetic modeling and small scale (FSBF) combustion testing with respect to main windbox vertical air staging.

One goal of the BSF testing was to generate design data in support of achieving NO_X emissions of 0.1 pounds/MM Btu through in-furnace firing system modifications (*i.e.*, prior to any post combustion process NO_X reduction system). Toward this end, various "conventional" global air staging techniques were tested in order to benchmark their NO_X reduction potential on the test fuel. This work included investigations of close-coupled overfire air (CCOFA), upper and lower (single) elevations of separated overfire air (SOFA), and an implementation of TFS 2000™ technology. All of the various overfire air configurations utilized the same main windbox arrangement, and all were performed with high fineness (90% - 200 mesh) coal grind, which is consistent with TFS 2000™ firing system design standards.

A summary of the results from testing various overfire air configurations with the test coal are given in Figure 1. As anticipated, the implementation of global air staging results in a significant reduction in furnace outlet NO_X emissions. Beginning with NO_X emissions of 0.52 pounds/MM Btu with a typical "baseline" (post-NSPS) firing system arrangement, NO_X reductions continued to a low of 0.13 pounds/MM Btu for an "optimized" TFS 2000™ firing system arrangement (Note: similar 0.13 pounds/MM Btu outlet NO_X emissions were obtained with the upper SOFA only, but this was at slightly degraded carbon in the fly ash performance). The "optimized" TFS 2000™ system incorporates improvements to the bulk stoichiometry history over the initial TFS 2000™ test, with identical main and overfire air windbox configurations. In all, a 75% reduction in NO_X from baseline levels was achieved with the "optimized" TFS 2000™ system. As expected, carbon in the fly ash increased as the global staging was increased, but remained below the limit of 5%.

Figures 1 & 2

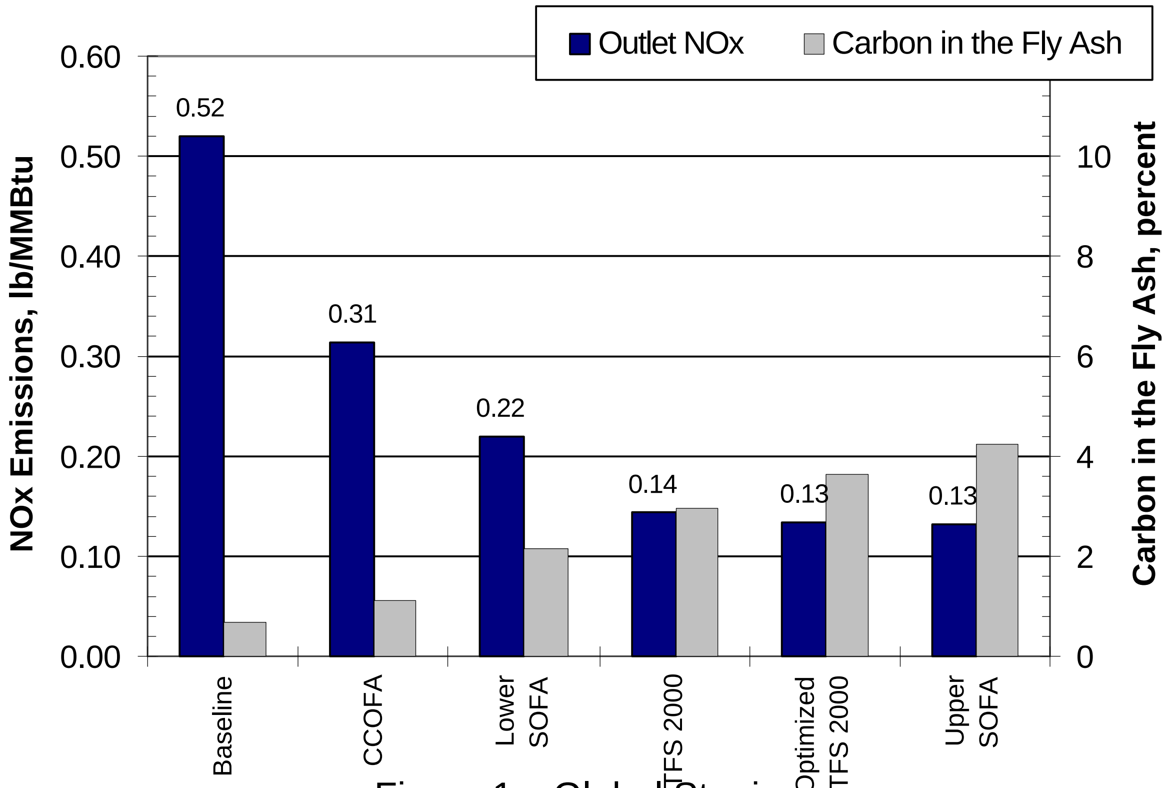

Figure 1 Global Staging

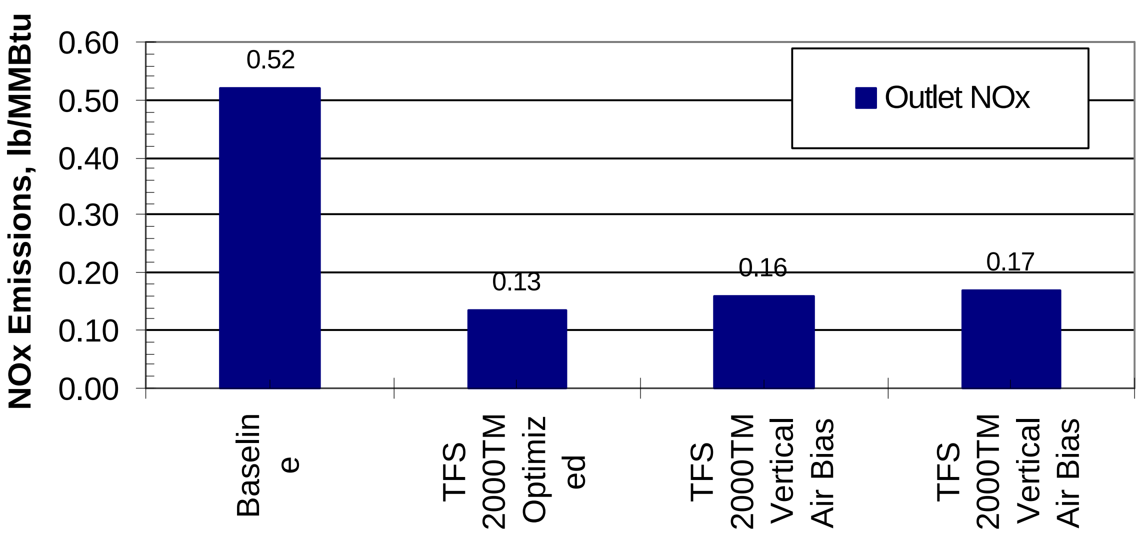

Figure 2 Effects of Vertical Staging on NOx

Figures 3 & 4

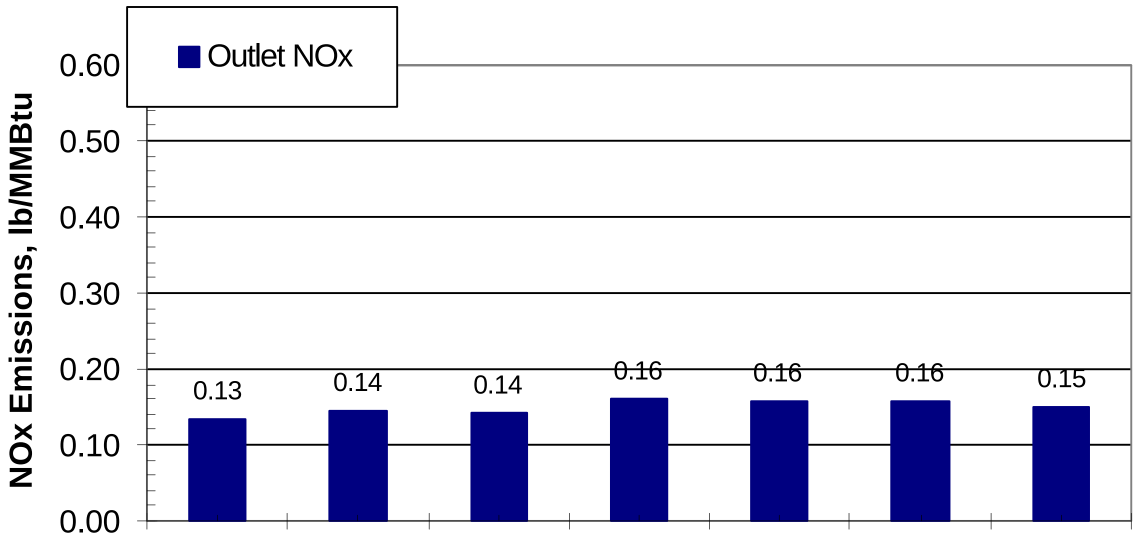

Figure 3 Effects of Horizontal Staging on NOx

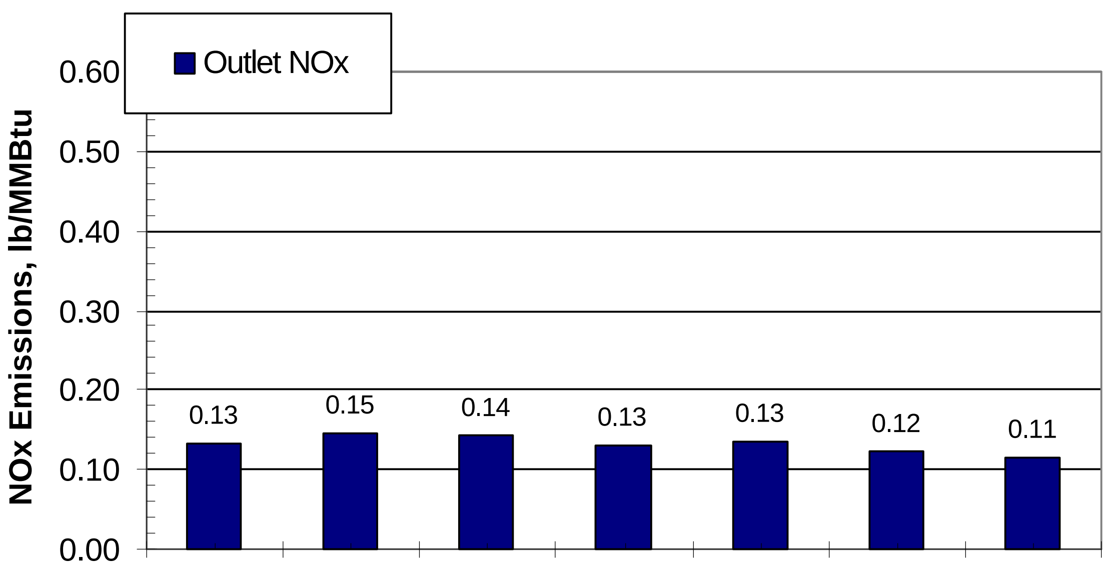

Figure 4 Effects of Integrated Staging on NOx

Having benchmarked the effects of global staging on firing system performance, both vertical and horizontal staging techniques within the main firing zone were subsequently tested to evaluate their effects on NO_X performance. The objectives of this work were to confirm the results of prior main windbox vertical air staging work, and to further reduce outlet NO_X emissions from the previously demonstrated "best" level of 0.13 pounds/MM Btu through the application of horizontal, and integrated vertical and horizontal main windbox staging techniques. As such, these methodologies were applied in concert with the "optimized" TFS 2000™ firing system, keeping the global stoichiometry history constant to allow meaningful comparisons.

First, vertical air staging within the main windbox was independently varied to demonstrate its effect on NO_X formation at this large pilot scale. Results from this testing, given in Figure 2, show that significant variation in NO_X emissions occur as main windbox vertical air staging is changed. In this case variations to the vertical air staging produced a +/- 13% deviation in outlet NO_X about the mean. This result confirms that the main windbox vertical stoichiometry history is an important contributor to overall NO_X formation, even with significant levels of global air staging. Overall, NO_X emissions increased when variations to the main windbox vertical stoichiometry build-up were applied to the previously "optimized" TFS 2000™ arrangement. This result is, however, expected since the "optimized" TFS 2000™ system incorporates the results of prior chemical kinetic modeling and small scale combustion test vertical air staging work into the configuration of its main windbox as noted above.

Next, horizontal staging, used to control the horizontal "build-up" of stoichiometry (corner to corner) within the main burner zone, was evaluated. This was accomplished by biasing the fuel and air between one or more of the four corners. Tested subsets of this technique are two corner firing, where all of the air and fuel are injected through two of four corners in a tangential arrangement, and opposed corner firing where the coal is injected from two corners, and the air from the remaining two. In general, independent implementation of horizontal staging techniques resulted in neutral to degraded NO_X emissions performance over that of the "optimized" TFS 2000™ firing system during the subject testing. This is seen in Figure 3, which shows the effect of independent variation of either fuel or air (horizontal staging) on overall NO_X emissions performance. These results demonstrate that, similar to the prior vertical staging experiments, outlet NO_X emissions can be affected by horizontal fuel and air distributions. However, these results also demonstrate that the global time-stoichiometry history (*i.e.*, the TFS 2000™ stoichiometry profile) dominates the NO_X formation and reduction processes at these levels of global air staging.

Finally, several configurations which applied integrated vertical and horizontal staging techniques as a means of "optimizing" the stoichiometry of combustion within the main windbox were evaluated. Integrated vertical and horizontally staged firing systems were extensively evaluated using CFD modeling prior to the BSF tests. In contrast to their independent performance, Figure 4 shows that when suitably combined, an integrated vertical and horizontal staging strategy offers a small, but consistent improvement to the NO_X emissions performance of the optimized TFS 2000™ system. At a NO_X emission level of 0.11 pounds/MM Btu, the "best" integrated system ("Integrated Config. 6") produced a greater than 10% reduction in NO_X over the previously "optimized" TFS 2000™ system. Carbon loss results (not shown) were also similar for the two firing systems.

Additional pilot scale testing of potential NO_X control subsystems in the BSF has been recently completed and results are being analyzed. The objective of this testing was to confirm the performance of the integrated vertical and horizontal staging technique, focusing on the repeatability of the present test results, while generating design information for this and other promising firing system concepts for eventual full scale utility boiler application.

CATALYTIC FILTER OPTIMIZATION

<u>Introduction</u>. The principal goal of the Catalytic Filter Optimization activities is the acquisition of initial field test data, which will be used for a larger field demonstration. These activities include the determination of feasible and reasonable operating conditions for the catalytic filter system. Data collected through testing will focus on particulate and NO_X removal efficiencies as well as filter draft loss.

The goals of this task are listed below in order of priority. It is desirable that these goals be achieved simultaneously.

- Particulate emissions of less than 0.003 lb/MMBtu
- Maximum filter clean-side draft loss of 8 inches w.g. at 4 ft/min at 775°F
- Operation with a Filter Face Velocity (FFV) of at least 4 ft/min at 650°F
- Minimum of 80% NO_X removal efficiency
- Ammonia slip of less than 15 ppm

Information gained from demonstration and evaluation will address the following issues:

- Confirm filter particulate removal efficiency.
- Determine the tubesheet differential pressure (filter draft loss) as a function of face velocity, cleaning cycle characteristics, operating time, and other parameters.
- Determine the NO_X reduction efficiency as a function of flue gas composition (NO_X inlet concentration, NH_3 stoichiometry, particulate removal), and flue gas temperature. Of further interest is the determination of the requirements to maintain the catalytic conversion efficiency.

Approach: The approach used is to test the Catalytic Filter System with four filter modules on a 100 ACFM (165 m^3/hr) slipstream at Richmond Power & Light's Whitewater Valley Station Unit 2, a 66 MWe pulverized coal-fired boiler. CeraMem manufactured the ceramic filter modules and Engelhard applied the NO_X reduction catalyst.

A slipstream unit was constructed and installed at the Richmond site, taking flue gas off the boiler at the economizer section, processing the gas to remove particulate and NO_X, and returning the gas to the air heater. The test system was installed at the site February and March of this year, and operation started immediately upon completion of installation. At this writing, an initial 500-hour test has been concluded, in which both particulate removal and NO_X reduction were investigated.

Preliminary Results: *The tubesheet differential pressure* (filter draft loss) is considered an essential element to the success and applicability of the catalytic filter to the LEBS Commercial Generating Unit (CGU) design. An excessive tubesheet differential pressure would require excessive fan power to move the flue gas through the system for processing. For the first 500-hour test, the initial tubesheet differential pressure was approximately 16 inches w.g. (FFV=4 ft/min, T= 650°F).

The filter permeance, a parameter inversely proportional to tubesheet differential pressure and independent of filter face velocity and process temperature, decreased through the first 150 hours of operation, as shown in Figure 5. This decrease indicated that the filter tubesheet differential pressure increased at constant process conditions, an effect that is typical of all ceramic particulate filters. This decrease in permeance or increase in tubesheet differential pressure is caused by the smaller particulate (less than 0.5µ diameter) becoming permanently lodged in the filter substrate. For all ceramic particulate filters, the filter permeance should stabilize at some point, indicating that essentially the pores that are able to become "plugged" have been, and that the filter is being cleaned efficiently. At this point, the tubesheet differential pressure will remain constant at constant process conditions. In the case of the initial 500-hour test, the tubesheet differential pressure rose to approximately 23-24 inches w.g. (FFV=4, T=650°F) after approximately 200 hours of operation and was stable for the remainder of the test.

Upon conclusion of the 500-hour test, the system was opened and the filter modules were inspected. Visual inspection showed that the filters were being cleaned effectively, with no particulate buildup being detected and no plugged channels being found.

Subsequent analysis of the catalytic filters indicate that catalyst addition was responsible for approximately 75 % of the tubesheet differential pressure.

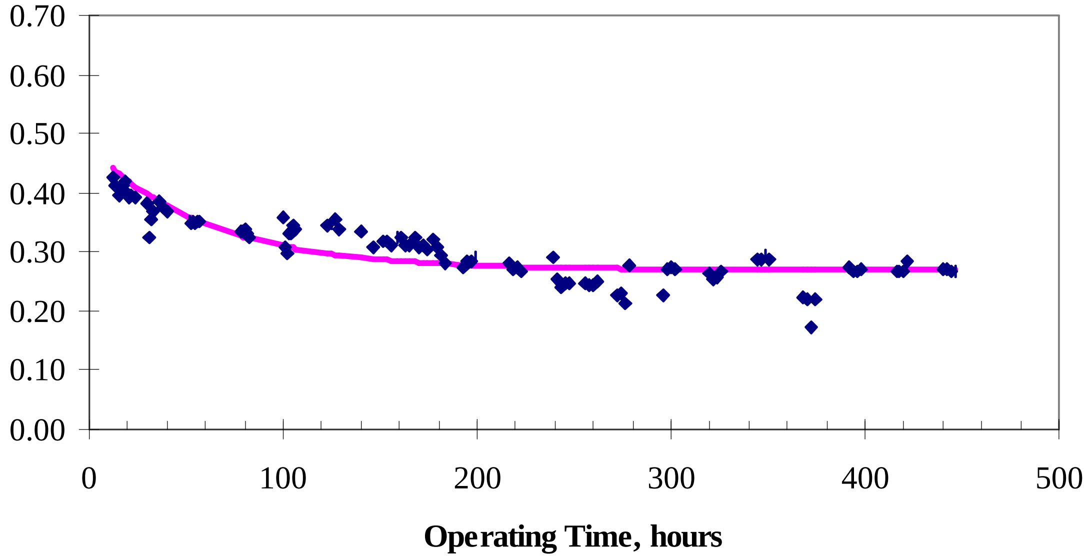

Figure 5 - Filter Permeance vs. Operating Time

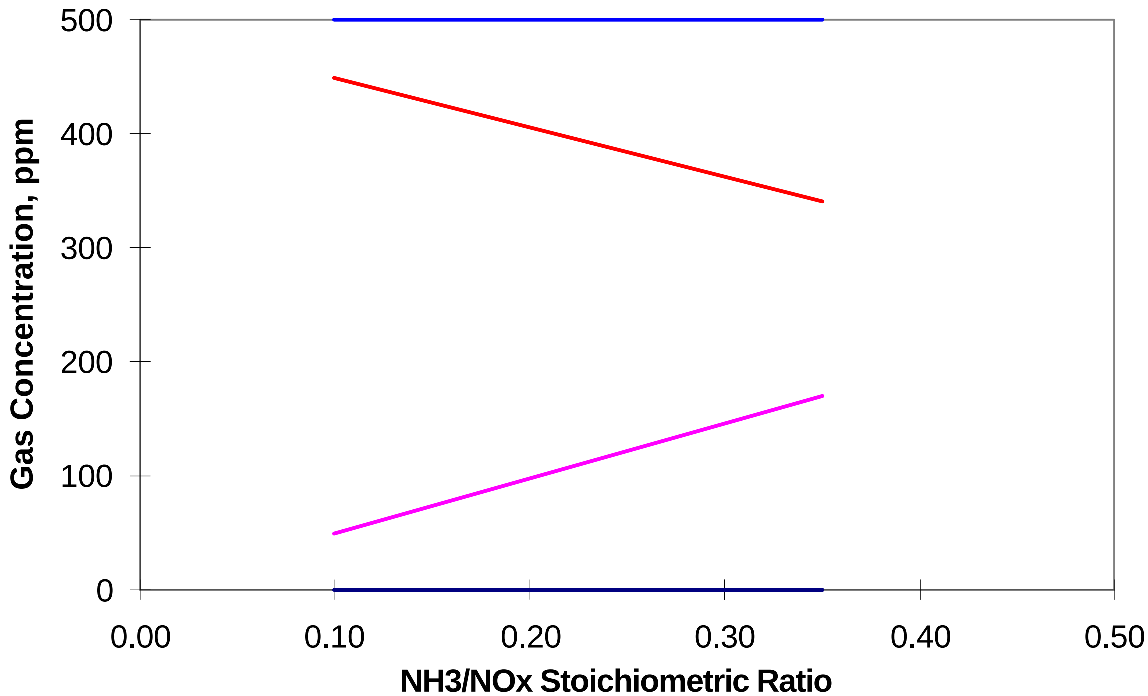

Figure 6 - NOx Reduction

Particulate removal for this filter system was expected to be near absolute. In previous testing of the filter system at ABB's corporate laboratory in Baden, Switzerland, outlet emissions from the filter could not be detected using a laser light-scattering measurement system, indicating that removal efficiency exceeded 99.99994%.

In the 500-hour test, two outlet particulate samples were taken, with results indicating a removal efficiency of 99.93% which is below the expected value.

Upon completion of the 500-hour test, the unit was opened and the tubesheet and vessel inspected. Lack of particulate matter on the "clean-side" of the tubesheet, particularly in cracks and crevices, tends to indicate that particulate matter was not passing through the filters and that the sampling results were reflective of material that had been left in the ducts when the system was being bypassed.

NO_X Reduction Efficiency testing was initiated after approximately 350 hours of operation. Ammonia was injected into the system to facilitate the NO_X reduction reaction. Inlet and outlet ammonia sampling was conducted to quantify ammonia injection rates and ammonia slip, while NO_X inlet and outlet concentrations were determined using two ThermoElectron Model 10 NO_X CEMs. Due to vendor problems that are beyond the scope of the paper, maximum injection stoichiometry was limited to 0.4 (maximum ammonia concentration in the inlet flue gas was approximately 200ppm).

Preliminary results indicate that the catalyst made efficient use of the ammonia, as shown in Figure 6. The ammonia was fully accounted for in the NO_X reduction reaction, and sampling and analysis found less than 3 ppm in the outlet flue gas in all samples.

Future Tests: It is unlikely that an advancement in catalyst deposition technology will be made that will achieve an initial tubesheet pressure differential of less than 8 inches w.g. within the 100 ACFM Test time frame. A second 500-hour test is presently under way to gather engineering data on the performance of a non-catalytic filter system. Catalyst development is continuing in a parallel program, with the hope of being able to achieve project goals by completion of Phase II.

POCTF DESIGN AND LICENSING WITH A KALINA CYCLE

Introduction: The centerpiece of the LEBS project is Phase IV which will undertake the design, construction and test operation of a proof-of-concept test facility (POCTF). These final-phase activities will provide the design and operating database critical to commercialization of the LEBS technologies. The current project plans are that only one of the three original LEBS teams, with their respective technologies, will be selected to implement Phase IV. The on-going Phase II and III tasks, however, include the precursor planning activities leading up to down-selection and Phase IV initiation. At present, the ABB LEBS team is developing a site-specific preliminary design for their POCTF, and has project licensing in progress.

Project Description: ABB has been fortunate in obtaining a commitment for an outstanding host site for their POCTF. Richmond (Indiana) Power & Light Co. (RP&L) has offered to host the project at their Whitewater Valley station. RP&L has a history of successful involvement in technology demonstration programs, including one of the earliest low NO_X burner installations, a LIMB installation, and a Clean Coal Technology project.

The Whitewater Valley plant is composed of two coal-fired, non-reheat units, with nominal ratings of 33 MWe (unit 1) and 66 MWe (unit 2). Unit 1 will be modified to accept the LEBS technology package. This unit is approximately 40 years old, and incorporates a 900F/900 psig steam cycle with a steam capacity of 325,000 lb/hr. The POCTF project will involve a major restructuring of the unit, that entails the replacement of the complete power system (boiler, turbine-generator, feedwater heaters, power piping) with a new Kalina-based power system, and addition of the LEBS flue gas cleanup system. The project will use the plant infrastructure to the maximum extent practical, including coal handling, heat rejection, ash handling, powerhouse structures, and auxiliary systems. Although the project is being implemented as a test facility, RP&L intends to use the unit for long-term production service following completion of the LEBS project. This criterion, therefore, has a dominant effect on specification and design of the equipment and the facility.

The approach taken in establishing the size of the modified unit has been to maximize its generating capacity, consistent with making maximum use of existing plant infrastructure. Key plant performance parameters are summarized in Table I.

Table I - UNIT 1 PERFORMANCE PARAMETERS
(Preliminary)

<u>Thermal</u>		<u>Existing</u>	<u>POCTF</u>	<u>Change</u>
Coal Heat Input	MM Btu/hr	400	440	+ 10%
Cooling Tower Load	MM Btu/hr	216	215	
Generator Output	MWe	35.6	54.6	
Auxiliary Load	MWe	2.2	6.7	
Net Unit Generation	MWe	33.4	47.9	+ 43%
Net Unit Heat Rate	Btu/kWh	12,000	9,186	- 23%
<u>Environmental</u>				
SO_2	lb/MM Btu	6.0 / 1.6(*)	0.1 to 0.2	/ - 90%
NO_X	lb/MM Btu	- / 0.5(*)	0.1 to 0.2	/ - 70%
Particulates	lb/MM Btu	0.19 / 0.19(*)	0.01	/ - 95%

(*) pre/post Phase II Clean Air Act Amendments (2000)

By leveraging the significant improvement in heat rate offered by the Kalina cycle with a modest 10% increase in coal heat input, the unit output will be increased a substantial 43% to about 48 MWe, with a corresponding 23% decrease in heat rate. At the projected net unit heat rate of about 9,200 Btu/kWh, the modified Whitewater Valley unit 1 will be the most efficient coal-fired unit of its size in the U.S. The planned project, in fact, compares favorably to the best coal-fired unit heat rate reported in the USA in 1994 of 8,889 Btu/kWh (annual average) for a 660 MW supercritical unit.

Equipment To date, an initial feasibility study for the project has been completed, and the preliminary design is in progress. Highlights of this on-going project conceptualization are described below.

Because the Kalina cycle optimizes at different thermodynamic conditions than a steam cycle, and because of the change in working fluid and the increase in generating capacity, the complete steam side of the power cycle is to be removed and replaced. These systems include the boiler and auxiliaries, turbine-generator and auxiliaries, condenser, condensate system and feedwater system. The size of the unit has been selected such that the new vapor generator will fit in the existing boiler support-steel cavity, and the new turbine-generator will fit the existing turbine pedestal (after pedestal modification). The fact that the Kalina cycle regenerates substantially more heat than a steam cycle results in a significant increase in the number of regenerative heaters, such that a turbine hall addition will be required to house this new equipment.

The vapor generator, or boiler, design for the POCTF is a single reheat, drum type with pumped circulation for cooling furnace wall evaporative tubes. The Kalina cycle, with its higher rate of heat regeneration, requires less evaporation but more superheater and reheater duty in the vapor generator. Thus, in addition to pendant and horizontal superheater and reheater surfaces, in the preliminary design portions of the upper furnace walls are used for superheating and reheating the working fluid. The design of these sections is the same as conventional radiant wall reheater designs. The vapor generator looks very much like a large utility unit designed for a Rankine cycle.

Turbine design performance for a Rankine or Kalina cycle is very similar. Ammonia has a molecular weight very close to that of pure water, (17 vs. 18). This allows the use of current designs for turbine blading and turbine shell to be used in a Kalina cycle. One major difference in the turbine, when used in a Kalina cycle, is that the turbine is changed to a back pressure configuration. In doing so, there is no need for the large low pressure section and vacuum system which are required in the Rankine cycle. This provides a capital cost saving as well as improved system efficiency.

In addition, the inclusion of the LEBS flue gas emissions control features dictates removal of the gas side power cycle systems. The replacement systems will include the low NO_X firing technology described previously, a new draft system, and a flue gas cleanup system. At present, two alternative processes are being evaluated for flue gas cleanup: the SNO_X^{TM} hot process and an advanced dry-scrubbing process.

Control requirements associated with the Kalina power cycle, and the fact that unit 1 still has its original control system, dictate that the project will include installation of a new unit-wide distributed control system. The increase in auxiliary power consumption associated with the modified unit also requires that the station service transformers for unit 1 (unit auxiliary and startup) be replaced with larger capacity units, and substantial new power distribution capability be added.

Licensing: A licensing plan and schedule have been developed for the project that has identified the need to obtain twelve individual environmental/safety permits and approvals. As indicated in Table I, the project will result in large reductions of all the regulated air emissions from unit 1. Thus, approvals for the air permits are expected to be relatively straight forward. Unique to this power project, however, is the significant ammonia inventory required for operation of the Kalina cycle. The presence of this material on site will require the development of plans to deal with a potential accidental ammonia release.

The licensing schedule is based on obtaining all approvals prior to the planned start date for Phase IV. At present, contact has been established with the Indiana Department of Environmental Management (IDEM). IDEM has been thoroughly briefed on the proposed project, and preparation of the long-lead permit applications is in progress.

CONCLUSIONS AND FUTURE WORK

Testing of the low-NO_X firing system has been completed. The work remaining is analysis of data from the second week of testing in the BSF. The NO_X emission target of 0.1lb/MM Btu with <5% carbon in the fly ash was achieved in the BSF (actually 0.11lb). However, at this time it cannot be predicted with certainty that 0.1 lb/MM Btu will be achieved in commercial size systems. There presently is no further LEBS firing system development work planned prior to construction of the POCTF.

The preliminary results of the catalytic filter field testing were very encouraging regarding particulate emissions and NO_X reduction. However, measured gas draft loss was excessive. Since approximately 75% of the draft loss is attributed to the catalyst, testing will continue with a non-catalytic filter system while catalyst deposition technology is reviewed. Also, since it is possible that the catalytic filter draft loss situation may not be resolved within the POCTF schedule, an alternative technology will be evaluated.

The POCTF design work was rescheduled to allow time to design the Kalina cycle components and to integrate them into the existing facilities at the host site. That work is essentially complete and plant design and licensing work has resumed and will be completed within the project schedule.

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