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ENHANCING THE USE OF COALS BY GAS REBURNING-SORBENT INJECTION

Quarterly Report No. 8-A
For the Period
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Prepared for
U.S. Department of Energy
Gas Research Institute
State of Illinois Department of
Energy and Natural Resources

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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 (NOx) and sulfur (SOx), on three coal fired utility boilers in Illinois. The units selected are representative of pre-NSPS design practices: tangential, wall, and cyclone fired. The specific objectives are to demonstrate reductions of 60 percent in NOx and 50 percent in SOx 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 NOx is converted to N_2. The combustion process is completed by overfire air addition. SOx emissions are reduced by injecting dry sorbents (usually calcium based) into the upper furnace. The sorbents trap SOx as solid sulfates that are collected in the particulate control device.

This project will be 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 will be accomplished through the formation of an industry panel. Phase I of the project commenced on June 5, 1987 and includes 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

During this quarter, the remaining final report (design package) on the Phase I work for CWLP's Lakeside Unit No. 7 was submitted. Comments on the previously submitted design packages for CILCO's Edwards Unit No. 1 and IP's Hennepin Unit No. 1 have been received, and EER submitted an Addendum volume to IP in response to IP's comments and questions. Similar Addendum volumes will be submitted to CILCO and CWLP during the next quarterly period.

Work was initiated on Phase AII-A overlap for Hennepin Unit No. 1, to pre-engineer and procure long lead time items in preparation for the beginning of Phase II proper, Construction and Startup, so that the Spring 1990 outage schedule of this unit could be met. Because of delays in finalizing negotiations with the utility, Phase AII-B, the balance of Phase II work for Hennepin could not be started on August 15, as planned. The general outlook is that these negotiations should be completed by the end of September, causing some delays in the schedule. Meeting the April-May, 1990 outage schedule is still possible, provided agreement is reached with the host no later than mid-October.

In Task 1, Project Management, close coordination of all project activities continued. In addition to finalizing the Lakeside design package and preparing the Addendum items for the other sites, a number of meetings were held with the project co-funders and the host utilities (with IP in particular).

A Participants Committee meeting was held on June 1, 1989 in Chicago, to review EER's final recommendation for restructuring Phase II and discuss plans for the Phase AII-A overlap work and the balance of the project, including schedule and cost projections. All three co-funders (DOE, GRI and ENR) approved EER's recommendation to restructure the project to a two-site demonstration of the GR-SI technology (at the Hennepin tangentially fired and the Lakeside cyclone fired sites), with the Edwards wall fired site being placed "on hold," pending the availability of additional funding.

On July 19, 1989, a management audit was held at DOE's request by Grant Thornton in Orrville, Ohio, with the participation of DOE and EER. The auditor expressed satisfaction that EER had the management tools in place for controlling schedules and costs, and to establish an "early warning" system if any significant changes occur.

On August 22, EER met with IP in Decatur to discuss the draft Construction and Services Agreement and the Escrow Agreement, the latter to be substituted in lieu of a professional liability errors and omissions insurance policy by EER. Substantive agreement was reached concerning both documents.

In Task 2, Installation and Startup, all work focused on the IP Hennepin Unit 1 project. Engineering work was performed under Phase AII-A overlap with Phase I to maintain the construction schedule for the April-May 1990 outage of the unit. Work was performed on negotiating subcontracts, construction CPM scheduling, the final design of the new Hennepin GR-SI ash pond, construction drawings and equipment purchasing.

Site subcontracts were prepared, including those of McCartin Mechanical, mechanical erector, and Westphal and Company, electrical contractor. A preliminary construction CPM activity list of 333 activities was prepared, working with Provost Construction. This was narrowed down to 296 activities, assuming an October 1, 1989 starting date for construction.

Ninety percent of the ash pond design has been completed during this quarter. EER contracted with Hammontree and Associates for the ash pond design. The pond will have a synthetic liner, leachate collection and a five foot clay liner, effluent treatment using sulfuric acid addition with a bulk storage system and the outfall piping. Due to the delay in initiating Phase II, the ash pond construction will be scheduled in parallel with the GR-SI equipment installation in 1990, rather than in the late Fall of 1989.

Constructions drawings were released to Black and Veatch, EER's A/E subcontractor and to McCartin Mechanical. EER's basic instrumentation design and control approach was found to be satisfactory by independent safety expert consultants. To satisfy some concerns, additional instrumentation has been added.

For all major equipment, purchase orders or letters of intent were issued by EER. Authorization of funds was limited to engineering required to issue certified equipment drawings.

A project manual to be used by all parties in the Phase II Construction and Startup work at Hennepin has been drafted and is now in internal review. It will be completed during September and included in the September 1989 monthly report.

Remaining environmental activities concerned final revisions to the Environmental Monitoring Plans (EMPs) and providing permit application preparation assistance to the host utilities. The EA has been approved for

preparation assistance to the host utilities. The EA has been approved for Lakeside, thus satisfying NEPA approval requirements.

Key Words

SOx	Ash	Emission
SO2	Coal	Control
NOx	Gas	Boiler
NO	Sorbent	Precipitator
Pond	Construction	Flue Gas
	Instrumentation	Contracts

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 three pre-NSPS utility boilers representative of the U.S. boilers which contribute significantly to the inventory of acid rain precursor emissions: tangentially fired, wall fired, and cyclone fired units.

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°C 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 or 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 three coal fired utility boilers having the design characteristics mentioned above. Host Site Agreements have been signed by EER and three 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). Alternate host sites would be utilized in the event that unforeseen problems develop with any of the above tests.

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 will be 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. For this reason, quarterly reports were issued during Phase I, combining the work done related to all three sites. Starting with Phase II, which will consist of a staggered schedule of eight months duration for each Test Site, separate reporting will be instituted to cover the work done at each site. This practice will be continued for the remainder of the total project schedule of 66 months, which includes the Phase III work at each site.

During the last quarter, Phase AII-A overlap with Phase I for the Hennepin tangentially fired Unit No. 1 was initiated. The purpose of this overlap is to perform engineering work related to the procurement of long lead time items, such as ash pond design and negotiating with subcontractors, mechanical, electrical and others so that Phase II work can be started on a timely basis. This should allow the installation of the GR-SI equipment during the annual maintenance outage of the unit in April-May 1990.

The principal objectives of the work performed during this quarter were as follows:

- Complete preparation and distribution of Phase I design packages and Addenda in response to questions and comments raised by the host sites.

- Obtain approval of the co-funders for the two-site Hennepin and Lakeside project restructuring, with the Edwards sit "on hold" pending availability of additional funding.

- Meet with co-funders and host sites in preparation of Phase II Construction and Startup work.

- Support host utilities in preparation of environmental construction and operating permits.

- Finalize remaining Environmental Monitoring Plans based on additional DOE comments.

- Draft Project Manual for Hennepin Unit No. 1.

- Place orders for all EER equipment.

- Issue EER/Black and Veatch (B & V) drawings for construction.

- Complete ash pond design and submit permit applications.

- Prepare CPM construction schedule.

- Select humidification atomizer design.

- Upon approval, initiate Phase II work at Hennepin.

3.0 PROJECT DESCRIPTION

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

Phase I: DESIGN AND PERMITTING

Task 1 - Project Management

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

Task 2 - Process Design

Subtask 2.1 - Host Site Characterization

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

Subtask 2.2 - Process Specification

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

Task 3 - Project Engineering

- o 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

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

Task 5 - Technology Transfer

- o Formation of an Industry Panel for technology transfer.
- o 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

- o Continuation of Phase I project management activities.
- o Arrangement of project review meetings at approximately the 20 and 100 percent completion points for each site.

Task 2 - Installation and Checkout

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

Task 3 - Technology Transfer

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

Task 4 - Restoration

- o 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

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

Task 2 - Technology Demonstration

Subtask 2.1 - Optimization Testing

- o Evaluation of effects of process variables on emission control performance.
- o 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

Work was initiated for Phase AII-A overlap with Phase I.

4.1 Task 1 - Project Management

Monthly and other reporting activities were fulfilled according to the requirements of the cooperative agreement and host site agreements.

Project rescoping plans were submitted to the co-funders who approved restructuring the project to the tangentially and cyclone fired sites with the wall fired site remaining "on hold" pending availability of additional funding.

Construction and Services agreements have been further negotiated with IP and CWLP. In lieu of professional liability errors and omissions insurance, escrow agreements covering IP's Hennepin Unit 1 and CWLP's Lakeside Unit 7 were drafted by EER. The drafts are under review by the funding organizations and the host utilities.

The Lakeside Station Environmental Assessment has been approved by DOE, thus providing NEPA clearance for this demonstration project. The Hennepin and Lakeside EMPs have been revised in accordance with DOE/PETC environmental staff's comments. Permitting assistance was provided to IP and CWLP.

4.2 Task 2 - Installation and Startup

All engineering activity performed during this reporting period was for the IP Hennepin Station. Work performed during this period, designated as Phase AII-A Subtask 2.1, was performed in order to maintain the IP Hennepin construction schedule with a Unit 1 outage scheduled for April and May 1990. Five critical areas were identified early on in the Phase II overlap period to meet the current construction schedule. The five areas are:

- Contract Negotiations
- Construction CPM Scheduling
- Ash Pond Final Design

- Construction Drawings
- Equipment Purchasing

4.2.1 Contract Negotiations

A total of six contracts were prepared by EER for the Phase II construction. The six parties involved are:

Black & Veatch - Engineering Support and Construction Management
Hammontree and Associates - Ash Pond Design
Provost Constructors - Construction Scheduling
United Conveyor - Ash System Modifications
McCartin Mechanical - Mechanical Erector
Westphal and Company - Electrical Contractor

Each of the six agreements have been finalized and approved by the project sponsors. EER is in the process of executing the agreements and returning a copy to each of the six parties. No other work in this area remains to be performed in this Phase.

4.2.2 Construction CPM Scheduling

EER worked with Provost Constructors to prepare a preliminary CPM activity list consisting of 333 activities. EER forwarded the activity list to United Conveyor, McCartin Mechanical and Westphal and Company for input regarding the structuring, duration and constraints of each activity. A meeting was held with McCartin Mechanical and Westphal and Company to discuss the information. United Conveyor was not included in the meeting as their construction activities are independent. Based on the meeting the activity list was reduced to 296 items. With equipment delivery dates provided by EER, McCartin Mechanical has completed a bar-chart schedule of their activities. EER is currently inputting the information provided by United Conveyor and McCartin into EER's CPM software package. Once completed, Westphal and Company will finalize their activities to coincide with the mechanical activities.

The work described above for the CPM was based upon an October 1, 1989 contractor mobilization. As of the time of writing this report, the delay in obtaining host site agreement approval has adversely affected the construction

schedule. Further delay will force the construction schedule to slip to a spring mobilization and summer 1990 construction. It will still be possible to make the scheduled outage by placing all outage activities at the start of construction.

4.2.3 Ash Pond Final Design

The detailed design of the new ash pond required for the SI process ash was started and 90 percent completed this reporting period. EER contracted with Hammontree and Associates for the ash pond design. The design drawings and specifications for the pond include the pond and settling basin construction with a synthetic liner, leachate collection and a 5-foot clay liner, effluent treatment using a sulfuric acid addition system with bulk storage and the outfall piping. A preliminary set of drawings and specifications were released to EER and IP for review in August. EER held a meeting with IP to review the documents to be submitted by Hammontree in mid-September. Due to the delay in completing the ash pond design and obtaining Phase 2 approval with IP, the ash pond construction will be scheduled for spring-early summer of 1990. Construction bids will not be solicited until January 1990.

4.2.4 Construction Drawings

Contract drawing were reviewed and stamped "Approved For Construction." The drawings were released to Black & Veatch and McCartin Mechanical. Holds were placed on drawings with major equipment to be purchased by EER pending receipt of certified vendor drawings. To date, vendor drawings have been received for all major equipment with long lead times. EER drawings are being revised and re-issued as they are completed. The physical size of the FGR fan as shown by the vendor drawing has prompted EER and IP to reconsider the location of the fan. Black & Veatch has also issued their mechanical drawings "For Construction." The electrical drawings will not be issued until Westphal and Company has submitted vendor prints for all of the electrical equipment to be purchased. Detailed wiring connections are needed to complete the drawings and finalize the raceway and circuit lists. EER has also added additional instrumentation to satisfy safety concerns raised by the third party review. The basic EER instrumentation and control approach was found to be satisfactory by independent safety experts.

4.2.5 Equipment Purchasing

Purchase orders or letters of intent were issued by EER authorizing vendor engineering for all major equipment. Authorization of funds was limited to the engineering required to issue certified equipment drawings. EER will not authorize any further funds for material procurement or fabrication until Phase II final approval. The delay in releasing the vendors to proceed has already caused considerable slippage in the planned construction schedule.

4.2.6 Miscellaneous

A DOE management audit was held in Orrville during July. All questions raised by the audit regarding EER's management structure to be used for Phase II were answered to DOE's and the auditor's (Grant Thornton) apparent satisfaction.

A project manual to be used by all parties involved in Phase II is being prepared by EER. A draft of the manual will be completed in September.

EER Engineering attended a CCT Phase I review meeting held at IP's Decatur office in June. IP presented EER with a list of questions regarding the Phase 1 Final Design Report. Engineering prepared a documented response for inclusion into an addendum to the report.

EER Engineering attended a meeting at the Hennepin Station to discuss IP manpower requirements during Phases II and III. All action items arising from the meeting have been concluded.

5.0 PLANNED ACTIVITIES

During the next quarter (September through November 1989) the following work is planned:

1. Complete Phase AII-A overlap work with Phase I for the Hennepin unit.

2. Negotiate Construction and Services and Agreements (Modifications to the Host Site Agreement).

3. Negotiate Escrow Agreements and establish Escrow accounts for IP and CWLP.

4. Obtain IP's and CWLP's agreement to enter into Phases II and III activities.

5. Initiate Phase II work for Hennepin and Lakeside.

6. Finalize Phase II project manuals for both sites.

7. Approve ash pond design jointly with IP.

8. Revise construction schedule based upon estimated Phase II approval timing.

9. Initiate mobilization and construction for Phase II at Hennepin.

10. Initiate Phase II engineering activity for Lakeside.

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