DOE/PC/91161--T12

COPY NO. _____

QUARTERLY TECHNICAL PROGRESS REPORT FOR THE DEVELOPMENT OF "A COAL-FIRED COMBUSTION SYSTEM FOR INDUSTRIAL PROCESS HEATING APPLICATIONS

CONTRACT DE-AC22-91PC91161

JANUARY 1995 - MARCH 1995

PREPARED FOR

U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

PREPARED BY

VORTEC CORPORATION
3770 RIDGE PIKE
COLLEGEVILLE, PA 19426

MASTER

APRIL, 1995

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

PETC has implemented a number of advanced combustion research projects that will lead to the establishment of a broad, commercially acceptable engineering data base for the advancement of coal as the fuel of choice for boilers, furnaces, and process heaters. Vortec Corporation's Phase III development contract DE-AC22-91PC91161 for a "Coal-Fired Combustion System for Industrial Process Heating Applications" is a project funded under the DOE/PETC advanced combustion program.

This advanced combustion system research program is for the development of innovative coal-fired process heaters which can be used for high temperature melting, smelting and waste vitrification processes. The process heater systems to be developed have multiple use applications; however, the Phase III research effort is being focused on the development of a process heater system to be used for producing value added vitrified glass products from boiler/incinerator ashes and industrial wastes. The primary objective of the Phase III project is to develop and integrate all the system components, from fuel through total system controls, and then test the complete system in order to evaluate its potential marketability.

During the past quarter, the major effort was concentrated on conducting the 100 hour demonstration test. The test was successfully conducted from September 12th through the 16th.

The test program consisted of one test run, with a duration of 100 hours at a nominal feed rate of 1000 lbs/hr. Throughout the test, the CMS was fired with coal and a coal by-product (i.e. coal-fired boiler flyash) as the primary fuels. Natural gas was used as an auxiliary fuel as necessary to provide process trim. The feedstock consisted of a coal-fired utility boiler flyash and dolomite and produced a stable, fully-reacted vitrified product. The fly ash, supplied by PENELEC, contained between 6 and 12% by weight of carbon because of the low NOx burners on the PENELEC boilers. Therefore, a substantial portion of the required thermal input came from the flyash.

The data from the test was reduced and was incorporated into a comprehensive Final Report. The Final Report is currently undergoing internal review.

2.0 INTRODUCTION/BACKGROUND

2.1 Introduction

The Pittsburgh Energy Technology Center (PETC) of the U.S. Department of Energy awarded Vortec Corporation this Phase III contract (No. DE-AC22-91PC91161) for the development of "A Coal-Fired Combustion System for Industrial Process Heating Applications". The effective contract start date was September 3, 1991. The contract period of performance is 36 months. The program established by this contract is described below.

2.2 Background

PETC has implemented a number of advanced combustion research projects that will lead to the establishment of a broad, commercially acceptable engineering data base for the advancement of coal as the fuel of choice for boilers, furnaces, and process heaters. This includes new installations and those existing installations that were originally designed for oil or gas firing. The data generated by these projects must be sufficient for private-sector decisions on the feasibility of using coal as the fuel of choice. This work should also provide incentives for the private sector to continue and expand the development, demonstration, and application of these combustion systems. Vortec Corporation's Coal-Fired Combustion System for Industrial Process Heating Applications is being developed under contract DE-AC22-91PC91161 as part of this DOE development program. The current contract represents the third phase of a three-phase development program. Phase I of the program addressed the technical and economic feasibility of the process, and was initiated in 1987 and completed 1989. Phase II was initiated in 1989 and completed in 1990. During Phase II of the development, design improvements were made to critical components and the test program addressed the performance of the process using several different feedstocks. Phase III of the program was initiated September 1991 and is scheduled for completion in 1994. The Phase III research effort is being focused on the development of a process heater system to be used for producing value-added vitrified glass products from boiler/incinerator ashes and selected industrial wastes.

This coal-fired process heater system is unique in several important aspects. The important advantages of the technology are as follows:

1. Significantly lower capital cost as compared to conventional gas/oil-fired and electric furnaces.

2. Substantially higher thermal efficiency as compared to conventional gas/oil-fired melting furnaces.

3. Satisfaction of projected future emission requirements for NOx, SOx and particulates.

4. The process heater system has a degree of operational flexibility unmatched by conventional fossil fuel fired glass melting or mineral wool systems. Several of the unique operational capabilities of this innovative technology include: multi-fuel use capability (including coal, coal slurry, petro-coke, oil and gas), rapid product changeover, and rapid startup/shutdown.

The primary components of the CMS are a counter-rotating suspension preheater and a cyclone melter. An artist rendering of the basic CMS concept is shown in Figure 2.2-1.

Coal combustion and in-flight suspension preheating of the batch ingredients take place in a counter-rotating vortex (CRV) combustion preheater. The ash and other feedstock materials are introduced into the CRV preheater through an injector assembly and are rapidly heated in the flame zone. Any unburned carbonaceous materials are rapidly volatilized and incinerated. The inert materials are heated to nominally 2200°F to 2900°F, depending on the feedstocks utilized, prior to entering the cyclone melter. Combustion air preheated to nominally 1000°F to 1400°F is used in the process. Therefore, high local flame temperatures (>4000°F) are achieved in the CRV preheater. However, NO_x emissions have been demonstrated in the pilot scale CMS to be low; typically less than 200 ppm.

Rapid temperature quenching of the combustion products by the inert waste glass particles and staged combustion provide an effective means of limiting NO_x emissions. The system also has the capability of utilizing natural gas reburning for additional NO_x control. The rapid temperature quenching and the staged combustion which occurs within the CMS are perceived to be the primary controlling mechanisms for reduced NO_x emissions. Experimental data obtained during the course of feasibility experiments with the pilot-scale

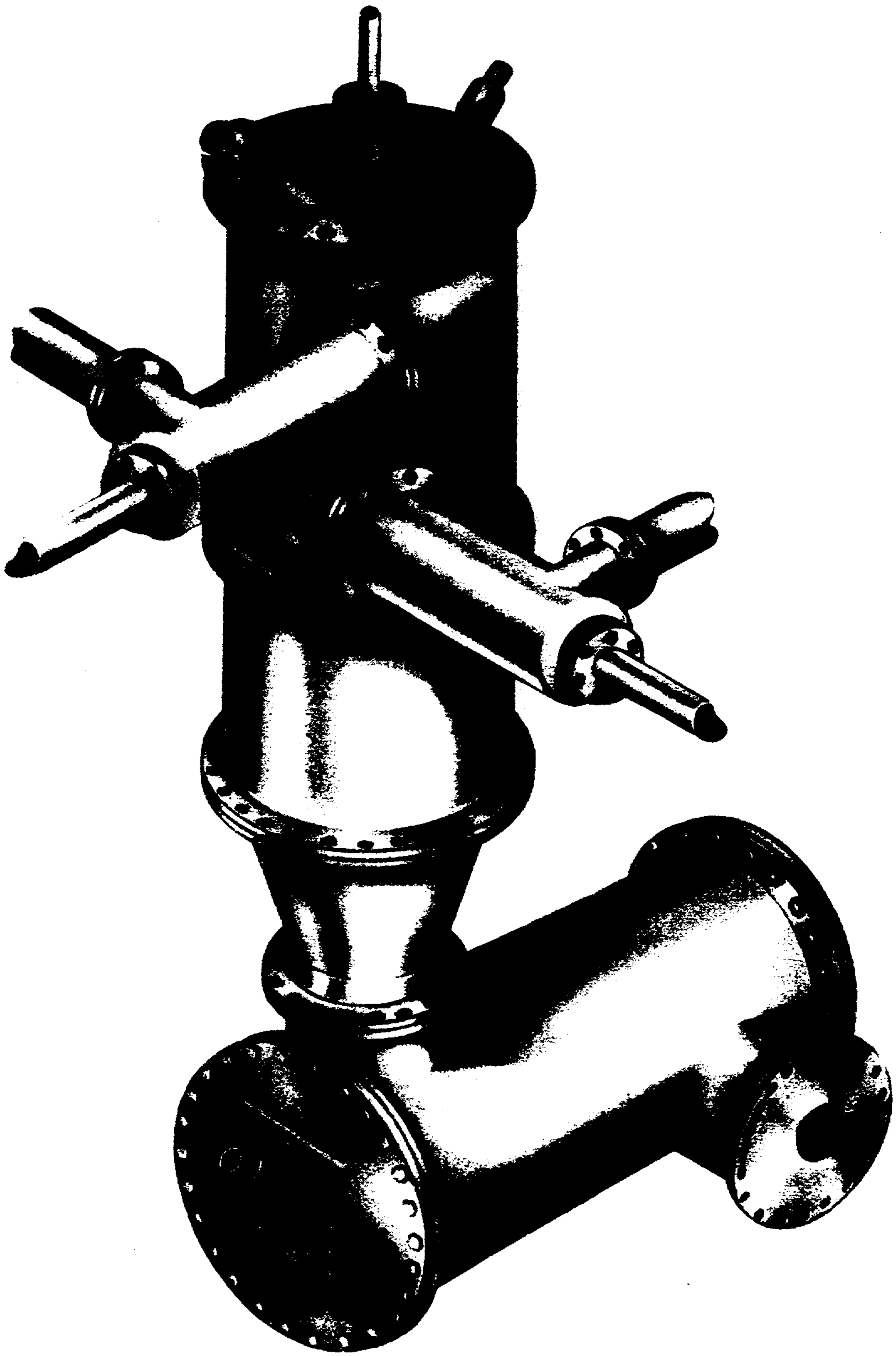

Figure 2.2-1. Artist Rendering of Basic CMS

CMS indicate NOx emissions are lower than the California emission standards (4.5 lbs per ton of glass produced) for glass melting furnaces. In this regard, it should be noted that the California glass melting emission standards for NOx are currently the most stringent in the United States.

The use of low sulfur or beneficiated coals is the initial approach for the control of SO_x emissions. However, since sodium containing compounds and limestone are ingredients used as fluxes for melting the incinerator ash, there are demonstrated reductions of SO_x emissions from the combustion of medium or high sulfur coals in the recycling system by sodium or limestone injection. The sulfates formed can be effectively removed by an electrostatic precipitator, bag house, or flue gas scrubber. Residual SO_2 or HCl emissions can be reduced using commercially available downstream acid gas scrubbers.

The preheated solid materials from the CRV preheater enter the cyclone melter where they are distributed to the chamber walls by cyclonic action to form a molten glass layer. The glass produced and the exhaust products exit the cyclone melter through a tangential exit channel and enter the separator/reservoir. The separator/reservoir separates the combustion products from the melted glass and provides a reservoir of hot glass for proper interfacing with product forming equipment. The hot exhaust products exit through an exhaust port which ties into a conventional radiation type recuperator with a nominal 1000°F to 1400°F delivered air preheat capability.

The particulate removal/stack assembly quenches the flue gas temperature exiting the radiation recuperator to 700-750°F by use of a water quench or air dilution system. Commercially available particulate control devices are incorporated into the design as dictated by local environmental regulations. The uncontrolled particulate emission levels of the CMS are about the same as conventional gas-fired glass melting furnaces. Therefore, the use of commercially available particulate control devices will be incorporated into the design as dictated by local flue gas emission regulations. Pilot plant testing to date indicates that a venturi scrubber will be suitable for some applications; however, wet or dry electrostatic precipitators may be necessary to achieve higher levels of particulate emissions control.

A process diagram of a Vortec CMS-based commercial ash vitrification and recycling system is shown in Figure 2.2-2. The basic elements of a commercial ash vitrification and recycling system include:

1. The Vortec multifuel-capable Combustion and Melting System (CMS), consisting of a counter-rotating vortex (CRV) combustor and a cyclone melter;
2. an upstream storage and feeding subsystem;
3. a separator/reservoir assembly;
4. a cullet handling and delivery subsystem;
5. a heat recovery subsystem;
6. a flue gas conditioning/distribution assembly; and
7. a particulate removal/stack assembly.

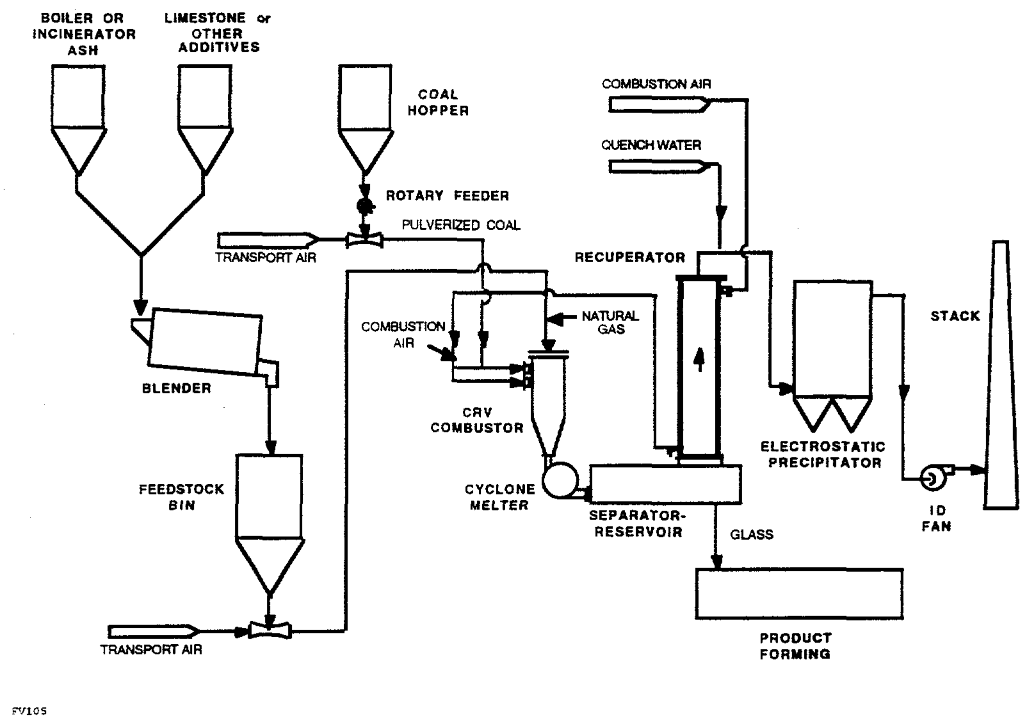

Figure 2.2-2. Vortec Ash Vitrification And Recycling System

Except for the CMS and the separator/reservoir, all other subsystems or assemblies are commercially available or modified versions of commercially available equipment. The basic CMS can be modified to accommodate the use of a variety of fuels, including pulverized coal, coal slurry fuels, natural gas, and oil. In some coal-fired applications, pulverized coal can be injected and burned directly in the counter-rotating vortex (CRV) preheater. In other coal-fired applications, the use of a pulverized coal precombustor is advantageous.

Boiler or incinerator ash is delivered to storage bins located within the processing facility. Additives required to produce a suitable product are stored in separate storage bins. The ash and additives are mixed on a batch basis and stored in a feedstock storage bin. The feedstock is then delivered via pneumatic transport or other means to the CMS. Pulverized coal, when used as the primary fuel, is delivered to the process facility in pneumatic transport vehicles and stored in a storage bin. The coal is then delivered via pneumatic transport to the CMS.

2.3 Objectives

This contract is the third phase of a three-phase R&D program which was initiated during March 1987. The objective of the program is to develop an advanced industrial process heater capable of using pulverized coal or coal-derived fuels as the primary fuel.

The objective of Phase I of the program was to verify the technical feasibility and economic benefits of Vortec's advanced Combustion and Melting System (CMS) technology using coal as the fuel of choice. Phase I consisted of two segments, Phase I-A and Phase I-B. During Phase I-A, detailed designs of a proof-of-concept scale coal-fired CMS and the supporting test facilities were completed. It also included tradeoff studies and techno-economic studies to cost optimize the advanced process heater and to evaluate the technical and economic feasibility of the process heater system. In Phase I-B of the program, critical components were tested to validate the feasibility of the Vortec process heater for glass melting with coal as the primary fuel. This phase involved the fabrication, installation and operation of a 3 to 5 x 10^6 Btu/hr coal-fired CMS test loop at Vortec's high temperature process test facility in Harmarville, PA. Glass melting with 100% coal firing was effectively demonstrated with minimal contamination effects. Glass cullet was the primary process feedstock during the Phase I test program. A conceptual design of a commercial scale CMS glass melter was also developed and techno-economic studies were continued.

The primary objective of the Phase II effort was to improve the performance of the primary components and demonstrate the effective operation of a subscale process heater system integrated with a glass separator/reservoir. The impact of coal ash on glass production quality was assessed and the melting of more complex glasses was evaluated during this phase. Additionally, due to Vortec's commitment to commercialize the process heater technology it is developing with DOE's support, we have analyzed several different markets, particularly in the areas of waste material recycling, in which the Vortec process heater system will offer unique technical and cost advantages. Some preliminary testing was performed using Vortec's pilot scale test system to demonstrate the feasibility of application of the Vortec process heater to these markets with encouraging results.

The primary objective of the Phase III project is to develop and integrate all the system components, from fuel through total system controls, and then test the complete system in order to evaluate its potential marketability. Vortec's primary target market for Phase III is boiler/incinerator ash vitrification. A secondary market application is the oxidation/vitrification of waste glass materials into glass frits which can be recycled into existing glass furnace operations. Potential end uses of the glass products include: mineral fiber manufacturing, glass frits, and aggregates. The glass frits produced can be used as filler for road base asphalt, granules for asphalt shingles and filler for bricks and concrete blocks. Aggregates can also be produced for landscaping and backfill applications.

3.0 PROJECT DESCRIPTION

3.1 Program Description

To accomplish objectives outlined in Section 2.3, Vortec will supply all the necessary personnel, facilities, materials, and services to execute the tasks in the contract Statement of Work. The program is divided into seven (7) technical tasks and a program management task distributed over 36 months as shown in Figure 3.1-1. The tasks in the contract's Statement of Work are provided below in Table 3.1-1.

U.S. DEPARTMENT OF ENERGY

DOE F 1332.3 (11 84) MILESTONE SCHEDULE ☐ PLAN ☒ STATUS REPORT FORM APPROVED OMB NO 1901-1400

1. TITLE A Coal-Fired Combustion System For Industrial Heating Applications	2. REPORTING PERIOD 10/1/94-12/31/94	3. IDENTIFICATION NUMBER DE-AC22-91PC91161
4. PARTICIPANT NAME AND ADDRESS VORTEC CORPORATION 3770 RIDGE PIKE COLLEGEVILLE, PA 19426		5. START DATE 9/3/91 6. COMPLETION DATE 6/30/95

7. ELEMENT CODE	8. REPORTING ELEMENT	9. DURATION FY 94												FY 95				FY				FY	FY	FY	FY	10. PERCENT COMPLETE	
		O	N	D	J	F	M	A	M	J	J	A	S	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4					plan	actual
1.0	Design, Fab. & Integ. Components																										
1.1	Component Design																										
1.2	Compoment Fabrication																										
1.3	Component Integration																										
2.0	Prelim. System Tests																										
2.1	Test Plan																										
2.2	System Tests																										
3.0	Proof-of-Concept Tests																										
4.0	Economic/ Comm. Plan																										
4.1	Economic Evaluation																										
4.2	Commercialization Plan																										
5.0	Conduct Site Demonstration																										
5.1	Demonstration Plan																										
5.2	Site Demonstration																										
6.0	Decommission Facility																										
7.0	Program Manag. & Reporting																										
8.0	TSCA Ash Testing																										

11. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE

Figure 3.1-1. Phase III Program Schedule

Table 3.1-1. Phase III Work Breakdown Structure

Task 1 -	Design, Fabricate, and Integrate Components Subtask 1.1 - Component Design Subtask 1.2 - Component Fabrication Subtask 1.3 - Component Integration
Task 2 -	Perform Preliminary System Tests
Task 3 -	Perform Proof-of-Concept System Tests
Task 4 -	Evaluate Economics/Prepare Commercialization Plan Subtask 4.1 - Economic Evaluation Subtask 4.2 - Commercialization Plan
Task 5 -	Conduct Site Demonstration Subtask 5.1 - Demonstration Plan Subtask 5.2 - Site Demonstration
Task 6 -	Decommission Test Facility
Task 7 -	Program Management and Reporting
Task 8 -	TSCA Ash Testing Subtask 8.1 - Laboratory Analysis & Surrogate Definition Subtask 8.2 - Pilot-Scale Testing

3.2 Background Patents and Proprietary Data

The basic elements of the proposed coal-fired Vortec Process heater are embodied in U. S. Patent 4,544,394 dated Oct. 1, 1985 and U.S. Patent 4,553,997 dated Nov. 19, 1985. Patent No. 4,957,527, dated September 18, 1990 was filed in accordance with OMB Circ. A-127 Trans. Memo No. 1, patent rights small business firms or non-profit organizations (April 1984). Vortec Corporation has elected to retain title licensing and royalty rights to this patent as per provisions under Contract No. DE-AC22-87PC79651, dated March 11, 1987. Vortec Corporation is in the process of filing additional patents for its process heaters, and will use proprietary information in the execution of this program. Procedures for protecting this proprietary information have been implemented with our subcontractors and consultants via non-disclosure/patent agreements.

4.0 PROJECT STATUS

During the past quarter, the major effort was completing the demonstration testing.

4.1 Facility Modifications

All of the facility modifications required to conduct the demonstration testing were completed. These modifications included the installation of a new coal handling transport and feeding system, modifications to the existing control system, and the installation of a mineral wool fiberizing system. Each of these systems was used extensively during the testing.

4.2 Test Planning

4.2.1 Test Matrix

The test matrix for the demonstration test is summarized in Table 4.2-1. The test program consisted of one test run, with a duration of 100 hours at a nominal feed rate of 1000 lbs/hr. Throughout the test, the CMS was fired with coal and a coal by-product (i.e. coal-fired boiler flyash) as the primary fuels. Natural gas was used as an auxiliary fuel as necessary to provide process trim.

Table 4.2-1 Test Matrix and Schedule

RUN NO.	TEST DURATION	FEEDSTOCKS	FUEL/OXIDIZER	TEST SCHEDULE
1	100 hours	Coal-Fired Boiler Flyash	Coal/Air	TBD

The objective of this test was to demonstrate the continuous operation of the CMS under normal user load. The feedstock consisted of a coal-fired boiler flyash and dolomite. Laboratory-scale testing was performed, prior to the demonstration test to determine the quantity of dolomite to produce a fully reacted, stable glass product. At several times throughout the test, sampling of all effluent streams, including EPA Method 5 and total hydrocarbon sampling of the flue gas, was performed during steady state operation. These samples are currently being analyzed to evaluate the melting performance of the CMS and to define the flue gas emissions from the Vortec CMS when processing a coal-fired boiler flyash. These data, along with the data logged by Vortec's computer-based process controller and test personnel, are being used to perform a heat and mass balance around the CMS.

4.2.2 Feedstock Preparation

The feedstock was a mixture of a coal-fired boiler flyash, supplied by PENELEC from their Homer City, PA plant, and dolomite. The chemical composition of the coal-fired boiler flyash supplied by PENELEC is shown in Table 4.2-2. Laboratory melt tests have identified the need for additional glass forming agents. Based the results of laboratory melt tests, an acceptable feedstock composition was determined to be 60% flyash and 40% dolomite.

Throughout the test, used a combination of three Pittsburgh seam coals. Due to the long duration of the test, the three different Pittsburgh seam coals were mixed to generate a sufficient quantity of a single coal with a uniform composition. Representative samples of the resulting coal mixture was taken and sent for analysis prior to the initiation of the test.

Table 4.2-2 Chemical Composition of the Coal-Fired Boiler Flyash from PENELEC

	Sample 1 wt %	Sample 2 wt %
SiO_2	36.2	42.4
Al_2O_3	19.8	24.0
K_2O	2.08	1.75
Na_2O	0.31	0.30
CaO	2.19	1.58
Fe_2O_3	9.75	2.53
MgO	0.70	0.67
TiO_2	0.93	1.19
C	6.2	11.6
LOD	17.9	7.3
LOI	7.7	12.5

4.2.3 Test Parameters and Data

Figure 4.2-2 is a process schematic of the Vortec test facility at UPARC. Included, with numerical designators, are the locations of the instruments used to control and assess the thermodynamic performance of the system. Table 4.2-4 presents the instrumentation type and its system location. The measurement procedures routinely applied to the operation of the Vortec CMS are described in the ensuing sections of this test plan.

The sampling point locations are indicated on Figure 4.2-2 with the designators S1, S2, S3, S4 and S5. These locations were selected because they are truly representative of the process inlet and exit state points and will represent the true potential of the system to physically alter the feedstock. Selection of sampling points elsewhere in the system would not be representative of the process's performance.

4.2.4 Instrument Monitoring, Data Acquisition, and Control System

The Vortec test facility is extensively instrumented. The facility uses a PC-based computer system to simultaneously operate the system, monitor the system's performance, and record time histories of selected system parameters. Four types of measurement time histories are made; namely: pressures, temperatures, weights, and flows. In addition, the concentrations of O_2, CO, NO_x, and SO_x in the flue gas are recorded.

The supervisory control and data acquisition (SCADA) system's architecture is based on the following components.

1. Measuring Element
2. Measurement Transmitter/Transducer
3. Analog to Digital (or D/A) Interface Hardware
4. Computer Monitor

The control system and data logging system is an IBM-486 computer which is dedicated to operating a Genesis control series program. The computer communicates with the

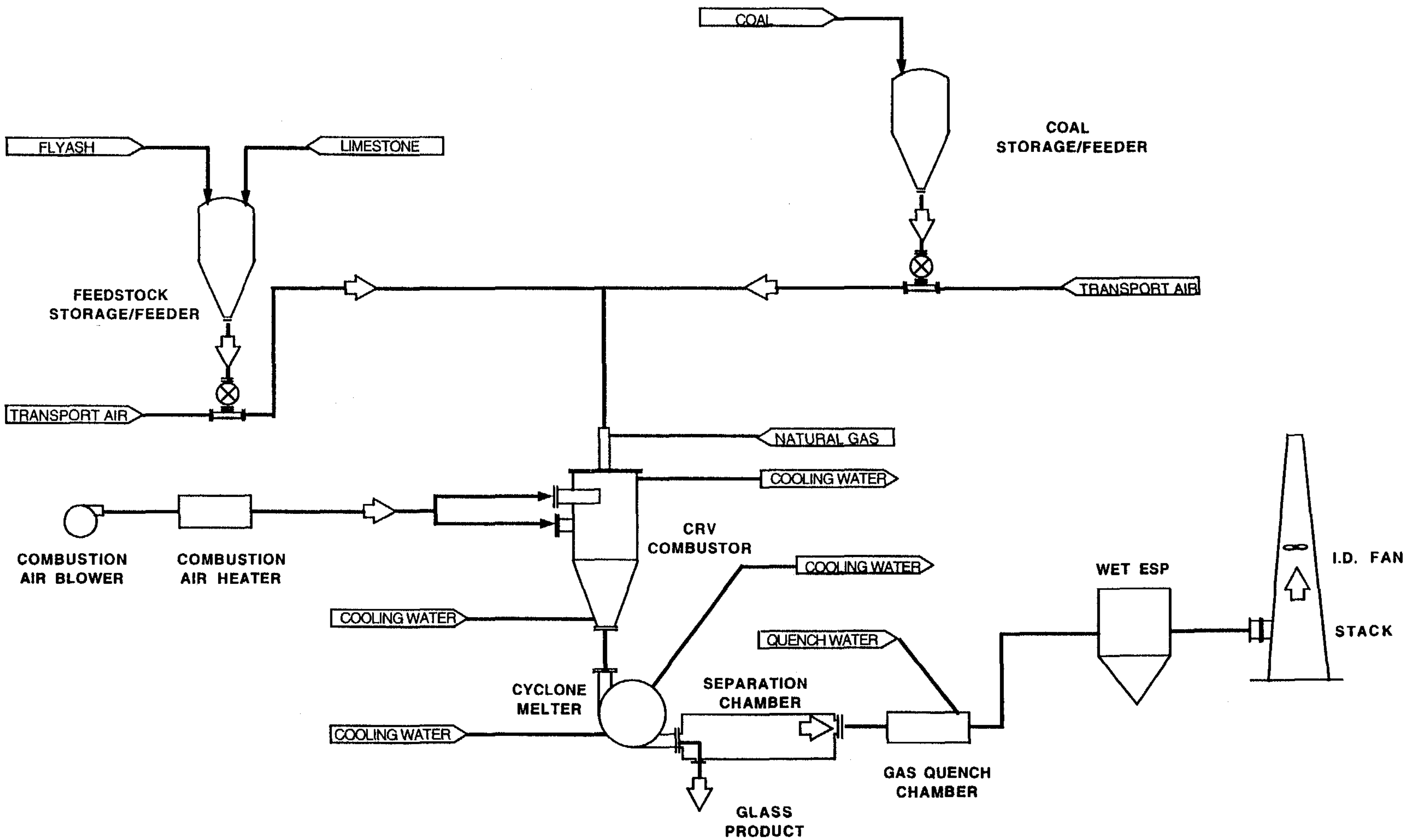

Figure 6.0-1 Process Schematic of Vortec Test Facility

Table 4.2-3 Test Facility Instrumentation

Process Instrumentation

NOTE: Work with sketch DMB-070291.

System	Station No.	Sub-system/ Component	Measurement	Instrument	Location	Recorded by
Process Air Supply and Preheat Air	1	Lamson Blower	Pressure Temperature Flow	Pressure Transmitter Pressure Gauge K thermocouple Dial thermometer Orifice plate	Blower outlet Blower outlet Blower outlet	Data Logger Reference only Data Logger Reference only Data Logger
	2	Air Heater	Temperature	K thermocouple	Heater outlet	Data Logger
Batch Supply/Feed	3	Batch Tank	Weight Coal Flow	Load cells Load cells	Tank supports Tank supports	Data Logger Manual - loss in weight calc.
	4	Transport Air	Pressure Temperature Flow	Pressure transmitter K thermocouple Orifice plate	Air supply line Air supply line Air supply line	Data Logger Data Logger Data Logger
CMS	6	CRV	Gas Temperature Gas Pressure Refractory Temperature	S Thermocouple S Thermocouple Pressure transmitter S Thermocouples	Inlet arm CRV outlet Viewport Embedded in refractory at CRV outlet	Data Logger Data Logger Data Logger Data Logger
	7	Cyclone Melter	Gas Temperature Gas Pressure	S Thermocouple Pressure transmitter	Cyclone melter endwall Viewport	Data Logger Data Logger
	8	Natural Gas	Pressure Temperature Flow	Pressure transmitter K thermocouple Orifice plate	Process gas supply line Process gas supply line Process gas supply line	Data Logger Data Logger Data Logger
Conditioning	9	Separator/Reservoir	Gas Temperature Refractory Temperature Gas Pressure	S Thermocouple S Thermocouple Pressure transmitter	Inlet Embedded in refractory Viewport	Data Logger Data Logger Data Logger
	10	Natural Gas	Pressure Temperature Flow	Pressure transmitter K thermocouple Orifice plate	Burner gas supply line Burner gas supply line Burner gas supply line	Data Logger Data Logger Data Logger
	11	Combustion air	Pressure Temperature Flow	Pressure transmitter K thermocouple Orifice plate	Eclipse blower outlet Eclipse blower outlet Eclipse blower outlet	Data Logger Data Logger Data Logger
Flue Gas/Quench	12	Stack	Flue gas temperature	K Thermocouple Dial thermometer	Spray channel outlet Spray channel outlet	Data logger Reference
	13	Spray Channel	Flue gas temperature	S Thermocouple	Spray Channel Inlet	Data Logger
	14	CMS Outlet	Excess oxygen CO NO/NOx SOx	Beckmann Model 755 Oxygen AnalyzerBeckmann Model 870 Non-Dispersive Infrared Analyzer Beckmann Model 951A NO/NOx Analyzer Beckmann Model 880 Non-Dispersive Infrared Analyzer	Spray Channel Inlet Spray Channel Inlet Spray Channel Inlet Spray Channel Inlet	Data Logger Data Logger Data Logger Data Logger
	15	Stack	Particulate	Anderson Analyzer	Stack	not in use
	16	Spray Channel	Particulate	Grab Sample	Spray Channel Drain	Manual
Cooling Water	17	Global view	Supply Temperature	K Thermocouple Dial Thermometer	Supply water header Supply water header	Data Logger Manual
	18	Global View	Ave. return temperature	K Thermocouple	Return water header	Manual
	Not Shown	Individual Circuit	Temperature Flow	K Thermocouple Dial Thermometer Rotameter	Component exit Component exit Component entrance	Data Logger Manual Manual

subsystems through digital and analog input/output and data highway communications cards.

The Genesis control series program uses drivers to facilitate communications between the computer and the input/output hardware connections. Using available data, Genesis runs a developed control strategy designed to provide the following functions: data acquisition, recording, trending, mathematical, logical, indication, status, digital control, analog control, alarming, sequencing, timing, reporting, and user intervention.

A five-point calibration procedure is performed for each component in each data channel when the components are initially installed. This five-point procedure involves monitoring the output of each component at 0, 25, 50, 75 and 100 percent of the input range, and is conducted in both directions, that is, with an increasing input signal and then with a decreasing input signal. The same five point calibration procedure is conducted on each complete data channel at selected intervals; usually at the beginning of a new test program, and if and when there is a question about data quality.

4.2.5 Flue Gas Sampling

Combustion Products

Two flue gas sampling systems are available for the measurement of the combustion products. Figure 4.2-3 shows a schematic of the sampling flow-train. The first sampling system is shown in dashed lines and the second with solid lines. It should be noted that the first system is the primary system.

The first system uses a heated sampling line connected directly to a Perma Pure sampling system. The Perma Pure system is designed to condition the gas and vapor streams by continuous selective removal of particulates and water vapor, without loss of the gases being measured. Continuous filtration of gas sample streams that contain a high percentage of solids is made with a high-efficiency bypass filter. The gas sample passes through the inside surface of the filter at a high velocity through a Teflon eductor. Particulates and condensable vapors are bypassed, and the resulting gas sample stream will contain only particulates smaller than one micron. When acid gases are present, the bypass filter can be heated to prevent condensation and corrosion of the filter. Because the sample gas has been conditioned by the Perma Pure system, secondary dryers and filters down stream of

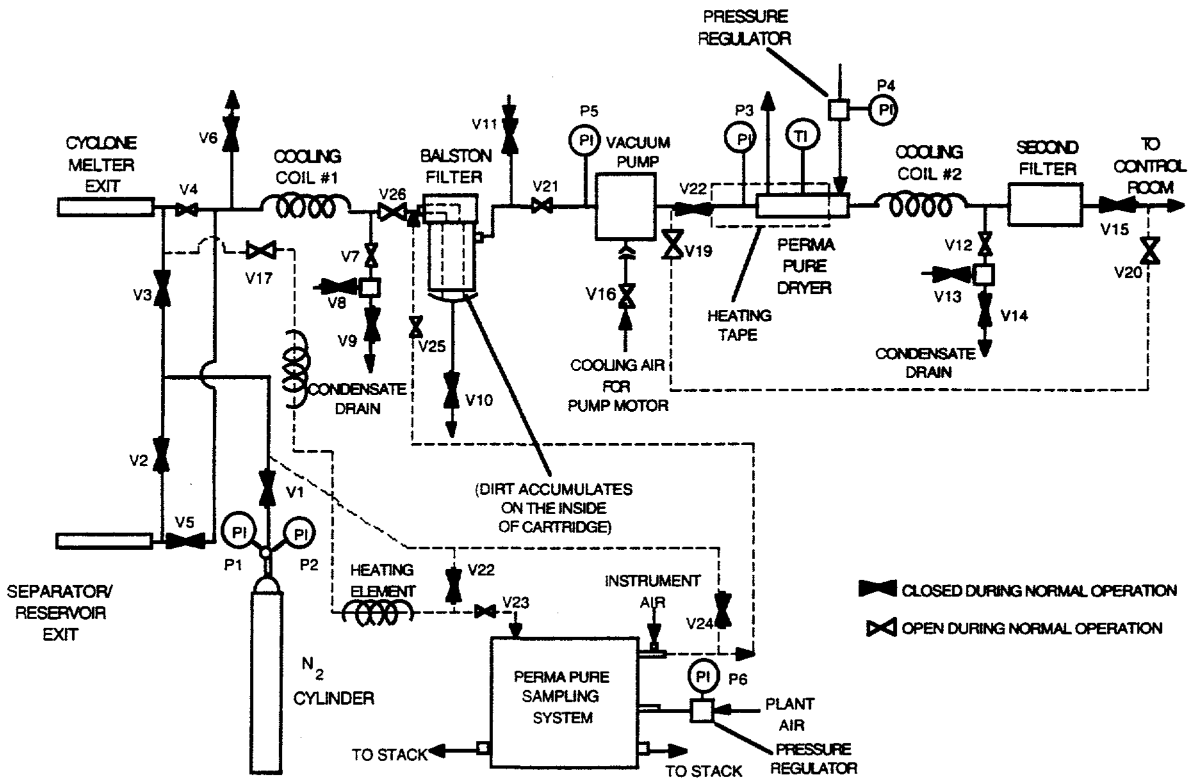

Figure 4.2-2 Instrumentation Process Schematic

the vacuum filter are bypassed. The moisture-free and particulate-free sample stream then goes to the control room to be analyzed.

In the second system, the sample gas passes through a cooling coil, where most of the condensate is drained, and a particulate filter prior to the vacuum pump. The second system shares the same vacuum pump used by the first system. After the vacuum pump, there is a dryer which is electrically heated to remove residual moisture in the sample stream. A second high-efficiency filter at a slightly lower temperature takes out fine particulates, while a dryer selectively removes the water vapor. The moisture-free and particulate-free sample stream then goes to the control room to be analyzed. A nitrogen purge is used on the sampling probes to remove possible material build-up.

The flue gas sample is analyzed using Beckman series analyzers (Models 755, 870, 951, and 880 for O_2, CO, NO/NO_x, and SO_x, respectively). Measurement of total hydrocarbon and other chemical species may also be performed depending upon the objectives of the test.

Particulates

The APC system consists of a flue gas quench assembly, a wet electrostatic precipitator (WESP), two recirculation tanks (one for the quench assembly and one for the WESP), and two water pumps. A slip stream is also pumped from the recirculation tanks and sent to a particulate filter, where the particulate material is removed and the water is recycled back to the recirculation tanks. The particulate is periodically removed from the filter, dried, and recycled backed to the batch tank for blending with original batch materials.

Provisions were made to use clean city water as the collection medium during sampling. When the particulate flow in the quench system was being sampled (location S5), the recirculating flow that carries particulate to the settling tank, was interrupted by adjusting a three-way valve and passing clean water through the spray nozzles of the quench system. Another three-way valve was used to divert all of the flow from the quench system exit line into the container used to collect the particulate laden water. The collection process lasted approximately five minutes. After the sample was collected, both three-way valves were closed, placing the system back in the recirculation mode.

The time to fill a 55-gal. container was measured with a stop watch. Once the container was filled to approximately three-quarters of its capacity, it was sealed, and the next measurement was made using another container. After the test is completed, each container was weighed. The flow rate is the quotient of net weight and time to fill.

The containers were set aside for several days to allow the solids to settle out, after which the solids were filtered from the water. The solids were dried and weighed. Again, the flow rate is the quotient of net weight and time to fill the container.

The particulate in the flue gas leaving the quench assembly was sampled during the test by an EPA Method 5 test procedure. Stack gas sampling will be conducted at location S4 by a qualified analytical laboratory, Comprehensive Safety Compliance (CSC), using the protocol described in Section 3.0 of the *Methods Manual for Compliance with the Boiler and Industrial Furnace Regulations.* This particular section is entitled "Sampling and Analytical Methods" and describes the sampling and analytical procedure for determining the metals content of the flue gas. The laboratory analytical procedures to determine the metals content of the samples are consistent with and refer to the methods described in SW-

846. The Method 5 sampling location is a point in the duct between the quench assembly and the WESP; therefore, there was no need to sample the particulate in the WESP.

4.2.6 Feedstock and Vitrified Product Streams Sampling

The experimental system at UPARC provides for relatively easy access to feedstock materials and vitrified products. Feedstock and vitrified product samples were collected in appropriate vessels (e.g., glass, polypropylene, polyethylene, stainless steel).

The feedstock and product were sampled throughout the tests in accordance with the sampling schedule shown in Figure 4.2-5. Selected samples have been sent to qualified laboratories for analysis.

Table 4.2-4 Sampling Schedule

Measurement	Sample Site	Frequency	Remarks
Feedstock Flowrate	Batch Tower (S1)	Continuously	Monitored by system computer
Feedstock Composition	Batch Tower (S1)	Sampled just prior to test	Sampled from batch tank
Glass composition	Cullet Cart (S2)	30-minute intervals	Ladle samples and cullet samples
Spray Channel water flowrate	Quench Exit (S5)	30-minute intervals during EPA Method 5 test	Measure time to fill known volume
Spray Channel water composition	Quench Exit (S5)	30-minute intervals during EPA Method 5 test	Samples taken as flowrate is measured
Spray Channel particulate composition	Quench Exit (S5)	30-minute intervals during EPA Method 5 test	Samples taken as flowrate is measured
Flue Gas flowrate	Exhaust Stack (S4)	Once during EPA Method 5 test	EPA/530-91-010
Flue Gas particulate flowrate	Exhaust Stack (S4)	Once during EPA Method 5 test	EPA/530-91-010
Flue Gas composition O2, CO, SO2, NOx	Exhaust Stack (S4)	Continuously	Monitored by system computer
System parameters: Temperature, Pressure, Flow	see Figure 6.0-1	Continuously	Monitored by system computer

5.0 PLANNED ACTIVITIES

The data from the test was reduced and analyzed, and incorporated into a comprehensive Final Report. The Final Report has been completed and is currently undergoing internal review. A no-cost contract extension until June 30, 1995 has been approved by DOE to allow for submission of the Final Report.