**HOT GAS CLEANUP TEST FACILITY FOR GASIFICATION AND
PRESSURIZED COMBUSTION**

**QUARTERLY TECHNICAL PROGRESS REPORT
JULY 1 - SEPTEMBER 30, 1992**

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1.0 INTRODUCTION AND SUMMARY

This quarterly technical progress report summarizes work completed during the Eighth Quarter of the First Budget Period, July 1 through September 30, 1992, under the Department of Energy (DOE) Cooperative Agreement No. DE-FC21-90MC25140 entitled "Hot Gas Cleanup Test Facility for Gasification and Pressurized Combustion." The objective of this project is to evaluate hot gas particle control technologies using coal-derived gas streams. This will entail the design, construction, installation, and use of a flexible test facility which can operate under realistic gasification and combustion conditions. The major particulate control device issues to be addressed include the integration of the particulate control devices into coal utilization systems, on-line cleaning techniques, chemical and thermal degradation of components, fatigue or structural failures, blinding, collection efficiency as a function of particle size, and scale-up of particulate control systems to commercial size.

The conceptual design of the facility was extended to include a within scope, phased expansion of the existing Hot Gas Cleanup Test Facility Cooperative Agreement to also address systems integration issues of hot particulate removal in advanced coal-based power generation systems. This expansion included the consideration of the following modules at the test facility in addition to the existing Transport Reactor gas source and Hot Gas Cleanup Units:

1. Carbonizer/Pressurized Circulating Fluidized Bed Gas Source.
2. Hot Gas Cleanup Units to mate to all gas streams.
3. Combustion Gas Turbine.
4. Fuel Cell and associated gas treatment.

This expansion to the Hot Gas Cleanup Test Facility is herein referred to as the Power Systems Development Facility (PSDF).

The major emphasis during this reporting period was finalizing the facility design documents for the PSDF, expanding the detailed design to include the PSDF and initiating the detailed design for the facility. The three volume Facility Design Document set describing the conceptual design and corresponding cost estimate for the PSDF was finalized and submitted to Department of Energy/Morgantown Energy Technology Center (DOE/METC). A proposal to expand the detailed design to include the PSDF was prepared and submitted to DOE/METC for approval. This expansion would include the Advanced Pressurized Fluidized-Bed Combustion (APFBC) system and corresponding balance-of-plant into the design of the facility. The detailed design of the facility (Phase 2) was initiated during this time period. This included starting the design for the Transport train and the balance-of-plant design for the facility. The request for proposals (RFP) for the Carbonizer/Transport particulate control devices (PCDs) and the PFBC were prepared and sent out for bids. SCS continued to support the DOE NEPA process by supplying additional information and initiating geotechnical activities to better characterize the Wilsonville site.

It should be noted that this report includes accounts of progress made by M. W. Kellogg (MWK), Foster Wheeler (FW), Southern Research Institute (SRI) and University of North Dakota Energy & Environmental Research Center (UNDEERC).

2.0 REVIEW OF TECHNICAL PROGRESS

2.1 PROJECT MANAGEMENT

Project management activities during this time period focused on finalizing the Facility Design Documents, initiating the detailed design of the facility (Phase 2) and expanding the detailed design for the PSDF. A paper describing the past year's work for the Cooperative Agreement was prepared and presented at the DOE/METC Gasification and Gas Stream Cleanup Contractors Meeting September 15-17, 1992.

The General Overview for the PSDF, Volume I of the Facility Design Document, was completed. The general overview describes the conceptual design of the PSDF and will serve as the basis for a report that DOE/METC will submit to Congress on the facility. The Cost Estimate for the PSDF was also completed and assembled into sperate volume to coincide with the General Overview and the Design Documents for the PSDF. The following is the arrangement of the Facility Design Documents:

- Volume I: General Overview
- Volume II: Design Documents
 - II.1 - Transport Reactor and Fuel Cells
 - II.2 - APFBC System Including Topping Combustor and Gas Turbine
 - II.3 - Particulate Control Devices and Balance of Plant Design
- Volume III: Cost Estimate

All of the Facility Design Documents have been submitted to DOE/METC.

SCS initiated Phase 2 in the First Budget Period of the Hot Gas Cleanup Test Facility (HGCTF) project on July 6, 1992. This included proceeding forward with the detailed design of the transport reactor system along with supporting particulate sampling and balance-of-plant systems. SCS also initiate the procurement effort for the particulate control devices (PCDs) for the facility. No detailed design work was started on the APFBC System, however, SCS will be identifying common balance-of-plant systems for the expanded Power Systems Development Facility that would be cost effective to design in the early stages of Phase 2.

A cost proposal to increase the level of effort for the detailed design to include the PSDF was submitted to DOE/METC in early August. The proposal was based on the overall cost estimate for the PSDF prepared in Task 1.5 for the facility expansion. SCS and the rest of the project team provided additional supporting data to DOE/METC as requested on the cost proposal. The expansion of the detailed design was approved by DOE/METC in late September.

2.2 PHASE 1 - CONCEPTUAL DESIGN ACTIVITIES

2.2.1 Task 1.4 Transport Reactor Development Unit

The final report on the Transport Reactor Test Unit (TRTU) has been issued to SCS, DOE, and EPRI.

A meeting was held with MWK, SCS, and UNDEERC which resulted in design modifications to reduce the cost growth of the transport reactor development unit (TRDU) without jeopardizing the intent of the test program. The TRDU process control diagram has been revised to reflect the consensus arrived at during this meeting.

The TRDU fabrication drawings has been reviewed including the design of various nozzles. Responses were provided on comments from UNDEERC and SCS regarding the TRDU spool pieces. Representatives from the MWK visited UNDEERC to finalize nozzle sizes, orientation, and nozzle locations and the spool piece drawings were revised accordingly. The process and instrumentation diagrams are being finalized and integrated with the existing UNDEERC system.

Modifications to the load-bearing floors at UNDEERC are under design. Construction will begin upon receipt of the final mechanical drawings of the TRDU and the structural load information from MWK. Design and drafting are expected to be completed by October 16. Construction is to be completed by November 6.

The preliminary installation order of the reactor spool pieces has been established and will be documented for approval by all parties. The refractory pouring procedures and refractory forms plans are being established. Construction of the forms should be completed by October 23.

Bid packages for the natural gas preheater have been rejected by UNDEERC. The UNDEERC will design and construct the unit. The coal blending system bid packages were received. Prior to the acceptance of any system, several surplus units are being investigated for use. The natural gas compressor bid was \$10,000 higher than anticipated due to the lack of instrumentation in previous quotes. The use of instrumentation from an existing compressor is being reviewed for use on the larger compressor.

Requisitions have been issued and bids have been received from three vendors for reactor system spool pieces composed of 26 sections. The bids have been reviewed, a precommitment meeting has been held and orders have been placed for the reactor spool pieces. Delivery is expected to allow installation in December 1992. The requisitions for the external pipe insulation and supports have been finalized for inquiry.

Requisitions and purchase orders have also been issued for the cyclone system to General Electric Environmental Systems Inc. as a "single source" supplier. The TRDU cyclone system design and calculations have been reviewed. MWK will continue to monitor the quality control of the cyclone subcontractor shop. The electrical heat tracing requirements for the first stage

cyclone dipleg have been calculated. A duty specification for the heating requirements is currently being developed.

The North Dakota State Health Department has given verbal approval to oxidize the limestone ash and dispose of the material in an approved industrial landfill. The municipal landfill that was in the permit application will not be acceptable. Written approval should arrive shortly.

A draft "Operating Procedures" and "Test Plan" has been issued to SCS and EERC for comments.

The following papers on the transport reactor development have been submitted for presentation at the Ninth Annual Pittsburgh Coal Conference, in Pittsburgh, Pennsylvania:

"Development of a Pressurized Transport Gasifier by the M. W. Kellogg Company", by E. A. Gbordzoe, G. B. Henningsen, and W. M. Campbell. The M. W. Kellogg Company.

"Gasification for the Wilsonville Power Systems Development Facility", by Z. Haq, R. Sears, and T. Pinkston. Southern Company Services Inc.

2.3 PHASE 2 - DETAILED DESIGN ACTIVITIES

At the beginning of the third quarter, Robert Lisauskas from Riley Stoker Corporation (a subsidiary of Deutsche-Babcock) visited SCS and made a presentation on their efforts in testing the hot gas filtration systems at the Friedrichsfeld test facility near Dusseldorf, Germany. Richard Abrams of CeraMem Corporation and Charles Davis of Ahlstorm Pyropower visited SCS and made presentation on their combined effort to develop CereMem hot gas filters and associated design.

2.3.1 Task 2.1 Detailed Design

The detailed design for the facility was initiated during this quarter. Initial effort in this regard was directed towards mobilizing manpower within the respective organizations for the design effort. A preliminary schedule for the detailed design was prepared by project participants and submitted to the design teams for review and comment. Work continued on developing an overall project schedule for the detailed design incorporating the design scopes for SCS, MWK, FW, SRI and PCD vendors. Also, during this quarter, bid packages for the PCDs to be installed at the PSDF were prepared and sent to various PCD vendors.

A budgetary listing of equipment, labor and resources that will be competitively bid by MWK, FW and SCS was developed during this quarter.

2.3.1.1 MWK: PSDF Transport Train

Major activities by MWK during this quarter concerning the design of transport train for PSDF

include the revision of Process Release 3 to incorporate the results of the Extended Conceptual Design Phase. The final design basis and process flow diagrams will be released early in the fourth quarter to SCS for review.

Specific tasks accomplished by MWK during the third quarter are listed below:

- Developed an overall engineering schedule for the transport train. Developed staffing plan and manpower assignments to ensure completion of design and procurement activities on schedule.
- Reviewed and refined process design basis for the transport train with SCS based on the results of extended Phase 1 (Conceptual Design). Completed changes in process design and process flow diagrams for release. These changes constitute Revision 4.
- Worked with SCS to establish coordination procedure and documentation requirements for Phase 2 of the project. Also, worked on establishing the degree of procurement effort (Phase 3) that will be required to obtain vendor data for proprietary items during Phase 2 of the project.

2.3.1.2 FW: PSDF APFBC Train

No detailed design work was started by FW on the APFBC train during this quarter. SCS identified common balance-of-plant systems between APFBC and transport trains that would be cost effective to design in the early stages of Phase 2. FW participated in the development of the Carbonizer and Combustor PCDs specifications that were included in the bid package prepared by SCS.

2.3.1.3 SCS Engineering: PSDF Balance-of-Plant Design

Major activities during the third quarter include initiating discussions with the Alabama Power Company (APCO) on the feasibility of providing power to the facility from a nearby 230 KV line. A meeting was held with APCO to discuss the 230KV tie-in, provide preliminary load requirements and temporary power needs during construction. Surveying plans and site core drillings to facilitate structural design were also initiated during this quarter.

The following specific engineering activities/milestones were accomplished by SCS Engineering during the third quarter of 1992:

- Started to proceed forward with the detailed design of the balance-of-plant systems along with the design of transport train and supporting particulate sampling program. Common balance-of-plant systems for the expanded design, which also includes FW's APFBC train, were identified and this will result in cost effective design in the early stages of Phase 2.
- Established lead engineers for the Civil, Mechanical, Electrical and I&C design. Relocated the dispersed design team to a common working area.

- Specified Intergraph systems to be utilized by the Mechanical and Civil disciplines. Initiated two year lease agreement for hardware and software. Identified training dates and requirements for employees to become proficient in use of the 3-D design software.
- Initiated process structure design for the transport and APFBC trains and common bay area by utilizing the 3-D intergraph system. Equipment and load points were established with input from MWK and FW on vessel weights and sizes.
- Received equipment loads from FW and agreed on a 15% margin on component weight in process structure.
- Transmitted the civil design structural Process Design System (PDS) files to MWK and FW. These files show the 3-D structure with preliminary equipment locations.
- Initiated power source development, moving from the 115 KV tie-in and 5.2 miles of access to a second option of tying to 230 KV transmission line and less than 1800 feet of access. Various options were discussed with APCO and a decision was made to recommend purchase of a spare transformer for 230 KV option. Preliminary load requirements were provided to APCO for transformer sizing. Also, construction and temporary power needs were addressed.
- Initiated master construction and design schedule by including the MWK and FW design and procurement information.
- Along with MWK and FW, reviewed the process flow diagrams from SRI for the PCD inlet and outlet particulate sampling system. Also, reviewed the flow diagrams for nitrogen supply for the particulate and alkali sampling systems.
- Provided a budgetary listing of equipment, labor and resources that will be competitively bid by MWK, FW and SCS Engineering. The amount that would be competitively bid was presented as a percent of the total budget.
- EPRI-owned mechanical/electrical equipment, analytical laboratory instruments and computer hardware from the existing facilities at Wilsonville were selected for use in the PSDF project.

2.3.1.4 SCS: ASPEN Simulation

During the third quarter, the major focus in this area was on simulating the FW's APFBC process using ASPEN. Much of the simulation was based on correlations developed by the Institute of Gas Technology (IGT). The IGT has prepared a simulation of the PFBC process which is described in detail by Robertson, *et al.* (1989). In IGT's simulation, the carbonizer performance and gas composition are predicted for air-blown carbonization of coal in the presence of a lime-based sorbent. The simulation takes into account data collected from past air

blown carbonizers as well as through an extensive literature search. The IGT's FORTRAN code uses correlations for yields of various gas phase and solid phase components as a function of temperature, pressure, and reactant quantities.

The IGT correlations has been transferred into ASPEN using the FORTRAN block feature and RYIELD blocks. The ASPEN simulation calculates carbonizer performance and compositions that are in good agreement with the results from the IGT code. IGT is updating its code and as the updates become available they can be implemented in ASPEN to predict the Power Systems Development Facility process stream conditions at the exit of the carbonizer and eventually for the entire facility.

In addition to using FORTRAN statements and RYIELD blocks to predict yields, three other approaches in ASPEN have been tried to predict carbonizer performance. The first approach involved the use of RSTOIC blocks to simulate the carbonizer in two zones, an upper zone and a lower zone, with different reactions going on in these zones. The extent of these reactions was determined by trial and error to match the material balance for the PSDF carbonizer. The second approach involved the use of an RGIBBS block which minimizes the Gibbs Free Energy of the expected product slate from the carbonizer. The presence of inert solids made the RGIBBS block difficult to converge. Therefore, a separator block was included to allow the inert solids to bypass the RGIBBS block. The output from this simulation was very different from the PSDF carbonizer mass balance information provided by Foster Wheeler. This simulation will be useful if the carbonizer products are at equilibrium. A third approach was to use a CSTR block to simulate the carbonizer. In ASPEN, when solids are present, the CSTR block requires a user supplied FORTRAN subroutine to describe the kinetics of the reactions in the carbonizer. A considerable amount of work would have to be expended to develop such a subroutine and SCS was working with ASPENTECH to begin to assemble an outline for the subroutine.

2.3.2 Environmental Information

The environmental information collected during this quarter primarily supports the National Environmental Policy Act (NEPA) requirements for government contracts. Focus has remained on the collection of appropriate information for NEPA documentation including existing facilities emissions (air and water) and proposed remediation work at the Clean Coal Research Center in Wilsonville. Permitting activities for the facility were initiated during this quarter.

The following additional information was compiled for the Tennessee Valley Authority (TVA) concerning the NEPA Environmental Assessment: permeability and design data for Gaston Steam Plant dry ash storage area, preliminary groundwater results from ORNL's study of the coal liquefaction facility, the general discussion of process used at the PSDF with a general flow diagram, and entire reports concerning natural resource surveys conducted for Railroad Environmental Assessment in 1989 ("Inventory and Assessment of Selected Wildlife Populations and their Habitats Along Proposed Railroad...", "Biological Study - Survey of Fishes", "Survey of Birds and Mammals", "Dominant Plant Communities", etc.). Two copies of Plant Gaston

316(a)(b) water quality reports were provided to TVA for review. It was agreed that these reports will not be duplicated at TVA and both copies will be returned to SCS when an Environmental Assessment is provided to DOE-METC.

TVA created a scope of work for water quality sample collection and laboratory analysis. SCS implemented the work through Alabama Power field crew, who collected both water quality composite samples, one in Yellow Leaf Creek upstream of the potential discharge point and the other in the Coosa River at the mouth of Yellow Leaf Creek. The water analysis was conducted by Alabama Power Company's (APCO) Environmental Testing Laboratory. All parameters indicated that the water quality in the receiving waters was good. Additional data concerning the water flow and dam elevations were provided to TVA.

The preliminary report from ENSR to TVA concerning air quality impacts from the PSDF was reviewed for accuracy. General comments were made on the document concerning the modelling techniques used and the permitting requirements for the facility.

On September 14, 1992 a meeting was held in Morgantown, West Virginia between DOE-METC, TVA and SCS to discuss the status of the NEPA document and what additional information would be required for the Environmental Assessment. Pursuant to the concerns of that meeting, a plan of action was drafted that would address potential soil contamination and possible groundwater contamination on the PSDF site. DOE-METC geologist, Mary Guide visited the site September 29th to observe the field work and discuss the geology of the area with SCS/APCO. A draft issue of the Phase I geological report was given to DOE-METC during the site visit.

Blank air permit applications were requested from the Air Division of the Alabama Department of Environmental Management (ADEM). A review of all appropriate forms began. SCS drafted a Permitting Strategy Document for the facility which outlines the details needed for the air, water and solid waste permits required for construction/operation.

2.3.3 Particulate Control

2.3.3.1 Particulate Apparatus and Instrumentation

Work on the detailed design phase began in July. SRI's portion of the detailed design work comprises four tasks:

- Task 2.4. Particulate Characterization and Collection (Sampling Apparatus and Instrumentation)
- Task 2.5. Particulate Control Technologies (Solicitation and Proposal Evaluation)
- Task 2.8. Experimental Test Plan

Work on Task 2.8, Experimental Test Plan, is scheduled to begin in January 1993.

2.3.3.2 Detailed Design Interface

SRI will be working with SCS, Kellogg, and Foster Wheeler on sampling and monitoring requirements that affect the facility design. These requirements include the sizes and locations of ports and platforms, piping arrangements, and provisions for access to sampling equipment and instrumentation.

SRI's first interface activity was to work with the SCS design group to establish a protocol for submittal, review, and revision of drawings. It was agreed that SRI would submit all drawings to SCS. SCS will review the drawings and send them to Kellogg and Foster Wheeler for their review. All comments and corrections will be forwarded to SRI through SCS. SRI's first set of drawings comprised two process flow diagrams for the sampling systems and one flow diagram for the purge nitrogen supply. (These drawings are presented in the discussion of Task 2.4.) These drawings were submitted to SCS in July. Comments from SCS and Foster Wheeler were received in September and will be incorporated in the drawings and resubmitted in October. In August, SRI submitted a second set of drawings showing proposed modifications to the Kellogg piping at the inlet and outlet of the PCD. The intent of these drawings was to incorporate piping geometries and sizes consistent with SRI's requirements for particulate sampling. The locations of ports for various sampling devices and monitors were included, as were platforms needed to access sampling and monitoring locations. The design philosophy embodied in the drawings is to use a common header upstream of each PCD inlet and downstream of each PCD outlet for installation of sampling devices. This approach reduces the number of sampling ports and sampling devices required. These drawings are being reviewed by SCS, Kellogg, and Foster Wheeler.

2.3.3.3 Task 2.4 Particulate Characterization and Collection

SRI completed the conceptual design of the particulate and alkali sampling system last quarter. Detailed design of the sampling apparatus began in July. SRI began work at the same time on the selection and placement of particulate monitors and the formulation of data acquisition requirements for PCD evaluation.

Particulate Characterization

SRI is characterizing particulate samples from the Kellogg and Foster Wheeler pilot plants and assisting SCS in the preparation of specifications for the PCD bid requests.

On June 30, SRI received four sets of particulate samples from the carbonizer test unit operated by Foster Wheeler in Livingston, NJ. Each set comprised a sample from the cross-flow filter drain and a sample from the primary cyclone drain. Two sets were collected while the carbonizer was fed with an Illinois No. 6 coal, and two sets were collected while the carbonizer was fed with an Eagle Butte Powder River Basin coal. SRI selected one set from the Illinois No. 6 tests and one set from the Eagle Butte tests for characterization. These two sets of samples (four samples in all) were characterized by the same procedures used on the samples from the Kellogg transport reactor test unit (TRTU), except that the Coulter Counter was not used. (SRI have determined that the Coulter Counter results are not reliable for this type of sample. The sorbent in the samples tends to dissolve in the liquid that is normally used in the

Coulter Counter, and, the char particles, which are predominantly carbon, may not be detected by the Coulter Counter.)

A discussion of the particulate's characteristics for the MWK TRDU and FW carbonizer samples are summarized in Appendix A.

Overview of SRI Sampling System. The particulate sampling system is being designed to function at pressures up to 300 lb/in² and at temperatures up to 1800°F. A new cascade cyclone assembly is being designed to obtain representative, size-fractionated samples of the particulate matter entering the PCDs. To obtain the same type of samples at the PCD outlet, SRI plan to modify the design of an existing high-pressure cascade impactor. The size-fractionated samples will be used to determine the collection efficiency of the PCD as a function of particle size. SRI will provide four inlet, cyclone sampling systems and four outlet, impactor sampling systems. Flow diagrams for the inlet and outlet sampling systems are shown in Figures 2-1 and 2-2. The systems are being designed to allow in-situ sampling of both particles and alkali vapor. Each of the eight systems will include a sampling probe, a nozzle, a sample collector, a mechanism for inserting and removing the probe, and means for metering and controlling the sample flow.

Sampling and Monitoring Points. The proposed sampling and monitoring points are illustrated conceptually in Figures 2-3 and 2-4. The types of sampling probes and instruments used at the various points are listed in Table 2-1. (SRI has recommended that the piping be modified to provide a common inlet sampling location for both of the PCDs on the Kellogg system.) One cyclone probe will be provided at the inlet sampling location for each of the PCDs in the Foster Wheeler system. The SRI impactor probes will be deployed in like manner at the outlet sampling locations. All eight of the SRI probes will be fitted with alkali vapor collectors downstream from the particulate samplers to allow the simultaneous measurement of particle size distribution and alkali vapor concentration. All of the SRI probes will be designed for an internal port diameter no larger than 6 in. SRI expects that the sampling runs with the SRI probes will last for two to four hours, with an additional two to four hours required for probe insertion, heating, retraction, cooling, and sample recovery.

Simultaneous measurements of the total mass loading and alkali vapor concentration will be made with the Westinghouse condensation probes to be supplied by Foster Wheeler. Because the Westinghouse probes are much lighter than the SRI probes, it will be possible to move the Westinghouse probes from one location to another, as needed. SRI plans to use the Westinghouse probes at the PCD inlets, at the PCD outlets (inlets of the alkali getter beds), and at the outlets of the alkali getter beds. The Westinghouse probes require an internal port diameter of 1.05 in. SRI expects that the duration of a sampling run made with the Westinghouse probe will be similar to the sampling time used with the SRI probe, but the Westinghouse probe should require less time for insertion, heating, retraction, and cooling.

In addition to the sampling ports discussed above, ports will be required for several different types of particulate monitors.

Figure 2-1. Flow diagram of inlet sampling system

SAMPLE GAS
HEAT EXCHANGER

DRAIN TO
SRI SAMPLE
CONTAINER

NOTES:

1. REFER TO SRI DRAWING NUMBER P7252-001.1-RO FOR DEFINITION OF SYMBOLS
2. PROBE ISOLATION VALVES ARE SIZED TO ALLOW MECHANIZED WITHDRAWAL OF SAMPLING DEVICE THROUGH THEIR BORE. SYSTEM MAY THEN BE ISOLATED FOR REMOVAL OF SAMPLING DEVICE.
3. SAMPLING RATE MEASURED BY ΔP ACROSS CALIBRATED ORIFICE.
SAMPLING RATE = 0.5 to 1 acfm.
4. SAMPLING SYSTEM CONFIGURATION THE SAME FOR TRANSPORT REACTOR, CARBONIZER, AND CPFBC PCD'S.
5. NITROGEN PURGE PRESURE = 350psl
NITROGEN PURGE FLOWRATE = 4 acfm
6. ACTIVATED BAUXITE CARTRIDGE.

A	10/7/92	ADDED NOTE 3-8			
O	7/25/92	ORIGINAL ISSUE	TJM	SHW	RLJ
NO.	DATE	DESCRIPTION	BY	CHK	APRV

REVISIONS:

CLIENT APPROVAL					
SRI APPROVAL					
	BY	CKD	ENR	APRV	PROJ

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SOUTHERN RESEARCH INSTITUTE

WILSONVILLE ALABAMA 36896

WILSONVILLE
HOT GAS CLEANUP
TEST FACILITY

CLIENT	SOUTHERN COMPANY SERVICES				
TITLE	PROCESS FLOW DIAGRAM PCD INLET PARTICULATE SAMPLING SYSTEM				
SCALE	NONE	DWG NO.	P7252-002.R1		
DATE			SMT 1 OF 1		

WULFO

NOTES:

1. REFER TO SRI DRAWING NUMBER P7252-001.1-RO FOR DEFINITION OF SYMBOLS
2. PROBE ISOLATION VALVES ARE SIZED TO ALLOW MECHANIZED WITHDRAWAL OF SAMPLING DEVICE THROUGH THEIR BORE. SYSTEM MAY THEN BE ISOLATED FOR REMOVAL OF SAMPLING DEVICE.
3. ACTIVATED BAUXITE CARTRIDGE.

(A)

A	10/7/92	ADDED NOTE 3			
O	2/28/93	ORIGINAL ISSUE	TJM	SMH	ELJ
NO.	DATE	DESCRIPTION	BY	CHK	APRV
REVISIONS					
CLIENT APPROVAL					
SRI APPROVAL					
DWG					
SIZE					
SOUTHERN RESEARCH INSTITUTE					
WILSONVILLE HOT GAS CLEANUP TEST FACILITY					
CLIENT	SOUTHERN COMPANY SERVICES				
TITLE	PROCESS FLOW DIAGRAM PCD OUTLET PARTICULATE SAMPLING SYSTEM				
SCALE	NONE	DWG NO.	P7252-003.R1		
DATE		SHT 1 OF 1			

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Figure 2-3. Sampling and Monitoring Points in Kellogg Transport Reactor System

Figure 2-4. Sampling and Monitoring Points in Foster Wheeler APFBC System

Table 2-1. Sampling Probes and Instruments Used at Points Indicated on Figures 3 and 4

Type	Description	Number Supplied by SRI		Access ID, in.	Sampling Flow Rate, scfm	Sampling Time, hr	
		Kellogg	Foster Wheeler			Active	Total
1. Batch	SRI cyclone/alkali	2 (inc. 1 spare)	2	6	1	2 to 4	6 to 8
2. Batch	SRI impactor/alkali	2 (inc. 1 spare)	2	6	1	2 to 4	6 to 8
3. Batch	Westinghouse filter/alkali	1	--	1.05	0.5 - 5.0	2 to 4	4 to 6
4a. Real-Time	Impact detector	4	4	1	NA ^a	continuous	
4b. Real-Time	Sniffer	4	4	2	3 15 ft/min @11"WG	data rate TBD ^b	
5. Real-Time	Transmissometer	1	--	4	NA	continuous	
6. Real-Time	Optical detector	0	0	4	NA	continuous	

^a - Not applicable

^b - To be determined

Design of Particulate Sampling System. The design work performed to date has focused on the particulate sampling probe, the probe insertion and retraction mechanism, and the cyclone assembly. SRI's current design concept is based on the use of a plug on a dummy probe. The dummy probe is inserted whenever the sampling probe is not in use. The plug fits against a lip on the inside of the metal sleeve lining the port.

SRI began work on establishing the details of the motorized mechanism for probe insertion and retraction, illustrated conceptually in Figure 2-5. As shown in the sketch, the probe is inserted into the process piping through a set of double-block-and-bleed isolation valves. The space between the two valves is pressurized with nitrogen, preventing the escape of the hot gas into the outer end of the system. The pipe nipple that extends from the outer valve serves as a cavity for holding the particulate and alkali samplers when the probe is retracted. A packing gland provides a seal between the probe and the flange on the outer end of the pipe nipple. When the probe is fully retracted and both valves are closed, the outer nipple can be depressurized, and the flange containing the packing gland can be disconnected from the nipple. The probe can then be completely withdrawn, and the particulate and alkali samplers can be removed for sample recovery. SRI originally established the details of this system based on the use of an internal port diameter of 4 in. It later became apparent that an internal diameter of 4 in. would not provide adequate clearance for the cyclone assembly, so the affected components are now being redesigned for an internal diameter of 6 in.

Considerable attention has been given to the design of the cyclone sampling assembly. SRI arrived at a new design concept based on the use of the interconnection manifold shown in Figure 2-6. The use of this approach allows for a very compact design, while keeping the cyclone bodies far enough away from the nozzle to avoid disturbing the flow into the nozzle. The compactness of this design also makes it possible for the inlet end of the alkali collector to protrude into the process gas stream, helping to maintain the alkali collector in a desirable temperature range.

Alkali sampling at the inlet and outlet of the PCD will be done using an alkali sample collector connected to the back end of the particulate sample collector (cyclone or impactor). The alkali samples obtained at the inlet and outlet of the PCD will serve to detect any uptake of alkali on the ceramic filter elements in the PCD. The combined particulate and alkali sampling will be accomplished using a modified particulate sampling probe in which an alkali sorbent trap is connected to the outlet end of the particulate sampler. The sampling of alkali alone will be accomplished using the Westinghouse condensation probe. The alkali sorbent trap to be used in the SRI probes is a cylindrical cartridge filled with activated bauxite. The activated bauxite cartridge will adsorb alkali vapors (primarily gaseous NaCl and KCl) from the sample gas stream. The concentrations of the alkali vapors will be determined by extracting the bauxite and analyzing the extract for sodium and potassium. Extensive work with bauxite cartridges at Argonne National Laboratory (ANL) has shown that any reduction in temperature can cause the loss of alkali vapor on metal surfaces, and the alkali cannot be recovered from the metal (Vogel, 1976; Lee and Johnson, 1979; Lee and Myles, 1986; Lee, 1992).

Figure 2-5. Sampling Probe Insertion and Retraction Mechanism

TYPICAL CYCLONE

HEAD-IN CYCLONE
MANIFOLD

5 STAGE SAMPLING
CYCLONE ASSEMBLY

Figure 2-6. Sampling Cyclones and Interconnection Manifold

In August, SRI began work on preliminary design calculations to determine the size and geometry of the activated bauxite cartridge. SRI used the ANL data to extract a rate constant for the alkali adsorption on the bauxite, assuming that the adsorption rate was first order with respect to the alkali vapor concentration. SRI used this rate constant in the integrated first-order rate equation to derive an expression for the exponential decay of alkali concentration with contact time in the cartridge. By expressing contact time in terms of the sampling rate and cartridge dimensions, SRI derived a working equation relating the sampling rate, cartridge dimensions, and capture efficiency. This working equation was used to generate a set of design curves giving the required cartridge length as a function of cartridge diameter for various collection efficiencies (see Appendix B). Based on these design curves and additional information received from ANL, SRI has tentatively selected a cartridge diameter of 3.5 inches and a cartridge length of 5 inches.

To examine the potential loss of alkali vapor caused by cooling ahead of the bauxite cartridge, SRI plotted the equilibrium alkali vapor concentration as a function of temperature (see Appendix B). The data for this plot were obtained from a thermodynamic model developed by Westinghouse (Mulik, et al, 1983). These data apply to an air-blown gasification case, similar to the Foster Wheeler carbonizer or the Kellogg transport reactor when operated in a gasification mode.

Selection of Particulate Monitors. Real-time particulate monitors are needed to detect fluctuations in the particulate mass concentrations in the gas streams entering and leaving the PCDs. SRI tentatively plans to provide one opacity monitor, eight sniffers (small, active filters inserted into the gas stream), and other monitors that appear to offer a reasonable chance of successful application at Wilsonville. These plans may be changed as warranted by developments in monitoring technology. Regardless of which technologies are ultimately selected, the goal is to ensure rapid and reliable detection of any significant failure of the PCD.

SRI is conducting a survey of available particulate monitors to identify those systems that are appropriate for evaluation at Wilsonville. The systems that are under consideration include

- Transmissometers (Lear Siegler, Data Test)
- Laser-based instruments (Malvern, Insitac PCSV, PMS)
- Triboelectric detectors (Auburn Triboflow)
- Impact detectors (Jonas)
- Active filters (Industrial Filter and Pump Sniffer)

Since no system has been proved to work under the conditions expected at Wilsonville, SRI has recommended ducting modifications and installation of additional ports to allow testing of several different types of monitors. In our discussions with the monitor vendors, SRI has also inquired into the possibility of testing the monitors prior to purchase.

Data Acquisition Requirements. SRI prepared a preliminary statement of our data acquisition requirements to assist SCS in the design of the data acquisition system (DAS). SRI presented

a summary of our needs for DAS performance to SCS at a meeting in early September. SRI identified three specific needs that SRI felt should be presented to SCS as early as possible:

- *Data obtainable in DOS format.*
- *Data storage and archiving.*

Real-time and recent history: These data would be stored on hard disk for immediate access.

Archived data: Data older than one month would be stored on removable media for retrieval on demand.

Tentative data logging needs are summarized in Appendix C. The data should be sampled once each minute and averaged over ten-minute and one-hour intervals. In addition to ten-minute and one-hour averages, the particulate emissions should be sampled and logged every second.

- *Simultaneous real-time access to three different sets of data:*
 1. Process Status and History Terminal (process information, gas flows, pressures, temperatures, PCD pressure drops, cleaning frequencies, coal feed flow, etc).
 2. Particulate Emission Monitoring Terminal (opacity, outputs from various particulate monitors).
 3. Manual Sampling Train Monitoring and Control Terminal (Sample temperatures, pressures, flow rates, etc.)

An example screen for one of the Process Status and History Terminal displays is shown in Appendix C.

2.3.4 Task 2.5 Particle Control Technologies

Preparation of bid packages to procure PCDs for the PSDF was initiated at the beginning of the third quarter. Information derived from a preliminary inquiry issued earlier in the Hot Gas Cleanup project formed the basis for the conceptual design, and this information was used in developing the bid package. Two separate bid packages were developed. One for the similar size PCDs to be used with the carbonizer and transport reactor interchangeably and the other bid package was for the larger size PCD to treat gases from the CPFBC combustor in the APFBC train. The bid package was reviewed by MWK, FW, SRI and SCS engineering and their comments along with DOE, EPRI and American Electric Power (AEP) inputs were included in the inquiry package.

The bid package for the smaller capacity PCDs specify the following process conditions as the

basis for PCD design: Transport reactor in combustion mode - 1000 acfm of gas flow at 1000-1600°F and 216-300 psia; Transport reactor in gasification mode - 1000 acfm of gas flow at 1000-1800°F and 197-315 psia; and Carbonizer - 1475-1700 acfm of gas flow at 1500-1800°F and 170 psia. The design coal is Illinois No. 6 bituminous coal with an alternative feed coal being a subbituminous coal from Powder River basin. While the current design calls for dust loading of 4,000 ppmw from transport reactor and 11,000 ppmw from Carbonizer, it could vary to as high as 41,000 ppmw.

The bid package for the larger capacity PCD to treat flue gases from the CPFBC in the APFEC train specify 6,200 acfm of gas flow at 1,600°F and 150 psia at the PCD inlet. The particle loading is expected to be 15,000 ppmw.

The PCD vendors are expected to design the PCDs with particulate loading at the PCD outlet not to exceed 20 ppmw. No more than one percent by weight of the particles should be larger than 10 μ m, and no more than five percent by weight of the particles should be larger than 5 μ m. These limits on the total particulate loading and the large particle loading are required to protect the gas turbine from excessive erosion.

The bid package for the smaller PCD was distributed on September 11 to the following PCD developers:

1. Babcock & Wilcox, Barberton, Ohio
2. CeraMem Corporation, Waltham, Massachusetts
3. Combustion Power, Menlo Park, California
4. Industrial Filter & Pump Mfg. Co., Cicero, Illinois
5. Lanxide Corporation, Newark, Delaware
6. LSR Technologies, Concord, Massachusetts
7. Purolator Products Company, Greensboro, North Carolina
8. Refraction Technologies Corp., Newark, New York
9. Riley Stoker Corporation, Worcester, Massachusetts
10. Westinghouse, Pittsburgh, Pennsylvania
11. 3M Ceramic Materials Department, St. Paul, Minnesota
12. Acurex Environmental Corporation, Mountain View, California
13. Pall Advanced Separation Systems, Cortland, New York

A prebid meeting was held with PCD developers at SCS on September 22. A uniform response to all questions related to smaller capacity PCD was provided to the PCD developers. The Proposal is due to SCS on November 12, 1992.

The bid package for the larger capacity PCD was issued on October 2. In addition to the above list of PCD developers, the bid package was also sent to the following:

14. Ahlstrom Pyropower, Inc., San Diego, California

Proposal for the larger capacity PCD is due on December 3, 1992. Both the bid packages stress the importance of PCD vendor participation in the test program. The vendor should plan to assist SCS and SRI in the preparation of the detailed test plan and to participate in the analysis and interpretation of the test data. The PCD suppliers are asked to demonstrate a minimum cost sharing of 20% of the delivered cost of the PCD, including engineering and support services for the test program.

Both SCS and SRI developed an evaluation strategy and schedule. The following schedule will be used to review the proposals:

Week of Nov. 16: Preliminary evaluation of smaller capacity PCD proposals
Week of Dec. 7: Preliminary screening of larger capacity PCD proposals
Week of Dec. 14: Final evaluation of smaller capacity PCD proposals
Week of Jan. 11: Final evaluation of larger capacity PCD proposals

All team members will participate in the final evaluation of the proposals.

2.4 PUBLICATIONS AND PRESENTATIONS

1. R. E. Sears, et al.
"Hot Gas Cleanup Test Facility for Gasification and Pressurized Combustion"
Presented at DOE/METC Gasification and Gas Stream Cleanup Contractors Meeting
September 15 - 17, 1992 - Morgantown, WV
2. E. A. Gbordzoe, et al.
"Development of a Pressurized Transport Gasifier by the M. W. Kellogg Company"
Presented at the Pittsburgh Coal Conference
October 13 - 15, 1992 - Pittsburgh, PA
3. Z. U. Haq, et al.
"Gasification for Wilsonville Powers Systems Development Facility"
Presented at the Pittsburgh Coal Conference
October 13 - 15, 1992 - Pittsburgh, PA

3.0 PLANS FOR FUTURE WORK

1. Continue detailed design of the transport train and balance-of-plant for the facility.
2. Initiate the detailed design for the APFBC system and modify the Foster Wheeler subcontract.
3. Receive and review PCD RFPs and select vendors for the Carbonizer/Transport PCDs.
4. Present paper at DOE/METC Heat Engines Contractors Conference in October.
5. Complete the geological characterization of the site and update the Environmental Information Volume for the PSDF.
6. Prepare the continuation application with supporting information for the second budget period which includes the installation of the facility.
7. Complete the procurement of materials and equipment and continue the installation of the TRDU at UNDEERC.
8. Submit to DOE/METC cost increases for the TRDU work.

REFERENCE

A. Robertson, R. Garland, R. Newby, A. Rehmat, L. Rubow, "Second Generation Pressurized Fluidized Bed Combustion Plant Conceptual Design and Optimization of a Second Generation PFB Combustion Plant, Phase 1, Task 1," Volume II, Appendix A. Foster Wheeler Development Corporation, Livingston, NJ. DOE Report No. DE9000492, September 1989.

Lee, S.H.D. Personal Communication to R.S. Dahlin. September 9, 1992.

Lee, S.H.D. and I. Johnson. Removal of Gaseous Alkali Metal Compounds from Hot Flue Gas by Particulate Sorbents. Presented at the ASME Annual International Gas Turbine Conference. San Diego, CA. March 11-15, 1979.

Lee, S.H.D. and K.M. Myles. Measurement of Alkali Vapor in PFBC Flue Gas and Its Control By A Fixed Bed of Activated Bauxite. In: Gas Cleaning at High Temperatures. R. Clift and M.Ghodiri (Eds.), Institution of Chemical Engineers Symposium Series No. 99, The Institution of Chemical Engineers (Great Britain), Pergamon Press Ltd., Oxford, England, 1986. pp. 149-166.

Mulik, P.R., M.A. Alvin, and D.M. Bachovchin. Simultaneous High-Temperature Removal of Alkali and Particulates in a Pressurized Gasification System. Final Technical Progress Report on DOE Contract No. DE-AC21-81MC16372, Report No. DE84005777, September 1983.

Vogel, G.J. A Development Program on Pressurized Fluidized-Bed Combustion, Annual Report. Report No. ANL/ES-CEN/1016. Argonne National Laboratory. Argonne, IL. 1976.

APPENDIX A

**PARTICULATE CHARACTERIZATION OF MWK TRTU AND
FW CARBONIZER SAMPLES**

Table A-1 summarizes the results of characterization tests run to date on the Kellogg and Foster Wheeler samples. For comparison, the table includes a summary of test results for samples from other fluidized-bed combustors (FBCs) and from other gasifiers. As shown in the table, the characteristics of particles produced in the Kellogg TRTU under combustion conditions are generally similar to the characteristics of particles produced by other FBCs in the SRI data base. The characteristics of particles produced in the TRTU under gasification conditions are generally similar to the characteristics of particles produced in the Foster Wheeler carbonizer and in other gasifiers. The aerodynamic mean particle size of the combustor particles does not differ markedly from the mean sizes of the gasifier and carbonizer particles. The test results suggest that the combustor particles tend to have less surface area and less porosity than the gasifier/carbonizer particles. The combustor particles tend to be denser than the gasifier/carbonizer particles, and the combustor particles tend to possess greater tensile strength. These differences in surface area, porosity, and density are to be expected since nonporous fly ash particles dominate the combustor samples, while the gasifier/carbonizer samples also contain highly porous char particles.

The tensile strength measurements suggest that the particles from the TRTU combustion runs may be more cohesive than the particles from the TRTU gasification runs and the particles from the carbonizer runs. The particles produced by gasification or carbonization of the Wyodak/Eagle Butte coal appear to be more cohesive than the particles produced by gasification or carbonization of the Illinois/Western Kentucky coal. During recent testing of a cross-flow filter at Foster Wheeler's pilot plant, the pulsing frequency required to maintain a given pressure drop was lower with the Eagle Butte coal than it was with the Illinois coal (Personal communication from Dr. Thomas Lippert, Westinghouse Science and Technology Center, July 24, 1992). One possible explanation for this result is that the relatively noncohesive Illinois dust cake was blown apart by the pulse gas, with the resulting particles being suspended in the gas and subsequently redeposited on the filter elements. The relatively cohesive Eagle Butte dust cake was probably blown off the filter elements in the form of large agglomerates that settled into the PCD hopper, thereby avoiding the problems of particle resuspension and redeposition. There have been no tests of PCD performance with the TRTU particles, but the tensile strength data suggest the potential for dust cake resuspension and redeposition when gasifying the Illinois coal in a transport reactor.

As shown in the table, the data on gas flow resistance are very limited. Data from other FBCs and other gasifiers suggest that the dust cakes produced under combustion conditions tend to offer less resistance to gas flow than do the dust cakes produced under gasification conditions.

Scanning electron microscopy (SEM) has been used to further study the size, shape, and structure of the particles produced by the TRTU and by the carbonizer. Figures A-1 and A-2 show SEM photographs of particles produced in the TRTU by combustion and gasification of the Illinois coal. Comparison of the two sets of photographs suggests that combustion tends to produce larger particles than does gasification. This observation is inconsistent with the measurements of mean aerodynamic particle sizes, which show little difference between the combustion and gasification samples. One possible explanation for this discrepancy is that the

Table A-1. Summary of Particle Characteristics

Particle characteristic	KELLOGG TRANSPORT REACTOR TEST UNIT				FOSTER WHEELER		OTHER	
	Combustion	Gasification			Carbonizer		Other	Other
		W. Kentucky	Illinois 6	Wyodak	Illinois 6	Eagle Butte	FBCs	Gasifiers
Aerodynamic mmd, μm	11 to 27	15	13 to 16	18	16	1.8	1.3 to 30	No data
Specific surface area, m^2/g	2.6 to 32	69	240 to 350	300	112	323	4.2 to 24	88
True density, g/cm^3	2.8 to 3.3	2.3	2.3	2.1	2.0	2.2	2.6 to 3.0	2.1 to 2.6
Uncompacted bulk porosity, %	74 to 84	No data	No data	No data	88	92	72 to 89	92
Compacted bulk porosity, %	No data	No data	No data	No data	75	80	70	71 to 92
Tensile strength, N/m^2	2.6 to 2.8	0.5	0.4 to 0.8	1.3	0.15	1.4	1.8 to >13	4.0
Gas flow resistance, in. $\text{H}_2\text{O} \cdot \text{min} \cdot \text{ft}/\text{lb}$	No data	No data	No data	No data	3.5	35	0.8 to 8.4	2.3 to 150
Drag-equivalent diameter, μm	No data	No data	No data	No data	1.1	0.26	0.6 to 20	0.1 to 0.7
Loss on ignition, %	2.0 to 23	40 to 47	No data	No data	No data	No data	0.6 to 16	1.6 to 78

a

b

c

d

Figure A-1. SEM Photographs of Particles Produced by the TRTU in the Combustion Mode
(photographs taken at magnifications of 100, 500, 1000, and 5000)

152-5

a

b

c

d

Figure A-2. SEM Photographs of Particles Produced by the TRTU in the Gasification Mode
(photographs taken at magnifications of 100, 500, 1000, and 5000)

larger particles in the combustion sample are cenospheres, which behave like smaller particles aerodynamically.

The particle shapes are generally irregular in both the TRTU combustion sample and the TRTU gasification sample. Both samples contain some particles that appear to be highly porous and other particles that appear to be relatively nonporous.

Figures A-3 and A-4 show SEM photographs of particles produced by the carbonizer pilot plant using the Illinois No. 6 coal and the Eagle Butte coal. Comparison of the two sets of photographs suggests that the Illinois coal tends to produce larger particles than does the Eagle Butte coal.

The particle shapes are generally irregular in both the Illinois sample and the Eagle Butte sample. Both samples contain some particles that appear to be highly porous and other particles that appear to be relatively nonporous. As with the TRTU samples, a small fraction of the carbonizer particles appear to be partially fused, even though the operating temperature of the carbonizer is well below the ash fusion temperature for either coal. In the Eagle Butte sample, many of the particles appear to be shards created by the explosion of cenospheres, although there are no cenospheres evident in the Eagle Butte sample. The presence of shards in the absence of cenospheres may mean that all of the cenospheres have exploded. Neither shards nor cenospheres are evident in the Illinois sample.

The carbonizer particles discussed above were produced at a freeboard pressure of 132 lb/in². After the characterization of these particles was done, it was learned that this freeboard pressure corresponded to a low-load condition at Wilsonville. (The freeboard pressure is expected to be about 190 lb/in² at full load.) Since the effect of freeboard pressure on the particle characteristics is unknown, SRI recommended to SCS that SRI characterize one of the samples produced at a freeboard pressure of 190 lb/in². A sample obtained from the cross-flow filter drain during the higher pressure run was characterized, and the results were compared to the results obtained with the cross-flow drain sample from the lower pressure run. The comparison cannot be used to determine the effect of the change in bed pressure alone, because the bed temperature was higher at the higher pressure: 1700°F at 190 lb/in² versus 1600°F at 132 lb/in². The comparison, summarized below, showed only minor differences in the characteristics of the particles produced at the two conditions.

<u>Particle Characteristic</u>	<u>132 psig, 1600°F</u>	<u>190 psig, 1700°F</u>
Aerodynamic mass mean particle size, mm	16.1	19.2
Specific surface area, m ² /g	112	157
Drag-equivalent diameter, μm	1.13	1.20
Relative gas flow resistance, in H ₂ O•min•ft/lb	3.5	3.3
Compacted bulk porosity, %	75	74
Uncompacted bulk porosity, %	88	87
True (skeletal) density, g/cm ³	2.04	2.17
Tensile strength, N/m ²	0.15	0.08

a

b

c

d

Figure A-3. SEM Photographs of Particles Produced in Carbonizer Pilot Plant Using Illinois No. 6 Coal

(photographs taken at magnifications of 100, 500, 1000, and 5000)

a

b

c

d

Figure A-4. SEM Photographs of Particles Produced in Carbonizer Pilot Plant Using Eagle Butte Coal

(photographs taken at magnifications of 100, 500, 1000, and 5000)

Based on our experience, SRI would not expect the differences shown above to produce significant differences in PCD performance.

APPENDIX B

ALKALI COLLECTOR DESIGN INFORMATION

Figure B-1. Design Curves for Alkali Collector (Bauxite Cartridge)

Figure B-2. Equilibrium Alkali Vapor Concentration as a Function of Temperature

APPENDIX C

**PARTICULATE SAMPLING PRELIMINARY DATA LOGGING
REQUIREMENTS**

Table C-1. Tentative Data Logging Needs

Description	Number	Sample Interval	Averaging Interval #1	Averaging Interval #2	Special Data Storage Interval	Store Data For	Resolution	Data Type
Particulate Emissions	20	1 sec	10 min.	1 hr.	1 sec.	1 month	1%	Integer
Sampling Temperatures	32	60 sec	10 min.	1 hr.		1 month	1 °F	Integer
Sampling Pressures	32	60 sec	10 min.	1 hr.		1 month	0.1 H ₂ O	Real
Sampling Flows	16	60 sec	10 min.	1 hr.		1 month	0.01 CFM	Real
Process Temperatures	36	60 sec	10 min.	1 hr.		1 month	10 °F	Integer
Process Pressures	36	60 sec	10 min.	1 hr.		1 month	1 PSI	Integer
Process Flows	36	60 sec	10 min.	1 hr.		1 month	10 CFM	Integer
Trace Gas Emissions	36	60 sec	10 min.	1 hr.		1 month	10 ppm	Integer
Process Differential Pressures	12	60 sec	10 min.	1 hr.		1 month	1 in. H ₂ O	Integer
Coal Feed Rate	2	60 sec	10 min.	1 hr.		1 month	10 lb/hr	Integer
Limestone Feed Rate	2	60 sec	10 min.	1 hr.		1 month	10 lb/hr	Integer
Air and Steam Flow	2	60 sec	10 min.	1 hr.		1 month	10 lb/hr	Integer
Gas Composition	144	60 sec	10 min.	1 hr.		1 month	1%	Integer
Face Velocity (calculated)	2	60 sec	10 min.	1 hr.		1 month	1 ft/min	Integer
Ca/S Ratio (calculated)	2	60 sec	10 min.	1 hr.		1 month		Integer
Thermal Input (calculated)	2	60 sec	10 min.	1 hr.		1 month		Integer
Pulse Frequency	4	Counter	10 min.	1 hr.		1 month	N/A	Integer
Pulse Pressure	4	Event-driven					10 PSI	Integer
Pulse Flow Rate	4	Event-driven					CFM	Integer
Purge N ₂ Flow Rate	16	60	None	None	Not stored			
Purge N ₂ Pressure	16	60	None	None	Not stored			

Storage of 420 tags each 10 min. = 24x6 pts/day x [(2 bytes/pt x 372) + (4 bytes/pt x 48)] = 134,784 bytes/day
Storage of 420 tags each hour = 24 pts/day x [(2 bytes/pt x 372) + (4 bytes/pt x 48)] = 22,464 bytes/day
Storage of 20 Part. Emission tags, once per second, all integers = 20 tags x 2 bytes/pt x 86400 pt/day = 3,456,000 bytes/day
Total daily storage: 3,613,248 bytes/day

Monthly storage: 108,397,440 bytes

KELLOGG TRANSPORT REACTOR SYSTEM

FEED RATES, lb/hr		Coal	Limestone	Air	Steam	Calculated Thermal Input, Btu/hr: XXX,XXX,XXX							
		XXXX	XXXX	XXXXXX	XXXX	Calculated Ca/S Ratio, mole/mole: X.XX							
FUEL/FLUE GAS		Temp, °F	Press, psig	Flow, acfm	Flow, scfm	Flow, lb/hr	%H2	%CO	%CO2	%H2O	%O2	%N2	ppm H2S
Reactor Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Heat Exchanger Inlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Heat Exchanger Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Cyclone Inlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Cyclone Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
PCD Inlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
PCD Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Thermal Oxidizer Inlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Thermal Oxidizer Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Baghouse Inlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Baghouse Outlet		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
Stack		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX
		XXXX	XXX	XXXX	XXXX	XXXXXX	XX	XX	XX	XX	XX	XX	XXX

Type of PCD XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXX

No. of Filter Elements XX Pulses/hr XX

Total Filter Area, ft2 XXX Pulse Gas XXXXX

Delta P Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

Alarm/OK

RECENT TRENDS

PCD Delta P, in. H2O
(FS = 200 in. H2O)

Face Velocity, ft/min
(FS = 10 ft/min)

Opacity, %
(FS = 25%)

Sniffer Delta P, psi
(FS = 10 psi)

Pulse Pressure, psig
(FS = 1000 psig)

Figure C-1. Example Screen Display for Process Status and History Terminal

END

DATE
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