1 of 1

RECEIVED
SOUTHERN COMPANY SERVICES
JAN 5 11 01

POWER SYSTEMS DEVELOPMENT FACILITY

QUARTERLY TECHNICAL PROGRESS REPORT JANUARY 1 - MARCH 31, 1993

Prepared by:

SOUTHERN COMPANY SERVICES, INC.
800 Shades Creek Parkway
P. O. Box 2625
Birmingham, Alabama 35202-2625

Work Performed Under DOE Cooperative Agreement No. DE-FC21-90MC25140

THE UNITED STATES DEPARTMENT OF ENERGY
Morgantown Energy Technology Center
3610 Collins Ferry Road
P. O. Box 880
Morgantown, West Virginia 26507-0880

MASTER *dk*

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

POWER SYSTEMS DEVELOPMENT FACILITY
QUARTERLY TECHNICAL PROGRESS REPORT
JANUARY 1 - MARCH 31, 1993

TABLE OF CONTENTS

1.0 INTRODUCTION AND SUMMARY	1-1
2.0 REVIEW OF TECHNICAL PROGRESS	2-1
2.1 Project Management	2-1
2.2 Phase 1 - Conceptual Design Activities	2-1
2.2.1 Task 1.4 Transport Reactor Development Unit	2-1
2.3 Phase 2 - Detailed Design Activities	2-2
2.3.1 Task 2.1 Detailed Design	2-2
2.3.1.1 MWK: PSDF Transport Train	2-2
2.3.1.2 FW Team Activities	2-4
2.3.1.3 Balance-of-Plant Activities	2-5
2.3.2 Task 2.2 Facility Design Document	2-7
2.3.3 Task 2.3 Environmental Permitting and NEPA Support	2-7
2.3.4 Task 2.4 Particle Characterization and Collection	2-9
2.3.5 Task 2.5 Particle Control Technologies	2-10
2.4 Publications and Presentations	2-11
3.0 PLANS FOR FUTURE WORK	3-1
APPENDIX A: PARTICLE CHARACTERIZATION AND COLLECTION	A-1
APPENDIX B: PARTICULATE CONTROL DEVICES SELECTION REPORT	B-1

1.0 INTRODUCTION AND SUMMARY

This quarterly technical progress report summarizes work completed during the Tenth Quarter of the First Budget Period, January 1 through March 31, 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 continuing the detailed design of the facility, finalizing the selection for the Carbonizer/Transport and the circulating pressurized fluidized-bed combustor (CPFBC) particulate control devices (PCDs), drafting the air permit for the facility and continue the installation of the transport reactor development unit (TRDU). The Continuation Application for Budget Period No. 2 was submitted and negotiated with DOE. The detailed design of the PSDF continued to refine interface points to streamline the design of the facility. Structural, process, electrical, instrumentation and controls, and mechanical information were exchanged between the engineering design team. SRI continued the design of the particulate sampling systems for the PSDF, working with the engineering design team and developing a plastic model of the sampling train. The proposals for the CPFBC PCDs were reviewed by the project review team and the final selection of the PCDs were agreed upon between SCS and DOE. Each of the project team prepared input to the Facility Design Document for the 25 percent detailed design mark. SCS continued to support DOE/METC in the DOE NEPA process. Additional emissions data was

supplied by project design team and a draft of the air permit was prepared and submitted for internal review within SCS. The installation of the TRDU continued at a reduced pace due to cost overruns caused by mechanical correction and shipping delays to the reactor spool pieces.

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 the submission and negotiation of the Continuation Application for Budget Period No. 2 and the initiation of the contract negotiations with the PCD vendors.

A letter agreement between FW and SCS was extended through April of 1993. Negotiations are continuing between FW and SCS to amend the FW subcontract established in the conceptual design to include the detailed design work scope. The amendments to the MWK and SRI subcontracts for the detailed design expansion were completed during this time period.

The end date for Budget Period No. 1 was extended by 30 days to April 13, 1993 by DOE for administrative reasons. SCS continued to supply DOE with addition backup information to clarify any questioned cost items in the continuation application prior to the negotiations. Negotiation for the Continuation Application for Budget Period No. 2 were completed in late March.

SCS initiated the contract negotiations with the selected PCD vendors for the project. Draft subcontracts were sent to Combustion Power Company, Industrial Filter & Pump and Westinghouse in March for their review. SCS continues to negotiate with the PCD vendors and expects to have subcontracts in place in the second quarter of 1993.

The first meeting for the PSDF steering committee was held on March 9 at the SCS offices in Birmingham, Alabama. The primary focus of the meeting was to determine the modus operandi for the steering committee and receive a status update on the project. The steering committee consist of representatives from DOE, EPRI, SCS and American Electric Power Company.

2.2 PHASE 1 - CONCEPTUAL DESIGN ACTIVITIES

2.2.1 Task 1.4 Transport Reactor Development Unit

M. W. Kellogg reviewed the design by EERC of the coal and limestone feed injector for the TRDU. It was found that the design did not follow MWK's recommendation that a solids to gas ratio of approximately 5:1 be used. After extensive consultation with EERC regarding their concerns, the injection nozzle size was increased so that a solids to gas ratio of 2 - 1.6:1 could be used. It was also recommended that a 4" solids feed pipe be connected to the smaller diameter feed injector by means of an eductor with a smooth transition from the larger diameter to the smaller diameter section.

The TRDU test program was revised incorporating comments from both EERC and

SCS. The test program was revised to provide for verification of the Wilsonville Transport Reactor system during the first stages of the test program. The startup, shutdown, and operating philosophy was also revised to include comments from both SCS and EERC.

M. W. Kellogg reviewed requirements for the cyclone dipleg heater and also reviewed the materials recommendations made by EERC. M. W. Kellogg recommended that a heating cable that can tolerate high temperatures be used (such as Brisket Heat KK-CAB). Such a cable is required due to the possibility that the reactor shell temperature may exceed the limits of other cables under certain conditions.

M. W. Kellogg continued in their support of EERC in the installation of the TRDU. Major efforts revolved around solutions to fabrication problems and selection of the cyclone dipleg heater. Kellogg reviewed the history of the TRDU and prepared a list of backcharges to the TRDU spool piece manufacturers for correcting fabrication errors.

Installation of the TRDU has been ongoing at the EERC. About 80% of the spool pieces have been installed and it was found that the top pieces were off by about an inch in elevation. There were some rotational discrepancies as well. This problem will be solved by cutting off the flange on the top overhead piece and rewelding it in place properly. All the pieces except two, have had their refractory poured and they have been partially cured. All of the spring cans are in place. Work is continuing on the piping installation for coal, steam, nitrogen feed, ash withdrawals, gas conditioning systems. Due to spool piece manufacturing defects the project has incurred some cost growth. Negotiations are being conducted between Kellogg, EERC, and SCS to determine the exact magnitude of the cost growth, responsibilities for its resolution, and its impact on the project.

2.3 PHASE 2 - DETAILED DESIGN ACTIVITIES

2.3.1 Task 2.1 Detailed Design

2.3.1.1 MWK; PSDF Transport Train

During the development of a preliminary Start-up, Shutdown and Operating Philosophy, a number of areas were uncovered which could be improved with regard to operability, reliability, availability and maintainability. Following is a brief description of these areas and the suggested improvements.

In the original design, spent solids were cooled to 600° F using a fluidized bed cooler in the case of the spent solids from the reactor, and jacketed pipe for the PCD solids. To simplify the design, and reduce the cost of the depressurization and solids discharge systems, it was recommended that the solids be cooled to 300° F utilizing Holo-flite screw coolers. Additionally, to provide control of the process side temperatures, it was

also recommended that a closed-loop heat transfer fluid be employed to remove the heat from the screw coolers.

Solids charging and discharging systems were originally conceived using lockhopper valves which are subject to a large number of cycles, or alternatively, large lockhoppers in order to increase the cycle time on the valves. Investigations into experienced suppliers indicated that it might be more prudent to utilize vendor proprietary designs for systems which had been proven in similar service, instead of designing the system in-house on a component by component basis. In addition to improving the operability of the system, the use of the vendor designed transport systems for discharged solids replaced gravity flow systems with pneumatic transport, thereby, reducing the elevation of Transport Reactor system and auxiliaries.

The original configuration of the Primary Gas Cooler permitted operation over the stated range of 1000°F to reactor discharge temperature in finite steps. This was accomplished by inserting appropriately sized restriction orifices during a shutdown. It was recommended that the use of internal or external bypasses be considered which would provide for a continuous range of operating temperatures that can be varied during operation. MWK is assembling cost data for SCS to evaluate the alternatives.

The design of the Transport Reactor system is based on delivering 1000 acfm of gas to the PCDs over the above mentioned range of temperatures. To accomplish this, the delivery pressure to the PCDs must vary directly with the temperature. As originally configured, the pressure letdown was to be accomplished stepwise by changing restriction orifices during unit shutdowns. Should it be decided to implement the Primary Gas Cooler Bypass, as described above, a variable pressure control device should be installed which would permit the pressure at the PCDs to be varied on-line over a continuum.

A new conceptual arrangement drawing was developed utilizing the most recent equipment sizes and the solids transport systems described above. The result of this update was that the footprint of the required structure was reduced from 4X2 bays to 3X2 bays, with attendant decreases in the cost of steel and concrete.

Several tasks were completed, they were: (i) the analytical design of the Steam Drum DR0402, but was not issued for review, (ii) list of control valves for vendor selection and (iii) issue 1 of P&ID drawings. MWK started developing the Battery Limit Summary to define all streams, both process and utilities which cross between MWK's and SCS' areas of responsibility.

Requisition packages issued in the Fall quarter are currently being reviewed technically for the Startup Burner, the Thermal Oxidizer and the Sulfator Cyclone. The Main Air Compressor has been technically reviewed. New requisitions for the Sulfator Startup Heater and the Disengager are currently being reviewed technically. Approximate delivery dates ranged from 24 to 34 weeks.

2.3.1.2 FW Team Activities

The Phase II detail engineering/procurement phase is proceeding (without release of any material for purchase). The project is on schedule for the activities to be initiated or completed during this report period. The following events were achieved:

- Budget Revision Information was coordinated with FWEC, FWDC, Allison and Westinghouse.
- A Project Review meeting was attended on February 2-3 in Birmingham, Alabama.
- Attended meetings with SCS to review and integrate coal and sorbent preparation and feed systems design. Requisitions for new Coal and Sorbent Surge Hoppers were developed.
- Meetings were held with SCS to define the close interdependence between FW piping design and SCS civil design. Updated arrangement drawings, equipment elevation tabulation and equipment load tabulations were issued to SCS. Preliminary loading data for the refractory lined pipes was issued. A layout drawing for vertical piping, looking East at Column "A" was also issued.
- A "25% Design Package" was issued to SCS, complete with all equipment requisitions.
- Nine Design change Notices were issued.
- Reviewed with SCS and deleted the APFBC condensate tank, exchanger and pumps. These will be part of SCS's "Balance of Plant" condensate system.
- Updated PDS file disks were issued to SCS.
- All job specs were issued and have been updated per SCS comments.
- SO_x, NO_x, and CO data for the Air Permit Application were provided to SCS.
- FWUSA's document defining the "HAZOP Procedure" was forwarded to SCS.
- The Fluid Bed Combustor system design requisition was issued to FWEC.

The status of the Westinghouse Topping Combustor was reviewed with SCS and FWDC. A potential problem exists with the topping combustor test program by Westinghouse. The long lead impact of both the turbine/generator and the topping combustor's fabrication/delivery cycle may require schedule adjustments in the future.

2.3.1.3 Balance-of-Plant Activities

During the first quarter of 1993, the primary activities of SCS Engineering included a review of drawings and specifications from MWK, FW and SRI, design and preparation of specification package for maintenance/warehouse building and coal preparation system. Further information was gathered in preparation for detailed design of process structure, foundation, utilities and control systems. A design status meeting was held with MWK, FW and SRI on February 2-3 in which all areas (from area 100 to 4000) were reviewed. A summary of activities carried out in the first quarter of 1993 is given below:

- Reviewed Foster Wheeler (FW) and M. W. Kellogg (MWK) drawings and specifications. Twenty-four (24) documentation packages containing some 89 drawings or specifications were reviewed and appropriate comments were noted on most of them. Continued review of M. W. Kellogg's Revision 5 of the Design Basis Document and process flow diagrams along with the 28 issued P&ID's. An engineering review and comments were provided to FW, MWK and SRI on drawings specifications and purchase requisitions related to their scope of work.
- Detailed discussions on the warehouse and maintenance shop were held. The Chemical Lab and the locker rooms were relocated to the warehouse/-maintenance building, and requirements for the locker rooms and lab furniture and equipment were established. Civil Engineering started working on the Architectural drawings for the Warehouse/Maintenance Building. Work continues on the inquiry/specification and the heating, ventilation and air conditioning design and drawings. Also, detailed drawings of the base slab for the warehouse has begun. Completed specification input and detail design of electrical aspects of the Warehouse/Maintenance Facility. Twelve electrical drawings and a Bill of Materials were completed. Ductwork and equipment layout drawings are being finalized for sign-off. Design was completed on the fire protection requirements for the warehouse/maintenance building.
- A Power Systems Development Facility Design status meeting was held in the SCS Birmingham office on February 2 and 3, 1993. Attendees were MWK, FW, SCS and SEI personnel. Each area from Feed Preparation (100) to Buildings and Structures (4000) was reviewed for scope changes, operability and sharing of design information between the Project Team. An updated construction and procurement schedule was issued for the new startup date of January 1995.
- Continued discussions with new project contact at Alabama Power Company regarding service connection, substation, transformer size, etc., even though they have not been released for work.
- Compiled information on site, water balance, plant discharges, waste streams and run-offs for use in environmental permitting. Determined that the

construction acreage for the site is less than 10 acres; therefore, no construction site run-off settling pond is required.

- Compiled information for FW on coal and sorbent feed streams and auxiliary fuel (propane) system. The SCS Design Engineering Civil and Mechanical lead engineers met with Foster Wheeler on February 23 and 24, 1993 in the Livingston, N.J. office. The purpose of the meeting was to discuss the coal and limestone handling systems process flow diagrams for interface points, design/-operation/maintenance issues and process structural interface between SCS and Foster Wheeler. Discussed with Foster Wheeler the size and location of the coal surge hopper in the FW portion of the Process Structure.
- Design continued on the development of the feed preparation systems. Met with operations and research personnel to determine the operation requirements for the feed preparation area. Outside plants were visited and contacted to determine the reliability of small coal pulverizing systems. Discussions continued with Foster Wheeler and M. W. Kellogg concerning the process requirements and transfer interfaces for the feed preparation systems. Prepared sizing calculations on the feed storage bin and hoppers. The feed preparation systems process flow diagrams were revised to indicate the current design philosophy.
- The grinding mill requirements were developed for the pulverizer technical procurement specification. Also, defined the coal and limestone system design parameters based on updated design input from FW and MWK and are in the process of issuing technical requirements.
- Compiled information for structural model (FW, SCS, and MWK equipment loads). Received the rough draft for the specification for the drilled pier foundations for the Process Structure.
- Investigated the interferences for proposed piping with the Process Structure building steel and the overhead crane.
- Began reviewing the proposed concept of using an overhead crane in the Process Structure vs. using a gantry crane located on the roof of the structure. Began a crane layout sketch to be used in preliminary talks with crane vendors.
- Received Agglomeration Site surveying benchmark information from SCS R&EA to be used for PSDF site. Walked down the Agglomeration Site and identified underground piping and structures as they will apply to PSDF design. Investigated methods of closing observation wells at the site.
- SCS Design engineering, R&EA and SRI met to discuss and review the location and technical requirements for the PCD test sampling ports. Hosted a meeting with MWK, SRI & SCS to discuss engineering interfaces and design problems.

Provided sampling port location guidance to FW based on SRI input.

- **Investigated the products and current installations of several potential control system suppliers for applicability to the facility including discussions with vendors and experienced SCS controls personnel. Visited current installation of a potential control system supplier for the PSDF facility.**
- **Completed an initial investigation of the usability of the micro-computer based cable routing system for the project.**
- **Reviewed BOP utilities requirements. Detail design of the cooling tower, service water and boiler feed water systems were initiated. Initial efforts were aimed at collecting the current requirements of the Foster Wheeler and M.W. Kellogg processes. Continued collecting Balance of Plant requirements from Foster Wheeler and M. W. Kellogg for updating the SCS design requirements. Revised the Design Basis Document based on current information collected to date for the 25% design point.**

2.3.2 Task 2.2 Facility Design Document

Towards the end of the first quarter of 1993, facility design document preparation was initiated to reflect 25% completion point of the detailed design of the facility. Four volumes of design documents are being prepared. Volumes I and II will contain design information on the MWK's transport train and FW's APFBC train, respectively, and the balance-of-plant design is covered in Volume III. Volume IV includes a discussion on particulate control devices selected for testing at the facility as well as details of the particulate and alkali sampling systems. Each design document is organized by relevant design areas. A list of design areas is shown in Table 2-1. These design volumes will be periodically updated as the design progress to completion. The design volumes will be submitted to DOE, EPRI and other project team members by second week of April for review and comments. A meeting will be held at DOE/METC on April 26 and 27 to review design progress and address interface issues with PCD developers.

2.3.3 Task 2.3 Environmental Permitting and NEPA Support

The first draft of the Air Permit application for the PSDF was issued for internal SCS review on February 18, 1993. The reviewers included SCS Engineering, SCS Research and Environmental Affairs, SCS Environmental Assessment Group, and Alabama Power Company. Comments were received back from the reviewers by March 1 and most have been incorporated into the Air Permit Application. The coal and limestone handling systems were reviewed and their emissions have been accounted for and included in the Air Permit. SCS expects to submit the Air Permit application to the Alabama Department of Environmental Management (ADEM) by the first week of May, 1993.

TABLE 2-1
POWER SYSTEMS DEVELOPMENT FACILITY AREA DESIGNATION

<u>AREA</u>	<u>DESCRIPTION</u>
100	FEED PREPARATION
200A 200B	TRANSPORT REACTOR GAS GENERATOR IN FW'S APFBC SYSTEM
300A/B	PARTICULATE CONTROL DEVICES
400A 400B	COOLING AND TREATMENT OF GAS IN MKW TRAIN TOPPING COMBUSTOR AND GAS TURBINE
500A	TRANSPORT REACTOR ASH HANDLING
600	SULFATOR (MWK TRAIN IN GASIFICATION MODE)
700	FINAL GAS TREATMENT
800A 800B	TRANSPORT REACTOR ASH DISPOSAL APFBC ASH DISPOSAL
900D	FUEL CELL
1000	INSTRUMENTATION AND DATA ACQUISITION
2000	UTILITIES: 2000 Boiler feedwater and steam systems 2100 Service Area (Cooling Water) 2200 Service/instrument air system 2300 Auxiliary fuel system 2400 Fire protection system 2500 Wastewater treatment system 2600 Nitrogen system 2700 Water treatment/chemical feed systems 2800 Safety/security systems 2900 Miscellaneous Utilities
3000	ELECTRICAL: 3000 Power Distribution 3001 Control & data acquisition circuitry 3002 Lighting 3003 Communications 3004 Heat tracing/freeze protection
4000	BUILDINGS AND STRUCTURE/PLOT DIAGRAMS
5000	SRI PARTICULATE AND ALKALI SAMPLING

The review process with ADEM is expected to take from 60 to 90 days.

By March 1, 1993, we had received emissions data from M.W. Kellogg and Foster Wheeler about CO, SO_x, and NO_x. These latest values have been incorporated into the Air Permit application. Based on this information, the PSDF is a non-major emission source and does not come under a Prevention of Significant Deterioration (PSD) review.

The flare issue was discussed and a decision was made to include two flares in the Air Permit Application. They will serve as air pollution control devices. Supporting the flare issue was modeling data which indicated that ambient air standards for HCN and H₂S would be violated in one hour of by-pass operation with both the Thermal Oxidizer and the Foster Wheeler Topping Combustor.

As required by regulations, a Public Notice for stormwater construction was placed in the Birmingham News on April 15, 1993. The News will send an affidavit of publication which will be included in the stormwater permit application. The stormwater construction permit is expected to be filed by beginning of May. The review process should take about 45 days.

The National Pollutant Discharge Elimination System (NPDES) Permit for the Clean Coal Research Center at Wilsonville expires in November 1993. The ADEM requires that the renewal be submitted six months in advance of permit expiration which sets a renewal date for June 1993. The permit will be renewed and modified to accommodate the discharges for the PSDF.

Process information and site data were provided to DOE in support of preparation of the Environmental Assessment report. Input was obtained from SCS Research and Environmental Affairs staff, SCS Engineering staff, subcontractors working on each train, and Alabama Power Company personnel.

2.3.4 Task 2.4 Particle Characterization and Collection

In the first quarter of 1993, work under this task focused on the detailed design of the particulate sampling system, the requirements for piping layout and ports, and the evaluation of particulate monitors. The general arrangement drawings of the particulate sampling system were modified by SRI to incorporate changes suggested by SCS and to provide information needed by FW and MWK to design the sampling ports in their respective trains. SRI representatives met with the SCS and MWK project engineering teams to discuss SRI's requirements for piping layout and ports. As a result of that meeting, SRI marked all sampling and monitoring systems on the MWK piping and instrument diagram (P&ID).

SRI continued to work with DTM on the production of the plastic pattern for the casting of the cyclone manifold and bauxite cartridge. Inspection of the first pattern produced

by DTM revealed that the inlet tube for the second cyclone was too short. This problem was corrected in the AutoCAD file, and a second pattern was produced in late March. A parts list for the particulate sampling and monitoring systems were prepared and submitted the list to a vendor who will specify the commercial components and prices.

In this quarter, detailed design information and drawings of sampling systems were prepared for inclusion in the facility design document. Further details of work performed under this task is given in Appendix A.

2.3.5 Task 2.5 Particle Control Technologies

During this reporting period the particulate control device vendors for the PSDF were selected. The project team's recommendations concerning the procurement of PCDs were presented at the design status meeting at SCS on February 2 and to DOE at a meeting between SCS and DOE on February 4. In subsequent discussions with DOE, it was decided not to defer the procurement of the second PCD for the MWK train as was recommended by the project team. Based on DOE and project team's recommendations, the selection of PCDs for the MWK and FW trains is as follows:

- Combustion Power Company granular bed filter on MWK transport reactor
- Industrial Filter & Pump (IF&P) lightweight ceramic candle filter on FW carbonizer
- Westinghouse candle filter on FW combustor
- Westinghouse cross-flow filter on MWK transport reactor

A complete report explaining the selection process has been prepared by SCS. This report is included in Appendix B. The PCD vendor selection is subject to adequate cost sharing and successful contract negotiations with SCS. SCS has made progress in contract negotiations with the successful vendors and hope to complete the process by May.

On March 30, SRI and SCS discussed the handling of proprietary information from the PCD vendors. DOE provided input on information pertaining to PCDs that should be considered for publication during operations in order to understand and better evaluate the PCD's performance characteristics. The contracts with the PCD vendors should include a requirement that SCS be allowed to publish all performance data (collection efficiency, pressure drop, face velocity, cleaning parameters, particle characteristics, temperature drop, and material and energy balances). SCS should also be allowed to publish the arrangement, geometry, dimensions, and general description of the filter elements; the general arrangement drawings of the PCD and subsystems; photographs of the PCD installation; and any evidence of structural failures or degradation of filter materials. Any details of the filter element manufacturing process or any details of the flow and pressure distributions within the PCD should be considered as proprietary.

2.4 PUBLICATIONS AND PRESENTATIONS

1. "Power Systems Development Facility"
Presented at Engineering Foundation's Conference on Environmental and
Economic Aspects of Coal Utilization - V, Santa Barbara, CA
Presented by T.E. Pinkston.

3.0 PLANS FOR FUTURE WORK

1. Complete the installation of the TRDU and begin shakedown of the unit.
2. Determine the cost overruns for the TRDU and impacts on future operations.
3. Prepare and submit the air permit application and construction stormwater management permit for the PSDF to Alabama Department of Environmental Management (ADEM). Modify and renew the existing National Pollutant Discharge Elimination System (NPDES) permit to accomodate water discharges from PSDF.
4. Conduct the 25 percent detailed design meeting with DOE and submit the updated Facility Design Documents for the 25 percent design point.
5. Continue the detailed design of the PSDF.
 - FW will continue to work on the P&IDs, stress studies of layout arrangement, the detailed design of the Carbonizer, and requisitions for equipment and instrumentation. Plant sampling requirements including sampling by SRI at the PCDs will be reviewed.
 - MWK will continue to work on piping layout and design of transport reactor nozzles, combustor heat exchanger, sulfator and reactor solids withdrawal system.
 - SRI will continue to work on the detailed design of the particulate and alkali sampling system, prepare assembly and fabrication drawings for the sampling system and establish contacts with potential fabricators and vendors of system components.
 - SCS will continue to work on the design of the process structures, prepare inquiry packages for the Warehouse/Maintenance and Administration/Control building and review P&IDs from FW and MWK.
6. Finalize the subcontract negotiations with FW and the PCD vendors.
7. Start integrating the PCDs into the design of the facility.
8. Finalize the approval of the Continuation Application for Budget Period No. 2 with DOE.

APPENDIX A
PARTICLE CHARACTERIZATION AND COLLECTION

Appendix A

Particle Characterization and Collection

A.1 Detailed Design Interface (Task 2.4.1)

Under this task, SRI is 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. In February and March, SRI participated in several meetings with SCS and MWK to address sampling requirements.

SRI presented an overview of the particulate sampling system and the plans for PCD evaluation at the Design Status Meeting held on February 2 and 3. As a result of the meeting, SRI was assigned responsibility for the following action items:

- Prepare and submit a general arrangement drawing of the sampling system showing the required dimensions of the sampling port and the system dimensions and weight
- Submit a list of motors and electrical loads for the sampling system
- Submit a list of equipment that requires emergency backup power
- Assess the need for a metal shroud inside the refractory-lined piping at the exit of the PCD in the transport train. (The piping in FW APFBC train will have metal shrouds to protect the turbine.)

The first three action items listed above have been accomplished. The general arrangement of the sampling system and the electrical loads are described in the discussion of Task 2.4.2, Particulate Sampling Equipment.

SRI reviewed with SCS the recommendations for sampling and monitoring ports on February 17 and 25. The recommended ports for the FW and MWK trains are illustrated in Figures A-1 and A-2. The functions and internal diameters (I.Ds) of the ports are given in Table A-1. This information was used to mark the physical locations of the various ports on FW's latest piping layout. It will be used to mark the ports for the MWK train once the piping layout is completed. The philosophy behind the port locations was discussed in detail. It was decided to defer any decisions on locations for the transmissometer, outlet extractive monitor, and other optical monitor until FW provides information on their potential locations. SCS forwarded the marked-up piping layout to FW so that the sampling and monitoring ports can be incorporated on the official FW drawings.

SRI presented the latest general arrangement drawing of their sampling system and

Figure A-1. Conceptual Sketch of Sampling and Monitoring Ports in the MWK Train

Figure A-2. Conceptual Sketch of Sampling and Monitoring Ports in the FW Train

Table A-1. Sampling and Monitoring Ports in the Kellogg and Foster Wheeler Trains

Number on Drawing	Type of Probe or Monitor	Type of Operation	Location	Number of Ports Required		Access ID, in. ^a
				Kellogg	Foster Wheeler	
1.	SRI cyclone/alkali probe	Batch Access	PCD inlet	1	2	6
1a.	Access port for above		PCD inlet	1	2	6
2.	SRI impactor/alkali probe	Batch Access	PCD outlet	1	2	6
2a.	Access port for above		PCD outlet	1	2	6
3.	Westinghouse alkali probe	Batch	PCD inlet	1	2	6 ^b
			PCD outlet	1	2	6 ^b
			Alkali getter outlet	1 ^c	2	6 ^b
3a.	Alternate port at 3	Alternate	PCD inlet	1	0	6 ^b
			PCD outlet	1	0	6 ^b
4a.	Acoustic detector	Real-Time	PCD inlet	1	2	1
			PCD outlet	1	2	1
4b.	Sniffer	Real-Time	PCD inlet	1	2	4
			PCD outlet	1	2	4
4c.	Alternate port at 4a	Alternate	PCD inlet	1	0	1
			PCD outlet	1	0	1
5.	Transmissometer	Real-Time	PCD outlet	4	4	4
6.	Other optical monitor (e.g., BHA CPM-2000)	Real-Time	PCD outlet	2	4	6
7.	Extractive monitor	Real-Time	PCD inlet	1	2	4
			PCD outlet	1	2	4

a. Excluding any required refractory lining or insulation

b. To be specified by Foster Wheeler

c. Not applicable

explained the general arrangement and various design features of the system. They pointed out that the selection of ball valves was a major uncertainty in the design. The 6-in. I.D. of the sampling port implies a 6.625-in. bore for the refractory. The extra clearance is needed to allow for the pipe sleeve that inserts into the port. SRI stated that FW would have to specify the dimensions of the port nipple and flange, taking into account the moment exerted by the sampling system. It was agreed that the foregoing information should be included on SRI's general arrangement drawing.

SRI described the distribution of weight along the sampling system and indicated the uncertainty in the valve weights. SCS advised us to base our weight estimate on the heaviest valves, even though these valves will probably not be used in the sampling system. Also, SRI pointed out that the 120-volt stepper motor for probe insertion would require only a standard 15-amp breaker.

SCS pointed out that the off-site power should be very reliable, but, if it goes out, the outage could last several days. SCS also informed us that they will provide two forms of backup power: an uninterruptible power supply (UPS) and a diesel generator. SRI stated that they could not foresee any need for UPS backup of our systems, but they will require diesel backup to allow probe removal during an outage. A memo on SRI's needs for backup power for the sampling system was subsequently submitted to SCS.

SRI met with representatives of SCS and MWK on March 26 to discuss their requirements for sampling and monitoring ports. SRI briefed the MWK representatives on their requirements for straight runs of piping, limits on gas velocity, and preferred orientations of sampling and monitoring ports. At the request of MWK, SRI agreed to mark their requirements on the MWK piping and instrument diagram (P&ID). All of SRI's sampling and monitoring systems were marked on MWK Drawing No. 62-D016 (P&ID for particulate control devices). SRI also marked on the drawing the required straight runs of piping, the gas velocity requirements, and the inside diameters (I.D.s) of all ports. The marked-up drawing was reviewed with SCS on March 30 and will be reviewed with MWK at a meeting in Houston on April 7. MWK will incorporate the changes into the official P&ID and design the ports accordingly.

A.2 Particulate Sampling Equipment (Task 2.4.2)

During this quarter, SRI continued to work on the design of the particulate sampling systems and the evaluation of particulate monitors. Specific items that were addressed this quarter included: detailed design of the sampling probe and insertion mechanism; refinement of the general arrangement drawing; specification of electrical loads and backup power requirements; design of the cyclone assembly, bauxite cartridge, and probe insertion mechanism; evaluation of particulate monitors; and preparation of a parts list for the monitors and batch sampling systems. The work performed on each of these items is discussed below.

General Arrangement. The general arrangement of the particulate sampling system is shown in Figure A-3. This drawing incorporates the additional information suggested by SCS. The most critical dimension is the internal bore of the refractory, which must be 6.625 in. to allow insertion of a 6-in., Schedule-40 pipe sleeve into the port to serve as a liner. The overall length of the insertion mechanism is about 15 ft, and the total weight of the mechanism is about 4200 lbs. The outside diameter (O.D.) and length of the sampling port are to be determined by FW and MWK, taking into account the moment exerted by our sampling system. The pipe hangers that support the system are to be specified by SCS. All of the information discussed above is included in SRI's write-up for Area 5000, particulate sampling and monitoring, which will be included in the design document for the facility.

Detailed Design of Sampling Probe and Insertion Mechanism. In January, SRI developed various concepts for pressurizing the probe annulus between the inner sample tube and the outer support pipe. They decided to use a sheathed thermocouple and to run the sheath through a guide tube in the probe annulus. A potential source for the long, sheathed thermocouple was identified. SRI is checking on the availability of small-bore, Haynes tubing to use as the guide tube for the thermocouple and as the sample tube.

The probe insertion mechanism has been described in previous reports. The insertion mechanism is rigidly attached to the sampling port flange so that no net force is exerted against the process pipe. The insertion force is transferred to the probe by a yoke that pushes against a flange welded on the probe. The probe is free to move about 1/4 in. in all directions within the yoke. This freedom of movement allows the tapered flange on the bauxite cartridge to ride over surface irregularities within the casing during insertion and retraction of the probe. The mechanism that rotates the probe into its sampling position is designed to move along with the probe during insertion and retraction.

In January, SRI incorporated into the general arrangement the rigid connection to the sampling port flange and the floating rotation mechanism mentioned above. The condenser and condensate trap were also incorporated into the general arrangement. A swivel joint was incorporated at the outlet end of the probe to allow the probe to rotate while the condensate trap remains stationary.

Cyclone Assembly and Bauxite Cartridge. During this quarter, SRI continued to work on the design of the modular cyclone assembly and bauxite cartridge. AutoCAD files for the cyclone assembly and bauxite cartridge were submitted to DTM in January, and the first plastic pattern was received from DTM in February. During the inspection of the first plastic pattern, SRI noted that the inlet tube to the second cyclone was shorter than it is in the standard five-stage cyclone assembly. Since the shorter inlet tube could alter the performance of this cyclone, SRI decided to modify the design to provide the same inlet tube length used in the standard assembly. The modified AutoCAD file, incorporating the longer inlet tube, was submitted to DTM, and the second plastic pattern was received in late February. The second pattern was acceptable, except that

REFRACTORY TYPICAL

GAS STREAM

VIEW A

PORT FLANGE SIZE BY CHARGES

PORT SAMPLE SIZE BY CHARGES

PORT DETAIL

VIEW A

SUPPORT COUPLERS AS REQUIRED

NOTE-PROBE CASING TO BE 6INCH DIA SCH 40 HAYNES230 PIPE
FOR PURPOSES OF CALCULATION OF MOMENTS AT PORT ROOT WELD
SMALL VALVES SHOWN ARE CL 300 ANSI B16.5 /10/34 VALVE & ACTUATOR
MAX WEIGHT 1000LB EACH APPROX
6.625 DIA CORE READ TO FIT 6 INCH DIA SCH 40 M230 PROBE CASING

Figure A-3. General Arrangement of the SRI Batch Particulate Sampling System

one of the support ribs for the cyclone assembly was missing. SRI is now working with the AutoCAD files to determine the cause of the missing rib.

Electrical Loads. In February, SRI determined the electrical loads for the sampling system. Each insertion mechanism will be powered by a 120-volt, 1200-watt stepper motor. Each sampling system will include a 120-volt, 300-watt heater; a 120-volt, 100-watt data line interface; and five 120-volt, 100-watt solenoids. In accordance with the National Fire Protection Association (NFPA) code, the stepper motor will be explosion proof, and all switches and solenoids will be nonsparking. SRI's electrical load requirements are tabulated in the write-up on Area 5000 in the facility design document.

Backup Power Requirements. The sampling system will not require any UPS backup. However, since a loss of off-site power could last for several days, the insertion mechanism should have access to backup power from the diesel generator. The backup power would be needed only for the time required to retract the probe (estimated to be about 20 to 60 min). The backup power should be provided to the stepper motor, solenoids, and data line interface. We would not require backup power for the heater. Pressurized nitrogen for purging should be available at least until the probe is retracted.

Particulate Monitors. SRI continued to gather information on particulate monitors this quarter, with the objective of identifying those systems that are appropriate for use at Wilsonville. The systems that are under consideration include:

- Transmissometers (Lear Siegler, Data Test)
- Other optical monitors (BHA CPM-2000)
- Laser-based instruments (Malvern, Insitex PCSV, PMS)
- Triboelectric detectors (Auburn Triboflow)
- Acoustic detectors (Jonas)
- Active filters (Industrial Filter and Pump Sniffer)

Tentative plans for deploying the monitors have been given in previous reports. SRI is continuing to prepare a parts list for the particulate monitors and for the instrumentation associated with the batch sampling systems. This quarter, additional information on the Industrial Filter & Pump (IF&P) Sniffer was obtained, and SRI contacted Ceramem Corporation about producing a small, membrane-type filter for particulate monitoring. Preliminary estimates of thermionic emissions (electron boil-off) from the triboelectric detector at elevated temperatures were made. The preliminary results suggested that electron boil-off could interfere with the triboelectric detection of particles, especially at temperatures approaching 18000 F. SRI may explore the possibility of minimizing electron boil-off by coating the detector with a noble metal that has a large electronic work function.

A.3 Alkali Measurement and Collection (Task 2.4.3)

The particulate sampling train is being designed to include an activated bauxite cartridge after the cyclone assembly or cascade impactor. 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. The bauxite cartridge will be an alumina tube packed with 8 to 10 mesh, spherical pellets of activated bauxite. The bauxite cartridge will be mated directly to the outlet of the backup filter for the cyclone assembly or cascade impactor. This arrangement will allow the front portion of the cartridge to protrude into the process gas stream, while the back portion of the cartridge is surrounded by stagnant process gas in the sample port. SRI believes that this arrangement will allow them to maintain the bauxite at a temperature that is only slightly below the process gas temperature, thereby minimizing loss of the alkali on metal surfaces. Extensive work with these 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).

The metal shell of the bauxite cartridge will be cast as an integral part of the cyclone connection manifold. The plastic pattern that was made by DTM included the shell of the bauxite cartridge, the cyclone connection manifold, and ribs that support the cyclones. An alumina cyclinder will slip into the metal shell of the bauxite cartridge and serve as a liner to prevent loss of alkali vapor on the metal surface. Perforated alumina disks will be used at both ends of the alumina cylinder to ensure that the gas is uniformly distributed across the bauxite bed. One of the perforated disks will be fixed, and the other disk will be removable for filling the cartridge with the bauxite pellets. The details of the alumina liner are being developed; the design will depend upon the configurations available from suppliers of alumina components. SRI had planned to discuss our requirements for the alumina liner with various suppliers this quarter, but decided to defer these discussions until after work is finished on the pattern.

A.4 References

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.

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 B
PARTICULATE CONTROL DEVICES SELECTION REPORT

**PARTICULATE CONTROL DEVICE SELECTION PROCESS FOR THE
POWER SYSTEMS DEVELOPMENT FACILITY, WILSONVILLE, ALABAMA**

**Report prepared for the U.S. Department of Energy
Morgantown Energy Technology Center, Morgantown, West Virginia**

**Prepared by Southern Company Services, Inc.
Birmingham, Alabama**

April, 1993

INTRODUCTION

Southern Company Services in cooperation with the Department of Energy is designing an integrated energy research facility called the Power Systems Development Facility (PSDF) to be located at Wilsonville, Alabama. The intent of the PSDF is to provide a flexible test facility that can be used to develop advanced power system components, evaluate advanced turbine and fuel cell system configurations, and assess the integration and control issues of these systems. The facility would provide a resource for parametric long term testing and performance assessment of particulate control devices (PCDs) that operate in high temperature coal gasification and coal combustion environments.

The PSDF will consist of five modules for systems and components testing. These modules include an Advanced Pressurized Fluidized Bed Combustion (APFBC) Module, an Advanced Gasifier Module, a Hot Gas Cleanup Module, Compressor/Turbine Module, and a Fuel Cell Module. The APFBC module consists of Foster Wheeler's technology for a second generation PFBC. This module relies on the partial conversion of the coal to a fuel gas in a carbonizer with the remaining char being combusted in a PFBC. Both the fuel gas and the PFBC exhaust gas streams are filtered to remove particulates, then combined to fire a combustion turbine. The advanced gasifier module consists of M. W. Kellogg's transport technology for pressurized combustion and gasification to provide either an oxidizing or reducing gas for parametric testing of hot particulate control devices. The PSDF will have the capability to operate the APFBC train and the advanced gasifier train simultaneously. This will allow both parametric and long term testing of the Particulate Control Devices in support of the DOE Clean Coal Program. Four separate PCD technologies will be tested at the facility by designing to allow rearrangement of the PCDs between the transport gasifier and the APFBC modules.

The hot gases coming off the transport reactor, carbonizer, and CPFBC will be cleaned by different PCDs. Because of its higher capacity, a larger particulate removal device will be tested with the combustion gases from the PFBC. Two Requests for Proposals (RFPs) for the larger and smaller capacity PCDs were issued in September-October, 1992. On the basis of the proposals the PCD technology from several different developers have been evaluated. The varying characteristics in terms of weight, envelope size, lifting requirements, operating conditions, and utility requirements have been taken into account in the PSDF design. The design will allow interchanging of PCDs between the carbonizer and transport reactor, if necessary, to increase flexibility and enhance utilization of the PCDs.

PCD TESTING PHILOSOPHY

The transport reactor train operating in the gasification or combustion modes is shown schematically in Figure 1. Note that two PCDs are shown in this flow diagram. Only one PCD will be tested at a given time with the transport reactor. The intent is to be able to install, change out, or provide maintenance on a second PCD while another is being tested. This will result in increased flexibility for the test facility and will reduce the downtime. The transport reactor has been designed to supply 1,000 ACFM of particulate laden gas to the PCD inlet over a range of temperatures from 1,000° F to 1,800° F and at pressures of 194 psia to 300 psia. The PCD in this train will receive coal ash laden gas from the transport reactor which can operate in either gasification or combustion mode. Provision has been made to feed particulate laden gas to this PCD for relatively short term parametric testing over a wide range of temperatures and dust loadings. Cleaned fuel gas from the PCD would go to a thermal oxidizer before being discharged. In the gasification mode, a fuel cell test skid will receive 10 - 15% by volume of the cleaned gas through a slip-stream. In the combustion mode, the flue gas would leave the PCD and bypass the thermal oxidizer and proceed to the gas cleanup area prior to discharge. Table 1 shows the envelope of operating conditions to be expected by the PCD on the transport train.

Table 1
Transport Reactor Design Basis

PCD Temperature	Coal flow (lb/hr)	Gas flow (lbmole/hr)	Particulate loading to PCD (ppmw)	PCD Inlet pressure
Gasification 1,000 F	3,166	753	4,000 - 10,000	197 psia
Gasification 1,768 F	3,166	753	4,000 - 10,000	315 psia
Combustion 1,000 F	1,611	823	4,000 - 10,000	216 psia
Combustion 1,600 F	1,611	823	4,000 - 10,000	320 psia

The APFBC train is shown schematically in Figure 2. The PCDs in the APFBC train will be subjected to tests for longer durations primarily to determine endurance and mechanical limitations. Two independent PCDs operating continuously are required in the APFBC train. One PCD would remove particulates from the carbonizer fuel gas and send this gas to the topping combustor. The other, larger PCD, would receive particulate laden flue gas (vitiated air) from the Circulating Pressurized Fluidized Bed Combustor (CPFBC) and the cleaned gas would also be sent to the topping combustor. Alkali getter beds would be located between the PCDs and the topping combustor to ensure sufficient alkali capture for turbine protection. The PCDs in the APFBC train are a part of the High Temperature Gas Cleaning system. This system includes a primary cyclone prior to each PCD and an alkali removal system after each

Figure 2. PSDF Advanced Pressurized Fluidized bed Combustion Train

PCD. The primary cyclone will remove the bulk of the relatively coarse fly ash particles. The PCD will achieve the final degree of particle removal. The alkali removal beds will capture sodium and potassium vapor phase species. The Gas Cleaning systems are designed to achieve sufficient levels of particulate and alkali removal to protect the gas turbine from erosion, deposition, and corrosion damage, and to satisfy plant emission standards for particulates. The nominal carbonizer fuel gas and CPFBC flue gas conditions to the PCD are shown in Table 2.

Table 2
APFBC High Temperature PCD Inputs

	Carbonizer	CPFBC
Temperature, F	1,500 - 1,800	1,800
Pressure, psia	170 psia	150 psia
Gas flow, acfm	1,475 - 1,700	6,200
Particulate loading to cyclones, ppmw	170,000	670,000
Maximum particulate loading to PCDs, ppmw	11,000	15,000
Alkali content, ppmw	85	0.10

While these nominal operating conditions provide the main basis for design of the Gas Cleanup systems, alternate feed systems, start-up, partial load, potential transients, and shutdown conditions are also incorporated into the Cleanup system design criteria. The major performance requirements of the Cleanup system are:

- o Achieve particle removal efficiency to meet both environmental standards and turbine protection standards - less than 20 ppmw of particulates in the stack gas is required to meet emission standards, while turbine protection may require stricter control of coarse particles.
- o Control alkali content (total sodium and potassium vapor) to less than 50 ppmw in the turbine gas.
- o Limit the maximum pressure drop across each train to 6 psi.
- o Because of the smaller size of the PCDs compared to commercial scale units, limit the temperature drop to less than 60 F across the carbonizer Gas Cleanup train and to less than 25 F across the CPFBC Gas Cleanup train.

The PCD test program will be designed to explore a wide range of technical and commercial issues at the PSDF. The PSDF will provide the utmost flexibility necessary to explore all aspects of PCD technology commercialization as it applies to gasification

and combustion based hot gas cleanup systems. Both parametric and long term testing of PCDs can be done in the following areas. This is by no means an exhaustive list and further issues will arise as the PCD test program evolves.

1. Dust cake characterization (detachment, removal)
2. Ceramic/metal interface (sealing, holding/supporting)
3. Material life and long term degradation (filter elements, tube sheet/support)
4. Ability to absorb upsets (thermal shock, particulate loading variations)
5. Pulse gas usage (economics, heat loss/thermal shock issues)
6. Pulse valve lifetime
7. Failsafe issues
8. Capability to follow power generation system loads
9. Instrumentation and control issues
10. Performance of the PCDs during the test program will be examined in the following areas:
 - Particulate collection efficiency and variation with particle size
 - Pressure drop across PCD
 - Face velocity
 - Flows, temperatures, pressure, compositions of streams that cross PCD
 - Pulse flow rate, temperature, pressure, and frequency
 - Temperature drop across PCD
 - Material and energy balances across PCD including trace components
11. Capital cost, operating and maintenance costs
12. System reliability and availability
13. Ease of maintenance
14. Integration into power generation systems in combustion mode, gasification mode, and any hybrid modes that might be developed in the future.
15. Ease of scaleup for commercial size applications

REQUEST FOR PROPOSAL FOR PCDs

Two separate Request for Proposals were released for PCD technologies. Four different PCDs will be tested at the PSDF. One PCD is required to remove particulates from the CPFBC flue gas in the APFBC train. This should be a large capacity filter, using proven technologies, to be used for longer term endurance tests. Three other PCDs are required to remove particulates from the carbonizer/transport reactor. Relatively newer technologies could be evaluated in short term parametric type tests on the gasification train. Hence, two separate RFPs were issued - one RFP for all the carbonizer/transport PCDs, and another RFP for the larger CPFBC PCD.

The first RFP was for a PCD to be placed in the carbonizer fuel gas stream, and for two PCDs to be placed in the transport gasifier fuel gas stream. Each PCD should be able to handle a particulate laden gas flow rate of about 1,500 acfm. These PCDs should be able to meet capacity requirements of the carbonizer, and of the transport train. Table 3 shows the required specifications of the carbonizer/transport PCDs as indicated in the RFP. This RFP was released on September 11, 1992.

Table 3
Anticipated Gas conditions at Inlet of Carbonizer/Transport PCD*

	Nominal operating conditions Transport Reactor (Combustion)	Nominal operating conditions Transport Reactor (Gasification)	Nominal operating conditions Carbonizer
Total Flow, lb/hr	24,744	18,735	19,000
Total flow, acfm	1,000	1,000	1,475 - 1,700
Temperature, F	1,000 - 1,800	1,000 - 1,800	1,500 - 1,800
Pressure, psia	216 - 300	197 - 315	170
Avg Molecular Weight	29.87	24.87	26.6
Component flows, lb/hr			
CO	0	3,876	1,300
H ₂	0	207	100
CO ₂	5,679	2,675	4,500
CH ₄	0	43	300
N ₂	17,543	10,781	10,000
O ₂	507	0	0
NH ₃	0	1	15
H ₂ S	0	6	15
COS	0		3
SO ₂	2	0	0
H ₂ O	1,064	1,140	2,367
C ₂	0	0	400
NO _x	38	0	0
HCN	0	4	
Particle loading, ppmw (PCD Inlet)	4,000	4,000	11,000
Particle mass mean diameter, μ m	**	**	~15

* This table was prepared with preliminary design information and trace components of the gas are not included.

** The size distribution will be determined once the range of particle loadings is defined

The second RFP was for a PCD to be placed in the CPFBC flue gas stream. This PCD should be able to handle 6,500 acfm of particulate laden gas. Table 4 shows the anticipated gas conditions at the inlet of the CPFBC PCD. This RFP was released on October 2, 1992.

Table 4
Anticipated gas conditions at inlet of CPFBC PCD*

	Nominal operating conditions for CPFBC
Total flow, lb/hr	75,235
Total flow, acfm	6,200
Temperature, F	1,600
Pressure, psia	150
Average molecular weight	29.5
Component flows, lb/hr	
CO	0
H ₂	0
CO ₂	6,500
CH ₄	0
N ₂	55,200
O ₂	12,100
Ar	950
SO ₂	
H ₂ O	485
C _s	0
NO _x	
Particle loading, ppmw (PCD Inlet)	15,000
Particle mass mean diameter, μ m	**

* This table was prepared with preliminary design information, and trace components of the gas are not included.

** The size distribution will be estimated during Phase 2 of the project.

The RFPs were reviewed by SCS, DOE, EPRI, Southern Research Institute, Foster Wheeler, M. W. Kellogg and American Electric and Power Corporation prior to release. RFPs were sent to 16 filtration vendors. A pre-bid meeting with the filtration vendors was held on September 22, 1992 at SCS. The RFP solicited the vendors to provide not only the complete particulate cleaning system equipment, but also to become

active participants in the development of their technologies at the PSDF by providing technical expertise, on-site personnel, cost sharing and other inputs as necessary. A 20 percent cost sharing commitment by each PCD vendor was strongly emphasized. The PCD testing should be viewed by the vendors as a key step in the commercialization of their technology and would provide data for scale-up of their PCDs to larger units. Table 5 provides a list of companies that received the RFPs and those that responded.

Table 5
List of Companies Receiving RFPs and Responses

Company	Location	Type of RFP sent	Response to RFP
3M Ceramic Materials Department	St. Paul, MN.	1 and 2	
Acurex Environmental Corp.	Mt. View, CA.	1 and 2	
Ahlstrom Pyropower Inc.	San Diego, CA.	2	
Babcock and Wilcox	Barberton, OH.	1 and 2	1
Calvert Environmental	San Diego, CA.	1	
CeraMem Corporation	Waltham, MA.	1 and 2	1
Combustion Power Co. Inc.	Menlo Park, CA.	1 and 2	1
Industrial Filter & Pump Mfg. Co.	Cicero, IL.	1 and 2	1 and 2
Joy Environmental Technologies	Houston, TX.	2	
Lanxide Corporation	Newark, DE.	1 and 2	
LSR Technologies Inc.	Concord, MA.	1 and 2	
Pall Advanced Separation System	Cortland, NY.	1 and 2	1 and 2
Purolator Products Co.	Greensboro, NC.	1 and 2	
Refraction Technologies Corp.	Newark, NY.	1 and 2	
Riley Stoker Corporation	Worcester, MA.	1 and 2	2
Westinghouse Science & Technology Center	Pittsburgh, PA.	1 and 2	1 and 2

1. PCDs for transport reactor/carbonizer
2. PCD for CPFBC

REVIEW PROCEDURE AND EVALUATION CRITERIA

The proposals were screened by SCS and SRI and further reviewed by representatives from DOE, EPRI, Foster Wheeler, and M. W. Kellogg. There were two broad categories for selection of the PCDs: commercialization capability and technical specifications. On the basis of these criteria a set of weighing factors was developed. This allowed overall comparisons to be made on an equitable basis taking into account all factors for each PCD proposal. Each reviewing organization assigned raw scores to each RFP. The raw scores of individual reviewers within each organization were averaged to arrive at the organizational scores. A list of the evaluation criteria is shown in Table 6.

Table 6
PSDF PCD Evaluation Criteria

1.0 CAPABILITIES FOR COMMERCIALIZATION OF TECHNOLOGY

- 1.1 Corporate capabilities, facilities, and resources**
 - Engineering and design
 - Fabrication and manufacturing (including quality control)
- 1.2 Relevant experience**
 - Experience in hot gas cleanup
 - Experience in particulate control technology
 - Understanding of major remaining obstacles to commercialization
- 1.3 Bidder's perspective**
 - Reasons for bidders interest in project
 - Perceived value of project for commercializing PCD
- 1.4 Participation in PCD test program**
 - Proposed level of involvement in testing and evaluation
 - Experience in PCD test programs and PCD evaluation
- 1.5 Cost estimate of commercial scale PCD**

2.0 TECHNICAL

2.1 Description of PCD System

System design

- General system description and arrangement (gas flow path, total filtration area etc.)
- Ash removal system and ash holdup
- Cleaning parameters and design of cleaning system, including control logic
- Design face velocity, ranges of face velocities, permeability range
- Maximum heat up and cool down rates, tolerance for other transients

Equipment design

Schematic drawings of major equipment

Materials of construction

Pressure vessel

Refractory

Internal structure such as tubesheet

Filter elements/media

Sealing system design and handling of thermal expansion

PCD mounting arrangement, mounting points, dimensions and weight

Maintenance requirements

Ease of maintenance

Demonstrated durability and reliability of filters and other components at design conditions

Utilities

Electricity (consumption, voltages, currents)

Blowback gas (pressure, temperature, flow, maximum moisture content)

Steam, air, water (pressure, temperature, quantity, purity)

Other auxiliary requirements

2.2 Ability of PCD to Meet Performance Requirements

Particulate collection efficiency (ability to meet turbine specifications)

PCD pressure drop (baseline and maximum)

Temperature drop

2.3 Description of Manufacturing Process

Quality control

Preoperational testing plan

A meeting was held on the week of December 7, 1992 to review and rank the proposals for the transport/carbonizer PCDs. The meeting was attended by representatives of DOE-METC, EPRI, SCS, Foster Wheeler, M. W. Kellogg, and SRI. Discussions were held on various aspects of the PCD technologies. The rankings of the transport/carbonizer RFPs from these discussions is shown in Figure 3. Combustion Power Company's Granular Bed Filter could be moved from one train to another although this would involve some extra design effort. The testing of two similar technologies (such as Westinghouse and Industrial Filter and Pump) was not necessarily a bad idea since there are significant differences in their design, operations, pulse cleaning strategies, etc. It was felt that the PCD selection should foster competition and improve the technology through different thinking processes.

Of the six responses for the transport/carbonizer PCDs, the three responses receiving top scores were from Combustion Power Company, Industrial Filter and Pump, and Westinghouse. Table 7 shows the characteristics of the three technologies for the transport/carbonizer PCDs.

Table 7
Transport/Carbonizer PCD Summary

Company	Technology
Combustion Power Company	Granular bed filter, alumina/mullite spheres
Industrial Filter & Pump	Fibrosic candle filter and tubesheet with design to allow backfit with a metal tubesheet if necessary
Westinghouse	Tier design with crossflow filters designed to backfit candles, CeraMem filter and ceramic bags

The recommendations of the review group, subject to review of the larger PCD proposals, were that:

1. The Westinghouse technology should be used for the carbonizer PCD. Candles or crossflow elements could be used in the Westinghouse shell, and this would be decided later after the large PCDs were reviewed. A choice could also be made after pilot scale tests of both filter types.
2. The Combustion Power filter should be used for one of the transport PCDs since this system provides an alternative to barrier filters. The cost sharing was low and attempts should be made to increase the level of cost sharing. There was a preference on the part of some participants for another barrier filter to be ranked second.
3. The Industrial Filter and Pump filter should be used for the other PCD on the transport gasifier. It should be made clear from IF&P that the interest is to test entire filter systems and not just filter elements.

Figure 3. Transport/Carbonizer Particulate Control Device Rankings

A meeting was held on January 27, 1993 with representatives of EPRI, Foster Wheeler, M. W. Kellogg, SRI, and SCS to review and rank the CPFBC PCD proposals as well as make final recommendations of PCD selections for both the gasification and the APFBC trains. Figure 4 shows the reviewers rankings of the CPFBC RFPs. The recommendation of the reviewers was that Westinghouse should be chosen as the manufacturer of the CPFBC PCD and the carbonizer PCD, and Industrial Filter and Pump should be chosen to fabricate the transport train PCD.

Of the four CPFBC proposals that were received, only two (Riley Stoker and Westinghouse) had significant operating experience with their PCD technologies. Due to the fact that the large PCD did not have a backup at the facility, operating experience was viewed by the reviewing team as critical in minimizing the risk of failure for this unit. Table 8 shows the characteristics of the two technologies for the CPFBC PCD.

Table 8
CPFBC PCD Summary

Company	Technology
Riley Stoker	Deutsche Babcock design with bottom supported silicon carbide candles
Westinghouse	Tier design with mulite candles capable of backfitting cross flow filters or ceramic bags

SCS presented the recommendations to DOE on February 4, 1993. Based on input from DOE and mutual agreement by SCS the following PCD vendors were selected and assigned to the following process streams:

PFBC: Westinghouse, Ceramic candles, tier design
 Carbonizer: Industrial Filter and Pump, Fibrosic candles and tubesheet
 Transport PCD #1: Combustion Power Company, Granular Bed Filter
 Transport PCD #2: Westinghouse, Cross flow, CeraMem or ceramic bag filters

Figure 4. Circulating Pressurized Fluidized Bed PCD Rankings

**DATE
FILMED**

10/26/93

END