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ENHANCING THE USE OF COALS BY
GAS REBURNING-SORBENT INJECTION

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LEGAL NOTICE

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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, Significant progress was made toward completion of the mechanical, electrical and ash handling construction. These activities will conclude during the next quarter..

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 continuation of the mechanical, electrical and ash handling subcontractor work.

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 approved as requested in December, 1991.

Key Words

SO_x

SO₂

NO_x

NO

Pond

Startup

CEMS

Reburning

Humidification

Ash

Coal

Gas

Sorbent

Construction

Instrumentation

Industry Panel

Injection

Emission

Control

Boiler

Precipitator

Flue Gas

Contracts

Control

Ducts

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. 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. Schedule and prepare for Permit Compliance Testing.
6. Inventory spare parts/supplies and restock as necessary.
7. 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.

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 in Springfield on November 13, 1991.

4.2 Task 2 - Installation and Startup

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

Lakeside - The fall boiler outage was completed including replacement of steam drum internals, installation of the sootblower and steam delivery system, changeover of the Westinghouse 7300 control system to the Westinghouse WDPF system, U.T. of the boiler tubes to establish baseline tubewall thickness, installation of the ash handling control valves and control system, and inspection of the stack and electrostatic precipitator.

Erection of the ash handling silo has been completed. All major silo area structures are now in place.

Baseline testing concluded in October. This three-week activity established the conditions of the boiler without GR-SI in operation for use in later operational comparisons.

4.2.1 Contracts

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

Lakeside - No contracts were awarded during the quarter other than minor ones involving boiler outage inspections.

4.2.2 Construction CPM Scheduling

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

Lakeside - During installation of the overfire air ductwork, it was discovered that the thermal motions of the boiler exceeded those shown on the boiler design drawings. As a result, modifications to both the overfire air and flue gas recirculations ductwork were required. The end of installation activities has been moved from December, 1991 to January, 1992 to accommodate the modifications. It is anticipated that the end of Phase CII will remain at March, 1992 and not affect the April start of testing.

Phase CII is currently estimated to be 88% complete.

4.2.3 Construction Drawings

Hennepin - All construction drawings are complete. As-built installation documentation is 80% complete and should be completed during the first quarter, 1992.

Lakeside - All construction drawings have been completed and released. However, revisions are being prepared which will define changes to the overfire air and flue gas recirculation ductwork.

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 equipment and materials to be supplied by EER to the subcontractors have now been delivered including the Westinghouse WDPF control system.

4.2.5 Miscellaneous

Hennepin - Meetings between Illinois Power and EER were held at Hennepin on a monthly basis during the past quarter.

Lakeside - The FGR fan shaft and rotor and related hardware was returned to the supplier for rework due to pitting and scratches on the shaft and bearing liners. The unit has since been returned and will be assembled in January, one month later than scheduled.

4.2.6 Testing

Hennepin - The following were completed during this quarter:

A. OUTAGE ACTIVITIES (September 15 thru October 30, 1991)

EER carried out system modifications as follows:

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 gas reburn nozzles to provide a more strongly focused jet and improve mixing.
3. Modify the humidification system to improve spray nozzle performance, improve gas flow distribution and facilitate solids removal. Perforated plates, larger turning vanes and two additional screw conveyors were the major additions to the system.
4. Perform maintenance on the CEMS, BPMS, and WDPF systems.

IP performed inspections of the boiler and electrostatic precipitator. No problems were found which could be attributed to GR/SI operation. IP also repaired the cracked expansion joints in the air heater to reduce air inleakage into the flue gas.

B. TESTING ACTIVITIES

EER performed a number of tests after the outage to verify the efficacy of the modifications. The results of these indicated the following:

1. Gas flow distribution in the humidification duct was improved, wall wetting was no longer significant and solids removal was sharply improved.
2. The amount of FGR needed to achieve NO_x reduction was reduced by the modifications to the gas injectors.
3. Air inleakage in the air heater was reduced from 30% to less than 15%.

Following the checkout period, validation tests at various loads were performed in preparation for resumption of long term testing. The system was shutdown December 18 for the holidays.

Lakeside - None

4.3 Technology Transfer

Two papers, one on Operating Experience with a Gas Reburning-Sorbent Injection System and the other on Field evaluation of Gas Reburning with Low NO_x Burners for NO_x Emission Control in a Wall Fired Boiler, were prepared and presented by EER at the ASME International Joint Power Conference in San Diego, California October 6 - 10, 1991. A third paper on Demonstration of Combined NO_x and SO₂ Emission Control Technologies Involving Gas Reburning was presented by EER at the AFRC-JFRC International Conference on Environmental Control of Combustion Processes in Honolulu, Hawaii October 7 - 10, 1991. These papers will present much of the recently obtained data from the Hennepin demonstration.

5.0

PLANNED ACTIVITIES

During the next quarter (January through March, 1992) 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. Operate as many hours as possible under GR/SI long term conditions. Based on IP's typical daily cycle, the boiler will be between 40MW and 70MW about 12 hours per day, Monday through Friday. Allowing for process startup, lineout and shutdown, it is estimated that 10 - 11 hours per day of testing can be achieved on most days if no unusual equipment problems are experienced.
3. Gradually begin to turn over the responsibility for GR/SI operation and maintenance to IP. In order to make this transition smoothly, some additional training will be necessary. A meeting is planned with IP on January 14, 1992 to discuss the turnover. The overall objectives of the long term testing phase is to demonstrate that the GR/SI process can be operated successfully by the utility without constant direction by EER.
4. Update the present O & M manual and provide updated training for IP operators in preparation for long term testing/operation.
5. Schedule and prepare for Permit Compliance Testing.

B. Lakeside Unit 7

1. Continue project management activities.
2. Complete mechanical, electrical and ash handling subcontractor activities.
3. Complete startup activities.
4. Mobilize for Phase CIII testing.

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