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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

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PREPARED FOR

**U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER**

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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 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 designs of the remaining major components of the integrated system were completed and the equipment was ordered. The funds allocated during FY 93 were expended earlier than planned because the costs associated with the maintenance and repair of the test system and installation of the ESP were greater than anticipated.

Although the funds were expended earlier than planned, it is anticipated that all of the facility modifications will be completed by the end of CY 93. After the modifications are completed, the long duration proof-of-concept tests and the demonstration tests will be completed. It is anticipated that the program will be completed on schedule and within the original budget.

DOE has modified to modify the scope of the existing R&D program being conducted under this contract to include testing of a simulated TSCA incinerator ash. The modification will be in the form of an additional Task (Task 8 - TSCA Ash Testing) to the original Statement of Work. Additional funding is expected in August which will allow the tests to be conducted during the next quarter. A detailed description of the work to be performed under this task is included in Section 5.1.

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 SO₂ 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 multi-fuel 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 10⁶ 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.

3.1 Program Description

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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

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

Although the FY 93 funds were expended earlier than planned, it is anticipated that all of the facility modifications will be completed by the end of CY 93. After the modifications are completed, the long duration proof-of-concept tests and the demonstration tests will be completed. It is anticipated that the program will be completed on schedule and within the original budget.

The primary reason that the FY 93 funds were expended during the last quarter was that the installation and integration of the ESP electrical and control subsystems proved to be more expensive and time consuming than anticipated. Additionally, maintenance and repair of the CMS test loop also proved to be more expensive than anticipated.

4.1 Design, Fabrication, Component Integration

The majority of the design effort under this program has been completed. The emphasis will now shift to the installation and integration of the remaining components. The next major component to be installed will be the new coal storage and feeding system. A Purchase Order has been issued to a vendor for the fabrication of the batch/coal handling modifications. During this same time period, the conversion of the existing coal tank to a batch tank will occur. This conversion is expected to take 1 to 2 weeks. These modifications are planned to be completed by the end of September. As the components arrive, they will be installed and checked out prior to beginning the longer duration proof-of-concept tests. After the modifications are completed, long duration coal-fired proof-of-concept tests are planned to be conducted in October.

The designs for the major components of the air heater (recuperator) have also been completed and a vendor has been selected for fabrication. Delivery of the air heater is expected in October with installation and integration being scheduled during the first quarter of FY 94.

4.2 Test Operations

A test was conducted using an anthracite coal and a surrogate industrial waste as the feedstock. The actual waste contains 30% anthracite and is a listed hazardous waste. The test was conducted with oxygen enrichment to assure complete combustion of the

anthracite. The feedstock melted at a very high temperature (approximately 2900°F). However, preliminary evaluation of the glass produced indicated that most of the carbon was combusted prior to the melting of the glass. The glass had a low carbon content and was light green in color. The light green color indicated that the glass was fully oxidized. If any carbon had been remaining when the glass was molten, the glass would have been reduced and black in color. This test was funded by the generator of the industrial waste.

Based on the results of the surrogate industrial waste, a second test was funded by the industrial waste generator using the actual waste as the feedstock. The objective of this test was to vitrify spent aluminum potliner (SPL) to produce a non-leachable glass product.

Approximately 1000 kg of SPL was delivered, pre-crushed to nominally minus 1/2 inch, to our pilot-plant test facility located in Harmarville, PA. This material was further crushed and screened to minus 40 mesh using Vortec's vibrating ball mill. This material was weighed and 250 kg was set aside for this test. The chemical composition of the SPL used for this test is provided in Table 4.2-1.

After the pilot-scale surrogate test, the batch formulation for the first treatability test was modified to include a small amount of glass cullet to improve the melting characteristics of the SPL. Additional additives included silica sand and limestone.

The additives and SPL were loaded into the batch tank and were air-blended in the batch tank. Carryover from the air-blending was collected in a bag house and returned to the batch tank prior to the start of the test.

For this test, oxygen was also introduced co-axially with the feedstock into the top of the CRV. The oxygen allows for more rapid combustion of the large amount of carbon in the SPL prior to the melting of the inorganic constituents. A commercial SPL process unit could be designed to provide additional residence time in the CRV combustor to allow complete combustion of the carbon without the use of oxygen.

The feedstock was introduced along the longitudinal centerline of the CRV. The feedstock was rapidly heated in the flame zone and the carbonaceous materials are rapidly volatilized and incinerated and the metal contaminants are oxidized. The inert materials were heated to nominally 2700°F.

Table 4.2-1 SPL Chemical Composition

Determination	Pulverized SPL (Wt. %)
Na ₂ O	23.8
Al ₂ O ₃	22.8
CaO	2.57
Fe ₂ O ₃	2.02
SiO ₂	16.5
SO ₃	0.27
C	23.8
F	13.2

The preheated solid materials from the CRV enter the cyclone melter where they are separated to the chamber walls to form a molten glass layer. The glass produced and the exhaust products exit the cyclone melter through a tangential exit channel and enter a glass separation chamber where the molten vitrified product is drained and the flue gases exit the system.

For this test, the feedstock was pneumatically transported and axially injected into the top of the CRV combustor using the existing dense phase pneumatic convey system at our test facility.

Prior to this test, the system had been idling with refractory temperatures maintained at approximately 2700°F. Because of the high anthracite content of the SPL, the systems natural gas thermal input to the CRV was ramped down to approximately 1.5 MM Btu/hr and the SPL batch feed was initiated. The SPL was initially fed to the system at a low rate to evaluate its melting characteristics. The feed rate was then ramped up to approximately 300 lbs/hr. After the batch feed had stabilized the feed rate increased to approximately 500 lbs/hr and remained relatively constant throughout the remainder of the test.

Before the batch feed had begun, oxygen flow was initiated at approximately 250 lbs/hr. This flow rate was selected based on the pilot-scale surrogate test previously conducted.

Oxygen flow was maintained throughout the test to assist in the complete combustion of the carbon.

Glass product samples were collected by Vortec for independent analysis. The glass chemistry and physical property analyses were conducted by Corning Engineering Laboratory Services (CELS) and the TCLP testing was conducted by Blue Marsh Laboratories.

From a qualitative standpoint, the glass produced from the SPL was green in color which generally indicates that the glass is fully oxidized. Some of the green coloring may also be caused by the chrome in the system's refractory. The chemistry analysis shows that the majority of the fluoride in the SPL was volatilized and not incorporated in the glass matrix. On a theoretical basis, if none of the fluoride was volatilized, the glass would contain approximately 9.6% fluoride. Therefore, only about 18% of the total fluoride in the SPL was captured in the glass. During the surrogate testing, the fluoride capture rate was only 2%. This suggests that the form of the fluoride compounds in the actual SPL are more readily incorporated into the glass matrix.

The glass chemistry also indicates that a substantial quantity of sodium was also volatilized during melting. Only approximately 50% of the total available sodium in the batch was captured in the glass. This is caused by the relatively high temperatures (about 2700°F) of the CMS during the test. To reduce the amount of sodium carryover, the next test will be run at a lower temperature if the molten glass remains flowable. Past experience indicates that sodium volatilization can be greatly reduced if the temperatures remain below 2500°F.

The remaining chemical species remained relatively stable with little volatilization or carryover. Based on the glass product chemistry, the glass produced is very stable and essentially non-leachable.

Two samples of glass cullet were sent to Blue Marsh Laboratory for TCLP Testing. The results of this testing is provided in Table 4.2-2. As can be seen in the table, the TCLP extract from Sample 1 contained no detectable quantities of RCRA metals, cyanide, or fluoride except for a small concentration of chromium. The chromium detected is most likely the result of the chrome refractory liner installed in the CMS. However, the concentration of chrome is still two orders of magnitude below the TCLP regulatory limit.

Table 4.2-3 Test 62 Product Glass TCLP Results

Parameter	62-1 06-3548	62-2 06-3549	P.Q.L.	RCRA/ TCLP Limit	EPA Method Used
MISC. on TOTAL: (mg/kg)					
pH (Corrosivity)	5.39	5.11	+/-0.01	2-12.5	9045
METALS on TCLP Extract: (mg/l)					
Arsenic	ND	ND	0.1	5.0	6010
Barium	ND	0.21	0.05	100.	6010
Cadmium	ND	ND	0.02	1.0	6010
Chromium	0.06	ND	0.02	5.0	6010
Lead	ND	ND	0.1	5.0	6010
Mercury	ND	ND	0.002	0.2	7470
Selenium	ND	ND	0.05	1.0	6010
Silver	ND	ND	0.02	5.0	6010
MISC. on TCLP Extract: (mg/l)					
Cyanide	ND	ND	0.01	---	335.2
Fluorene	ND	ND	0.001	---	625

ND = The compound indicated was not detected at or above the practical quantitation limit (PQL) listed for the method performed.

The Sample 2 extract also contained no detectable concentrations except for barium. The barium concentration was also several orders of magnitude lower than the regulatory limit.

Two glass samples were sent to CELS for petrographic analysis by transmitted light microscopy. The purpose of this testing is to determine if any unmelted batch components (stones) were in the glass product. Sample 1 was glass cullet collected from the cullet cart. The cullet contained the following inclusion (stone) varieties: Cr₂O₃ stones, "opaques" with secondary Cr₂O₃ at peripheries, and primary and secondary ZrO₂ stones.

The second sample was a solid piece of glass which was thin sectioned to facilitate the analysis. The stones in this sample were essentially the same as in the first sample with the exception of an occasional small silica batch stone and one 1.5 mm metallic sphere. The metallic sphere was contamination from a previous test run which processed wastes

containing a large amount of iron. The silica stones are the result of the limited glass residence time. During the test, the glass was drained from the system immediately after exiting the cyclone melter. In a commercial system, the glass would pass through a small reservoir to ensure complete dissolution of the silica. The glass produced readily passes TCLP requirements. Additional silica dissolution will only lead to the production of a more stable glass.

Some of the stones detected are from the CMS refractory liner. Because of the thermal cycling of the test system, the refractory liner develops small cracks which allows small pieces to spall off into the molten glass. The zirconia stones are from the refractory mortar in the separator/reservoir. The commercial SPL processing system will have a refractory system specifically designed to minimize refractory wear. The commercial system also will not be thermally cycled which will eliminate refractory spalling.

Overall the test was very successful with no operational problems. The feedstock was easily transported and injected into the CMS where it melted readily. The CMS was able to completely oxidize the carbon prior to the formation of the glass. The glass produced appeared to be fully oxidized and contained very little unmelted batch. The glass product also easily passed TCLP regulatory requirements. Because of the success of the test, the SPL generator is funding additional testing to be conducted in August.

4.3 Commercialization Planning

The Business Plan was completed and was submitted to Dawnbreaker, a DOE sponsored small business development consulting firm. The Plan was reviewed by Dawnbreaker, and changes suggested by them were incorporated in a revised plan. Vortec has been notified by Dawnbreaker that its Business Plan has been selected to undergo additional review and will be evaluated by a panel of venture capitalists in late CY 93.

4.4 Project Management

All of the FY 93 funds have been expended. Therefore, any additional modifications or testing conducted during this fiscal year will use funds from outside industrial/government sources. A contract modification is expected in August which will provide additional funds to conduct testing using TSCA ash as a feedstock. A description of the work to be conducted under this modification is provided in the following section.

5.0 PLANNED ACTIVITIES

The primary activity planned for the next quarter is the vitrification testing of the TSCA incinerator ash surrogate. It was determined by DOE to modify the scope of the existing R&D program being conducted under this contract to include testing of a simulated TSCA incinerator ash. The modification will be in the form of an additional Task (Task 8 - TSCA Ash Testing) to the original Statement of Work.

5.1 Task 8 - TSCA Ash Testing

The Vortec Combustion and Melting System (CMS) is a candidate process for vitrification of incinerator ash, and TSCA incinerator ash has been specifically identified as a candidate waste stream for initial testing. The purpose of this task is to establish the advantages of the CMS on present and future TSCA mixed waste streams processing (e.g., liquids):

- (1) to establish if the Vortec technology can match or exceed the efficiency of a cyclone/baghouse;
- (2) improve regulatory acceptance of a TSCA Incinerator; and
- (3) provide data to allow cost benefit analysis.

An additional systems study will be conducted to determine if the CMS system may be able to function as a secondary combustion unit on other thermal treatment systems (e.g., a plasma process).

The Contractor shall conduct all activities necessary to establish the feasibility of the CMS in this type of application. Demonstration tests of the CMS as a vitrification process for incinerator ash shall be conducted in FY93. Demonstration tests will not be performed with actual TSCA ash. The tests will utilize an approved surrogate material, with composition defined based on the ash from the TSCA incinerator at K-25 in Oak Ridge. The Contractor shall acquire sufficient quantities of the surrogate material to perform the required tests. The demonstration will determine if the CMS system can meet the requirements for processing of TSCA and other DOE incinerator system ash.

Several test on surrogate ash (including surrogates for radionuclides) will be conducted:

- (1) Process variables will be examined including temperature, feed rates, and amount of additives
- (2) The off-gas will be characterized for particulate and metal emissions.

- (3) The vitrified product will be characterized using leaching tests (PCT and TCLP) and standard chemical analysis techniques.

5.1.1 Subtask 8.1 Laboratory Analysis & Surrogate Definition

The objectives of this task are to (1) establish the composition of the simulated TSCA ash to be evaluated, (2) obtain representative simulated TSCA ash for pilot-scale feasibility testing, and (3) conduct laboratory analysis of the simulated ash to determine the type and quantity of glass forming additives required to form a fully vitrified product at an acceptable temperature. The research performed during this Task will define the constituents and percentages of glass formers required to produce non-leachable glass products from the TSCA ash. This data will provide the basis for defining surrogate feedstock compositions and the operating parameters for the pilot scale experiments.

Small quantities (approximately 1 kg) of representative simulated TSCA ash materials will be shipped to or prepared for testing in Vortec's laboratory in Collegeville, PA. The composition of the simulated ash will be analyzed by qualified laboratories for carbon content, inorganic oxides, metals, and effective heating value. The compounds to be addressed in the analyses will be based on data obtained from Oak Ridge and data published in existing DOE reports.

Crucible melts using Vortec laboratory furnaces will be conducted to establish appropriate mixtures of ash and glass former blends for vitrification in the Vortec CMS. Additionally, the mixtures developed under this task will be the basis for the simulated TSCA ash feedstock formulation to be used during pilot scale testing. Existing Vortec laboratory scales and blending equipment will be used to prepare the various feedstock mixtures for the crucible melt vitrification treatability tests. Baseline compositions of the feedstock mixtures will be established by qualified laboratories such as Corning Laboratories or Spectrochemical Laboratories. The potential glass batch mixtures to be used in the program will be established by evaluations of inputs provided by Vortec ceramic engineers and our glass science consultants.

A primary result of this task will be the determination of the simulated TSCA ash composition, the development of an ash/glass former blend composition, and the verification that the simulated TSCA ash can be effectively vitrified and consistently pass TCLP testing.

5.1.2 SubTask 8.2 - Pilot-Scale Testing

Vortec shall prepare a test plan which defines the following:

1. Test program objectives
2. Test schedule
3. Type and range of test parameters and nature of the data that will be obtained
4. Sampling and analysis methods/instrumentation
5. Methods for data acquisition and analysis
6. Test data evaluation and interpretation.

Vitrification tests using simulated TSCA ash will be performed using the Vortec experimental Combustion and Melting System (CMS) at Vortec's pilot plant test facilities in Harmarville, Pennsylvania.

The objectives of the pilot-scale testing will be to accomplish the following:

1. Determine the overall operating characteristics of the CMS when processing simulated TSCA ash, define the feedstock melting characteristics, required operating temperature for effective melting and product throughput capacity.
2. Determine the heat rate (fuel thermal energy required per ton of waste) of the Vortec CMS when vitrifying the ash.
3. Determine the amounts of NO_x, SO_x, CO, O₂, and particulates in the flue gas from the Vortec CMS during ash vitrification.
4. Determine the characteristics of the vitrified product produced by the CMS.
5. Identify any special operating problems or requirements which may be unique to processing TSCA ash.

Two test runs will be conducted under this subtask. Each test run will consist of a 20 hour heat up period during which the thermal input to the system will be ramped up to bring the refractory and gas temperatures in the system to operational levels, initiation of feedstock flow to the system and ramp up of the material flow to a normal operating level, 4 to 8 hours of vitrified material production, and a 20 hour period during which glass production is terminated and thermal input to the system is decreased to ramp down system

temperatures. The feedstock for the first test run will be an ash/glass additive mixture ratio as determined under Subtask 8.1.

During the vitrification tests, stack gas and scrubber water from the vitrification system will be sampled and analyzed after the system has been operating for a length of time sufficient to reach a steady state thermal condition. Additionally, samples of the vitrified product from the CMS, particulate washed out in the water quench, and scrubbing water will be taken for analysis. The test system is instrumented to provide fuel and combustion air flow rates, feedstock feed rate, vitrified product temperature, product gas temperature at various locations, cooling water flow rates and temperatures to provide input to heat and mass balance calculations. The system is also instrumented to provide on-line monitoring and recording of O₂, CO, SO₂, and NO_x in the stack gas.

The stack gas will be sampled and analyzed by an outside testing laboratory, such as Geraghty & Miller, Inc. Air Quality Group, for flow rate, molecular weight, and particulate matter. The basic framework for the stack gas testing program will utilize promulgated EPA Methods 1 through 5.

A minimum of two vitrified product samples from each test will be sent to an outside testing laboratory such as Corning Laboratory Services. These samples will be tested for chemical composition, TCLP, and PCT.

The data from the tests will be collected and compiled into a comprehensive Test Report. The data will be of sufficient detail to prove the feasibility of the CMS to process TSCA ash and provide for the development of an accurate cost benefit analysis.

6.0 SUMMARY

The facility modifications are progress smoothly. The installation of the recuperator will complete the system modifications required to make the test loop a completely integrated coal-fired pilot-scale melt system capable of operating on a continuous basis.

Because of the lack of funding through the end of the next quarter, work planned under the original Statement of Work is being held in abeyance. However, the addition of the TSCA incinerator ash testing will enable the program to continue without interruption.

After the TSCA ash testing and the installation of the remaining equipment, several 24 hour proof-of-concept tests will be conducted to shakedown the integrated system. Following these tests, the demonstration tests will be conducted. The demonstration tests are currently planned to begin in early CY 94.

**DATE
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12/22/93

END