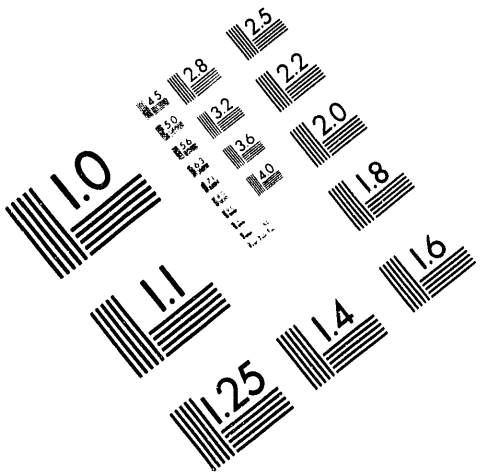

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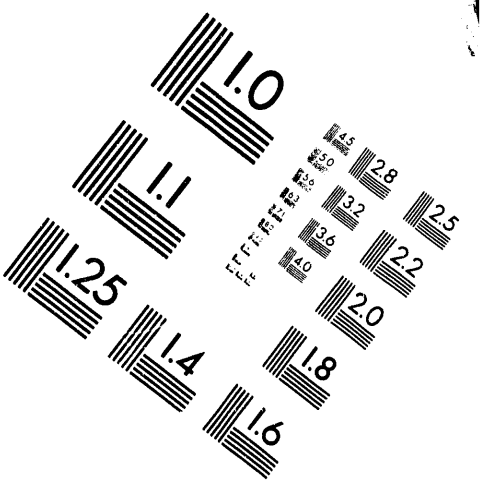

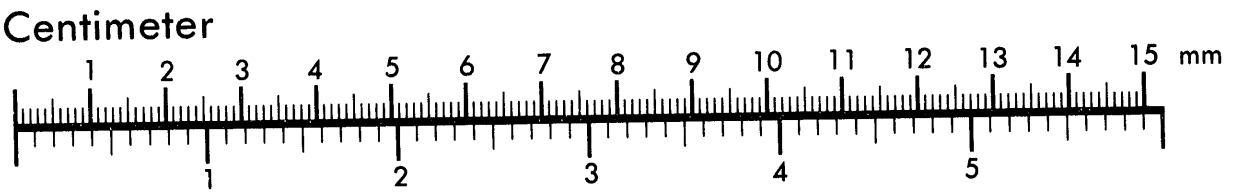

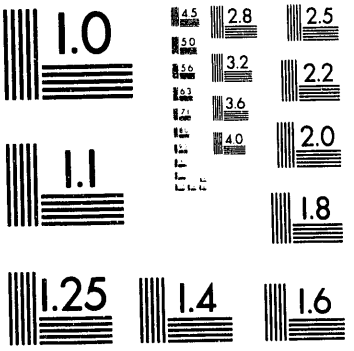

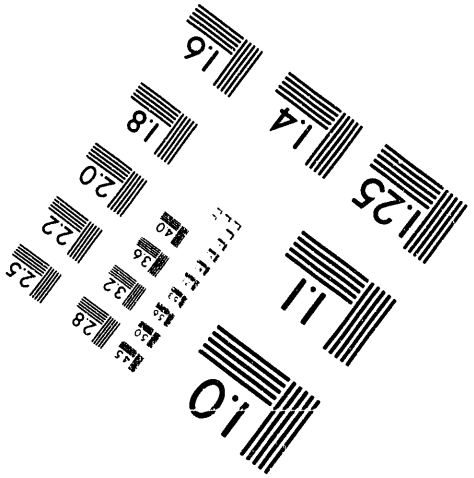

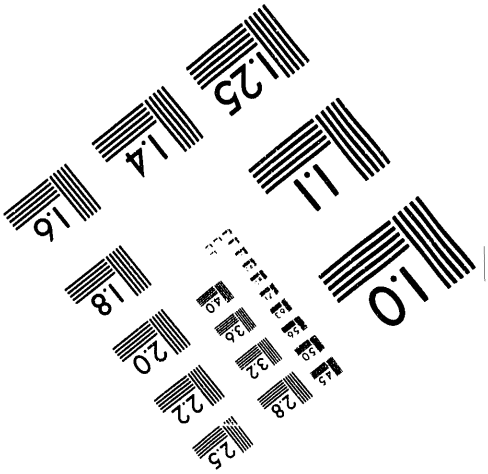

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CLEAN COAL TECHNOLOGY III (CCT III)

10 MW DEMONSTRATION OF GAS SUSPENSION ABSORPTION

DOE Cooperative Agreement
DE-FC22-90PC90542
91

AirPol Job Number
RD-43

TECHNICAL PROGRESS REPORT

THIRD AND FOURTH QUARTERS, FY 1992 (04/01/92 - 09/30/92)

Cleared by Office of Patent Counsel
Chicago Operations Office
U.S. Department of Energy

Prepared by:

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MASTER

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EXECUTIVE SUMMARY

The 10 MW Demonstration of Gas Suspension Absorption (GSA) program is designed to demonstrate the performance of the GSA system in treating the flue gas from a boiler burning high sulfur coal.

The demonstration project is divided into three major phases:

Phase I - Engineering and Design

Phase II - Procurement and Construction

Phase III - Operation and Testing

The project was previously on hold pending the re-definition of the overall project schedule. A revised schedule reflecting a one year delay of the project was established by AirPol and approved by DOE. Phase I engineering and design work was resumed as of May 1, 1991 and completed on December 31, 1991. Phase II work started in January 1992 and completed on September 30, 1992. The following progress was made during the reporting period:

Task I - Project and Contract Management

The AirPol - TVA Subcontract Agreement has been finalized and executed.

Environmental Monitoring Plan has been prepared and approved pending the addition of air toxics test description.

Task II - Procurement and Furnish Material

AirPol Purchasing Department and Project Management Department completed procurement of all GSA material and components. All material manufacturing has been completed and delivered.

Task III - Construction and Commissioning

The construction of the GSA has been completed on schedule and below budget.

The GSA system and components was checked out and ready for start-up.

ACKNOWLEDGEMENT

The planning, execution, and reporting of this project were a combined effort of many people and organizations. We wish to acknowledge the following for their outstanding effort.

U.S. Department of Energy: Sharon K. Marchant, Jerry L. Hebb, George Pukanic

Tennessee Valley Authority: Dr. Chao Ming Huang, Thomas A. Burnett, Ken M. Schuppert, Ed Puschaver, Mike Little
AirPol: Willard L. Goss, Shyam K. Nadkarni, Bindu Mistry, Paul Sisler, Bill Kelleher, Billy Boswell

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INTRODUCTION

The Clean Coal Technology Demonstration Program (CCT Program) is a government and industry co-funded technology development effort to demonstrate a new generation of innovative coal utilization processes in a series of full-scale, "showcase" facilities built across the country. These demonstrations will be on a scale large enough to generate all the data, from design, construction, and operation, for technical/economic evaluation and future commercialization of the process.

The goal of the program is to furnish the U.S. energy marketplace with a number of advanced, more efficient, and environmentally responsive coal-using technologies. These technologies will reduce and/or eliminate the economic and environmental impediments that limit the full consideration of coal as a viable future energy resource.

To achieve this goal, a multi-phased effort consisting of five separate solicitations is administered by the Department of Energy. Projects selected through these solicitations will demonstrate technology options with the potential to meet the needs of energy markets and respond to relevant environmental considerations.

The third solicitation (CCT-III), issued in 1989, targeted those technologies capable of achieving significant reductions in the emission of SO_2 and/or NO_x from existing facilities to minimize environmental impacts, such as transboundary and interstate pollution, and/or provide for future energy needs in an environmentally acceptable manner.

In response to the third solicitation, AirPol Inc. submitted a proposal for the design, installation and testing of the Gas Suspension Absorption (GSA) system at Tennessee Valley Authority's (TVA) Shawnee Test Facility (STF). On July 25, 1990, a Cooperative Agreement was signed by AirPol for the project entitled "10 MW Demonstration of Gas Suspension Absorption". The project was approved by Congress in October of 1990, and the Cooperative Agreement for the project was awarded by DOE on October 11, 1990.

This low-cost retrofit project will demonstrate the GSA system which is expected to remove more than 90% of the SO_2 from coal-fired flue gas, while achieving a high utilization of reagent lime. The host site facility will be the STF located at the Shawnee Fossil Plant in West Paducah, Kentucky.

Over the past 15 years, the STF has served as a testground for flue gas desulfurization (FGD) systems. At the present time a semi-dry process employing 10 MW capacity spray dryer is being tested at the facility. Upon completion of the current spray dryer test, the GSA system will be tested for a period of eleven (11) months.

The Gas Suspension Absorber was initially developed as a calciner for limestone used for cement production. It has been used successfully to clean the gases from commercial waste to energy plants in Denmark where it has also captured chloride emissions. The GSA system brings coal combustion gases into contact with a suspended mixture of solids, including sulfur-absorbing lime. After the lime absorbs the sulfur pollutants, the solids are separated from the gases in a cyclone device and recirculated back into the system where they capture additional sulfur pollutant. The cleaned flue gases are sent through a dust collector before being released into the atmosphere. The key to the system's superior economic performance with high sulfur coals is the recirculation of solids. Typically, a solid particle will pass through the system about one hundred times before leaving the system. Another advantage of the GSA system is that a single spray nozzle is used to inject fresh lime slurry.

The GSA system is expected to be the answer to the need of the U.S. industry for an effective, economic and space efficient solution to the SO_2 pollution problem.

PROJECT DESCRIPTION

This project will be the first North American demonstration of the Gas Suspension Absorption (GSA) system in its application for flue gas desulfurization. The purpose of this project is to demonstrate the high sulfur dioxide (SO_2) removal efficiency as well as the cost effectiveness of the GSA system. GSA is a novel concept for flue gas desulfurization developed by F. L. Smidth miljo (FLS miljo). The GSA system is distinguished in the European market by its low capital cost, high SO_2 removal efficiency and low operating cost.

A 10 MW GSA demonstration system shall be installed and tested at the Tennessee Valley Authority (TVA) Shawnee Fossil Plant at West Paducah, Kentucky. The new GSA system will replace the existing spray dryer that was installed previously as a test unit. The experience gained in designing, manufacturing and constructing the GSA equipments through executing this project will be used for future commercialization of the GSA system. Results of the operation and experimental testing will be used to further improve the GSA design and operation.

The specific technical objectives of the GSA demonstration project are to:

- Effectively demonstrate SO_2 removal in excess of 90% using high sulfur U.S. coal.
- Optimize recycle and design parameters to increase efficiencies of lime reagent utilization and SO_2 removal.
- Compare removal efficiency and cost with existing Spray Dryer/Electrostatic Precipitator technology.

In order to accomplish these objectives, the demonstration project is divided into phases and tasks as shown in the Work Breakdown Structure (WBS) below:

Phase I - Engineering and Design

- Task I - Project and Contract Management
- Task II - Process and Technology Design
- Task III - Environmental Analysis
- Task IV - Engineering Design

Phase II - Procurement and Construction

- Task I - Project and Contract Management
- Task II - Procurement and Furnish Material
- Task III - Construction and Commissioning

Phase III - Operation and Testing

- Task I - Project Management
- Task II - Start-up and Training
- Task III - Experimental Testing and Reporting

The design phase was completed on schedule in December 1991. The construction phase was completed at the end of September 1992. The testing phase will start in October 1992 and end in September 1993.

PROJECT STATUS

Phase II

A. Task I - Project and Contract Management

Project Management - AirPol continued to provide overall project management by interfacing with DOE on all aspects of the project, and coordinating the site-related activities with TVA.

AirPol has submitted project reports as specified in the Federal Assistance Reporting Checklist as attached to the Cooperative Agreement.

Continuation Application - In accordance with Article VIII, section (B) of the Cooperative Agreement, AirPol submitted a Continuation Application for DOE's approval to proceed with the project tasks under Budget Period 2 as defined in the Cooperative Agreement. In addition, AirPol requested DOE's approval of a proposal for expanding the scope of work of Phase III to include additional operation and testing tasks.

AirPol has successfully completed all the work contained in Phase I and Phase II of the project and is ready to begin Phase III, Operation and Testing on October 1, 1992.

In response to DOE's requirement for including air toxics in the Environmental Monitoring Plan (EMP), AirPol has prepared a proposal for expanding the work scope to include air toxics testing and operation/testing of a 1 MW fabric filter. In addition to fulfilling the EMP requirement, the findings from the additional operation/testing will demonstrate GSA's ability in removal of air toxics as well as the advantage of GSA operating in conjunction with a fabric filter. It was estimated that one (1) additional month of operation is required for performing the additional tests.

A five (5) months extension of the project duration was proposed to allow for additional testing and reporting activities.

In cooperation with AirPol's proposal, TVA has committed to extend the availability of the host site for the additional operation and test and to provide in-kind contribution towards the cost of the added work.

The Continuation Application and the Project Evaluation Report were submitted on August 21, 1992 and is currently under DOE review.

Cost Management - A computerized spread sheet has been used to track the cost and progress of the project. Currently there is a positive variance of $1,069,896, which can be attributed to the substantial saving in material and construction cost.

The saving of $256,161 in furnish of material can be attributed to the following factors:

- Extra engineering effort was made during the design phase to achieve the most efficient and cost effective design of the system.

- Saving was accrued by utilization of existing equipment such as the Foxboro Control, various existing instruments, slurry pumps, and stair tower through thorough site investigation and efficient engineering design.

- The down turn of the business environment in the manufacturing industry resulted in favorable pricing for material procured for this project.

The total construction cost is $711,144 below budget. The favorable variance is attributable to the following reasons:

- The budget figure was high because a contingency of $754,201 was imposed on AirPol's budget by DOE during negotiation of the Cooperative Agreement.

- Saving in construction cost accrued from improved design.

- With the AirPol Construction Department acting as a general contractor, the markup and administration cost of a would-be general contractor was saved.

Schedule Update - The project has been progressing according to the amended schedule, which calls for completion of material procurement and fabrication by April 30, 1992, and completion of construction by September 30, 1992.

Mechanical erection was completed at the end of June 1992. The erection time was greatly reduced by designing the GSA components in such a way that they could be fabricated and preassembled in the largest possible shipping pieces. For example, the support structure tower was shipped in four preassembled segments which require just a few days to be erected in the field. The additional engineering effort was more than compensated by savings in construction time and cost.

The final tie-in of the inlet and outlet duct, tie-in of the lime preparation system and the ash conveying system was completed by July 31, 1992. The overall construction work was completed on August 31, 1992, one month ahead of schedule.

TVA Subcontract - The agreement was signed on May 1, 1992. The delay in signing the agreement impacted the material procurement with a delay of two (2) months, which was later made up by overlapping the material furnishing task with the field construction task. This delay also impacted on the schedule for the preparation of the Environmental Monitoring Plan (EMP), which was to be prepared by TVA after the subcontract agreement was in place. The EMP work was immediately resumed after the signing of

the agreement and was completed within the redefined time frame approved by DOE.

Project Review Meeting - In August 1992 a project review meeting participated by DOE, AirPol and TVA was held at TVA Shawnee Plant. The following topics were discussed:

- Start-up - TVA indicated that they will need about two weeks to load the GSA control program into the Foxboro computer. The start-up date is set for October 19, 1992 accordingly.

- Test plan - TVA is in the process of preparing a draft test plan which will be ready for review by AirPol and DOE.

- Dedication ceremony - TVA presented their plan for the dedication ceremony and finalized the invitation list with DOE and AirPol.

- Environmental monitoring plan - The discussion concluded that TVA should start the work of incorporating the description of air toxics testing into the EMP in order to complete the EMP by the end of September 1992.

- Center for Applied Energy Research (CAER) Test Program - CAER is currently performing a TVA sponsored test program which involves using an existing fluidized combustion chamber model to approximately simulate the GSA process. Tests results were presented and discussed.

Test by Center for Energy Research (CAER), University of Kentucky - On September 4, Sharon Marchant and George Pukanic of DOE and Frank Hsu and Bindu Mistry of AirPol attended a progress review meeting at CAER, Lexington, Kentucky. The purpose of the meeting is to review the progress and result of a GSA simulation test (funded by TVA) performed by CAER. The test results appeared very favorable with SO_2 removal reaching 95% +. AirPol commented that the residence time in the test model is too high (approximately 10 seconds as compared to 2.5 seconds in the prototype) and it should be changed to simulate the real GSA operation. CAER is looking into the possibility to accommodate this requirement.

Environmental Analysis - Preparation of the EMP has been performed by TVA as a part of the subcontract with AirPol. The responsible TVA office for the EMP is the Operations Support Section, Atmospheric Science Department, Muscle Shoals, Alabama. The final submittal of the EMP was made on July 17, 1992 and was approved by DOE on July 27, 1992 pending the addition of air toxics testing descriptions. The addition of air toxics testing was incorporated and a final draft was submitted to DOE on 9/30/92.

Dedication Ceremony - The dedication ceremony was scheduled for October 27, 1992. TVA will host the entire program.

B. Task II - Procurement and Furnish Material

Procurement - Selections of subvendors for material supplies have all been made on a competitive basis. Names of subcontractors were submitted to DOE to verify that they were eligible for participation in the federal assistance program.
Material Fabrication - The AirPol Construction Department assumed the duty of material inspection and quality control and was very successful in ensuring that the equipment was produced according to the specified standards and in conformance to the AirPol design. Due to a late start of the material fabrication work, there was an overlap planned between the fabrication and construction work in order to compensate for the delay. The fabrication work was completed in late June and construction progress was not adversely impacted by the delay.

C. Task III - Construction and Commissioning

Construction - No subcontract for a general construction contractor was required since AirPol decided to act as the general contractor for the construction of the GSA system. This decision has been proven to be a good one by the fact that construction cost is substantially below budget and completion is more than one month ahead of schedule.

Supervision of construction subcontractors was performed by two full time construction engineers and the part time involvement of the Construction Manager.

A field construction work reporting system was established prior to the beginning of the construction work. The system provides for the weekly submission of the following reports:

. Daily work progress report

. Weekly labor summary

. Weekly field expense summary.

. Construction record photos.

Monthly construction review meetings were held either at the construction site or at the AirPol office.

The effectiveness of the cost and schedule control system is demonstrated by the outstanding results of the construction tasks.

Commissioning - During the week of September 7, 1992, start-up engineers from AirPol and FLS miljo jointly inspected the GSA installation as a final construction check and

pre-start-up inspection. The construction work of the unit was found to be satisfactory, and modifications to the unit for better operation and easier maintenance were recommended. The areas to be modified are:

- Piping in front of the injection lance to be re-arranged so as to allow more space to maneuver the lance.
- Enlarge the platform area in front of the injection lance for ease of lance removal.
- Add local start-stop button at the water pump for ease of maintenance.
- Add local instruments for pressure indication at the injection lance.
- Add inspection port at following location for viewing purpose: bottom of reactor under the venturi, top of the feeder box, top of the feeder screw, top of the reactor.
- Add rapping anvil on the cyclone hopper.
- Add shut-off valves on the air and water lines at the injection lance.
- Add local instrument for the weight indication of the dust load inside the feeder box.

During the week of September 21, 1992, AirPol start-up engineers were on site for the purpose of carrying out the modification works and to check out and start-up all motors. As of the report date, the GSA system is ready for start-up.

Instruction manual containing operating and maintenance procedure, vendor literature and equipment drawings were prepared and issued to TVA operating unit.

PLAN FOR NEXT QUARTER (PHASE III)

A. Task I - Project and Contract Management

Project Management - Continue monitoring project cost and produce reports according to the Federal Assistance Reporting Checklist. Continue monitoring the progress of the project and update the project schedule accordingly.

Proceed with the Dedication Ceremony as planned.

Revise cost plan to reflect the addition of air toxics testing and fabric filter testing work.

B. Task II - Start-up and Training

Complete the start-up of the GSA system as planned.

C. Task III - Experimental Testing and Reporting

Proceed with the experimental testing according to the test plan.

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