DOE/PC/89652--T8

DE93 005988

INNOVATIVE CLEAN COAL TECHNOLOGY (ICCT)

DEMONSTRATION OF SELECTIVE CATALYTIC REDUCTION (SCR) TECHNOLOGY FOR THE CONTROL OF NITROGEN OXIDE (NOx) EMISSIONS FROM HIGH-SULFUR COAL-FIRED BOILERS

Quarterly Report No. 8
For the Period
April-June, 1992

August 1992

DOE Contract
DE-FC22-90PC89652

SCS Contract
C-91-000026

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Patents Cleared by Chicago on August 20, 1992

LEGAL NOTICE

DISCLAIMER

Section 1
SUMMARY

The objective of this project is to demonstrate and evaluate commercially available Selective Catalytic Reduction (SCR) catalysts from U. S., Japanese and European catalyst suppliers on a high-sulfur U. S. coal-fired boiler. SCR is a post-combustion nitrogen oxide (NOx) control technology that involves injecting ammonia into the flue gas generated from coal combustion in an electric utility boiler. The flue gas containing ammonia is then passed through a reactor that contains a specialized catalyst. In the presence of the catalyst, the ammonia reacts with NOx to convert it to nitrogen and water vapor.

Although SCR is widely practiced in Japan and Europe, there are numerous technical uncertainties associated with applying SCR to U. S. coals. These uncertainties include:

(1) potential catalyst deactivation due to poisoning by trace metal species present in U. S. coals that are not present in other fuels.

(2) performance of the technology and effects on the balance-of-plant equipment in the presence of high amounts of SO_2 and SO_3.

(3) performance of a wide variety of SCR catalyst compositions, geometries and methods of manufacture under typical high-sulfur coal-fired utility operating conditions.

These uncertainties will be explored by constructing a series of small-scale SCR reactors and simultaneously exposing different SCR catalysts to flue gas derived from the combustion of high sulfur U. S. coal.

The demonstration will be performed at Gulf Power Company's Plant Crist Unit No. 5 (75 MW capacity) near Pensacola, Florida. The project will be funded by the U. S. Department of Energy (DOE), Southern Company Services, Inc. (SCS on behalf of the entire Southern electric system), and the Electric Power

Research Institute (EPRI). SCS is the participant responsible for managing all aspects of this project.

The project is being conducted in the following three phases:

- Phase I - Permitting, Environmental Monitoring Plan and Preliminary Engineering
- Phase II - Detailed Design Engineering and Construction
- Phase III - Operation, Testing, Disposition and Final Report

During this reporting period, detailed design engineering and construction continued. The personnel/catalyst hoist erection specifications were issued for bids, bids received, the bid evaluation completed, and a contract was awarded. Major equipment delivered to the site included the air heaters, fly ash cyclones, flue gas/air fans, bypass heat exchangers, 4KV switchgear, venturis, 480V motor control center, flue gas/air electric heaters, portions of the air compressor system, and dampers/actuators.

Specifications were issued for bids on the reactor vessels and reactor transition ductwork. Bids were received, an evaluation completed, and a contract was awarded.

Ductwork and fan system analyses during this period indicated certain fans had insufficient static pressure capability. As resolution to this problem, modifications to the small reactor fans and hot air fan were made, and certain ductwork has been increased in size to improve the system pressure drop. Modifications to the large reactor fans were not deemed to be cost effective. The maximum flue gas flow rate for the large reactor fans may only exceed the design rate by 25 percent, instead of the originally planned maximum rate of 50 percent greater than design. Even if this proves to be the case, it will not change the overall objectives of the demonstration.

In reviewing vendor drawings for the reactor sootblowers, it was discovered that there were interferences with the retractable sootblower system and the structural steel support for the demonstration facility. The sootblowers length was reduced and the sootblowers were relocated to resolve this issue.

The control system hardware and software were delivered to SCS and configuration of the control system was begun.

Construction of the Plant Crist SCR demonstration facility continued with the concrete/piling work being essentially completed with 98% of all foundations finished. Steel fabrication began and the first of four sequences, representing half of all the steel, was completed.

The contract for the structural steel erection package was awarded. The subcontractor mobilized and began structural steel erection.

The specifications were issued for bids, bid responses were evaluated and a contract was awarded for the following two construction packages: control room and gas analyses system buildings, and mechanical/insulation erection. The electrical/I&C erection specifications were finalized and issued for bids. Bid responses were received and the evaluation was essentially completed.

SCS issued a revised laboratory testing protocol to the catalyst suppliers for final review and approval. A proposed Evaluation Agreement was submitted for approval to the catalyst supplier selected in the evaluation conducted previously (replacing a catalyst vendor who withdrew from the project). The final scope of work was developed for the testing and analytical services and a proposed contract was submitted to the selected testing services subcontractor.

Monthly project review meetings were held between SCS and Gulf Power at Plant Crist. A project review meeting was held with DOE and EPRI on April 16. A press briefing and dedication ceremony were held for the project at Plant Crist on June 30 and July 1, 1992, respectively.

The onsite operations engineer and process engineer positions were filled during this reporting period.

Section 2
INTRODUCTION

The Innovative Clean Coal Technology (ICCT) Program is designed to demonstrate clean coal technologies that are capable of retrofitting or repowering existing facilities to achieve significant reduction in sulfur dioxide (SO_2) and/or nitrogen oxides (NOx) emissions. The technologies selected for demonstration are capable of being commercialized in the 1990s and are expected to be more cost effective than current technologies.

This ICCT project is jointly funded by the U. S. Department of Energy, the Electric Power Research Institute (EPRI), and by Southern Company Services (SCS) on behalf of the entire Southern electric system. The project's objective is to demonstrate the selective catalytic reduction (SCR) process that removes nitrogen oxides (NOx) from the flue gas of boilers that burn U.S. high-sulfur coal. The SCR technology involves the catalytic reduction of NH_3 which is injected into the flue gas to react with NOx contained in the flue gas to produce molecular nitrogen (N_2) and water vapor.

A simplified SCR process flow diagram with major equipment is shown in Figure 1. Specifically, hot flue gas leaving the economizer section of the boiler is ducted to the SCR reactor. Prior to entering the reactor, NH_3 is injected into the flue gas at a sufficient distance upstream of the reactor to provide for complete mixing of the NH_3 and flue gas. The quantity of NH_3 can be adjusted and it reacts with the NO_x from the flue gas. The flue gas leaving the catalytic reactor enters the air preheater where it transfers heat to the incoming combustion air. Provisions are made for ash removal from the bottom of the reactor since some fallout of fly ash is expected. Duct work is also provided to bypass some flue gas around the economizer during periods when the boiler is operating at reduced load. This is done to maintain the temperature of the flue gas entering the catalytic reactor at the proper reaction temperature of about 700°F. The flue gas leaving the air preheater goes to the electrostatic precipitator (ESP) where fly ash is removed. The ESP is part of the existing plant and is generally unaffected by the SCR system except as higher SO_3 content affects the electrical resistivity of the fly ash or if NH_4HSO_4 co-precipitates with the fly ash.

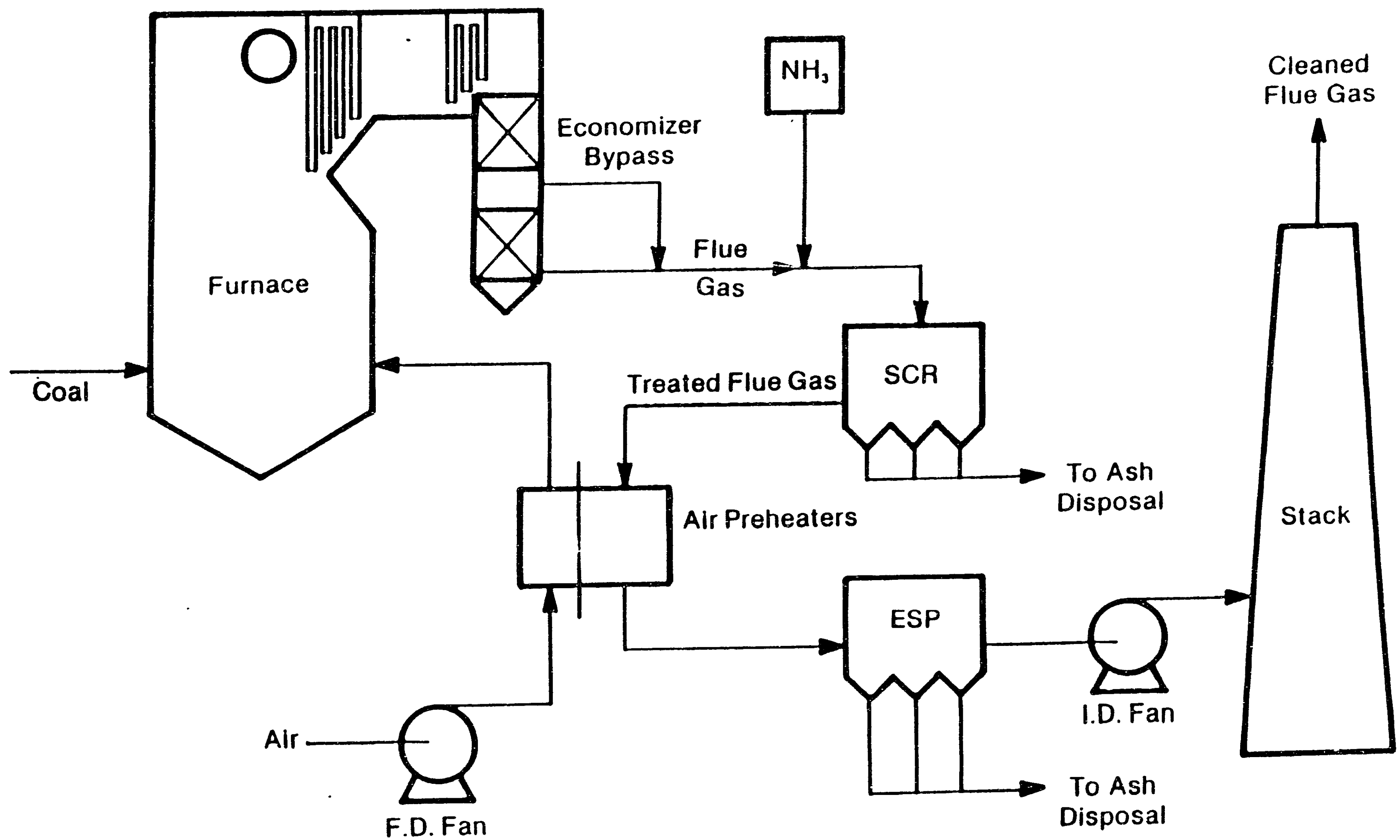


FIGURE 1. BLOCK FLOW DIAGRAM OF SCR INSTALLATION.

The SCR technology is in commercial use in Japan and western Europe on gas, oil, and on low-sulfur, coal-fired power plants. The first utility applications of SCR catalyst technology started in Japan in 1977 for oil- and gas-fired boilers and subsequently in 1979 for coal-fired boilers. As of 1986, ninety utility boilers in Japan had been equipped with SCR catalyst technology including twenty-two coal-fired boilers. These coal-fired boilers represent a combined capacity in excess of 6500 MWe and are typically fired with a low-ash, low-sulfur coal.

In addition to Japanese experience, several countries in western Europe (most notably Germany and Austria) have passed stringent NO_x emission regulations that have all but mandated the installation of SCR. Prior to commercial SCR installations in Germany, utility companies demonstrated several types of SCR facilities in prototype demonstration programs similar to this ICCT project. Over 50 SCR pilot plants were built and operated in western Europe. These pilot plants ranged from 19 to 6200 SCFM and provided the data base that led to commercialization of the SCR technology in western Europe.

Previously completed U. S. work with the SCR process on utility boilers consists of three projects which were carried out in the late 1970s and early 1980s. One of these was carried out on a natural gas fired boiler by Southern California Edison. Another project consisted of a pilot test conducted for the EPA at Georgia Power's Plant Mitchell. This pilot plant treated a 1000 ACFM (0.5 MWe) slip stream of flue gas resulting from the combustion of low- to medium-sulfur coal. A third pilot-scale project, carried out at the Public Service Company of Colorado's Arapaho Station treated a 5000 ACFM (2.5 MWe) slip stream of flue gas resulting from the combustion of U. S. low-sulfur coal.

Although SCR is widely practiced in Japan and Europe, there are numerous technical uncertainties associated with applying SCR to U. S. coals. These uncertainties include:

(1) potential catalyst deactivation due to poisoning by trace metal species present in U. S. coals that are not present in other fuels.

(2) performance of the technology and effects on the balance-of-plant equipment in the presence of high amounts of SO_2 and SO_3.

(3) performance of a wide variety of SCR catalyst compositions, geometries and methods of manufacture under typical high-sulfur coal-fired utility operating conditions.

These uncertainties will be explored by constructing a series of small-scale SCR reactors and simultaneously exposing different SCR catalysts to flue gas derived from the combustion of high sulfur U. S. coal.

The first uncertainty above will be handled by evaluating SCR catalyst performance for two years unoer realistic operating conditions found in U. S. pulverized coal utility boilers. The deactivation rates for the catalysts exposed to flue gas from high sulfur U. S. coal will be documented to determine accurate catalyst life, and thus, accurate process economics.

The second uncertainty above will be explored by performing parametric testing and through the installation/operation of air preheaters downstream of the larger reactors. During parametric testing, operating conditions will be adjusted above and below design values to observe deNOx performance and ammonia slip as functions of the change in operating conditions. Air preheater performance will be observed to evaluate effects from SCR operation upon heat transfer, and therefore, upon boiler efficiency.

The third uncertainty is being handled by using honeycomb- and plate-type SCR catalysts from U. S., Japan and Europe of various commercial composition. Results from the tests with these catalysts will expand our knowledge of performance on a variety of SCR catalysts under U. S. utility operating conditions with high-sulfur coal.

The intent of this project is to demonstrate commercial catalyst performance, proper operating conditions, and catalyst life for the SCR process. This project will also demonstrate the technical and economic viability of SCR while reducing NO_x emissions by at least 80%.

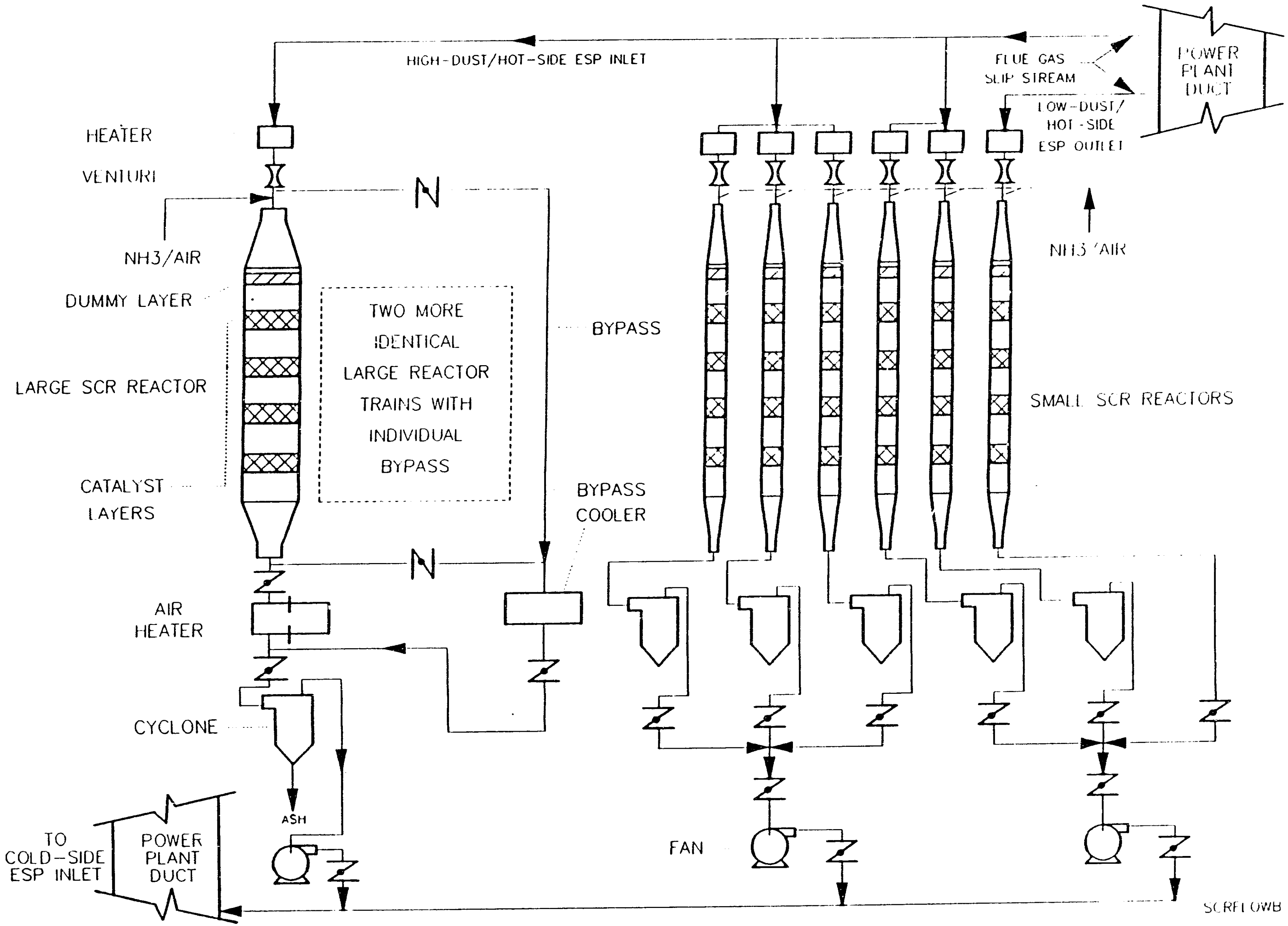
The project will be conducted at Gulf Power Company's Plant Crist Unit 5, a commercially operating 75 MW unit, located in Pensacola, Florida, on U. S.

coals with a sulfur content near 3.0%. Unit 5 is a tangentially-fired, dry bottom boiler, with a hot and cold side ESPs for particulate control. The SCR process to be used in this demonstration will be designed to treat a slip-stream of flue gas and will feature multiple reactors installed in parallel. With all reactors in operation, the maximum amount of combustion flue gas that can be treated is 17,400 standard cubic feet per minute (scfm) which is roughly equivalent to 8.7 MWe.

The SCS facility is a slip-stream SCR test facility consisting of three 2.5 MWe (5000SCFM) SCR reactors and six 0.20 MWe (400SCFM) reactors that will operate in parallel for side-by-side comparisons of commercially available SCR catalyst technologies obtained from vendors throughout the world. Figure 2 presents a simplified process flow diagram for the proposed facility. The large (2.5 MWe) SCR reactors will contain commercially available SCR catalysts as offered by SCR catalyst suppliers. These reactors will be coupled with small-scale air preheaters to evaluate the long-term effects of SCR reaction chemistry on air preheater deposit formation and the deposits' effects on air preheater. The small reactors will be used to test additional commercially available catalysts. This demonstration facility size will be adequate to develop performance data to evaluate SCR capabilities and costs that are applicable to boilers using high-sulfur U. S. coals.

The demonstration project is organized into three phases: (1) Phase I - Permitting, Environmental Monitoring Plan and Preliminary Engineering; (2) Phase II - Detail Design Engineering and Construction; and (3) Phase III - Operation, Testing, Disposition, and Final Report. The cooperative agreement was signed June 14, 1990, and the project completion date is now projected to be mid-1995. The original total estimated project costs are $15,574,355. The co-funders are SCS ($6,049,017), DOE ($7,525,338), and EPRI ($2,000,000).

PROTOTYPE SCR DEMONSTRATION FACILITY–PROCESS FLOW DIAGRAM



Section 3
PROJECT DESCRIPTION

Within the three phases of the project, the following tasks will be conducted to effectively demonstrate the SCR process:

Phase I - Permitting, Environmental Monitoring Plan and Preliminary Engineering

Task 1.1.1 - Prototype Plant Permitting Activities
Task 1.1.2 - Develop Environmental Monitoring Program
Task 1.1.3 - Preliminary Engineering
Task 1.1.4 - Engineering and Construction Contracts Scope Development
Task 1.1.5 - Project Management and Reporting

Phase II - Detail Design Engineering and Construction

Task 1.2.1 - Detailed Design Engineering
Task 1.2.2 - Construction
Task 1.2.3 - Operation Staff Training
Task 1.2.4 - Planning for Detailed Testing
Task 1.2.5 - Start-Up/Shakedown
Task 1.2.6 - Project Management and Reporting

Phase III - Operations, Testing, Disposition and Final Report

Task 1.3.1 - SCR Demonstration Facility Operations and Maintenance
Task 1.3.2 - Process Evaluation
Task 1.3.3 - Environmental Data Management and Reporting
Task 1.3.4 - Economic Evaluation
Task 1.3.5 - Dismantling/Disposition
Task 1.3.6 - Project Management and Reporting

Section 4
PROJECT STATUS

Progress during April-June, 1992, is summarized below for each of the on-going tasks in the Scope of Work.

PHASE I - PERMITTING, ENVIRONMENTAL MONITORING PLAN AND PRELIMINARY ENGINEERING

Task 1.1.2 - Develop Environmental Monitoring Program

Radian and SCS are still preparing a response to the only remaining issue raised by DOE on the Environmental Monitoring Plan regarding fly ash analysis. The suggested plan and revised Environmental Monitoring Plan will be submitted to DOE during the next quarter.

PHASE II - DETAIL DESIGN ENGINEERING AND CONSTRUCTION

Task 1.2.1 - Detailed Design Engineering

The detailed design engineering phase continued during this reporting period with over 80 percent on the total project completed. The personnel/catalyst hoist erection package was issued for bids, bids were received and the evaluation of bids was completed. The purchase order was issued to USA Hoist on June 18, 1992. Major equipment delivered to the site included the air heaters, fly ash cyclones, flue gas/air fans, bypass heat exchangers, 4KV switchgear, venturis, 480V motor control center, flue gas/air electric heaters, dampers/actuators, and portions of the air compressor system. A summary of equipment ordered and its delivery status is given in Appendix A.

Design work and specification preparation was completed for the reactor vessels and reactor transition ductwork and the specifications were released for bids. The bid responses were received, and based on the evaluation results, a contract was awarded to Central Alabama Fabricators.

Ductwork and fan system analyses during this period indicated certain fans had insufficient static pressure capability. As resolution to this problem, modifications to the small reactor fans and hot air fan were made, and certain ductwork has been increased in size to improve the system pressure drop. Modifications to the large reactor fans were not deemed to be cost effective. It is anticipated that the maximum flue gas flow rates which may be achieved during parametric testing for the large reactor trains may only exceed the design rate by 25 percent. The originally planned maximum rate was 50 percent greater than design. However, even if this proves to be the case, it will not change the overall objectives of the demonstration.

In reviewing vendor drawings of the reactor sootblowers, for which a contract was awarded during the previous quarter, it was discovered that there were interferences with the retractable sootblower system and the structural steel support for the demonstration facility. In resolving this issue, the sootblowers's length was shortened and the sootblowers were relocated perpendicularly to the original orientation (i.e., the sootblower traverses the width of the reactor instead of the length).

The data acquisition and distributed control system hardware and software were delivered to SCS. Configuration of the control system was begun and is still in progress.

SCS issued a revised laboratory testing protocol to the catalyst suppliers for final review and approval. This revision was based on the latest responses from catalyst suppliers regarding the proposed common laboratory testing protocol.

Efforts continued to replace Norton, a catalyst vendor who withdrew from the project. A proposed Evaluation Agreement and accompanying documentation were submitted for approval to the supplier selected in the evaluation conducted during the previous quarter. Negotiation of the agreement continues but is close to completion.

The final scope of work was developed for the testing and analytical services. Major portions of the drafted scope of work are included in Appendix B. A proposed contract was submitted to the selected testing services subcontractor and contract negotiations are essentially complete.

Task 1.2.2 - Construction

Construction of the Plant Crist SCR demonstration facility continued during this quarter with the concrete/piling work being essentially completed. All of the pilings were driven, major foundations poured and 98 percent of all foundations were finished.

Steel fabrication began and the first of four sequences was completed. This first sequence represents about 50 percent of the total steel to be manufactured. Fabrication of the second sequence was underway.

Vendor bids were received, evaluated, and the contract awarded to Kan-Duit Construction on the structural steel erection package. This subcontractor mobilized and began structural steel erection in June.

Specifications were issued for bid on the control room and gas analysis systems buildings. A prebid meeting was held on April 9 and bids were received on April 29, 1992. The bids were evaluated and alternative bids were subsequently requested for the heating and air conditioning portion of the bid. The alternative bids were evaluated and a contract was awarded to Martin Johnson on June 4, 1992.

With the specifications on the passenger elevator within the control room building having been released for bid during the previous quarter, a prebid meeting was held on April 20, 1992. Bids were received on April 30, the bid evaluation was completed and a contract awarded to Miami Elevator on June 5, 1992.

The combined mechanical and insulation construction package specifications were issued for bids. A prebid meeting was held on May 5, 1992, and vendor bids were received on May 27, 1992. The evaluation of bids was completed and a contract awarded on June 30, 1992 to R. N. Pyle. The award included having 12 inches of insulation on the SCR reactors and reactor inlet ducting. Originally, the planned insulation thickness was only 6 inches. However, the insulation thickness was increased based on recommendations from catalyst suppliers, with their previous pilot plant experiences, and from EPRI. EPRI's SCR pilot plants have 6-inch thick insulation, but have experienced problems and are planning to increase the insulation thickness. EPRI agreed with our plans to have more insulation.

The specification packages for electrical and I&C erection were combined into one construction package and issued for bids. A prebid meeting was held on May 18 and bids were received on June 9, 1992. The evaluation was essentially completed and contract award was in progress at the end of this reporting period.

Preparation of painting specifications was begun during this reporting period. Asbestos removal specifications were finalized and were added in the individual construction packages as warranted.

Task 1.2.6 - Project Management and Reporting

Weekly coordination meetings were held with Design Engineering. The MIS, developed for tracking overall budget and schedule information, was used to monitor budget and schedule and to help fulfill DOE reporting requirements. Monthly progress reports were submitted to DOE.

Monthly project review meetings to discuss design and construction status were held between SCS and Gulf Power at Plant Crist. A project review meeting was held in Birmingham with DOE and EPRI on April 16.

A press briefing and dedication ceremony were held for the project at Plant Crist on June 30 and July 1, 1992, respectively. The press briefing provided the local press an opportunity to ask questions of a panel representing DOE, SCS, and Gulf Power about the project, the technology, and the local impacts. Representatives from DOE, EPRI, Gulf Power, SCS, catalyst suppliers, and state environmental agencies were present for the dedication ceremony. These events were reported in local newspaper articles and television news stories.

Project cost growth has been projected based on improvements to the facility design and solicitation of funding for the cost growth continued. The onsite operations engineer and process engineer positions were filled during this reporting period.

Section 5
PLANNED ACTIVITIES

During the July - September, 1992 quarter, the following activities are planned:

- Complete the following portions of Phase II, detailed engineering design and construction package awards:

    1. Complete structural steel fabrication and erection.
    2. Begin mechanical/insulation and electrical/I&C construction work. Install fans, switchgear, bypass heat exchangers, cyclones, air preheaters, air compressor, and ammonia handling system. Begin ash system modifications and installation of ductwork, service water and air piping, electrical systems, fire protection systems, and instrumentation.
    3. Begin construction of control room and gas analyses system buildings.
    4. Finish developing specifications, issue inquiries for vendor bids, and complete evaluations of vendor bid packages for painting.
    5. Receive reactor, reactor transition ductwork, and reactor sootblowing systems.

- Continue control system configuration, select pilot plant operators, and prepare for operator training on the control system.

- Secure signed agreements for testing and analytical services and for selected replacement catalyst supplier.

- Begin developing data reduction methodology.

APPENDIX A

Purchase Order Tracking Report

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C91-000854	SCR-700	HEAT PIPE AIR PREHEATER	ABB AIR PREHEATER	05/17/91	05/01/92	RECEIVED
	ADDEND-1	CHANGE-SPT MODIFICATION	[redacted]	11/15/91	05/01/92	
C91-000855	SCR-701	ROTARY TYPE AIR PREHEATER	ABB AIR PREHEATER	05/17/91	05/01/92	RECEIVED
C91-001152	SCR-702	EXHAUST GAS/COOLING AIR FANS	HOWDEN SIROCCO	06/21/91	07/01/92	PARTIAL
	ADDEND-1	CHANGE MOTOR HORSEPOWER	[redacted]	09/16/91	07/01/92	RECEIPT
	ADDEND-2	ADD-TRANSMITTERS	[redacted]	02/21/92	07/01/92	Bal-14Aug92
C91-001260	SCR-703	GAS FLOW VENTURI'S	FLOW-LIN CORP	07/09/91	06/29/92	RECEIVED
C91-001434	SCR-708	480V MOTOR CONTROL CENTER	SOUTHERN ENGINEER	08/15/91	06/01/92	RECEIVED
	ADDEND-1	ADDRESS CHANGE	NO PRICE CHANGE			
	ADDEND-2	SCOPE REVISION	[redacted]			
C91-001608	SCR-704	DIST CONTROL/DATA ACQ SYSTEM	BAILEY CONTROLS	08/26/91	02/03/92	RECEIVED
	ADDEND-1	ADD: GAS ANALYZER SYSTEM	[redacted]	12/09/91	02/03/92	
	ADDEND-2	DEDUCT: MISC EQUIP/TRAINING	[redacted]	05/11/92	NA	
C91-001624	SCR-709	FLY ASH CYCLONES	FISHER-KLOSTERMAN	08/28/91	05/15/92	RECEIVED
C91-001672	SCR-706	DUCTWORK HEAT EXCHANGER	XCHANGER, INC	08/30/91	05/15/92	RECEIVED
C91-001673	SCR-707	MISC POWER TRANSFORMERS	ABB POWER T/D	08/30/91	06/01/92	RECEIVED
	ADDEND-1	ADDRESS CHANGE				
	ADDEND-2	ADD-TEMP EQUIP	[redacted]			
C91-001707	SCR-705	4KV METAL CLAD SWITCHGEAR	SIEMENS ENERGY	09/06/91	06/01/92	RECEIVED
C91-002003	SCR-710	FLUE GAS/AIR ELECTRIC HEATERS	WATLOW SYSTEMS	10/17/91	06/15/92	RECEIVED
C91-002312	SCR-711	SERVICE/COOLING WATER PUMP	PEABODY FLOWAY, INC	11/27/91	06/01/92	08/07/92
C91-002553	SCR-712	GAS ANALYZER SYSTEM	LEAR SIEGLER	12/27/91	09/01/92	10/01/92

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C91-002554	SCR-712A	OXYGEN ANALYZER SYSTEM	LEAR SIEGLER	12/27/91	09/01/92	10/01/92
			1992			
C92-000039	SCR-714	PLANT AIR COMPRESSOR	HYDROMATICS, INC	01/15/92	06/01/92	PARTIAL
C92-000043	SCR-713	BULK AMMONIA SYSTEM	LAROCHE INDUSTRIES (Lease Contract)	01/15/92	05/31/92-TANK 11/01/92-AMMON	AS REQ
C92-000047	SCR-1018-01 ADDEND-1	DAMPERS/ACTUATORS SCOPE CHANGE: ADD EQUIPMENT	PRECISION ENG PROD [redacted]	01/16/92	06/01/92	RECEIVED
C92-000051	SCR-1018-02	SOOTBLOWERS	COPES-VULCAN, INC	01/17/92	07/31/92	09/21/92
C92-000201	SCR-1113-01/01A	LOW VOLTAGE TRANSFORMERS	GRAYBAR ELECTRIC	02/05/92	04/01/92	RECEIVED
C92-000241	SCR-715 ADDEND-1	STRUCTURAL STEEL/GRATING SCOPE CHANGE: ADD STEEL	STEEL SYSTEMS [redacted]	02/12/92	06/01/92	AS REQ BY CONTRACTOR
C92-000301	SCR-0220-01	125 VOLT DC BREAKER	MCCOMBS BROS ELECT	02/21/92	03/25/92	RECEIVED
C92-000336	SCR-0123-01	BARGRAPH INDICATORS	DIXSON INSTRUMENTS	02/26/92	04/01/92	RECEIVED
C92-000337	SCR-0114-04	PRESSURE SWITCHES	AWC	02/26/92	08/01/92	AS REQ
C92-000342	SCR-0114-01	GAS FLOW CONTROLLER	SIERRA INSTRUMENTS	02/28/92	06/01/92	RECEIVED
C92-000380	SCR-0114-03	PRESSURE TRANSMITTERS	TECHNICAL SPEC	03/05/92	08/01/92	RECEIVED
C92-000570	SCR-0114-02	THERMOCOUPLES	JMS SOUTHEAST, INC	04/01/92	08/01/92	AS REQ
C92-000618	SCR-1223-01	SEGREGATING VALVES	JOY ENVIRON EQUIP	04/07/92	07/01/92	RECEIVED
C92-000620	SCR-0124-01	WEAR RESISTANT PIPE/FITTINGS	ULTRA TECH	04/07/92	07/01/92	RECEIVED

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C92-000623	SCR-0131-01	480V CONTROL PANEL	INSTRUMENT CONT SVC	04/07/92	08/01/92	AS REQ
C92-000624	SCR-1217-01	ROTARY VALVES	ROTOLOK, INC	04/08/92	07/01/92	RECEIVED
C92-000629	SCR-0123-04	KNIFEGATE VALVES	DEZURIK	04/08/92	07/01/92	RECEIVED
C92-000630	SCR-0123-03	PLUG/CHECK VALVES	PIPING & EQUIPMENT	04/08/92	07/01/92	RECEIVED
C92-000636	SCR-0401-01	UDS MODEMS	HALL-MARK ELECTR	04/09/92	ASAP	RECIEVED
C92-000643	SCR-0123-05	CS TRANSITION PIECES	CMC CORPORATION	04/10/92	07/01/92	RECEIVED
C92-000818	SCR-0123-02	MASS FLOW METERS	SIERRA INSTRUMENTS	05/14/92	08/01/92	AS REQ
C92-000894	SCR-0428-01	SERVICE WATER STRAINER	VOIGT-ENGLAND CO	05/29/92	07/15/92	SHIPPED
C92-000965	SCR-0512-01	3/C 250 MCM CABLE	OKONITE CO	06/10/92	09/01/92	09/25/92
C92-001034	SCR-716	PERSONNEL HOIST	USA HOIST	06/18/92	09/01/92	10/15/92
C92-001068	SCR-717	REACT/TRANS DUCTWORK	CENTRAL ALABAMA FAB	06/26/92	START-09/01/92 COMP-09/07/92	AS REQ
C92-001152	SCR-0410-02	BALL VALVES	GULF COAST MARINE S	07/10/92	07/31/92	AS REQ
C92-001154	SCR-0610-01	THERMOCOUPLES	JMS SOUTHEAST, INC	07/10/92	07/31/92	AS REQ
C92-001156	SCR-0410-01	GLOBE VALVES	MASONEILAN	07/10/92	08/01/92	AS REQ

DENOTES EQUIPMENT RECEIVED

APPENDIX B

Testing and Analytical Services Scope of Work

Section 3
TECHNICAL PLAN

In this section the technical plan for performing the tasks is presented. An overall schedule of activities is presented for each task and the overall project, and tables are provided listing the manhours assigned to key personnel and supporting staff for each task.

PLANNING AND PREPARATION

During the period from July through December 1992 activities will be in progress in preparation for formal startup of the test facility in January 1993. For the convenience of the discussion in this section, as well as the preparation of the cost proposal, activities during this time are referred to as Task 0. During this six-month period there are a number of scheduled meetings to review the status of preparations. Equipment to set up the laboratory at the test facility will be purchased during this time. The equipment will be transported to the site and installed. Toward the end of this period the testing personnel assigned to the project will begin working at the facility. [redacted] and [redacted] will work with SCS in the selection and location of sampling ports and other details related to the performance of sampling protocols on the reactors. Testing enclosures will be erected on the test facility and arrangements for the storage of test equipment will be made. These activities will ensure that the test program will proceed at a normal pace even during inclement weather conditions. During the last month of this preparatory period, intensive activities will begin in [redacted] and at the test facility toward the commissioning of the test facility (Tasks 1, 2, and 3).

COMMISSIONING THE PILOT PLANT

The startup and commissioning of the SCR Pilot Plant at Gulf Power Company's Plant Crist is scheduled for a fifteen week period. Tasks 1, 2, and 3 are to be performed during the commissioning exercises. Table 1 presents a weekly schedule for the completion of these tasks.

Table 1. Startup and Commissioning Test Schedule

Startup and Commissioning Tests	WEEK 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Task 1: Commissioning Without Catalyst and Ammonia															
Calibrate Flow Control Venturis	■														
Verify Gas Sampling System	■														
High Load Tests															
Measure Mass Concentration & Collect Ash Samples		■													
Collect Trace Metal Samples		■													
Measure Concentrations of O_2, NO, N_2O, HCl, NH_3, SO_3		■													
Measure SO_2 & SO_3 Concentrations at Reactor Heaters		■													
Analyse Ash Samples and Trace Metal Samples		■	■	■	■	■									
Low Load Tests															
Measure Mass Concentration & Collect Ash Samples			■												
Collect Trace Metal Samples			■												
Measure Concentrations of O_2, NO, N_2O, HCl, NH_3, SO_3			■												
Measure SO_2 & SO_3 Concentrations at Reactor Heaters			■												
Analyse Ash Samples and Trace Metal Samples			■	■	■	■									
Complete Verification of Gas Sampling System				■											
Complete Any Tests From Weeks 1, 2, 3				■											
Task 2: Commissioning Without Catalyst & With Ammonia															
Monitor Ammonia Oxidation					■	■									
Verify Ammonia Flow Control and Ammonia Mass Balance					■	■									
Determine Gas Sampling System Equilibrium Times					■	■									
Task 3A: Commissioning With Catalyst & Without Ammonia															
Measure SO_2/SO_3 Conversion Rates							■	■	■						
Task 3B: Commissioning With Catalyst and Ammonia															
Measure Velocity, NOx, and NH_3 At Reactor Outlets										■	■	■	■	■	■
Collect Ash Samples At Reactor Outlets										■	■	■	■	■	■
Preliminary Parametric Test Sequence										■	■	■	■	■	■

TASK 1. Commissioning Without Catalyst and Without Ammonia Injection

The objectives of task 1 are to measure the performance of the flue gas extraction system, to define the baseline physical and chemical properties of the flue gas at various points in the pilot plant ducting, and to confirm the accuracy of the flue gas continuous monitoring system. The three full-time on-site [redacted] personnel will be augmented by an [redacted] field testing crew during this four-week period. The temporary crew will primarily be engaged in particulate sampling and analysis while the resident crew will be engaged in gaseous sampling and analysis. This task will require four weeks to complete. The details of this work are provided below.

WEEK 1 - Calibrations and Verifications

A. The flow control venturis for each of the nine reactors will be calibrated by measuring gas velocity (Pitot traverses), temperature, and static pressure at three flow rates; minimum, design, and maximum, 3000, 5000, and 7500 scfm for the large reactors and 240, 400, and 600 scfm for the small reactors. This work will be carried out by the field testing crew. We estimate that two to three venturi calibrations can be completed each day. One full week is allotted for this work.

B. The [redacted] on-site crew will assist in the verification of the gas sampling system. This may include characterization of flue gas composition (O_2, CO, CO_2, NO_x, SO_2) at selected gas sampling points. The following methods will be used:

O_2 - Teledyne Oxygen Analyzer
CO - Fyrite analyzer
CO_2- Fyrite analyzer
NO_x - Portable ThermoElectron Chemiluminescence Monitor
SO_2 - H_2O_2 bubbler, Ion Chromatography

WEEK 2 - High Boiler Load

A. While the unit 5 boiler is at stable high-load operation, particulate mass concentration and particle size distribution will be measured at eleven locations in the pilot plant and unit 5 ducts. These locations are:

Unit 5 Hot-Side ESP Inlet Duct (source of high-dust stream)
Unit 5 Hot-Side ESP Outlet Duct (source of low-dust stream)
Each of the Nine Reactor Inlets

The high load mass concentration at each sampling point will be determined for two, consecutively-run, EPA method 17 mass trains. This sampling will require 22 method 17 runs.

B. The particle size distribution of the combined mass train catches for each pair of method 17 runs will be determined in [redacted] laboratory using a Shimadzu particle sizing device. Quality assurance for this laboratory work will be provided by a pair of consecutive cascade impactors and a pair of consecutive six-stage series cyclones run at the Unit 5 hot-side ESP inlet duct (the source of the high-dust stream) to verify the Shimadzu particle size distributions. This activity will require 11 laboratory particle sizings and four in-situ particle sizing runs.

C. The combined mass train catches for the pair of method 17 runs at the Unit 5 hot-side ESP inlet duct (the source of the high-dust stream) will be subjected to an ash mineral analysis.

D. The high-load baseline trace metals profile of the pilot plant will be documented using modified Method 5 (EPA) metals trains. The metals trains will be run at the high-mass extraction scoop (Unit 5 hot-side ESP inlet duct), at the low-mass extraction scoop (Unit 5 hot-side ESP outlet duct), at the inlet to one of the large reactors, and at the inlet to the low-dust small reactor. The high-load trace metals profile will require 4 sampling runs and the analysis of 4 samples.

E. The fly ash samples collected with the six-stage series cyclone sampling train at the Unit 5 ESP inlet duct will be subjected to a size-specific mineral and trace metals analysis (ICAP).

F. High-load baseline concentrations of HCl, NH_3, SO_2/SO_3, NO, N_2O, and O_2 will be measured in the two main ducts at the extraction points; the unit 5 hot-side ESP inlet and outlet ducts. Three samples will be collected at each location for each species. O_2 will be measured using a portable Teledyne O_2 analyzer. NO will be measured using a portable NO_x analyzer and N_2O will also be measured with a portable instrument. The determinations of HCl, NH_3, and SO_2/SO_3 will require manual sampling methods and subsequent laboratory analysis of individual samples. This sub-task will require 9 instrumental determinations, nine manual stack sampling runs, and nine laboratory analyses all done by the on-site [redacted] staff temporarily augmented by one [redacted] chemist.

G. Concentrations of SO_2 and SO_3 will be measured simultaneously in one of the large reactors before and after the reactor heater and at the reactor outlet. Identical SO_2/SO_3 measurements will be made for one of the small reactors. Two samples will be collected at each sampling site (twelve in all). Additional testing on other reactors will be performed if warranted by the results of these tests.

H. Laboratory analysis of particulate samples and trace metals samples will begin. These analyses will be conducted at the [redacted] laboratory. These analyses should be completed prior to the beginning of Task 3 (commissioning with catalyst).

WEEK 3 - Low Boiler Load

A. While the unit 5 boiler is at stable low-load operation, particulate mass concentration and particle size distribution will be measured at twelve locations in the pilot plant and unit 5 ducts. These locations are:

Unit 5 Hot-Side ESP Inlet Duct (source of high-dust stream)
Unit 5 Hot-Side ESP Outlet Duct (source of low-dust stream)
The Economizer Bypass Duct
Each of the Nine Reactor Inlets

The low-load mass concentration at each sampling point will be determined for two, consecutively-run, EPA method 17 mass trains. This sampling will require 24 method 17 runs.

B. The particle size distribution of the combined mass train catches for each pair of method 17 runs will be determined in [redacted] laboratory using a Shimadzu particle sizing device. Quality assurance for this laboratory work will be provided by a pair of consecutive cascade impactors and a pair of consecutive six-stage series cyclones run at the Unit 5 hot-side ESP inlet duct (the source of the high-dust stream) to verify the Shimadzu particle size distributions. This activity will require 12 laboratory particle sizings and four in-situ particle sizing runs.

C. The combined mass train catches for the pair of method 17 runs at the Unit 5 hot-side ESP inlet duct (the source of the high-dust stream) will be subjected to an ash mineral analysis.

D. The low-load baseline trace metals profile of the pilot plant will be documented using modified Method 5 (EPA) metals trains. The metals trains will be run at the high-mass extraction scoop (Unit 5 hot-side ESP inlet duct), at the low-mass extraction scoop (Unit 5 hot-side ESP outlet duct), at the economizer bypass duct, at the inlet to one of the large reactors, and at the inlet to the low dust small reactor. The low-load trace metals profile will require 5 sampling runs and the analysis of 5 samples.

E. The fly ash samples collected with the six-stage series cyclone sampling train at the Unit 5 ESP inlet duct will be subjected to a size-specific mineral and trace metals analysis (ICAP).

F. Low-load baseline concentrations of HCl, NH_3, SO_2/SO_3, NO, N_2O, and O_2 will be measured at two locations; after the point at which the economizer bypass mixes with the flue gas from the hot-side ESP inlet and at the hot-side ESP outlet duct. Three measurements of each species will be made at each location. O_2 will be measured using a portable Teledyne O_2 analyzer. NO will be measured using a portable NO_x analyzer and N_2O will also be measured with a portable instrument. The determinations of HCl, NH_3, and SO_2/SO_3 will require manual sampling methods and subsequent laboratory analysis of individual samples. This sub-task will require 9 instrumental determinations, nine manual stack sampling runs, and nine laboratory analyses all done by the on-site [redacted] staff temporarily augmented by one [redacted] chemist.

G. Concentrations of SO_2 and SO_3 will be measured simultaneously in one of the large reactors before and after the reactor heater and at the reactor outlet. Identical SO_2/SO_3 measurements will be made for one of the small reactors. Two samples will be collected at each sampling site (twelve in all). Additional testing on other reactors will be performed if warranted by the results of these tests.

H. Laboratory analysis of particulate samples and trace metals samples will begin. These analyses will be conducted at the [redacted] laboratory. These analyses should be completed prior to the beginning of Task 3 (commissioning with catalyst).

WEEK 4 - Wrap-up

A. The field test crew will finish any tests scheduled for the first three weeks that were not competed.

B. The on site [redacted] crew will complete the verification of the gas sampling system begun during week 3.

C. Laboratory chemical analysis of size segregated particulate samples and trace metals samples will continue at [redacted] laboratory.

The Request For Proposal indicated that an option may be offered related to on-line tracking of changes in particulate characteristics, specifically the particle size distribution. Cascade impactors and series cyclones are the most reliable method for measuring particle size distribution on a routine basis in flue gas streams. Periodic measurements using these instruments will be performed during the test program on an as-needed basis. [redacted] also proposes to monitor the response of the SCR reactors to transient effects, such as soot blowing, during commissioning and the parametric testing. Depending on the response of the SCR reactors to these transient events, [redacted] can easily transport instrumentation (real-time optical particle counters with dilution probes, an INSITEC in situ particle classifier) [redacted] to the test facility to evaluate changes in particulate characteristics during these short term events.

TASK 2 - Commissioning Without Catalyst and With Ammonia Injection

The objective of task 2 is to verify ammonia flow control, establish the ammonia mass balance, and to measure ammonia oxidation across the reactors prior to loading catalyst into the reactors.

Two weeks have been allotted to complete this task. The mass flow rate of ammonia into each of the nine reactors will be determined, the ammonia mass balance for the system will be verified, and the distribution of ammonia across each reactor inlet cross section will be measured. Ammonia oxidation at four combinations of flue gas flow rate and temperature will be measured on one large reactor and on one small reactor.

Weeks 5 & 6: NH_3 Distribution and Mass Balance

A. Ammonia oxidation will be profiled at a NH_3/NO_x ratio of 1 for two typical reactor streams; one through a large reactor and one through a small reactor. The profile will be constructed from samples at these conditions:

High Temperature (750°F), Low Flow Rate (3000 or 240 scfm)
High Temperature (750$_o$F), High Flow Rate (7500 or 600 scfm)
Low Temperature (620°F), Low Flow Rate (3000 or 240 scfm)
Low Temperature (620°F), High Flow Rate (7500 or 600 scfm)

This testing will require simultaneous sampling for NH_3 at the inlet and the outlet of each of the two reactors at each of the above combinations of temperature and flow rate. Following each NH_3 run, the sampling trains will be modified by changing condensers to allow SO_3 to be measured. Thus four NH_3 and four SO_3 runs (two of each at the reactor inlet and two of each at the reactor outlet) will be required at each of the four conditions; 16 NH_3 runs and 16 SO_3 runs in all.

B. Verification of ammonia flow control and confirmation of ammonia mass balance will be monitored by measuring ammonia in the gas phase and on particulate at the inlet and outlet of each of the nine reactors. Measurements will be conducted in the four quadrants of the inlet and outlet cross sections of each of the large reactors at an NH_3/NO_x ratio of 1.0. Due to constraints imposed by the physical size of the small reactors, the cross section available for measurements is limited.

C. The time to reach equilibrium when turning on or shutting off ammonia to each reactor will be determined. This "dead time" will be determined using the gas sampling system augmented by manual sampling as necessary.

TASK 3 - Commissioning with Catalyst, Without Ammonia Injection and With Ammonia Injection

Under Task 3, [redacted] will complete the following testing: measure the conversion rate of SO_2 to SO_3 across each reactor with catalysts installed but without ammonia injection, collect isokinetic ash samples at the outlet of each reactor under two operating conditions (with catalyst and ammonia), measure the velocity distribution, NO_x concentration and NH_3 distribution across each reactor outlet cross section at a single operating condition (with catalyst and ammonia), and perform a preliminary parametric test sequence (with catalyst and ammonia). Each of these measurements is described in more detail below. Task 3 will require nine weeks to complete.

Weeks 7, 8, & 9

TASK 3-A Commissioning with Catalyst and Without Ammonia Injection

The primary objective of Task 3-A is to characterize the SO_2/SO_3 conversion across each of the nine reactors with catalyst, but without ammonia injection.

A. To fully characterize conversion over the range of temperatures and flow rates anticipated during parametric testing, SO_2 and SO_3 concentrations will be measured at the inlet and outlet of each reactor at nine conditions; three flow rates (design, minimum, and maximum), and three temperatures (620°F, 700°F, and 750°F). The characterization of SO_2/SO_3 conversion for each reactor (each with a different catalyst) will require simultaneous inlet/outlet SO_2/SO_3 runs at each of the nine combinations of temperature and flow rate. Consecutive pairs of runs will be made to provide minimal statistical validity. Thus 18 pairs of runs will be needed to fully characterize each reactor, a total of 324 sampling runs. The assistance of an additional chemist from the [redacted] will be required to allow us to work as two, two-man sampling teams, each team testing a single reactor; one chemist/technician sampling at the inlet of a reactor while the other samples simultaneously at the outlet of the same reactor. Each team will sample one reactor at one temperature and three flow rates each day. At this rate each team will complete a test matrix for a single reactor in three days. Allowing for minimal time-loss due to upsets and delays in setting up the desired reactor temperatures and flow rates, we estimate that this subtask will require three weeks for completion.

Weeks 10, 11, 12, 13, 14, and 15

TASK 3-B. Commissioning with Catalyst and With Ammonia Injection: [Preliminary Parametric Test Sequence]

The commissioning activities under Task 3-B will be centered around a preliminary parametric test sequence that will be performed after the catalysts are installed in the reactors and with ammonia injection. The matrix of flue gas temperatures, flow rates, and NH_3/NO_x ratios for this testing is shown in table 2. These 16 tests are a subset of the 35 tests scheduled for the parametric

Table 2. SCR Reactor Preliminary Parametric Test Sequence

Test Parameters						Special Measurements	
Day	Test #	Temperature F	Rank	Flowrate SV, fraction of base case	NH3/NOx Ratio	NH3 Outlet	SO3 Outlet
1	3	700	A	1.5	0.8	X	
1	4**	700	A	1	0.8	X	X
1	5	700	A	1	0.9	X	
1	6	700	A	1.5	0.9	X	
1	7	700	A	1.5	1	X	
1	8	700	A	1	1	X	
2	12	750	A	1.5	0.8	X	X
2	13	750	A	1	0.8	X	
2	15	750	A	1	0.9	X	
2	17	750	A	0.6	1	X	X
2	18	750	A	1.5	1	X	X
3	22	620	A	0.6	0.8	X	X
3	23	620	A	1.5	0.8	X	X
3	24	620	A	1	0.9	X	
3	25	620	A	1	1	X	
3	26	620	A	0.6	1	X	X

Notes: Rank: A, first tier of tests, considered most important
**: This test will also include tests at the reactor outlet for HCl and particulate concentration
Shading: These tests will include gas/particulate ammonia measurements at the reactor outlet to confirm ammonia mass balance

evaluations that will begin after commissioning is completed. Most of the testing will consist of NH_3 runs at the reactor outlets at each of the combinations of space velocity, temperature, and NH_3/NO_x ratio shown in table 2.

A. The NH_3 sample trains will be configured with a condenser and bubblers to capture gas-phase NH_3 and a heated filter to capture particulate for solid-phase NH_3 determinations. The samples will be collected as the probe traverses the duct at sampling points dictated by duct cross-section geometry and sampling rates controlled to maintain isokinetic sample collection. We do not anticipate the need for solid-phase NH_3 determinations of all of the particulate samples but, we will have the capability to analyze these samples as needed.

B. A series of gas/solid phase NH_3 determinations will be run at the outlet of one of the large reactors at the six operating conditions included in table 2 defined by temperatures of 620°F and 700°F, space velocities of 1.0 and the maximum dictated by fan capacity, and NH_3/NO_x ratios of 0.8 and 1.0. The primary purpose of these sampling runs is to provide data to ensure closure of the NH_3 mass balance with catalysts loaded into the reactors.

C. In addition to the routine NH_3 measurements, further testing will be conducted to define possible flow channeling through the reactors. Under test condition 4 (design point for 80% NO_x removal; 700°F, space velocity = 1, and NH_3/NO_x = 0.8), the velocity, NO_x, particulate, HCl, N_2O, and NH_3 profiles across each reactor outlet cross section will be measured. These velocity and concentration profiles will require test runs at the centroids of equal area polygons across the reactor outlet cross section. The selection of testing points may be limited by the availability of ports, and in the case of the small reactors, the size of the probe in relation to the reactor cross section. The ash samples will be combined for subsequent mineral and trace metals analysis.

D. Outlet SO_3 concentration will be measured on each reactor at the seven conditions indicated in table 2. These tests are intended to monitor SO_2 to SO_3 conversion across the reactors. Measurement of HCl and particulate concentration will also occur during test condition 4.

Five or six days will be needed for the three-man [redacted] test crew to complete the preliminary parametric test sequence on two reactors. Single sample train runs for NH_3 and SO_3 measurements will be made with additional runs as time permits. The following test sequence is envisioned for each reactor:

Day 1: Test condition 4; map the flue gas velocity profile, NO_x concentration profile, and NH_3, and N_2O concentration profile across the outlets of the two reactors.

Day 2: Test condition 4; map the HCl and particulate concentration profile at the outlets of the two reactors.

Day 3: Test conditions 3, 4, 5, 6, 7, 8; measure NH_3 and SO_3 concentrations at the outlets of the two reactors.

Day 4: Test conditions 12, 13, 14, 15, 17, 18; measure NH_3 and SO_3 concentrations at the outlets of the two reactors.

Day 5: Test conditions 22, 23, 24, 25, 26; measure NH_3 and SO_3 concentrations at the outlets of the two reactors.

Day 6: Contingency day.

Approximately six weeks will be required to complete these tests on all nine reactors (two reactors per five-six days). At the conclusion of the preliminary parametric test sequence, the air heaters will be placed in service and NH_3, SO_3, and particulate concentrations will be measured at the three air heater outlets.

TASK 4. REACTOR PARAMETRIC TESTING AND AIR HEATER PERFORMANCE EVALUATION

Upon completion of commissioning, the test facility is scheduled for two years of long-term operation with parametric tests scheduled at regular intervals for each reactor. During the parametric testing, the performance of each SCR reactor will be evaluated at a variety of operating conditions (variations of space velocity, temperature, and NH_3/NO_x molar ratio). The air heaters associated with the three large SCR reactors will also be closely scrutinized during this operating period. [illegible] testing activities during this two-year period are included in Task 4. The specific testing activities are described in more detail below.

Task 4-A. Reactor Parametric Testing.

Long-term operation of the nine reactors will begin after completion of the commissioning tests and the preliminary parametric test sequence. Upon completion of the preliminary parametric test sequence under Task 3-B, the reactors will be set up to operate in their design mode. The initial parametric testing will begin after a pre-determined period of routine operation. When parametric testing of a reactor is completed, the reactor will return to its design operating mode or other optimal operating conditions determined during the parametric testing. Seven or eight parametric test sequences are scheduled for each reactor during the two-year long operating period.

Table 3 gives details of the parametric test matrix and also lists additional measurements that will be performed by [redacted] Reactor performance will be evaluated at thirty-five combinations of space velocity, temperature, and NH_3/NO_x molar ratio. The parametric tests of each SCR reactor will be run during a four-day period as shown in Table 3. This testing schedule will allow us to evaluate, on average, a single reactor each week. Nine of the thirteen weeks during each three month period will be dedicated to parametric testing.

During each four-day parametric test sequence, testing will include up to 35 reactor outlet NH_3 concentration measurements, 13 reactor outlet SO_3 concentration measurements, four reactor outlet particulate mass concentration measurements (including ash mineral analysis), and four reactor outlet HCl and N_2O concentration measurements. Single sampling runs will be made for each measurement of gaseous concentration with duplicate runs made as time permits.

The four weeks not scheduled for parametric testing will be used by [redacted] to perform any uncompleted parametric tests, analyze samples, maintain equipment, replenish testing supplies, perform required QA/QC activities, and reporting. In addition to these routine tasks, it is anticipated that special testing will be required from time to time. Among the special tests that we anticipate are additional size-specific trace metals tests using six-stage cyclones and/or modified Method 5 sampling trains and measurements of mid-level NH_3 concentration between catalyst beds. Additional trace metals analyses will most likely be run at the mid-point and end-point of the parametric testing. These tests will be scheduled by the SCS project engineer.

Table 3. SCR Reactor Parametric Test Sequence

Test Parameters						Special Measurements			
Day	Test #	Temperature F	Rank	Flowrate SV, fraction of base case	NH3/NOx Ratio	NH3 Outlet	SO3 Outlet	Particulate	Other Analyses
1	1	700	B	1	0.6	X	X		Coal
1	2	700	B	1.5	0.6	X			
1	3	700	A	1.5	0.8	X			
1	4	700	A	1	0.8	X	X	X	HCl, N2O
1	5	700	A	1	0.9	X			
1	6	700	A	1.5	0.9	X			
1	7	700	A	1.5	1	X			
1	8	700	A	1	1	X			
1	9	700	B	1	1.1	X	X		
1	10	700	B	1.5	1.1	X			
2	11	750	B	1.5	0.6	X	X		Coal
2	12	750	A	1.5	0.8	X	X		
2	13	750	A	1	0.8	X			
2	14	750	B	0.6	0.8	X	X		
2	15	750	A	1	0.9	X			
2	16	750	B	1	1	X			
2	17	750	A	0.6	1	X	X		
2	18	750	A	1.5	1	X	X		
2	19	750	B	1.5	1.1	X	X		
3	20	620	B	1	0.6	X			Coal
3	21	620	B	1	0.8	X			
3	22	620	A	0.6	0.8	X	X		
3	23	620	A	1.5	0.8	X	X		
3	24	620	A	1	0.9	X			
3	25	620	A	1	1	X			
3	26	620	A	0.6	1	X	X		
3	27	620	B	1.5	1	X	X		
3	28	620	B	1	1.1	X			
4	29	660	A	0.6	0.8	X		X	HCl, N2O, Coal
4	30	660	A	1	0.8	X		X	HCl, N2O
4	31	660	A	1.5	0.8	X		X	HCl, N2O
4	32	660	A	1.5	0.9	X			
4	33	660	A	1	0.9	X			
4	34	660	A	1	1	X			
4	35	660	A	1.5	1	X			

Notes: Rank -- A: First tier of tests, most important
B: Second tier of tests, secondary importance

Task 4-B. Air Heater Performance Evaluation

Each of the large pilot SCR reactors includes a downstream air heater. The effect of the SCR process on the performance of these air heaters is an important aspect of the over-all research program. Thus the test plan includes a long-term air heater evaluation. The air heaters will be bypassed during parametric testing to ensure that the data collected will reflect only reactor operation at the design conditions. Table 4 lists the tests that will be performed to characterize air heater performance. In general, these tests will be performed at one, three, or six-month intervals.

Data collected during parametric testing at the large reactor outlets at the design point will be representative of air heater inlet conditions. Thus, only air heater outlet testing before each parametric test begins will be needed to complete the air heater characterizations. Specific metallurgical tests have been scheduled to study air heater basket corrosion rate. These will include measurements of weight loss, metallographic examination, (sample removal, grinding, polishing, mounting, scanning electron microscopy, x-ray diffraction analysis) deposit composition (ash mineral and trace metal analysis), and morphology. It is expected that the air heaters will be washed periodically (every three to six months). Specific tests to analyze the wash water are also outlined in Table 4.

[redacted]

[redacted]

[redacted]

[redacted]

Table 4. Air Heater Test Schedule

Measured Parameter	Measurement Location	Number of Measurements per Air Heater	Measurement Frequency
NH3 (ppm)	AH Inlet	1	Quarterly
NH3 (ppm)	AH Outlet	1	Quarterly
SO3 (ppm)	Reactor Inlet	1	Quarterly
SO3 (ppm)	AH Inlet	1	Quarterly
SO3 (ppm)	AH Outlet	1	Quarterly
HCl (ppm)	AH Inlet	1	Monthly
Ash Concentration	Manifold	*	Semi-Annual
Ash Composition	Manifold	*	Monthly
Ash Particle Size	Manifold	*	Semi-Annual
Ash Concentration	AH Inlet	1	Semi-Annual
Ash Composition	AH Inlet	1	Monthly
Ash Particle Size	AH Inlet	1	Semi-Annual
Ash Concentration	AH Outlet	1	Quarterly
Ash Composition	AH Outlet	1	Quarterly
Flue Gas Flowrate	AH Inlet	1	Monthly
AH Basket Analysis			
Corrosion Rate	Air Heater	1	Quarterly
Weight Loss	Air Heater	1	Quarterly
Metallographic Examination	Air Heater	1	Quarterly
Deposit Composition	Air Heater	1	Quarterly
Morphology	Air Heater	1	Quarterly
AH Wash Water Analysis			
Total Suspended Solids	Air Heater	1	Quarterly
Total Dissolved Solids	Air Heater	1	Quarterly
pH, Chlorides	Air Heater	1	Quarterly
Trace Metals	Air Heater	1	Quarterly

*: These tests in ducting prior to split to the three large SCR reactors.

END

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