DOE/PC/91161--T16

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

CONTRACT DE-AC22-91PC91161

OCTOBER 1993 - DECEMBER 1993

PREPARED FOR

U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

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January 30, 1994

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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 completing the system modification installation designs, completing the TSCA ash testing, and conducting additional industry funded testing.

Final detailed installation designs for the integrated test system configuration are being completed. The equipment is being fabricated and deliveries have begun. A construction schedule is being developed so that the modifications can be accomplished without affecting the testing schedule.

The industry funded testing consisted of vitrifying Spent Aluminum Potliner (SPL) which is a listed hazardous waste. This testing has verified that SPL can be vitrified into a safe, recyclable glass product.

Two pilot-scale tests using a surrogate TSCA ash composition as the feedstock were conducted. The test produced a homogeneous glass product which should, based on a preliminary evaluation of the data, be essentially non-leachable.

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 NO_x, SO_x 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

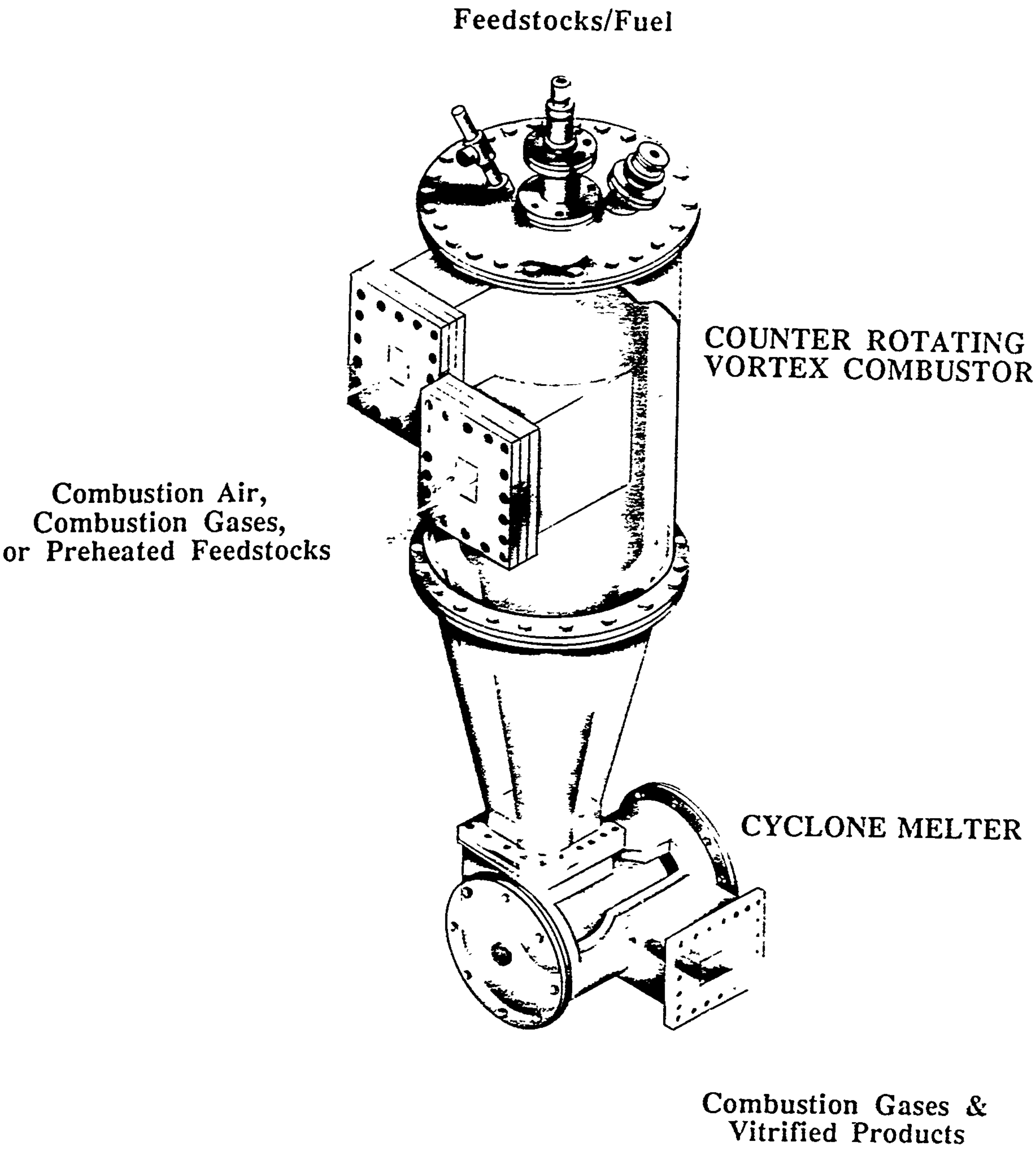

Figure 2.2-1. Artist Rendering of Basic CMS

CMS indicate NO_x 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 NO_x 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.

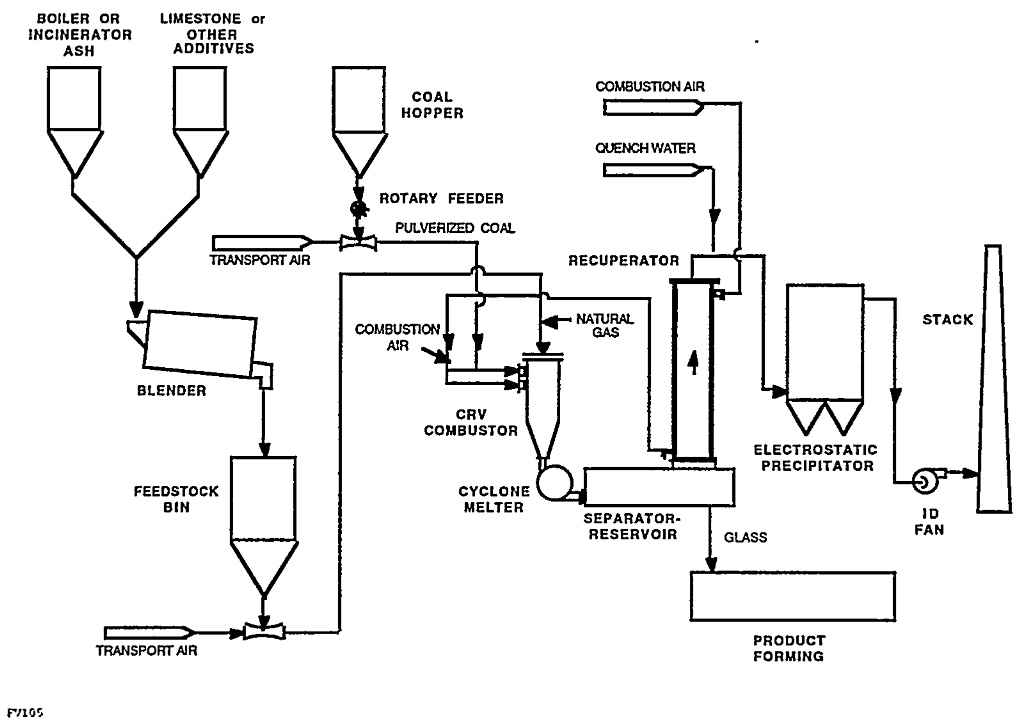

Figure 2.2-2. Vortec Ash Vitrification And Recycling System

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.

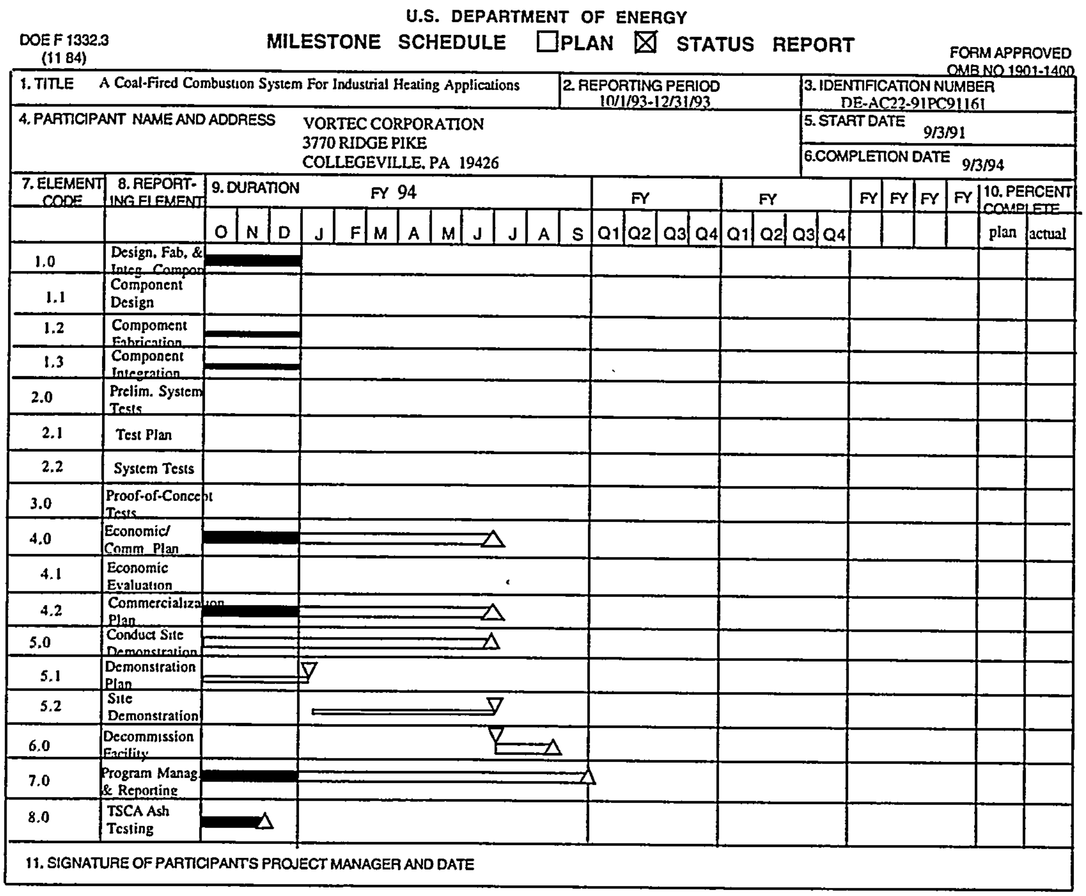

Figure 3.1-1. Phase III Program Schedule

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 system modification installation designs, completing the TSCA ash testing, and conducting additional industry funded testing.

Final detailed installation designs for the integrated test system configuration are being completed. The equipment is being fabricated and deliveries have begun. A construction schedule is being developed so that the modifications can be accomplished without affecting the testing schedule.

The industry funded testing consisted of vitrifying Spent Aluminum Potliner (SPL) which is a listed hazardous waste. This testing has verified that SPL can be vitrified into a safe, recyclable glass product.

Two pilot-scale tests using a surrogate TSCA ash composition as the feedstock were conducted. The test produced a homogeneous glass product which should, based on a preliminary evaluation of the data, be essentially non-leachable.

4.1 Design, Fabrication, Component Integration

Equipment maintenance and modifications to improve equipment performance are ongoing. The experimental test facility activities for the last quarter are as follows:

Air Preheat Subsystem

The installation design for the air preheat system has been completed. The air preheat subsystem modifications consist of 1) modification of the top of the separator/reservoir to allow for the installation of the radiation recuperator air heater, 2) installation of the recuperator on top of the separator reservoir, 3) installation of the plenum and evaporative cooler after the recuperator, and 4) installation of all of the associated ductwork and recuperator start-up burner controls. An elevation view of the integrated test system is shown in Figure 4.1-1.

Modification to the existing combustion air ductwork is under way. The existing ductwork is being modified so that the capability of using the existing thermoflux gas-fired air heater

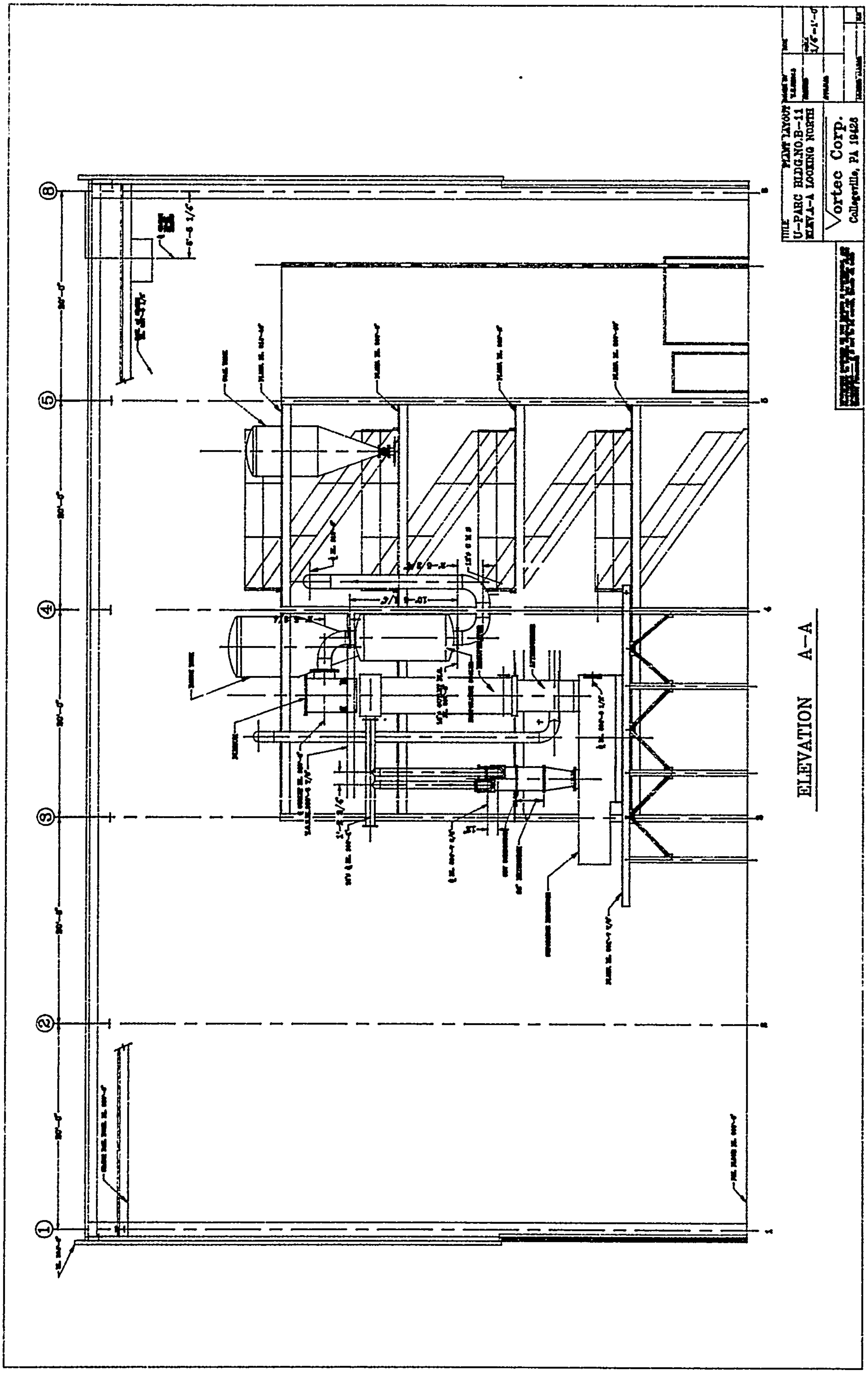

Figure 4.1-1 Elevation View of Integrated Test System.

is retained. This will allow the test system to be operated using either the external air heater or the recuperator.

The recuperator is currently being manufactured by ECT Inc. There will be a start-up burner located at the base of the recuperator as shown in Figure 4.1-2. The purpose of the burner is to provide heat to the recuperator during the start-up of the system. The burner is a premixed natural gas burner rated at 1.5 MMBtu/hr.

Combustion and Melting Subsystem

A spool piece section is being added to the CRV combustor to increase its combustion residence time. This modification will improve the carbon burn-out in the CRV and should allow the use of larger sized feedstocks. The modified CRV is shown in Figure 4.1-3. This modification will require removing the CRV from the test tower and lowering it to ground level. The CRV will be disassembled and all of the refractory will be removed. the new spool section will be installed between the existing top and bottom sections. The modified CRV will be relined using a low cement castable refractory which will be cast in place. The modified CRV will then be reinstalled in the test tower. These modifications are expected to begin early next quarter.

Coal Handling Subsystem

The design of the coal handling modifications have been completed and the equipment is currently being fabricated. The new coal storage and handling system will be installed outside, adjacent to the test facility. The foundation and support steel for the new coal tank have been installed. Some of the equipment for the coal storage and handling has been received and will be installed. Most of the coal handling equipment will be delivered in February.

Controls Subsystem

The controls subsystem consists of a 486 type personal computer, Metra Byte and Digitronics I/O cards, Genesis software, and the additional instrumentation required to integrate the various vendor subsystems into an integrated controls package.

Modifications to the control system to incorporate the controls required for the integration of the recuperator and the coal handling system are on going.

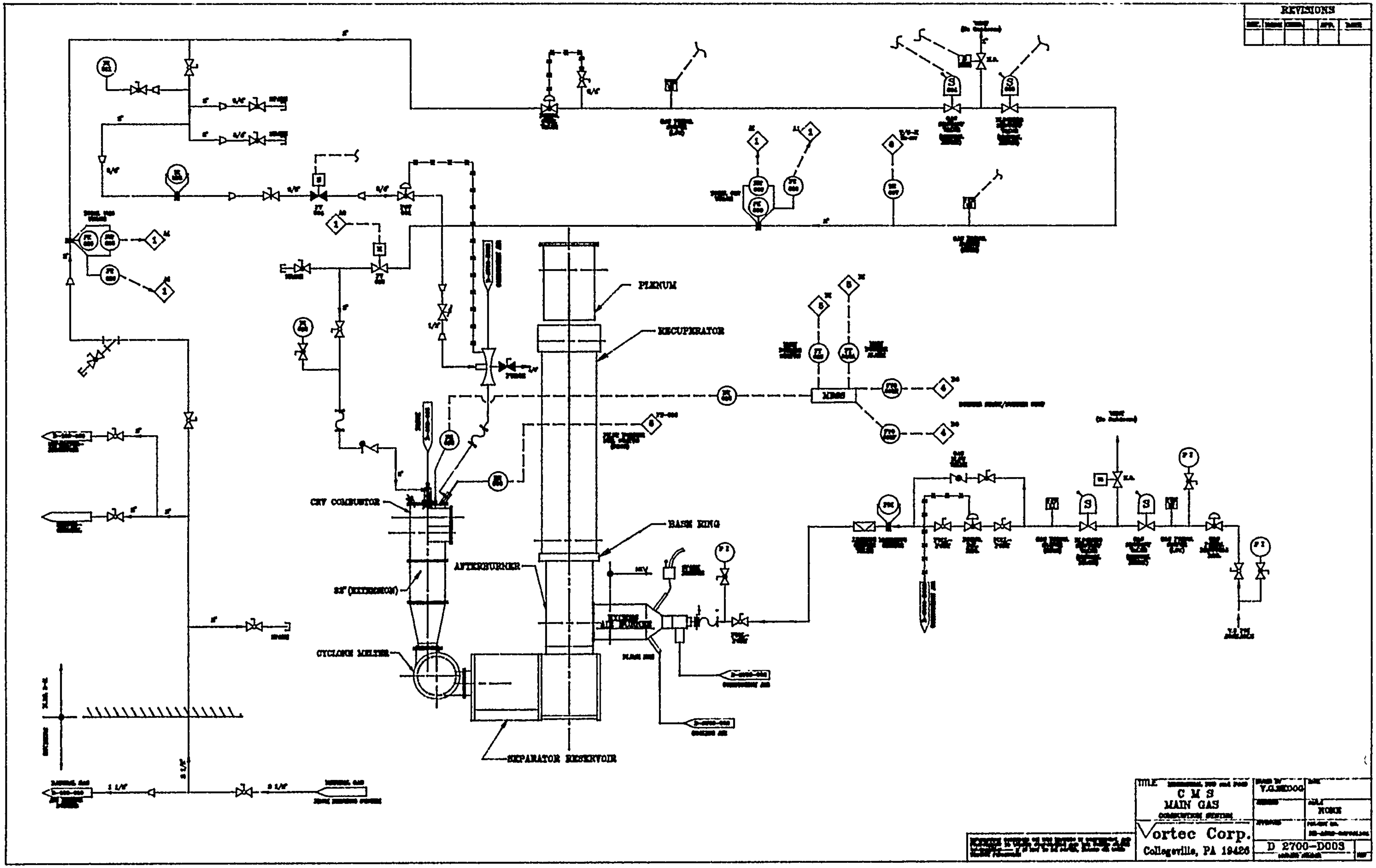

Figure 4.1-2 Drawing of CMS, Start-up Burner, and Recuperator Integration

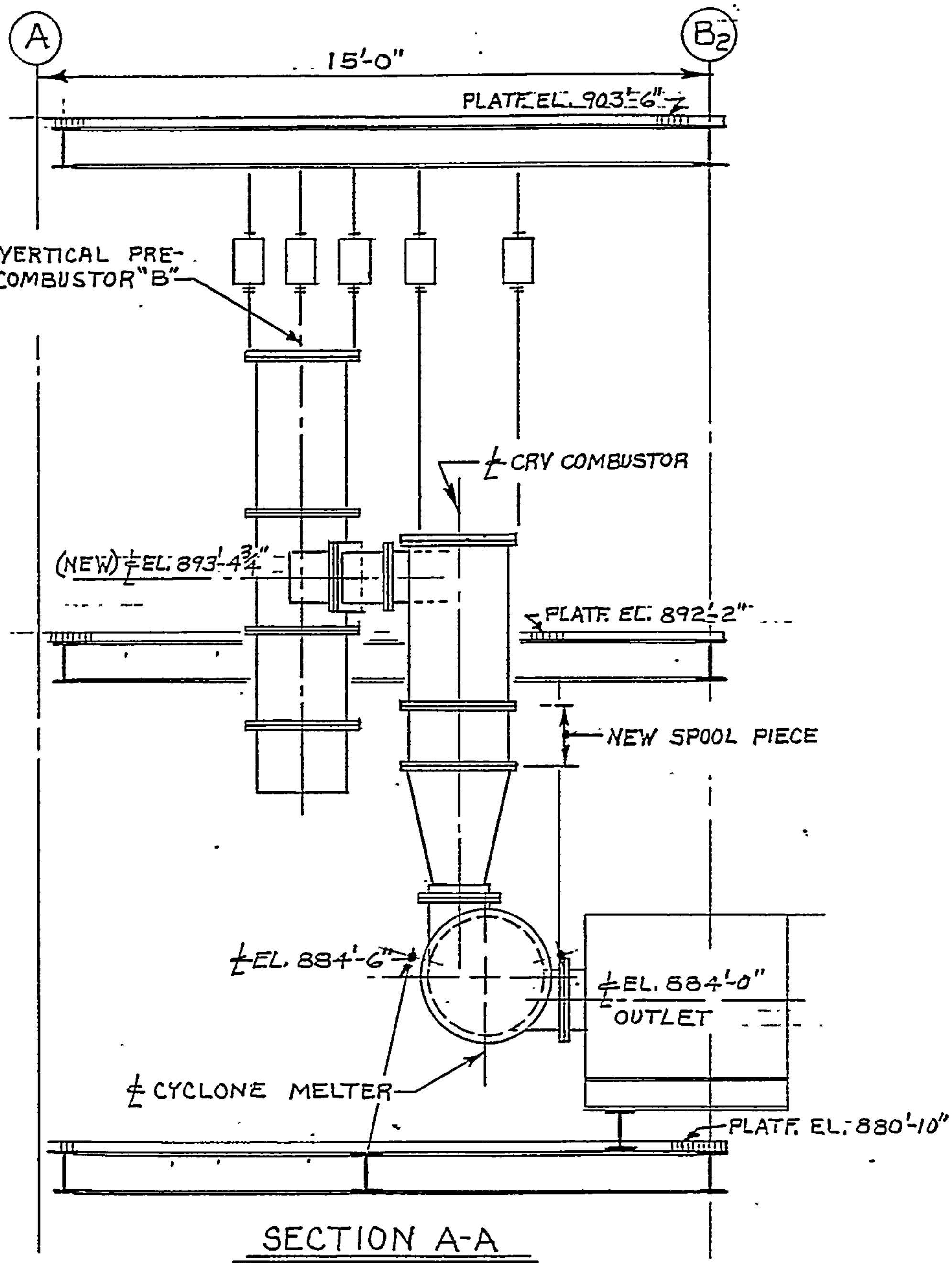

Figure 4.1-3 Modified CRV

Equipment Design

Vortec continually gets requests asking for the cost of a commercial CMS system. Engineering on conceptual designs is ongoing, and budget pricing for various sizes of equipment are continually being obtained. Our data base on equipment costs is rapidly growing, as well as our conceptual designs for systems with capacities of up to 400 tons per year. Engineering has developed a proprietary computer code for use in developing heat and mass balances as well as for sizing the CRV and cyclone melter for CMS systems. The use of the computer code allows us to rapidly establish the specifications needed to obtain the budget pricing for the various pieces of equipment required in a system.

4.2 Test Operations

4.2.1 Spent Potliner Testing

During the last quarter, a test was conducted using Spent Aluminum Potliners (SPL) as the feedstock. This test was independently funded by the generator of the potliner, and followed four previous successful SPL tests where 1000 kg of SPL was combined with various glass-forming ingredients and vitrified into a non-leachable glass product. The purpose of this additional test was to evaluate the effectiveness of the CMS in vitrifying SPL at higher feed rates.

The SPL feedstock consists of an anthracite coal liner and refractory insulation materials. It is a listed hazardous waste (K088) because it contains measurable quantities of cyanide which can leach from the SPL if it is exposed to rain. During the first four tests, the CMS produced a fully oxidized, non-leachable glass.

As during the first tests, 1000 kg of SPL was crushed and screened to minus 40 mesh using Vortec's vibrating ball mill. The SPL and additional glass-forming materials consisting of silica sand, limestone, and glass cullet were loaded into the batch tank and air-blended. Carryover from the air-blending was collected in a bag house and returned to the batch tank prior to the start of the test.

Prior to the test, the system had been idling with refractory temperatures maintained at approximately 2700°F. The feedstock was introduced along the longitudinal centerline of the CRV. The feedstock was rapidly heated in the flame zone and the carbonaceous materials were rapidly volatilized and the metal contaminants were oxidized.

During the course of the test, the system was held at a constant feed rate and thermal input for 1 hour so that an isokinetic flue gas particulate sample could be obtained using EPA Method 5 procedures and data could be recorded for the calculation of an accurate heat and mass balance. A separate particulate capture was also performed and the particulate was sent out for analysis.

Samples of the glass cullet for each of the tests were collected by an independent laboratory for detailed analysis to be included in the delisting petition. Additional samples were collected by Vortec for independent analysis. The glass chemistry and physical property analyses is currently being conducted by Corning Engineering Laboratory Services (CELS) and the TCLP testing is being conducted by Blue Marsh Laboratories. The testing of the particulate captured during the test is also being conducted by Blue Marsh Laboratories. The results of this testing have not yet been received.

No major operational problems were encountered during the test. Reduction of the data from the glass and flue gas analyses will be completed in 1 to 2 months. Cost sharing support for the trials is being provided by the waste generators.

4.2.2 TSCA Ash Testing

A Test Plan was developed for the pilot-scale vitrification testing of surrogate TSCA incinerator ash, and was approved by DOE. The approved test matrix for the test program is summarized in Table 4.2-3. The testing was composed of two demonstration tests which provided a database on the performance and operation of the CMS when vitrifying surrogate TSCA incinerator ash feedstocks. Each test used natural gas as the primary fuel. The feedstock (including surrogates for radionuclides) was a mixture of municipal solid waste incinerator (MSWI) bottom ash and fly ash, and heavy metal oxides.

The surrogate ash mixture used for each of the tests is shown in Table 4.2-4. Based on inputs from DOE and other DOE contractors, the original proposed composition of the surrogate ash was changed to include cesium and cerium. Table 4.2-5 lists the composition of the combined MSWI bottom ash and fly ash which was used as the base component for the surrogate TSCA ash. The carbon content was varied between the two tests to study its effect on the capture rate of the heavy metals into the vitrified product. The first test was performed without the addition of coal; therefore, the carbon content of the surrogate ash was approximately 1.8 wt%. In the second test, pulverized coal was added to the ash mixture to increase the carbon content to 12 wt%. The chemical composition of the coal is listed in Table 4.2-6. Appropriate quantities of arsenic, barium, cadmium, chromium, lead, cerium (all in their oxide forms), and cesium chloride were added to the MSW ash to increase the concentration of each metal to the values displayed in Table 4.2-4.

A composition being evaluated by DOE for use as a surrogate for TSCA incinerator ash is also shown in Table 4.2-4 for comparison with the surrogates used in the vitrification tests. Several compounds in the surrogate being considered by DOE were not included in the surrogate ash for this test program. The F-listed wastes are not included, since these compounds are not truly expected to be present in the TSCA ash, although they are expected to be in the waste processed in the TSCA incinerator. Several metal compounds were excluded due to their high costs or because Vortec presently considers these materials to be too hazardous to handle at our pilot facility. In similar test programs, surrogate compounds have been used to simulate the behavior of hazardous compounds in the CMS. However, the metals which will be added to the surrogate ash represent both semi-volatile and non-volatile metals; therefore, the behavior of the excluded metals can be estimated based on the behavior of the metals included in the surrogate ash.

Table 4.2-1 Test Matrix and Schedule

RUN NO.	T DURATION (HRS)	FEEDSTOCKS	FUEL/OXIDIZER	TEST SCHEDULE
1	4-6	Low Carbon Content Surrogate TSCA Ash	NATURAL GAS/AIR	Dec. 7
2	4-6	High Carbon Content Surrogate TSCA Ash	NATURAL GAS/AIR	Dec. 8

Table 4.2-2 Characterization of TSCA Incinerator Ash and Surrogate Ash

Chemical Constituent	Surrogate Ash Test 1 wt%	Surrogate Ash Test 2 wt%	Estimated TSCA Ash wt%
bottom ash (excluding D-listed metals and carbon)	48.1	43.	40.
fly ash (excluding D-listed metals and carbon)	48.1	43.	40.
carbon	1.8	12.	12.
F001 (trichloroethylene)	-	-	1.
F002 (tetrachloroethene)	-	-	1.
F003 (acetone)	-	-	1.
F005 (methyl ethyl ketone)	-	-	1.
D004 Arsenic	.3	.3	.5
D005 Barium	.3	.3	.5
D006 Cadmium	.3	.3	.5
D007 Chromium	.3	.3	.5
D008 Lead	.3	.3	.5
D009 Mercury	-	-	.5
D010 Selenium	-	-	.5
D011 Silver	-	-	.5
Cerium (surrogate for uranium)	.3	.3	uranium not specified
Cesium Chloride	.3	.3	not specified
oxygen associated with metals	.4	.4	NA

Table 4.2-3 Chemical Composition of Combined Bottom Ash and Fly Ash Mixture

	wt%		wt%
SiO_2	37.4	CdO	0.006
Al_2O_3	10.0	Cr_2O_3	0.07
K_2O	1.60	PbO	0.32
Na_2O	3.98	HgO	<0.01
CaO	19.7	SeO_2	<2ppm
Fe_2O_3	5.30	Ag_2O	<0.002
MgO	5.13	C	1.81
SO_3	3.81	Cl	4.1
BaO	0.10	H_2O	1.5
		Volatiles	5.17

Table 4.2-4 Chemical Composition of Coal

Proximate Analysis	dry wt%	Ash Analysis	dry wt%
ash	1.23	SiO_2	47.17
volatile	35.38	Al_2O_3	30.9
fixed carbon	63.39	K_2O	1.46
sulfur	0.61	Na_2O	1.32
		CaO	3.46
Ultimate Analysis	**wt %**	Fe_2O_3	10.09
carbon	85.44	MgO	0.89
hydrogen	5.32	SO_3	1.32
nitrogen	1.62	BaO	0.32
chlorine	-	TiO_2	1.89
sulfur	0.61	P_2O_5	0.31
ash	1.23	SrO	0.39
oxygen	5.78	Mn_3O_4	0.06

The cerium oxide was added to the surrogate ash to simulate the radionuclides uranium and cesium chloride was added as a simulant for radioactive cesium. Simulated radionuclides are non-radioactive metals, the behavior of which will simulate the behavior of the true radionuclide species in the CMS. Cerium Oxide will simulate the behavior of uranium within the CMS, for its chemical properties are similar to those of uranium. For example, cerium oxide has a large atomic radius, forms the same oxidation states as uranium, and has a vapor pressure similar to that of uranium. Based on the composition of the surrogate ash and laboratory melt testing, no glass-forming additives were necessary.

The MSWI bottom ash and fly ash, coal as required for Test 2, and metal oxides were blended at Vortec's UPARC facility prior to each of the tests. The resulting contaminated mixtures were stored in 55-gallon drums until the day of the tests. The drums were then loaded into the batch tank and reblended to ensure a homogenous mixture.

The first test was conducted on December 7th, with the surrogate consisting of an MSW ash containing 5% carbon and spiked with heavy metal oxides including cesium and cerium. The primary objective of the first test in the sequence was to evaluate the melting performance of the Vortec CMS when processing a surrogate TSCA incinerator ash containing approximately 2 wt% carbon, and to obtain baseline emissions data from the system.

Throughout the test, the glass exited the separator reservoir at the tap hole closest to the melter exit. Steady state glass flow were established, and the glass was allowed to flow for approximately 6 hours with samples taken every 15 minutes. During steady state flow, a total of four EPA Method 5 sampling procedures were performed by Comprehensive Safety Compliance, Inc., an outside environmental testing company. Two samples were collected before the wet ESP to evaluate the total carryover from the process, and two samples were collected after the ESP to evaluate ESP performance. Additionally, several large captures of carryover particulates were taken so that the particulate could be analyzed to establish the partitioning of the heavy metal and radionuclide surrogates.

Approximately 5,100 lbs of surrogate was vitrified and glass samples were collected for analysis. The glass samples taken during the first test are being analyzed chemically to determine the composition of the glass and petrographically to determine if any un-dissolved feedstock materials remain in the glass. The glass is also being analyzed using the TCLP and PCT leaching and glass durability tests. Success will be measured by the ability of the CMS to produce a vitrified product which passes both TCLP and PCT.

All of the data from the testing has not yet been received. The data obtained by the Method 5 test and the glass analysis, along with the data logged by Vortec's computer-based process controller and test personnel, will be used to perform a heat and mass balance around the CMS. This data will also be used to determine the partitioning of the heavy metal and radionuclide surrogates.

Having established a baseline performance for the vitrification of surrogate TSCA ash using the CMS combustor, a second test was conducted on December 8th using a surrogate consisting MSW ash again spiked with heavy metal oxides including cesium and cerium. However, during this test the carbon content of the surrogate was also increased to 12% to evaluate the effect of carbon content on the vitrification process and on the capture rate of the heavy metal and radionuclide surrogates in the vitrified product. Approximately 4,900 lbs of surrogate was vitrified during this test and glass samples were collected for analysis.

As in the previous test, the flue gas was sampled four times using Method 5 procedures to establish carryover rates for the process, and particulate samples were collected for analysis. Also the glass sampling and analysis was conducted using the same procedures as those used during the first test.

No operational problems were noted during either test. The glass produced was black and appeared fully vitrified. The glass samples will be analyzed for chemical composition, and glass leachability and stability will be measured using the TCLP and PCT tests.

4.3 Commercialization Planning

The Business Plan has been completed. Vortec is actively marketing the process for glass melting, industrial waste treatment, and contaminated site remediation applications.

4.4 Project Management

Copies of the revised Management Plan, Cost Plan, Labor Plan, and Schedule Plan were submitted to the Document Control Center as per contract requirements. The revisions to these plans reflect the program plan for FY 1994.

The Semi-Annual Summary Report of DOE-Owned Plant and Capital Equipment was submitted to DOE as per contract requirements.

5.0 PLANNED ACTIVITIES

The data from the surrogate TSCA pilot-scale melt trials will be reduced and analyzed, and the results of this analysis will be incorporated into a comprehensive Test Report.

Modifications to the test system are under way. The CRV and melter will be removed for relining and the installation of the spool piece in the CRV. Modifications to the existing duct work to allow the installation of the recuperator will also begin. Deliveries of the major equipment components (coal tanks and recuperator) are expected to occur next quarter. Installation of the equipment will begin next quarter and should be completed by the second quarter of CY 1994.

6.0 SUMMARY

The TSCA ash testing was completed and the data is currently being analyzed. Additional industry funded proof-of-concept testing has been successfully completed using SPL as the primary feedstock. The test system is currently being modified for the installation of the new coal storage and feeding system and the recuperator. These modifications should be completed during the second quarter of CY 1994. When the modifications are completed, longer duration demonstrations testing will begin.

It is anticipated that the program will be completed on schedule and within the original budget.