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CLEAN COAL TECHNOLOGY III (CCT III)

10 MW DEMONSTRATION OF GAS SUSPENSION ABSORPTION

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TECHNICAL PROGRESS REPORT

FOURTH QUARTER, FY 1991 (10/01/91 - 12/31/91)

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

Prepared by:

AirPol Inc.  
32 Henry Street  
Teterboro, N.J. 07608

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*Mark P. Dworske April 18, 1992*  
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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. During the reporting period the following progress was made:

Task I - Project and Contract Management

AirPol and TVA have reached preliminary agreement on the Subcontract Agreement which provides for TVA to operate the GSA system and perform testing during Phase III.

Technical Transfer Agreement between AirPol and FLS miljo has been finalized and executed.

Task II - Process and Technology Design

Completed compilation of the GSA process calculation program. Conducted final process calculation for the subject project using AirPol process calculation program.

Task III - Environmental Analysis

Work on Environmental Monitoring Plan will not start until the TVA subcontract is finalized.

Task IV - Engineering Design

Completed all engineering design work needed for the manufacturing of the GSA system. Conducted field check to verify feasibility of the GSA system design.

#### 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.

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AirPol: Willard L. Goss, Shyam K. Nadkarni, Bindu Mistry, Stuart L. Turgel, Paul Sisler, Chuck S. Marchese

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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<sub>2</sub> and/or NO<sub>x</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>) 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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

According to the revised project schedule the design phase will be complete in December 1991, the construction phase will be complete by the end of September 1992, and the testing phase will end in September 1993.

## PROJECT STATUS

### Phase I

#### 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. A computerized spread sheet has been used to track the cost and progress of the project.

Schedule Update - The project has been progressing according to the amended schedule, which calls for completing Phase I, Engineering Design by the end of the reporting period (12/31/91). All engineering work except for design of field installed material (piping and electrical wiring) has been completed on schedule.

TVA Subcontract - The draft agreement for the AirPol-TVA Subcontract was reviewed and approved by DOE. Key issues relating to TVA's contribution to the operating and testing cost and TVA's future right to use the GSA process are being resolved.

FLS miljo Technology Transfer Agreement - The final agreement was signed by FLS miljo on October 1, 1992. As of the end of this reporting period, FLS miljo has completed and delivered the following technical information to AirPol:

- o GSA process design principles
- o GSA process calculation and computer programming guidelines
- o GSA equipment sizing principles
- o Mechanical design of reactor, cyclone, feeder box and injection lance
- o Design of gas flow turning vanes at reactor inlet and inlet elbow
- o Recommended Process and Instrumentation Scheme
- o Control logic flow diagram
- o Electrical wiring schematic
- o Instrumentation list
- o Start-up and shut-down sequence diagram
- o Instruction and maintenance manual

FLS miljo will provide technical assistance during the start-up and operating/testing period on an as required basis.

## B. Task II - Process and Technology Design

AirPol Process Department has completed the final computer program for the GSA process calculation. During a technical review meeting in October and a subsequent meeting in November, detailed review of the program was conducted by Bindu Mistry, AirPol Process Engineer, and Jorn Touborg, FLS miljo Process Specialist. Calculation procedures for the following items were reviewed:

- o Calculation of lime, water and air consumption
- o Determination of stoichiometric ratio
- o Determination of cyclone outlet temperature
- o Calculation of by-product
- o Sizing of reactor, cyclone, feeder box and ductwork
- o Estimation of power consumption

Based on outcome of the discussion, the AirPol program was revised and finalized. The program was used to produce the final process calculation for the subject project.

Inputs to the program are: coal analysis; flue gas temperature, volume, and pressure; removal efficiency requirement.

Outputs of the program are: flue gas composition; stoichiometric ratio; air, water and slurry requirements; the flue gas composition, flow rate, temperature, pressure, enthalpy, density and humidity at the inlet and outlet of all equipment; heat loss from GSA, dust collector and stack; reactor, reactor venturi, and cyclone sizing; power consumption.

The calculation results obtained for the subject project were found to be in close consistency with that of FLS miljo's calculation. The process flow diagrams for both the base condition and the process with recirculation are contained in Attachment 1.

## C. Task III - Environmental Analysis

It was determined that the work related to the Environmental Monitoring Plan would best be performed by TVA. This work cannot be started until the subcontract with TVA is in place which will occur in Phase II. All environmental work is to be reported during the Phase in which it is incurred since environmental work, like project management, is ongoing through out the life of the project.

## D. Task IV - Engineering Design

During the reporting period, all design work was completed and

the design drawings were issued to FLS miljo, TVA and AirPol Construction Department for review and comment.

A design review meeting was held during the week of October 28, at FLS miljo, Denmark. The following topics were discussed:

- General testing and operation concept - Based on recent test data and operating results of the GSA units in Europe, FLS miljo determined that the GSA unit should be capable of achieving 90% SO<sub>2</sub> removal efficiency without the benefit of the recirculation system. A decision was made to leave out the recirculation system from the initial installation, but make all necessary provisions for the future addition of the recirculation system. The necessity of the addition will be determined after the preliminary testing is completed. The recirculation system is defined as the recirculation fan, fan damper, and associated foundation and ductwork.
- Design drawing review - FLS miljo's comments were particularly on the general arrangement drawings in the following areas: duct layout as related to pressure loss and gas flow distribution, arrangement of access door and access facility as related to inspection/maintenance requirements. FLS miljo also provided guidelines for detail design of the reactor, cyclone and feeder box.
- Control concept finalization - Based on field operating experience, FLS miljo concluded that there is little advantage in either removal efficiency or lime consumption by having a feed forward and feed backward control system, and that feed backward only will be the standard control method in the future. However, for the subject project, a feed forward system is required to maintain a constant stoichiometric ratio during a test series. It was agreed that the final hardware configuration will be determined jointly with TVA Shawnee Test Facility personnel based on the existing site condition.
- Construction and operation experience - AirPol personnel visited two GSA installations and obtained information regarding construction and start-up of the GSA system from FLS miljo field engineers.

General Arrangement - Completed revision of general Arrangement drawing to reflect the following changes as recommended by FLS miljo:

- Relocation of the recirculation fan and recirculation

duct for the purpose of achieving more uniform gas flow to the GSA reactor and reducing overall pressure drop within the recirculation system.

- Re-arranged cyclone outlet ductwork to smooth off the bends and reduce pressure loss.
- Arranged the gas recirculation system in a manner that it can be isolated and installed at a later date.
- Expanded the enclosure to enclose the lower portion of the reactor per FLS miljo recommendation. The added enclosure will provide personnel protection in the most frequented area of the GSA plant and also shields the air sluice, slurry and water pipes from inclement weather.
- Re-arranged access system to provide better access to the lower operating area (injection nozzle level) and to accrue savings by eliminating the need for a stair tower.

A design review meeting was held on December 18, 1991 between AirPol's Frank E. Hsu and TVA Shawnee Test Facility personnel to review and confirm AirPol's general arrangement design, mechanical and electrical design. Following items were discussed:

- TVA confirmed availability of the utility and suitability of existing equipment required for the operation of the new GSA system:
  - Air compressor - 100 psig, 237 lb/hr capacity required.
  - Slurry pump - 960 gph, pressure at nozzle level to be 100 psig.
  - Water supply to the system - 3,000 gph.
  - Electric power - Eight (8) additional motor starters in the existing motor control panel.
  - Instrumentation - Inlet and outlet gas flow measurement; inlet flue gas SO<sub>2</sub> & O<sub>2</sub> monitors; temperature measurement at outlet of the GSA cyclone; slurry flow measurement.
- TVA confirmed that, if necessary, the existing I.D. fan can be dampered down to 50% of the present operating flow volume. This is necessary for the test of GSA with maximum (100%) recirculation.
- It was jointly decided that the existing Foxboro Control will be used for the GSA system control, and that the start-up and shut-down sequence will be manually performed. This is consistent with the present operation of the spray dryer system and is preferred by TVA operating/testing unit. the Foxboro Control will be programmed to perform the control of the following three

process control loops: slurry feed, water injection and reinjection of used lime. The Foxboro Control will also be programmed to perform all required alarm annunciations.

- TVA committed to provide both the hardware and software required for the Foxboro Control to perform the GSA control functions.
- It was decided that the on-and-off switches will be mounted as addition to the existing switch panel located in the control room.
- Based on TVA prior experience, it was decided that dew point measurement (at outlet of the cyclone) will be performed manually using the wet bulb method.
- TVA requested that test ports and access platforms be provided at appropriate location for the ductwork between the cyclone outlet and the inlet of the existing precipitator.

During the trip AirPol completed a field check of all interfaces of the new installation and existing facilities and confirmed that all interfaces are feasible and free of any interference.

Instrumentation and Control - Process control and electrical power supply for the GSA system has been defined jointly with TVA as follows:

- The three major process control loops for the GSA process will be performed by the existing Foxboro Control. AirPol will supply formulas to TVA for them to re-program the Foxboro Control.
- On and off switches for motors will be mounted in the same control room as the Foxboro Control. Power will be supplied off the existing motor control center.
- Control panels for heaters and heat tracing will be mounted locally.

Attachment 3 is the updated Process and Instrumentation Diagram.

Electrical - FLS miljo completed the electrical package which includes: single line diagram; interconnection diagrams; instrumentation specification; and control logic diagrams. Layout of field wiring is being prepared by AirPol based on the conceptual wiring scheme. AirPol has redrawn these drawings to make them suitable for use in the United States.

General Arrangement - Comments from FLS miljo and TVA have been incorporated in the latest general arrangement drawings which are shown in Attachment 2.

Equipment Design - FLS miljo comment on design of GSA reactor, cyclone and feeder box has been incorporated.

Structural Design - The structural design was revised to reflect the changes of the general arrangement of the GSA system.

Access System - The access system was rearranged to incorporate the comments from FLS miljo and TVA.

For the purpose of reducing field labor and construction time, the support structure/access facility was designed to be shop assembled in four bulk shipping pieces.

Ductwork - Ductwork design was revised in accordance with the revised general arrangement drawings.

All design drawings were reviewed by AirPol Construction Department and comments were incorporated.

PLAN FOR NEXT QUARTER (PHASE II)

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.

Finalize Subcontract Agreement with TVA.

Engineering Design - Complete checking of all detail fabrication drawings. Complete field wiring and piping drawings.

Environmental Analysis - TVA to commence work on Environmental Monitoring Plan.

B. Task II - Procurement and Furnishing Material

Complete procurement of all GSA material.

Start fabrication of major GSA components.