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ENHANCING THE USE OF COALS BY GAS REBURNING-SORBENT INJECTION

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1.0 SUMMARY

The objective of this project is to evaluate and demonstrate a cost effective emission control technology for acid rain precursors, oxides of nitrogen (NO_x) and sulfur (SO_x), on two coal fired utility boilers in Illinois. The units selected are representative of pre-NSPS design practices: tangential and cyclone fired. Work on a third unit, wall fired, has been stopped because of funding limitations. The specific objectives are to demonstrate reductions of 60 percent in NO_x and 50 percent in SO_x emissions, by a combination of two developed technologies, gas reburning (GR) and sorbent injection (SI).

With GR, about 80-85 percent of the coal fuel is fired in the primary combustion zone. The balance of the fuel is added downstream as natural gas to create a slightly fuel rich environment in which NO_x is converted to N_2. The combustion process is completed by overfire air addition. SO_x emissions are reduced by injecting dry sorbents (usually calcium based) into the upper furnace. The sorbents trap SO_x as solid sulfates that are collected in the particulate control device.

This project is conducted in three phases at each site: (1) Design and Permitting, (2) Construction and Startup, and (3) Operation, Data Collection, Reporting and Disposition. Technology transfer to industry is accomplished through the formation of an industry panel. Phase I of the project commenced on June 5, 1987 and concluded on May 15, 1989. It included five tasks as follows:

Task 1 - Project Management

Task 2 - Process Design

- Subtask 2.1 - Host Site Characterization
- Subtask 2.2 - Process Specification

Task 3 - Project Engineering

Task 4 - Environmental Reports, Permitting Plans and Design

Task 5 - Technology Transfer

In Phase AII at Hennepin, Task 1 - Project Management coordinated the completion of the startup work and wrap up of all contractual issues prior to the close out of EER Job Number 8657 (Phase AII) at the end of September.

In Phase CII at Lakeside, Task 1 - Project Management, the civil construction and natural gas line installation were completed. Significant progress was made toward completion of the mechanical, electrical and ash handling construction.

Close coordination was maintained at both sites with host representatives. Some of the coordination meetings were attended by representatives of DOE, GRI and ENR.

In Phase AII at Hennepin, Task 2 - Construction and Startup, the Sorbent Injection startup work proceeded simultaneously with gas reburning optimization during the third quarter of 1991. With the completion of these activities this quarter construction and startup activities are now complete.

In Phase CII at Lakeside, Task 2 - Construction and Startup, focused on the continuation of the mechanical, electrical and ash handling subcontractor work. Contracts were let for completion of asbestos abatement and replacement of steam drum internals.

Phase AIII at Hennepin - Testing, Data Collection, Reporting and Disposition proceeded in parallel with the completion of the Phase AII activities. Gas reburning runs were made that indicate 77% reduction in NO_x emission using about 18% gas. Gas Reburning - Sorbent Injection test results indicated 57% reduction in SO_2. These results are significantly higher than the project emission reduction goals of 60% NO_x and 50% SO_2 and provide a wide safety margin for maintaining the 60% and 50% emission reductions during long term routine testing.

Phase CIII at Lakeside - The Continuation Application for entry into Phase CIII was submitted in August, 1991.

Key Words

SO_x	Ash	Emission
SO_2	Coal	Control
NO_x	Gas	Boiler
NO	Sorbent	Precipitator
Pond	Construction	Flue Gas
Startup	Instrumentation	Contracts
CEMS	Industry Panel	Control
Reburning	Injection	Ducts
Humidification		

2.0 INTRODUCTION

Clean Coal Technology implies the use of coal in an environmentally acceptable manner. Coal combustion results in the emission of two acid rain precursors: oxides of sulfur (SO_x) and oxides of nitrogen (NO_x). This clean coal technology project will demonstrate a combination of two developed technologies to reduce both NO_x and SO_x emissions: gas reburning and calcium based dry sorbent injection. The demonstrations will be conducted on two pre-NSPS utility boilers representative of the U.S. boilers which contribute significantly to the inventory of acid rain precursor emissions: tangentially fired and cyclone fired units. (A demonstration on another representative boiler type, wall fired, has been stopped because of funding limitations.)

Gas reburning is a combustion modification technique that consists of firing 80-85 percent of the fuel corresponding to the total heat release in the lower furnace. Reduction of NO_x to molecular nitrogen (N_2) is accomplished via the downstream injection of the remaining fuel requirement in the form of natural gas (which also reduces the total SO_x emissions). In a third stage, burnout air is injected at lower temperatures in the upper furnace to complete the combustion process without generating significant additional NO_x.

Dry sorbent injection consists of injecting calcium based sorbents (such as limestone, dolomite, or hydrated lime) into the combustion products. For sulfation of the sorbent to $CaSO_4$, an injection temperature of about 1230 °F is optimum, but calcium-sulfur reactions can also take place at lower temperatures. Thus, the sorbent may be injected at different locations, such as with the burnout air, at the exit from the superheater, or into the ducting downstream of the boiler with H_2O added for humidification. The calcium sulfate and sulfite products are collected together with unreacted sorbent by the particulate collection device, usually an electrostatic precipitator or bag filter.

The specific goal of this project is to demonstrate NO_x and SO_x emission reductions of 60 percent and 50 percent, respectively, on two coal fired utility boilers having the design characteristics mentioned above. Host Site Agreements have been signed by EER and utility

companies in the State of Illinois: Illinois Power Company (Test Site A, Hennepin Unit 1, 71 MW_{net} tangentially fired boiler in Hennepin), Central Illinois Light Company (Test Site B, Edwards Unit 1, 117 MW_{net} front wall fired boiler in Bartonville), and City Water Light and Power (Test Site C, Lakeside Unit 7, 33 MW_{net} cyclone fired boiler in Springfield). (As discussed above, GR-SI demonstrations are now planned only at sites A and C.)

Co-funding for this project is provided by the Gas Research Institute (GRI) and the State of Illinois Department of Energy and Natural Resources (ENR)--the other Funding Participants. GRI and ENR are responsible for funding approximately one-third and one-sixth, respectively, of the total project costs.

To achieve the objectives of the project, it is being conducted in the following three phases at each host site.

Phase I: Design and Permitting
Phase II: Construction and Startup
Phase III: Operation, Data Collection, Reporting and Disposition

Phase I of the project was conducted in parallel for test sites A, B and C over a period of 22 months, starting in June 1987. During the period of May 15-August 15, 1989, Phase AII-A pre-engineering overlap work was conducted on the tangentially fired site A. After continuing negotiations with the host of site A, a Host Agreement Modification was signed on January 19, 1990. Phase AII-B (the balance of the Construction and Startup work) was resumed immediately, and essentially completed during the third quarter of 1991. Also, GR and GR/SI optimization testing was done at Hennepin, while Phase CII Construction and Startup work continued at Lakeside.

During the past quarter the principal objectives of the work performed were as follows:

A. Hennepin Unit 1

1. Continue standard project management activities of preparation of deliverables, coordination of the project team's activities, and reporting events and issues to the project sponsors on a timely basis.
2. Modify the humidification system to improve performance and minimize solids accumulation.
3. Complete the SI/H parametric tests.
4. Complete the GR/SI optimization tests.
5. Begin long term tests about August 1, 1991 to allow about six weeks of testing with variable loads prior to the scheduled unit 1 outage on September 14, 1991.
6. Perform a boiler and equipment inspection during the early portion of the outage to assess the effects of GR/SI startup and testing which began in November, 1990.

B. Lakeside Unit 7

1. Continue project management activities.
2. Complete the procurement activities for all equipment.
3. Receive all equipment.
4. Complete mechanical construction activities.
5. Install the natural gas line.
6. Install the controls system.
7. Begin the installation of the ash handling system.
8. Install steam drum internals.
9. Perform operator training.
10. Perform baseline testing.
11. Begin startup activities.

3.0 PROJECT DESCRIPTION

Within the three phases of the project, the following tasks will be performed to demonstrate the cost effective control of NO_x and SO_x emissions from pre-NSPS coal fired utility boilers:

Phase I: DESIGN AND PERMITTING

Task 1 - Project Management

- Coordination of all Participant and subcontractor efforts
- Coordination with the host sites
- Planning and scheduling all tasks
- Monitoring all technical efforts
- Keeping DOE, GRI, and ENR fully informed of project status
- Continual review of relevant ongoing technical developments

Task 2 - Process Design

Subtask 2.1 - Host Site Characterization

- Establishment of the condition of each host site, including field evaluations.

Subtask 2.2 - Process Specification

- Preparation of GR-SI process designs, aiming at 60% and 50% reduction in NO_x and SO_x, respectively.
- Continuing bench scale tests to define key process parameters.

Task 3 - Project Engineering

- Preparation of site specific detailed engineering designs, construction plans and schedules, cost estimates, startup plans and Phase III test plans.

Task 4 - Environmental Reporting, Permitting, Plans and Design

- Preparation of relevant environmental data for obtaining NEPA approval.
- Preparation of Environmental Monitoring Plan.
- Assistance to host sites in obtaining environmental permits.

Task 5 - Technology Transfer

- Formation of an Industry Panel for technology transfer.
- Arrangement of Panel meetings on (1) process design and (2) detailed engineering design and plans for Phases II and III.

Phase II: CONSTRUCTION AND STARTUP

Task 1 - Project Management

- Continuation of Phase I project management activities.
- Arrangement of project review meetings at approximately the 40 and 90 percent completion points for each site.

Task 2 - Installation and Checkout

- Installation of the emission control and auxiliary equipment.
- Checkout of functional operation of all components.

Task 3 - Technology Transfer

- Continuation of technology transfer activities initiated in Phase I.
- Meetings with Industry Panel to review installations and plans.

Task 4 - Restoration

- Decision on disposition of test equipment if project is discontinued: to be retained by host sites or removal and restoration work.

Phase III: OPERATION, DATA COLLECTION, REPORTING AND DISPOSITION

Task 1 - Project Management

- Continuation of Phases 1 and 2 project management activities.
- Conducting final project review at conclusion of project.

Task 2 - Technology Demonstration

Subtask 2.1 - Optimization Testing

- Evaluation of effects of process variables on emission control performance.
- Determination of operating conditions for optimum overall performance.

Subtask 2.2 - Evaluation of Alternative Coals and Sorbents

- Evaluation of performance of alternative coals and sorbents:
  - High and medium sulfur coals, with consideration of cleaned and run-of-mine coals.
  - Selection of sorbents from high calcium and dolomite limestones, hydrated limestones and limes.

Subtask 2.3 - Long-Term Testing

- Operation of GR-SI equipment under optimized conditions for approximately one-year duration at each host site.
- Measurement of emission control system performance.
- Determination of boiler impacts.

Task 3 - Evaluation of Demonstration Results

- Analysis of test data.
- Preparation of guideline manuals for application of GR-SI technology, including design recommendations, cost projection and comparisons with competing technologies.

Task 4 - Restoration

- Disposition of GR-SI equipment installation:
  - To be retained by host site or removal and restoration work.

Task 5 - Technology Transfer

- Continuation of technology transfer activities from Phases I and II.
- Meeting with Industry Panel at one host site to review results obtained there and plans for other two host sites.
- Meeting with Industry Panel at completion of project.

4.0 PROJECT STATUS

4.1 Task 1 - Project Management

Monthly and other reporting activities were fulfilled according to the reporting requirements of the Cooperative Agreement.

Work Progress was monitored continuously. Coordination with IP took place at monthly meetings in Hennepin and by telephone. The project co-funders were apprised of progress and development through telephone conferences and meetings at the Hennepin site.

Activities were coordinated for the construction segment of Phase CII including reviews of drawings and equipment specifications. Baseline test preparation for Phase CIII was also coordinated. A project review meeting with the project co-funders was held at CWLP on April 3, 1991.

4.2 Task 2 - Installation and Startup

Hennepin - Installation and Startup activities were officially completed September 30, 1991.

Lakeside - During the past quarter the natural gas line delivery system was installed by CILCO. This is a 2000-foot line extending through the CWLP grounds and terminating at a gas meter local to the Lakeside facility. The line was further extended by an additional subcontractor to the boiler house wall. The mechanical contractor has completed its tie-in.

The ash handling contractor, UC Service Corporation, mobilized and is on schedule. Currently, significant progress has been in the erection of the ash handling silo.

The mechanical construction activities completed during the past quarter include erection of the electrical building, setting of the sorbent injection and FGR fans, natural gas line including associated valves and instrumentation, and asbestos abatement.

4.2.1 Contracts

Hennepin - A local electrical/mechanical contractor has provided support as needed during the operation/testing phase of the project.

Lakeside - A contract was awarded to Production Control Inc. to complete the asbestos abatement activities at the overfire and multiclone breech points. The work was performed under the supervision of Ecosafe, a consultant subcontractor of EER. No further abatement will be required.

A contract was awarded to Babcock & Wilcox Co. to replace the internals in the steam drum. The replacement was necessitated by the results of a boiler circulation study performed by B&W at the request of CWLP. Installation is scheduled for the fall outage.

4.2.2 Construction CPM Scheduling

Hennepin - Startup and demonstration activities continued through this quarter with additional studies and minor modifications of the humidification duct of the Sorbent Injection system.

Lakeside - Due to delays in completion of mechanical construction activities, the fall boiler outage originally scheduled for September has moved to November. Major activities include installation of the control systems, sootblowers, steam drum internals, and injection nozzles. This is the last major boiler outage required prior to the initiation of testing. Delays have also impacted the progress of the electrical subcontractor and the initiation of startup.

Phase CII is currently estimated to be 67% completed.

4.2.3 Construction Drawings

Hennepin - All construction drawings are complete. As-built installation documentation is 80% complete and should be completed by December, 1991.

Lakeside - All construction drawings have been completed and released.

4.2.4 Equipment Purchasing

Hennepin - Purchase orders for materials and services were placed during this quarter. The purchases were largely intended to provide replacement parts for "wear" items and for modifications to the humidification system to improve solids removal and flow distribution in the ductwork.

Lakeside - All planned equipment and materials to be supplied by EER to the subcontractors have been delivered to the construction site with the exception of the Westinghouse control system which will be delivered just prior to the November installation.

4.2.5 Miscellaneous

Hennepin - Meetings between Illinois Power and EER were held at Hennepin on a monthly basis during the past quarter. Representatives of the project funders attended some of the meetings, including the August 22/23 Participants Meeting.

Lakeside - The discrepant situation involving the power feed to the silo area has been corrected.

A project overview was presented to the CWLP staff to familiarize them with the GR-SI program.

4.2.6 Testing

Hennepin - The following test program steps were completed during this quarter:

* Gas Reburn Series 2 Tests
* SI Parametric Tests
* Automatic Reburn Operation with load following
* GR/SI Optimization Tests
* Initiation of Long Term GR/SI Testing

All of the above were performed prior to September. By mutual agreement amongst the sponsors , the first two weeks of September (prior to the outage) were devoted to some special tests on gas firing with gas reburning and gas/coal cofiring without reburning. These tests were sponsored solely by GRI and the timing was selected to take advantage of a period of very low gas prices. All of the tests during this reporting went well and operational experience was quite satisfactory. Hennepin Unit 1 shut down on September 14, for a 7 week scheduled outage which will include Turbine/Generator overhaul. During the outage other repairs will be made by IP to the boiler as needed and modifications to the humidification will be made by EER.

Lakeside - Baseline testing was initiated during the past quarter and will be completed during October. The three-week activity will establish the conditions of the boiler without GR-SI in operation for use in later operational comparisons.

4.3 Technology Transfer

A paper on demonstration of Combined NO_x and SO_2 Emission Control Technologies Involving Gas Reburning was presented by EER at the Environmental Program of the AIChE 1991 Summer National Meeting August 18 - 21, 1991. Two were prepared for presentation at the ASME International Joint Power Conference in San Diego, California October 6 - 10, 1991. These papers will present much of the recently obtained data from the Hennepin demonstration.

5.0 PLANNED ACTIVITIES

During the next quarter (October through December, 1991) the following work is planned.

A. Hennepin Unit 1

1. Continue standard project management activities of preparation of deliverables, coordination of the project team's activities, and reporting events and issues to the project sponsors on a timely basis.
2. Perform detailed GR/SI System inspections and maintenance as necessary.
3. Modify the Humidification System to incorporate improved flow distribution, spray performance and solids removal.
4. Perform maintenance on the CEMS, BPMS, and WDPF and incorporate improvements as needed.
5. Update the present O & M manual and provide updated training for IP operators in preparation for long term testing/operation.
6. Schedule and prepare for Permit Compliance Testing.
7. Inventory spare parts/supplies and restock as necessary.
8. Continue Long Term Demonstration after resumption of boiler operation.

B. Lakeside Unit 7

1. Continue project management activities.
2. Replace steam drum internals.
3. Replace sootblowers and install control system.
4. Install WDPF control system.
5. Complete mechanical and electrical subcontractor activities.
6. Complete baseline testing.
7. Perform U.T. tubewall thickness inspection.
8. Begin startup activities.

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