OXYGEN ENHANCED COMBUSTION **FOR NO_x CONTROL**

QUARTERLY TECHNICAL PROGRESS REPORT

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ABSTRACT:

This quarterly technical progress report will summarize work accomplished for the Program through the thirteenth quarter, April-June 2003, in the following task areas: Task 1 - Oxygen Enhanced Combustion, Task 3 - Economic Evaluation and Task 4 - Program Management.

The program is proceeding in accordance with project objectives. REI's model was modified to evaluate mixing issues in the upper furnace of a staged unit. Analysis of the results, and their potential application to this unit is ongoing.

Economic evaluation continues to confirm the advantage of oxygen-enhanced combustion. A contract for a commercial demonstration has been signed with the Northeast Generation Services Company to supply oxygen and license the oxygen enhanced low NO_x combustor technology for use at the 147-megawatt coal fired Mt. Tom Station in Holyoke, MA. Commercial proposals have been submitted. Economic analysis of a beta site test performance was conducted.

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A. Executive Summary

The objective of this program is to demonstrate the use of oxygen enhanced combustion as a technical and economical method of meeting the EPA State Implementation Plan for NO_x reduction to less than that of 0.15lb/MMBtu for boilers and coal. This program will develop both oxygen based low NO_x technology and the new low cost oxygen transport membrane (OTM) oxygen production technology.

The breakdown of the program work consists of the following four major tasks:

- Task 1.0 Oxygen enhanced combustion
- Task 2.0 Oxygen transport membranes
- Task 3.0 Economic evaluation
- Task 4.0 Program management

Task 1 work focused on two areas: CFD modeling results from Reaction Engineering International (REI) (Task 1.1.1) in general showed lower sensitivity of staging on LOI as compared to the measured results. The modeling also showed a lower sensitivity to oxygen addition on LOI as compared to the measured results.

Task 2 OTM element and process development was completed last quarter.

Task 3 work confirmed the economic advantages of oxygen enhancement based on beta site test results. Target boiler utilities were identified. A contract for a commercial demonstration has been signed with the Northeast Generation Services Company to supply oxygen and license the oxygen enhanced low NO_x combustor technology for use at the 147-megawatt coal fired Mt. Tom Station in Holyoke, MA. Commercial proposals were also submitted.

Program management (Task 4) continued on track throughout this quarter. All subcontracts and amendments to subcontracts have been negotiated and executed. Subcontracts with REI and the University of Utah have been extended through September 2003. Project documentation has been prepared and delivered to the US DOE in accordance with the cooperative agreement.

B. Experimental Methods

B.1. Combustion Modeling (Task 1.1.1) Experimental Methods

Computational fluid dynamic (CFD) modeling activities were performed by Reaction Engineering International (REI) for Praxair's United States Department of Energy (US DOE) program entitled "Oxygen Enhanced Coal Combustion for NO_x Control". The objective of this work was to illustrate the benefit of oxygen addition to low NO_x coal firing systems. Modeling performed during the last quarter evaluated mixing in the upper furnace at the current test facility.

C. Results and Discussion

C.1. Combustion Modeling (Task 1.1.1) Results and Discussion

During the last quarter REI's model was modified to evaluate mixing issues in the upper furnace of a staged unit. Preliminary modeling results were based on a uniform firing strategy (i.e. all burner rows in services and staged to the same stoichiometric ratio). These results suggested that elevated CO emissions (or high steam temperatures) could be related to poor mixing between CO formed near the burner wall and the overfire air. The model was also modified to consider other firing strategies and various methods to facilitate OFA mixing on the front wall. Analysis of the results, and their potential application to this unit is ongoing. Additionally, modeling work was initiated to quantify the impact on corrosion of going from an unstaged boiler to one stage with oxygen for NO_x control.

C.2. Economic Evaluation (Task 3) Results and Discussion

Oxygen enhancement advantage versus SCR/SNCR was confirmed with utilities. Based on pilot-scales tests, commercial burner performance tests, and the beta site test results, the economic advantage of oxygen enhancement was confirmed.

The market segmentation was completed with target boiler utilities identified. Commercial proposals have been submitted. A contract for a commercial demonstration has been signed with the Northeast Generation Services Company to supply oxygen and license the oxygen enhanced low NO_x combustor technology for use at the 147-megawatt coal fired Mt. Tom Station in Holyoke, MA.

C.3. Program Management (Task 4) Results and Discussion

The Program Management highlights for the US DOE NO_x program are as follows:

- Teleconferences were held among combustion team members.
- Monitoring of accounts established within the Praxair accounting system to track labor hours and costs was ongoing.
- Project documentation has been prepared and delivered to the US DOE in accordance with the cooperative agreement including quarterly technical progress reports and financial status reports.

D. Conclusion

This quarter, progress was made toward achieving the DOE NO_x program objectives as follows:

Oxygen Enhanced Combustion Tasks:

CFD modeling experiments compared REI's modeling results for James River Unit 3 with the NO_x and LOI results obtained during the demonstration program at that facility.¹ Results showed lower sensitivity of staging on LOI as compared to the measured results. The modeling also showed a lower sensitivity to oxygen addition on LOI as compared to the measured results. Based on upper furnace modeling, testing and control strategies were developed. A scaled version of Riley Power's newest low NO_x burner design was fabricated at the University of Utah

to explore both the effectiveness of oxygen addition with this design and the best way to add oxygen. Preliminary tests indicated that NO_x emissions were much higher in the scaled burner than observed with the full-scale burner. Based on discussions with burner suppliers these tests were discontinued due to scaling issues. The successful demonstration of oxygen enhanced combustion for NO_x control at the pilot and full-scale single burner levels led to an agreement between Praxair and City Utilities of Springfield, Missouri to test oxygen enhanced combustion at full scale (separately funded). The results from the full-scale demonstration project at the James River Power Station indicated that oxygen enhanced combustion can substantially reduce NO_x emissions from coal-fired power plants.

Economic Evaluation:

The advantage of oxygen enhancement versus SCR/SNCR was confirmed with utilities. Based on pilot-scales tests, commercial burner and beta site performance tests, the economic advantage of oxygen enhancement was confirmed. Also, market segmentation was completed with target utilities and boilers identified. Discussions were held during this quarter with utilities to confirm economics and identify issues limiting the commercialization of the technology.

Commercialization activity further accelerated during this quarter. A contract for a commercial demonstration has been signed with the Northeast Generation Services Company to supply oxygen and license the oxygen enhanced low NO_x combustor technology for use at the 147-megawatt coal fired Mt. Tom Station in Holyoke, MA.

E. References

1. Thompson et. al, "Oxygen Enhanced Combustion for NO_x Control", Quarterly Technical Progress Report for US DOE Award No. DE-FC26-00NT40756, April 2003.