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INNOVATIVE CLEAN COAL TECHNOLOGY (ICCT)

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

**Technical Progress Report
Fourth Quarter 1992**

**DOE Contract
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Prepared by:

**Southern Company Services, Inc.
800 Shades Creek Parkway
Birmingham, Alabama 35209**

MASTER

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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 SO₂ and SO₃.
- (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, the Environmental Monitoring Plan (EMP) was revised based on previously received comments. The revised EMP was submitted to DOE and DOE later supplied additional comments. Another revision of the EMP was completed and released to DOE at the end of December.

Detailed design engineering and construction continued. Engineering on the total project is essentially complete with the exception of assistance during equipment check out and start-up. Major equipment delivered to the site during this period included the gas analysis system, personnel and catalyst hoist, and the data acquisition/control system.

The previously designed ductwork expansion joints were procured and delivered to the site. Additional platforms for access to instrumentation were designed and the award made for their installation. The contract for the painting of the structural steel was awarded.

Check out of the control system configuration was completed to the extent possible in the engineering labs at Birmingham during October. The control system was delivered to the site during November and installation of the equipment was completed. The system was energized and check out on site is underway.

Manufacturing of the gas analysis system was completed and a final witness test visit was made in October prior to shipment of the system. The gas analysis system was delivered to the site during November. Installation was begun and continued through December.

An Evaluation Agreement was signed with Cornetech as the selected catalyst supplier to replace Norton, a catalyst vendor who previously withdrew from the project.

Construction of the Plant Crist SCR demonstration facility continued with the erection of the control room and gas analysis room buildings being completed, with the exception of HVAC unit installation and some remaining painting.

The mechanical and insulation contractor installed both the small and large reactor vessels, mounted the reactor sootblowers, finished the service air and service water pump and piping system installation, and completed erection of all major gas/air fans. Installation of all the test facility ductwork was begun and a majority has been completed. Insulation of the equipment continued and insulation of the ductwork was begun. Installation of the ammonia and dilution air supply systems and the purge air system was begun. Equipment was lubricated and coupled to the motors.

The electrical and I&C erection continued during this reporting period. The switchgear was set and cable trays were installed. The 115KV transformer and switchgear were successfully energized in November. The 4160V/480V transformers and the motor control centers were energized during December. A substantial portion of the electrical cable was installed. Installation of the instrumentation was begun.

The erection of the personnel/catalyst hoist was started. The installation of some additional platform steel was begun. The check out of the service water system, instrument air system, and air heater drives was initiated. The necessary tie-ins for the demonstration facility with the host unit (gas, air, steam, etc.) were made in late December during a brief unit outage.

Operator training was conducted on the data acquisition/distributed control system during October. Operator training for the equipment/process familiarization continued through December. Operators assisted in preparing procedures for check out and start-up, and at the end of the reporting period, operators were supporting equipment check out.

Copies of the sampling and analytical methodology, plus the testing plans were sent to the project participants for review. Comments were received from the catalyst suppliers, and incorporated into the test plan.

Southern Research Institute personnel, who will be conducting the testing and analytical services during the operations phase, began their onsite work. A trailer was set up and preparation of equipment and testing and analytical procedures was begun.

Development of the data reduction methodology continued. This work included plans for retrieval and storage of data within the Bailey Control System, transfer of data into a DOS data base format, extraction of data from the gas analysis system, and use of the data in modeling results. Customized software was purchased for modifying the data format and enhancing data archiving capabilities.

Weekly coordination meetings were held with Design Engineering. Monthly project review meetings were held between SCS and Gulf Power at Plant Crist. Papers describing the status of the project and design issues were presented at the Pittsburgh Coal Conference in Pittsburgh on October 15, and at the International Joint Power Generation Conference in Atlanta on October 20. One of the three U.S. catalyst suppliers was visited to discuss reactor design, catalyst module design, testing protocol, and testing plans (the other two were visited previously).

The Continuation Application and request for additional funds, which were submitted to DOE during the previous quarter, continue to be considered for approval. Ontario Hydro signed an agreement to become an additional co-funder in this demonstration.

A project review meeting was held with DOE, EPRI, Ontario Hydro, the catalyst suppliers, and other subcontractors on November 10 to discuss the status of design and construction.

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 (NO_x) 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), Ontario Hydro, 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 (NO_x) 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 NO_x 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

Figure 1. Flow Diagram Of Typical SCR Installation

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. 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 IOCT 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 under 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 original co-funders are SCS (\$6,049,017), DOE (\$7,525,338), and EPRI (\$2,000,000).

Figure 2. Prototype SCR Demonstration Facility-Process Flow Diagram.

PROJECT DESCRIPTION

Section 3

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 October - December, 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

The suggested changes regarding fly ash analysis and all other previously received comments were addressed by SCS and Radian for modifying the Environmental Monitoring Plan (EMP). Quality control procedures were also finalized with the testing and analytical services subcontractor and incorporated into the EMP. The revised EMP was submitted to DOE in November. During December, DOE supplied new comments. After several discussions regarding these latter comments, another revision of the EMP was completed and released to DOE on December 31, 1992. A few minor comments were to be forthcoming from DOE during the first quarter of 1993, but a conditional approval letter is being drafted until the EMP can be finalized to incorporate the additional comments. The draft Quality Assurance Program Plan included in the EMP is shown in Appendix A.

PHASE II - DETAIL DESIGN ENGINEERING AND CONSTRUCTION

Task 1.2.1 - Detailed Design Engineering

The detailed design engineering phase continued during this reporting period and was essentially completed with the exception of assistance during equipment check out and start-up. Major equipment delivered to the site during this period included the gas analysis system, personnel and catalyst hoist, and control system. A summary of equipment ordered and its delivery status is given in Appendix B. Instruction books for some of the major equipment already delivered were received and provided to construction and operations personnel.

The ductwork expansion joints, designed and ordered by SCS Engineering during the previous quarter, were procured and delivered to the site. Design of additional platforms to provide access to instrumentation (requested based on review by the testing services subcontractor) was completed and the award was made for installation of these additional platforms.

The contract for the structural steel painting was issued after completion of bid evaluations by SCS Engineering and Gulf Power. Within the electrical engineering scope, both the high and low voltage system designs and procurement of materials were completed.

Instrumentation and Controls personnel completed configuration check out and testing of the Bailey Control System to the extent possible in the engineering labs at Birmingham during October. Updating of domestic loop diagrams was completed and the control system was prepared for operator training during October. The control system was delivered to the site during November and installation continued through December. The system was energized in December and check out on site was begun. Work continued on revisions to the control system configuration, development of the graphic screens, and programming to trend and archive data.

Manufacturing of the gas analysis system was completed. A final witness test visit was made by SCS during October prior to shipment of the system to the site. The gas analysis system was delivered to the site during November. Installation commenced immediately and continued through December.

An Evaluation Agreement was signed with Cornmetech as the selected catalyst supplier to replace Norton, a catalyst vendor who previously withdrew from the project. Comments were received from Cornmetech on the previously provided laboratory testing protocol information. There were no major issues to be resolved.

Task 1.2.2 - Construction

Construction of the Plant Crist SCR demonstration facility continued during this quarter. The control room and gas analysis room buildings were erected

with completion of the roof and siding, flooring, ceiling, walls, lighting, and HVAC ductwork. Remaining work includes HVAC unit installation and some painting.

The mechanical and insulation contractor installed both the small and large reactor vessels and completed erection of the service water pump and piping system. With installation of the small reactor fans and air return fan, erection of all major gas/air fans were completed. Work was begun and essentially completed in installation of all the test facility ductwork; i.e., ducts between the main takeoff scoop and the reactor inlets, the return ducts from the fans to the re-injection point on the plant's duct, the bypass ductwork, and the combustion air ductwork. Remaining work included installation of some expansion joints and some minor work on the ducts. Insulation of the equipment continued and insulation of the ductwork was begun and a majority of the ductwork insulating was finished. The reactor sootblowers were erected and work was completed on the service air system. Work was begun and substantial progress made in the installation of the ammonia and dilution air supply systems and the purge air system. However, some work still remains to be completed. Equipment was lubricated and coupled to the motors.

The electrical and I&C erection continued during this reporting period. The switchgear was set and cable trays were installed. The 4160V cable was installed to the control room building. Gulf Power personnel completed their check out of the 115KV transformer. The 115KV transformer and switchgear were successfully energized in November. During December, the 4160V/480V transformers and the motor control centers were energized. A significant amount, but not all, of the electrical cable was installed. Installation of instrumentation was begun. Pressure taps and thermocouples were installed on the reactors during November. Installation of other temperature, pressure, and flow measuring devices continued through December and has not yet been completed.

Erection of the personnel/catalyst hoist was started and almost completed. The installation of some additional platform steel was begun. The starting and check out of some equipment was initiated, e.g., service water system,

instrument air system, and air heater drives. The necessary tie-ins (gas, air, steam, etc.) for the demonstration facility were made with the plant in late December.

Task 1.2.3 - Operations Staff Training

The operator training on the data acquisition/distributed control system was conducted during October at the SCS Engineering labs. Operator training for equipment/process familiarization continued through December and was essentially concluded. Operators assisted in preparing procedures for check out, start-up, and emergencies. At the end of December, operators were supporting equipment check out. The process of securing operating and maintenance manuals on most major equipment continued.

Task 1.2.4 - Planning for Detailed Testing

Southern Research Institute, the testing subcontractor, submitted a Quality Assurance Program Plan for obtaining reliable monitoring data and method verification. Copies of the sampling and analytical methodology, plus the testing plans were sent to the project participants for review. Comments were received from the catalyst suppliers and, where appropriate, incorporated into the test plan.

SRI personnel who will be conducting the testing and analytical services for the two years of operation began their onsite work. The trailer which houses the majority of the analytical equipment and working space was delivered, set up, and utility connections were made. Preparation and set up of equipment and testing and analytical procedures was begun.

Development of the data reduction methodology continued. This included work on plans for retrieval and storage of data within the Bailey control system, transfer of data into a DOS data base format, extraction of data from the gas analysis system, and use of the data in modeling results. Customized software has been purchased for modifying data format and enhancing data archiving capabilities.

Task 1.2.6 - Project Management and Reporting

Weekly coordination meetings were held with Design Engineering. The Management Information System, 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. Papers describing the status of the project and design issues were presented at the Pittsburgh Coal Conference in Pittsburgh on October 15, and at the International Joint Power Generation Conference in Atlanta on October 20. One of the U.S. catalyst suppliers was visited in late October to discuss reactor design, catalyst module design, testing protocol and testing plans (the other two were visited in September).

A Continuation Application and request for additional funds, which were submitted to DOE during the previous quarter, continue to be considered for approval. The Continuation Application requests DOE's approval for matching funds of Budget Period 2 to continue the project to completion. Budget Period 2 provides DOE funding for Phase III, which includes operations, testing, disposition, and final report. Project cost growth has been projected based on improvements to the facility design and additional funding is being requested from DOE in the amount of 25% of DOE's original funding of the project. Funding from other sources is also being solicited to cover the entire cost growth. Ontario Hydro signed an agreement to become an additional co-funder of this demonstration.

A project review meeting was held with DOE, EPRI, Ontario Hydro, the catalyst suppliers, and other subcontractors on November 10 at Pensacola to discuss the status of design and construction. Some of the information presented during the meeting is shown in Appendix C.

Section 5
PLANNED ACTIVITIES

During the January - March, 1993 quarter, the following activities are planned:

- o Provide remaining engineering needed for completion of construction and to assist with start-up.
- o Complete the remaining construction items:
 1. Complete mechanical/insulation and electrical/I&C construction work: insulation of equipment and ductwork: installation of electrical wiring and instrumentation, ammonia supply system, HVAC units, and personnel/catalyst hoist; and painting.
 2. Complete installation and check out of gas analyses system.
 3. Make any needed construction corrections/modifications.
- o Continue check out of control system and modify as needed.
- o Continue and complete process equipment check out and begin start-up/commissioning activities.
- o Continue developing data reduction methodology.

APPENDIX A

Quality Assurance Program Plan

SRI-ENV-92-933-7613

QUALITY ASSURANCE PROGRAM PLAN

Submitted by

Southern Research Institute

Prepared for

**Southern Company Services, Inc.
Birmingham, AL**

As Required by SCS Contract Number C-92-000320

**Testing and Analytical Services for the Innovative Clean
Coal Technology Demonstration for Selective Catalytic
Reduction (SCR) Technology for the Control of Nitrogen Oxide
(NO_x) Emissions from High Sulfur Coal-Fired Boilers**

November 2, 1992

SRI Project Number 7613.07

Revised 12/29/92 by Radian Corporation

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INTRODUCTION

This document describes the Quality Assurance Program Plan (QAPP) instituted by Southern Research Institute (SRI) as required under the contract with Southern Company Services (SCS) for "Testing and Analytical Services for the Innovative Clean Coal Technology Demonstration of Selective Catalytic Reduction (SCR) Technology for the Control of Nitrogen Oxide (NO_x) Emissions from High Sulfur Coal-Fired Boilers."

The QAPP includes the following elements: sampling procedures; sample custody; calibration procedures and frequency; analytical procedures; data reduction, validation, and reporting; internal quality control checks, performance and systems audits; preventive maintenance; and corrective action.

The objectives of this QA Program Plan are to ensure:

That a consistent QA policy is observed by SRI for all work performed under this contract;

That all QA requirements for the work performed by SRI under this contract are satisfied;

That available resources are effectively utilized to resolve technical problems related to the implementation of the QA program, as necessary;

That usable data are obtained.

The methods SRI will use to perform the tasks required under this contract are described in the revised technical proposal to SCS dated June 9, 1992. Data will be collected regarding three species occurring in the aerosol in the high-sulfur coal SCR process. In general, applicable EPA reference methods will be used to collect data. These test methods are described in detail in Title 40 Code of Federal Regulations Part 60, Appendix A - Test Methods, U.S. General Services Administration, Office of the Federal Register, National Archives and Records Service, July 1, 1991. The test methods detailed in that document are hereafter referred to as EPA Method 5, etc. Particulate mass concentration, particle size and mineralogical composition will be determined from samples collected using EPA Method 17. Sampling with Method 17 type sampling trains will include particulate filters, cascade impactors, and five-stage series cyclones. Trace metals concentrations in the solid and vapor phases will be determined using EPA modified Method 5 to collect samples to be analyzed by Inductively Coupled Argon Plasma Emission Spectrometry (ICAPES), atomic absorption spectrometry (AAS), and cold-vapor atomic absorption. Liquid samples collected with a controlled condensation sampling method similar to EPA Method 8 will be analyzed by ion-specific electrodes or ion chromatography to determine the concentrations of the gaseous species of interest. A single component, nitrous oxide, will be analyzed by gas chromatography of carefully conditioned grab samples of the flue gas.

The scope of work under this contract requires SRI to determine flue gas velocity to calculate volumetric flow rates for flow meter calibrations and to determine particulate sampling train flow rates to maintain isokinetic sampling conditions. SRI will use "S" type pitot tubes, standard pitot tubes, and hot-wire anemometers designed for high-temperature operation to measure flue gas velocity. The methods used for this work are described in EPA Methods 1 and 2. Supporting measurements of temperature and static pressure will be made with appropriate thermocouples and manometers as described in EPA Methods 2 and 5 (1).

Southern Research Institute will follow the guidelines published by the United States Environmental Protection Agency; von Lehden, D. J., DeWees, W. G., and Nelson, C., Quality Assurance Handbook for Air Pollution Measurement System, Volume III - Stationary Source Specific Methods, EPA-600/4-77-027b, U. S. Environmental Protection Agency, Research Triangle Park, North Carolina, January 1980 with subsequent updates; (hereafter referred to as EPA Volume III) for quality assurance and quality control for the sampling and analysis for the SCR project. The remainder of this document will indicate sections of EPA Volume III that apply to the testing to be performed under this contract, and discuss specific instances where we will vary from the recommended procedures .

SAMPLING PROCEDURES

PARTICULATE SAMPLING

Mass Concentration.

A comprehensive chemical and physical profile of the particulate component of the aerosol entering the SCR reactors is essential because catalyst plugging and catalyst deactivation are expected to be important issues. EPA Method 5 is commonly used to measure particulate emissions from industrial processes. However, we believe that superior results will be obtained with EPA Method 17 because the particulate concentration and chemical composition of the particulate component of the aerosol may be dependent on stack temperature. At the temperatures encountered in the SCR process, in a stack environment rich in water and sulfur oxides in the presence of slip ammonia, the formation of ammonium bisulfate and ammonium sulfate is unlikely. However, if a nominal reference temperature of 250°F is established for particulate, as in EPA Method 5, a significant portion of the ammonia in the gas stream may be collected as particulate. For these reasons, SRI has elected to use EPA Method 17 for the required mass concentration measurements.

EPA Method 17 is an in-stack sampling system designed to be used in conjunction with EPA Methods 1, 2, 3, and 4 , along with appropriate sampling and analytical procedures. In Method 17, a gas sample is extracted isokinetically from the source and particulate matter is collected on a filter situated in the flue gas stream. The mass is determined gravimetrically after the removal of uncombined water. Method 17 is not applicable in stacks where the projected cross-sectional area of the filter holder exceeds 5% of the stack cross sectional area. This restriction would prohibit the use of Method 17 for

sampling in the small SCR reactors being evaluated at Plant Crist. However, we propose to use a sampling strategy whereby the filter holder will be housed in a sampling port; a 4-in. diameter nipple that is 12 in. long. A nipple made of 1/2 in. stainless steel pipe will connect the body of the filter holder to the sampling nozzle. This nipple will be sized to locate the nozzle at the centroid of the duct cross-section. We will not attempt to traverse the small reactor ducts because the cross-sectional area is less than one square foot. Temperature sensors will be included in the apparatus so that, if necessary, filter temperature can be maintained at the gas temperature by means of electric heaters. The large reactors will be traversed as required in EPA Methods 1, 5, and 17.

Quality control for the EPA Method 17 sampling protocol is addressed in Sections 3.0, 3.1, 3.2, 3.4, and 3.11 of EPA Volume III. SRI will adhere closely to the QA/QC procedures described in the applicable portions of that document.

The methods SRI will use to measure stack gas velocity to determine isokinetic sampling flow rates are described in EPA Method 1 and in EPA Method 2. These methods will also be used to calibrate venturi flow meters in the SCR pilot plant. The technical considerations necessary to insure the quality of the data produced with these methods are presented in Sections 3.0 and 3.1 of EPA Volume III. SRI will adhere to the QA/QC recommendations presented there.

Particle Size Distribution.

Fly ash particle size distribution will be determined in SRI's Birmingham laboratories from particulate samples collected with Method 17 mass trains. The determination of particle size distribution will be performed with a Shimadzu SA-CP4 centrifugal particle size analyzer. This instrument is reliable, simple to use, and gives reproducible results. It employs combined gravitational/centrifugal sedimentation with photometric detection to determine the particle size distribution of the sample. This technique requires only a 0.1 g sample to perform a triplicate analysis. Thus, sufficient particulate will remain for subsequent chemical analysis.

During start-up, two pairs of cascade impactors and two pairs of six-stage series cyclones will be run at the unit 5 hot-side ESP inlet to compare the laboratory particle sizing results to well-established field sampling techniques for measuring particle size distributions. Cyclones provide adequate resolution of the size distribution and permit longer sampling times so that the inlet samples, where the particle concentration will be high, represent better temporal averages of the entrained particulate matter. The particulate collected with the cyclones will also be used to obtain size-specific mineralogical and trace metals concentration information. The approximate cuts in particle-size distribution with the two types of samplers are as follows:

Series cyclones - 8, 4, 2, 1, and 0.5 μm

University of Washington impactors - 8, 3, 2, 1, 0.5, 0.2, and 0.06 μm

In either device, the last stage is a back-up filter.

The reliability of the particle-size cut-points of impactor and series cyclones is an important issue. We establish cut-points by relating physical properties of the device such as jet-to-plate spacing and jet diameter to a theoretical performance factor.

Quartz fiber impactor substrates will be used to avoid weight increases due to the reaction of the substrate with SO_2 in the flue gas. An impactor with a high-efficiency particulate filter in the place of the sampling nozzle will be run on each test day as a quality control measure to quantify whatever weight change may occur as a result of chemical reactions.

GAS SAMPLING

SRI will measure the concentrations of four gases with manual sampling methods and subsequent chemical analysis under this contract. The species to be resolved are sulfuric acid vapor (SO_3), ammonia (NH_3), hydrochloric acid (HCl), and nitrous oxide (N_2O). EPA Method 8 describes a method for determining SO_3 concentration. However, we prefer an alternate sampling method for SO_3 as described in our technical proposal. The methods we will use to sample for NH_3 and HCl are also described in the technical proposal. The application of these sampling methods and relevant quality control topics are described below.

Sulfur Trioxide Vapor Concentration (SO_3)

SO_3 in the flue gas will be collected by the controlled condensation method. In this method, the flue gas is sampled with a train of a heated, quartz-lined probe, a quartz-fiber filter supported on a frit in a heated quartz filter holder, and finally a Pyrex condensing element maintained around 160°F . The condenser used by SRI is a bulb with connections on both ends containing a packing of glass wool. The temperature of the condenser is maintained with a heated water jacket.

As the gas stream is cooled from a duct temperature above 600°F , the SO_3 present begins to undergo a hydration reaction with the water vapor that is present, producing H_2SO_4 . As the temperature of the gas stream continues to drop, the H_2SO_4 and excess water vapor begin to condense concurrently to produce a condensate of concentrated aqueous H_2SO_4 . If the concentration of SO_3 in the gas stream is about 75 ppm, condensation begins at around 300°F . At 160°F , condensation is essentially complete, leaving a residual vapor concentration of SO_3 well below 1 ppm.

The potential interaction of SO_3 and NH_3 can introduce problems in regard to solids formation. Thus, it is critical that the probe, the quartz-fiber filter, and its holder, be maintained at the flue gas temperature to avoid solids formation ahead of the condenser. Under these sampling conditions, all of the SO_3 present in the flue gas is collected for subsequent analysis, whether as H_2SO_4 , NH_4HSO_4 , or as $(\text{NH}_4)_2\text{SO}_4$.

Other than the use of a heated quartz-fiber filter to remove particulate, and the condenser for collecting H_2SO_4 , the controlled condensation sampling train is similar to that described in EPA Method 8. This method, along with detailed quality control considerations, is described in detail in Section 3.7 of EPA Volume III. The quality control procedures detailed there, along with those described for EPA Methods 1, 2, 3, and 4, will be adhered to for this work.

Ammonia Concentration, (NH_3)

NH_3 will be collected by drawing a stream of flue gas through a heated probe and a heated particulate filter and then through an air-cooled condenser and a series of bubblers filled with dilute sulfuric acid. A substantial part of the NH_3 that gets through the filter will condense, along with water vapor, in the air-cooled condenser, as the result of the low-temperature reaction of NH_3 with HCl or SO_3 to produce NH_4Cl , NH_4HSO_4 , and $(\text{NH}_4)_2\text{SO}_4$.

Temperatures at which the probe and filter are to be controlled will have to be determined after the operating conditions (duct temperatures and flue gas concentrations) are better known. Attempts will be made to retain on the filter any particulate matter that contains NH_3 (which may be fly ash with adsorbed NH_3 or aerosol particles or ammonium sulfate and bisulfate). Ideally, the probe and filter would be operated at the temperature of the duct being sampled; in this way, in principle, the distribution of NH_3 between the solid phases and the gas phase would not be disturbed. Both NH_3 retained in particles on the filter and collected in the condenser and bubblers would be analyzed separately. In practice, however, some shift in temperature away from that in the duct may prove desirable when tests are conducted at the air heater outlets downstream of the large reactors.

Hydrogen Chloride Concentration, (HCl)

HCl will be collected by drawing flue gas through a heated probe, a heated particulate filter, an air-cooled condenser, and a series of bubblers filled with dilute NaOH or Na_2CO_3 solution. In principle, the sampling train for HCl is similar to the apparatus used to collect NH_3 , except that the absorbent solution contains a base rather than an acid. The quality control considerations described in Section 3.7 of EPA Volume III will be employed, as applicable, for the sampling activities for HCl . QA/QC techniques for the required IC analysis are described in EPA Method 300.0 and in Section 3.15.2 of EPA Volume III.

Nitrous Oxide Concentration, (N_2O)

At least two N_2O monitors of the NDIR type are commercially available. However, these instruments are a poor choice for measuring small N_2O concentrations in flue gas

because of overwhelming interferences caused by several common flue gas constituents. For this reason, SRI will measure N_2O concentrations by withdrawing grab samples of the SCR inlet and outlet gas for laboratory determination of N_2O concentration. These samples will be conditioned by passing them through phosphorous pentoxide to remove water and a sodium carbonate solution to remove SO_2 . Sample conditioning in this manner is needed to prevent the formation of an N_2O artifact in the sample bag. This sampling artifact can be as much as several hundred parts per million where no N_2O was originally present.

SAMPLE CUSTODY

The objective of our sample custody procedures is to create an accurate written record which can be used to track the possession and handling of each sample from the moment of its collection through its analysis and storage.

FIELD SAMPLING OPERATIONS

A label will be affixed to each sample or to its container when the sample is collected. A sample number with encoded information identifying the location from which the sample was collected, the type of sample, and the test series of the sample will appear on this label. The identity of the scientist who collected the sample will also appear on the label. A permanent marker (Sharpie) will be used to place this information on the sample label.

A bound logbook will be maintained in which a permanent record of all samples will be entered. Each category of sample, i.e. Method 17 mass train, will be assigned a serial number including alphanumeric characters identifying the sample category and the sampling location. The sample log book will contain a permanent record of these sample identification serial numbers, and a description of the sample, its collection method, the time and date of collection, and a description of any pertinent physical characteristic.

A field record of each sampling run will be recorded as the sample is collected. The pitot tube velocity traverse used to determine isokinetic flow rates, and summary data (flow rates, temperatures, etc.) recorded during the sampling run will be recorded. These run sheets will be stored in a three-ring notebook and can also be used to track individual samples.

LABORATORY OPERATIONS

Appropriate log books will be used to provide records of sample analysis. Sample identification numbers will be used to refer to all samples throughout all analytical work and subsequent reporting. An instrument logbook will contain a record of the calibration, maintenance and use of each instrument or balance used in the project. For example, the GC logbook will contain sample identities, concentrations of standards, type of GC column and detectors, project number and initials of the analyst. In addition, the logbook will provide a permanent record of instrument failures, corrective action taken and preventive maintenance.

A standard logbook will contain a permanent record of reagents or reference standards and the preparation of standard stock solutions or mixtures. The source, lot numbers, purity, amount of standards measured, the dilution solvents and the responsible analyst will be noted.

The SRI supervisor or other designated person will review and sign all notebook entries. Data summaries will be compiled by the SRI supervisor with the assistance of the analyst and submitted to the SCS process engineer at regular intervals.

CALIBRATION PROCEDURES AND FREQUENCY

In most particulate sampling involving mass trains, cascade impactors, and series cyclones, the accuracy, precision, and comparability of gas volume and flow rate measurements are critical to achieving data quality objectives. For this reason the flow metering systems must have dependable calibrations.

We propose to calibrate our orifices and dry gas meters using a laminar flow element rather than a wet test meter as prescribed in the EPA Method 5 and in EPA Volume III. We currently use the Meriam Model No. 50MJ10 Laminar Flow Element which has been calibrated against Meriam flow standards which are traceable to the National Institute of Standards and Technology. The calibration supplied by Meriam with these devices indicates that the laminar flow element agrees with the Meriam flow standard within 0.5%.

Type S pitot tubes will be calibrated according to the procedure in EPA Method 2. All temperature sensors in the sampling systems will be checked periodically against mercury in glass thermometers for proper calibration using the procedures outlined in EPA Method 5.

High-accuracy oil manometers with inclined scales are considered calibration standards for pressure measurements. SRI will also have occasion to use U-tube or well-type manometers with mercury or water as the working fluid. These are also considered standards for pressure measurements.

Calibration and maintenance of analytical balances will be performed at one-year intervals. A standard weight check with control weights is performed by the analyst for each set of weighings.

ANALYTICAL PROCEDURES

Volumes and weights of Method 17 sampling elements will be measured according to EPA specifications in the respective sampling methods (EPA Methods 1, 2, 3, 4, 5, and 17). Many physical elements, such as the volume of water or of a solution need not be measured with high accuracy. However, calibrated glassware will be used for most volumetric measurements, and ASTM Class S weights will be used for weighing.

The impactor substrates used to collect particulate matter for weighing, will be weighed on a Cahn micro balance, which has a resolution of 0.001 mg. Thimble-type filters used to collect particulate where mass loading is higher will be weighed on a Mettler analytical balance with a resolution of 0.1 mg. Calibration and maintenance of analytical balances will be performed at regular intervals by professional service personnel. A standard weight check with control weights will be performed by the analyst for each set of weighings. Mass measurements requiring less resolution, such as determinations of the mass of water collected in desiccant columns, will be determined on a triple beam balance having a resolution of 0.1 grams.

We will use ion chromatography to analyze condensate samples for sulfate ion to determine the concentration of SO_3 , and to analyze impinger liquid for chloride ion to determine the concentration of HCl in the flue gas. EPA Test Method 300.0, "The Determination of Inorganic Anions in Water by Ion Chromatography", details the analytical procedure that will be used. The quality control measures recommended there will be adopted for our analytical work using ion chromatography. In addition to the EPA recommendations, the operating instructions provided by the manufacturer of the instrument will be closely followed.

A simple method for determining NH_3 that is collected as the chloride or as a sulfate salt is to make the solution alkaline (converting NH_4^+ ion to free NH_3 in solution) and measure the concentration with an ammonia-selective electrode, associated with a reference electrode and attached to a pH meter. The voltage output of the pH meter is used to calculate the concentration of NH_3 as follows:

$$\ln[\text{NH}_3] = (\Delta E)/RT + C$$

where:

- ΔE = the voltage output of the pH meter;
- R = ideal gas constant;
- T = absolute temperature; and
- C = calibration content.

The ammonia electrode is calibrated with a series of aqueous solutions containing known concentrations of ammonium ion. Applicable reference methods include EPA 350.3 and ASTM D-1426.

On occasion, when NH_3 as a component of the particulate matter suspended in the flue gas must be determined, the sample retained on a filter will be analyzed. The filter cake will be extracted with a dilute solution of H_2SO_4 ; the extract will then be processed as described for samples containing the gaseous fraction.

Flue gas samples conditioned by removing water vapor and sulfur dioxide and stored in Tedlar gas sample bags will be analyzed for N_2O with a gas chromatograph equipped with an electron capture detector (GC/ECD). The analyst will prepare a calibration curve for the gas chromatograph using an external standard technique. A minimum of three standards will be used to prepare the calibration curve. When flue gas samples are

analyzed, the expected concentrations of N_2O should be within the range of the calibration curve. The calibration curve will be verified on each working day by the measurement of a calibration standard. If the response for the calibration check varies from the predicted response by more than two standard deviations, the test will be repeated with a fresh calibration standard. Alternatively, a new calibration curve will be prepared.

Inorganic analyses for trace metals and to determine ash mineralogy will be performed in the SRI Birmingham laboratories by Inductively Coupled Argon Plasma Emissions Spectrometry (ICAPES) and by Atomic Absorption Spectrometry (AAS) methods. ICAPES or AAS analyses will use the method of standard additions for calibration (in the latter case, the graphite furnace method, the cold-vapor method, or the hydride generation method as required for some specific analytes).

In most instances, duplicate samples will be collected to provide a minimal assessment of the precision of the sampling techniques. In so far as possible, each sample will be split and duplicate analyses performed, again to provide an assessment of the precision of the analytical technique. Ideally, more than two replicates would be performed, but budgetary constraints limit us to two analyses of each sample. Several analytical techniques will be used, either separately or in combination, to insure the quality of our analytical work. These are as follows:

Standards. The standards used for analytical work are of the highest quality. In most cases, these standards come from EPA or commercial sources. As standards for coal and fly ash, the Standard Reference Materials provided by the National Institute of Standards and Technology are employed. A record of the origin, lot number, and purity of each standard is maintained.

Reagent Blank Analysis. Reagent blanks are routinely analyzed to establish background interferences and possible analyte detection limits. Duplicate analyses are used to establish analytical precision and spiked blanks and matrix samples are analyzed to determine analytical accuracy.

Standards Analysis. Authentic analytical standards or reference materials, either from commercial and government sources or prepared in-house, are analyzed alongside routine samples to check the accuracy of analytical procedures.

Sample Blank Analysis. Sample blanks are analyzed to assess possible contamination or interferences in an analysis and to establish a zero base line or background value which may be used to adjust or correct routine analytical results. Sample blanks include:

Reagent blanks (Method blanks). These blanks are used as a base for the analytical portion of a method. The blank is processed exactly as a real sample is processed (same glassware, reagents, solvent, etc.). A method blank is processed for each set of analyses and whenever a new source of reagent or solvent is introduced into an analytical scheme.

Field blanks. These blanks are sent to a monitoring site, left at the site for the normal period of sampling, returned to the laboratory and analyzed. The field blank is not exposed to the analyte.

Matrix spike analysis. Samples that contain additions of known amounts of authentic standards are processed and analyzed in the same manner as the field samples. The calculated concentration of the spiked compound is compared with the true amount of compound added to the matrix. The recovery of the compound of interest is an estimated measurement of accuracy. Matrix spiked samples are used to check the performance of a routine analysis or the recovery efficiency of an analytical method.

Replicate analysis. Replicate analyses (at least two analyses) are performed to determine the precision of the analysis. For those determinations where a sufficient number of results were accumulated over time, precision criteria may be developed. A minimum of 15 replicates at a particular concentration or concentration range where linearity exists are required to establish an on-going program for QC charts.

Surrogate spike analysis. Surrogate standards are added to GC samples prior to analysis. The use of surrogate standards cannot detect all possible problems, but this method can help to eliminate several sources of error. Surrogate standards are chemically similar to the compounds in the sample being analyzed. Also, surrogate standards should be compounds that would not likely be found in the matrix. The purpose of the surrogate spikes is to provide QC on every sample by constantly monitoring for unusual matrix effects, gross sample-processing error, etc. Surrogate spikes are generally not used as internal standards for quantification purposes.

Internal standard analyses. Authentic standards are added to the sample or extract of the sample prior to its injection into the analytical instrument to minimize the possibility of losses due to evaporation, adsorption, or chemical reaction and to compensate for variation in injection volumes. The internal standard is chemically similar to compounds in the fraction being analyzed. Compounds used as internal standards are not to be used as surrogate standards.

Standard (calibration) curve. Prior to the analysis of samples, a standard curve that covers the entire working range of the method must be constructed with at least three to five concentrations of authentic standards. The standard should include one near the upper limit of the concentration range and one near the lower limit of the concentration range. The other standards should be equally spaced throughout the operating concentration range. Each day, if operation is continuous, or prior to analyzing each group of samples, if operation is discontinuous, standards must be analyzed to establish the validity of the original standard curve. If this standard falls outside the established limits, a new standard curve must be constructed. These limits are specified in the standard methods to be used.

Internal audits. Internal audits of specific work will be periodically conducted. Audits involve an independent check of the performance of the laboratory analysts to determine if prescribed procedures are being followed.

DATA REDUCTION, VALIDATION AND REPORTING

Data processing includes handling, transmission, storage, validation, verification and reduction of data. The necessary procedures will be used to protect the integrity of any results reported from this project. Without established procedures, data may be lost, distorted, misinterpreted, incorrectly transcribed, improperly transposed, or overlooked. The analyst will develop the raw data by performing the analysis. The calculated results require verification to eliminate outliers or extraneous results.

The analyst in the laboratory reads measurements from balances, spectrometers, chromatographs, meters and other instruments and equipment. All data, calculations, and final results will be kept in bound notebooks reserved for this project. Entries in these notebooks will be made and initialed by the analysts doing the sample collection, preparation and analysis. The importance of accuracy in recording laboratory results will be stressed. Acceptance criteria for specific methods will be established and data will be flagged when values fall outside of the criteria.

The analytical information reported will include the measured physical characteristic, significant details of the analysis, and the reported data values. Laboratory observations, information, data, calculations and final results may be maintained in one or more of the following forms:

Performance logbook. This will provide a permanent record of performance audits. These audits may be internal or external in origin and consist of quantitative or qualitative analyses or evaluations with chemical standards, materials, or devices with known properties and characteristics.

Project notebook. A permanent record of the sample preparations, data calculations and final results. Data that may be found in a sample logbook are often recorded in this notebook. Some projects may have individual notebooks, whereas others are assigned to a general project notebook.

IC and GC chromatograms. Coded to pages in project notebooks will be stored digitally on disc, and hard copies will be stored in separate folders.

The majority of the data reported by SRI will be derived from laboratory analysis of samples collected manually in the field. Laboratory data will be recorded manually or by computerized data acquisition. In either case, the analyst who generates the data will be responsible for its documentation. Data that are not available on computer printout are to be recorded by the analyst in research laboratory notebooks assigned to the project. Data on computer printouts (chromatograms, mass spectra and computerized data) are to be dated, coded and initialed by the analyst and to be traceable to the project research-laboratory notebooks and/or to the instrument logbook.

PERFORMANCE AND SYSTEMS AUDITS

Quality assurance audits provide an independent assessment of the measurement efforts. The primary objective of an audit is to ensure that reliable, useful data are produced. Further, an audit may identify problems with the effort and thus provide a means to implement corrective action. These audits should be directed toward evaluating the performance of the effort and of the technical systems employed.

TECHNICAL SYSTEMS

A periodic review of the total sampling and analytical system is needed to review the overall effectiveness of the operation. Necessarily, these technical systems audits are a subjective evaluation of all systems in use with respect to strengths, weaknesses, and potential problem areas. The audit is a comprehensive review of all aspects of the measurements.

Typically, the audit involves a review of calibration procedures and documentation, a check of data recording practices and reporting, a review of data validation procedures, sample custody procedures, overall quality control practices, and equipment operation and maintenance.

The technical audit is simply a review of equipment use and standard operating procedures. It does not address questions regarding data quality or the methods used to evaluate the quality of the data.

PERFORMANCE EVALUATIONS

The performance evaluation audit assesses the quality of the data. Specifically, this audit addresses the capabilities of the measurement systems to generate quality data. Generally, this is accomplished by comparing the various systems with accepted reference standards. The performance audit evaluates the accuracy and precision of the measurement system, compares quality control data against actual data, evaluates each system against its established control limits, and searches for deviations in data quality over time. The performance evaluation audit indicates when the system is not performing within the desired quality control constraints but does not necessarily identify appropriate corrective action.

QUALITY ASSURANCE REPORTS

SRI will submit a quarterly quality assurance report to allow an assessment of the usefulness of the data reported. This report will summarize quality control measures including any audits that may have been conducted. It will also describe any problems that were encountered and summarize corrective actions.

APPENDIX B

Purchase Order Tracking Report

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C91-000854	SCR-700 ADDEND-1	HEAT PIPE AIR PREHEATER CHANGE-SPT MODIFICATION	ABB AIR PREHEATER	05/17/91 11/15/91	05/01/92 05/01/92	RECEIVED
C91-000855	SCR-701	ROTARY TYPE AIR PREHEATER	ABB AIR PREHEATER	05/17/91	05/01/92	RECEIVED
C91-001152	SCR-702 ADDEND-1 ADDEND-2 ADDEND-3 ADDEND-4 ADDEND-5	EXHAUST GAS/COOLING AIR FANS CHANGE: SHIP TO ADDRESS CHANGE MOTOR HORSEPOWER ADD-TRANSMITTERS ADD-FAN MODIFICATIONS ADD-CARBON STL RINGS	HOWDEN SIROCCO NO CHANGE	06/21/91 06/25/92 09/16/91 02/21/92 08/26/92 12/23/92	07/01/92 07/01/92 07/01/92 07/01/92 07/01/92 ASAP	RECEIVED
C91-001260	SCR-703	GAS FLOW VENTURI'S	FLOW-LIN CORP	07/09/91	06/29/92	RECEIVED
C91-001434	SCR-708 ADDEND-1 ADDEND-2	480V MOTOR CONTROL CENTER ADDRESS CHANGE SCOPE REVISION	SOUTHERN ENGINEER NO PRICE CHANGE	08/15/91	06/01/92	RECEIVED
C91-001608	SCR-704 ADDEND-1 ADDEND-2 ADDEND-3	DIST CONTROL/DATA ACQ SYSTEM ADD: GAS ANALYZER SYSTEM DEDUCT: MISC EQUIP/TRAINING ADD-COAXIAL CABLES	BAILEY CONTROLS	08/26/91 12/09/91 05/11/92 01/06/93	02/03/92 02/03/92 NA ASAP	RECEIVED
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 ADDEND-1 ADDEND-2	MISC POWER TRANSFORMERS ADDRESS CHANGE ADD-TEMP EQUIP	ABB POWER T/D	08/30/91	06/01/92	RECEIVED
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

APPENDIX B

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C91-002312	SCR-711 ADDEND-1	SERVICE/COOLING WATER PUMP CHANGE MOTOR REQUIREMENTS	PEABODY FLOWAY, INC	11/27/91 08/26/92	06/01/92 ASAP	RECEIVED
C91-002553	SCR-712	GAS ANALYZER SYSTEM	LEAR SIEGLER	12/27/91	09/01/92	11/10/92
C91-002554	SCR-712A	OXYGEN ANALYZER SYSTEM	LEAR SIEGLER	12/27/91	09/01/92	11/10/92
					1991 TOTAL:	
					1992	
C92-000039	SCR-714 ADDEND-1	PLANT AIR COMPRESSOR ADD-START-UP SERVICE	HYDROMATICS, INC	01/15/92 01/12/93	06/01/92 COMPLETE	RECEIVED
C92-000043	SCR-713	BULK AMMONIA SYSTEM	LAROCHE INDUSTRIES (Lease Contract)	01/15/92	05/31/92-TANK 11/01/92-AMMON	TANK RECD
C92-000047	SCR-1018-01 ADDEND-1	DAMPERS/ACTUATORS SCOPE CHANGE: ADD EQUIPMENT	PRECISION ENG PROD	01/16/92	06/01/92	RECEIVED
C92-000051	SCR-1018-02 ADDEND-1	SOOTBLOWERS SCOPE CHANGE	COPE-S-VULCAN, INC	01/17/92 08/26/92	07/31/92 09/21/92	RECEIVED
C92-000201	SCR-1113-01/01A	LOW VOLTAGE TRANSFORMERS	GRAYBAR ELECTRIC	02/05/92	04/01/92	RECEIVED
C92-000241	SCR-715 ADDEND-1 ADDEND-2 ADDEND-3	STRUCTURAL STEEL/GRATING SCOPE CHANGE: ADD STEEL SCOPE CHANGE ADD-MISC STEEL/LESS BACKCHARGE	STEEL SYSTEMS	02/12/92 08/26/92 01/12/93	06/01/92 AS REQ	RECEIVED
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

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
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	RECEIVED
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
C92-000623	SCR-0131-01	480V CONTROL PANEL	INSTRUMENT CONT SVC	04/07/92	08/01/92	RECEIVED
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	RECEIVED
C92-000894	SCR-0428-01	SERVICE WATER STRAINER	VOIGT-ENGLAND CO	05/29/92	07/15/92	RECEIVED
C92-000965	SCR-0512-01	3/C 250 MCM CABLE	OKONITE CO	06/10/92	09/01/92	RECEIVED
C92-001034	SCR-716	PERSONNEL HOIST	USA HOIST	06/18/92	09/01/92	11/15/92
C92-001068	SCR-717 ADDEND-1	REACT/TRANS DUCTWORK ADD: DUCT SUPPORTS ADD: MISC STRUCT SPTS	CENTRAL ALABAMA FAB	06/26/92 08/26/92 08/26/92	START-09/01/92 COMP-09/07/92	RECEIVED
C92-001152	SCR-0410-02	BALL VALVES	GULF COAST MARINE S	07/10/92	07/31/92	RECEIVED
C92-001154	SCR-0610-01	THERMOCOUPLES	JMS SOUTHEAST, INC	07/10/92	07/31/92	RECEIVED

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C92-001156	SCR-0410-01	GLOBE VALVES	MASONEILAN	07/10/92	08/01/92	PARTIAL
C92-001285	SCR-2606-01	EXPANSION JOINTS	UNAFLEX, INC	08/03/92	08/03/92	RECEIVED
C92-001334	SCR-0207-01	SAFETY RELIEF VALVES	INDUSTRIAL VALVE	08/14/92	09/30/92	AS REQ
C92-001407	SCR-2807-03	SOLENOID VALVES	GULF COAST MARINE	09/21/92	09/30/92	RECEIVED
C92-001548	SCR-2508-02	TRANSMITTER/TWO WIRE	RONAN ENGINEERING	09/22/92	10/15/92	RECEIVED
C92-001550	SCR-2508-03	WINDSOCK	ARADYNE PRODUCTS	09/22/92	10/15/92	RECEIVED
C92-001551	SCR-2508-01	LEAK DETECTOR	MITCHELL INSTRUMENT	09/22/92	10/15/92	RECEIVED
C92-001552	SCR-2807-02	CHAIN HOISTS	PENSACOLA MILL SUP	09/22/92	10/15/92	RECEIVED
C92-001567	SCR-2807-01	FIRE PROTECTION EQUIP	FIREMASTER	09/24/92	10/30/92	RECEIVED
C92-001577	SCR-033002	INTEGRAL ORIFICE PLATES	TECHNICAL SPECIALTIE	09/22/92	11/15/92	RECEIVED
C92-001576	SCR-718	DUCTWORK EXPANSION JOINTS	SENIOR FLEXONICS	09/25/92	10/16/92	AS REQ
C92-001707	SCR-VERB	APARTMENT RENTALS	J.M. ENDRY REALTY	10/22/92	10/22/92	RECEIVED
C92-001792	SCR-VERB	MISC TEST EQUIP (SRI)	MILLIPORE PRODUCTS	10/28/92	12/01/92	AS REQ
C92-001799	SCR-2110-07	MISC TEST EQUIP (SRI)	MICRO FILTRATION	10/28/92	12/01/92	AS REQ
C92-001802	SCR-2110-08	MISC TEST EQUIP (SRI)	MERIAM INSTR	10/28/92	12/01/92	AS REQ
C92-001826	SCR-1510-01	MISC TEST EQUIP (SRI)	BYTE SIZE COMPUTER	10/31/92	11/15/92	AS REQ
C92-001827	SCR-2110-03	MISC TEST EQUIP (SRI)	BAXTER SCIENTIFIC	10/31/92	11/30/92	AS REQ
C92-001842	SCR-2110-04	MISC TEST EQUIP (SRI)	DWYER INSTRUMENTS	11/04/92	11/15/92	AS REQ
C92-001843	SCR-2110-05	MISC TEST EQUIP (SRI)	GEORGE S EDWARDS C	11/04/92	11/15/92	AS REQ

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C92-001860	SCR-VERB	SUBSTRATE MATERIAL	CORNING, INC	11/04/92	11/15/92	12/30/92
C92-001861	SCR-0311-02	MISC TEST EQUIP (SRI)	SOUTHERN RESEARCH	11/04/92	12/01/92	AS REQ
C92-001863	SCR-VERB	SOFTWARE/DATA BACKUP	SOFTWARE CITY	11/04/92	11/15/92	AS REQ
C92-001881	SCR-2110-006	CHART RECORDER (SRI)	FISHER SCIENTIFIC	11/06/92	12/01/92	AS REQ
C92-001882	SCR-VERB	MISC TEST EQUIP (SRI)	FISHER SCIENTIFIC	11/06/92	12/01/92	AS REQ
C92-001884	SCR-VERB	MISC TEST EQUIP (SRI)	DIONEX CORP	11/06/92	12/01/92	AS REQ
C92-001886	SCR-VERB	MISC TEST EQUIP (SRI)	VARIAN ANALYTICAL	11/06/02	12/01/92	AS REQ
C92-001889	SCR-2110-01	MISC TEST EQUIP (SRI)	OMEGA ENGINEERING	11/06/92	12/01/92	AS REQ
C92-001892	SCR-719	FIRE PROTECTION SYSTEM	GRINNEL-MOBILE	11/06/92	ASAP	ASAP
C92-001943	SCR-10-11-01	DDCS RELOCATION	MCCOLLISTER MOVING	11/12/92	11/16/92	AS REQ
C92-001947	SCR-0311-03	MISC TEST EQUIP (SRI)	GRASEBY NUTECH	11/13/92	12/01/92	AS REQ
C92-001948	SCR-0311-01	MISC TEST EQUIP (SRI)	JANDEL SCIENTIFIC	11/13/92	12/01/92	AS REQ
C92-001951	SCR-0311-04	SMAR TRANSMITTERS	TECHNICAL SPEC	11/13/92	12/01/92	AS REQ
C92-001987	SCR-0611-01	METAL EXPAN JOINTS	AMERICAN BOA	11/18/92	12/15/92	AS REQ
C92-002304	SCR-VERB	SPECIALTY GASES	AIR PRODUCTS & CHEM	12/29/92	AS REQ	AS REQ
C92-002308	SCR-VERB	MISC ANALYSIS EQUIP (SRI)	CURTIN-MATHESON	12/29/92	01/15/93	AS REQ
C92-002311	SCR-VERB	STEAM TRAPS	ROWAN & ASSOC	12/30/92	01/06/93	AS REQ

YTD TOTAL:
PROJECT TOTAL:

PURCHASE ORDER	INQUIRY NO	DESCRIPTION	VENDOR	PO DATE	REQUIRED DATE	PROMISED DATE
C93-000073	SCR-VERB	PITOT TUBE	DWYER INSTRUMENTS	01/14/93	01/29/93	AS REQ
C93-000124	SCR-1214-01	LIFT TRUCK	CLARKLIFT OF ALABAMA	01/20/93	04/15/93	ASAP
C93-000127	SCR-VERB	LOUVER DAMPER	PRECISION ENG PROD	01/20/93	03/15/93	ASAP
C93-000206	SCR-VERB	LIMIT SWITCHES	TECHNICAL SPEC	02/10/93	03/01/93	AS REQ
C93-000235	SCR-VERB	COMPUTER SOFTWARE	MORE ENGINEERING	02/02/93	02/15/93	AS REQ
C93-000287	SCR-VERB	POSITION TRANSMITTER	J.F. GASKILL	02/11/93	02/26/93	AS REQ
C93-000291	SCR-VERB	POSITIONER (TBI BAILEY)	REGAL-BROWN	02/15/93	03/01/93	AS REQ
C93-000292	SCR-VERB	REPLACEMENT THERMOCOUPLE	JMS-SOUTHEAST	02/11/93	03/01/93	AS REQ

APPENDIX C

**POWER SUPPLY SCHEMATICS AND DRAFT CONTROL SYSTEM SCREEN DISPLAYS
PRESENTED AT NOVEMBER 10, 1992 MEETING**

APPENDIX C
POWER SUPPLY SCHEMATIC

850 CIRCUITS TO DATE

DRAFT VERSION OF CONTROL SYSTEM SCREEN DISPLAYS

15788

OVERVIEW

10:44:28 22-SEP-92 TUESDAY

1
K-1
P-1
con
TUN
SHF

11:13:24 22-SEP-92 TUESDAY

SNGL LINE

15785

DTC SG1F8
CLOSE/TRIP 4160
VOLT SMGR FR 8

CLOSED

TRIP ☐

SP

TARGET: TRIP

NH3 DILUT AIR F-302

SERVICE WATER PUMP

AIR COMPRESSOR

SOOT BLOWERS

1
K-1
P-1
CON
TUN
SHF

11:14:46 22-SEP-92 TUESDAY

UNIT 5 GAS/AIR

15788

TO REACTOR INLETS
PUSH A B C D E F G H or J
FOR INDIVIDUAL REACTORS

TO UNIT 5
COMBUSTION
AIR SYSTEM

SV
DMP507
CLOSED

ZT502
%

ZZ502
0.00 %

PT502
-12. IN H2O

FAN502

TE502
63.96 DEG F

TE503
65.25 DEG F

STOP

M

UNIT 5

MASTER FUEL
TRIP MFT001
RESET

WATTS JT101
PSIG

NATURAL GAS
FLOW FT002
LB/HR

LIGHTER OIL
FLOW FT001
LB/HR

1
K-1
P-1
con
TUN
SHF

FROM
UNIT 5
FD FAN

IP506
0.00 %

ZT506
2.67 %

FCD506

TE507
66.5 DEG F

17.7 IN H2O
PT508

TO APH'S &
HEAT PIPE
PUSH 1A, 1B
OR 1C

11:15:54 22-SEP-92 TUESDAY

NH3 SUPPLY

15788

TRANH3PB
TRAIN A NH3 VALV
E OPEN/CLOSED

CLOSED ■
OPEN

TARGET:CLOSED

1
K-1
P-1
con
TUN
SHF

11:00:44 22-SEP-92 TUESDAY

REACTOR "A" AIR PREHEATER

15788

1
K-1
P-1
con
TUN
SHF

11:17:23 22-SEP-92 TUESDAY

REACTOR A FLUE GAS HEATER

15783

1
K-1
P-1
con
TUN
SHF

11:18:48 22-SEP-92 TUESDAY

REACTOR "B" BYPASS

1578S

1
K-1
P-1
con
TUN
SHF

11:10:36 22-SEP-92 TUESDAY

REACTOR D, E & F CYCLONES

15788

GO TO
OVERVIEW
PUSH A

1
K-1
P-1
con
TUN
SHF

11:12:00 22-SEP-92 TUESDAY

DILUT AIR

15788

1
K-1
P-1
con
TUN
SHF

11:12:18 22-SEP-92 TUESDAY

RCTRS A B & C GAS SAMPLING

15788

FLUE GAS FLOW FROM UNIT 5 ECONOMIZER OUTLET - (HIGH DUST !!)

1
K-1
P-1
CON
TUN
SHF