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WORK PLAN
FOR SILOS 1 AND 2
PROOF-OF-PRINCIPLE TESTING

REVISION 0

Vortec Corporation's CMS™ Test Facility
University of Pittsburgh Applied Research Center
(U-PARC)

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Fluor Daniel Fernald Program Work Plan

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1.0 INTRODUCTION

This draft Work Plan is specialized for the testing to be conducted at the Vortec Test Facility for the Fluor Daniel Fernald Proof-of-Principle program.

1.1 PROJECT DESCRIPTION

Vortec will utilize its High Temperature Test Facility at Harmarville, PA to perform Proof-of-Principle Testing of the Cyclone Melting System (CMS™) to demonstrate the viability of its vitrification technology for the processing of surrogate Silo 1 and 2 materials. Following preliminary tests, a 72-hour demonstration will be conducted to establish system performance. Samples will be obtained of all the effluent and influent streams during the test to define partitioning of the contaminants among the effluent streams. The final waste form, glass, will be tested to establish compliance with the expected waste acceptance criteria of typical DOE waste repositories.

In addition, a preliminary design of a full-scale system will be developed that is capable of processing the 6800 m³ of waste material in Silos 1 and 2 during three years of operation. This design will be the basis of the life cycle cost comparison needed by FDF to complete a feasibility study.

1.2 TEST OBJECTIVES

The overall objective of the Proof-of-Principle Test is to demonstrate the suitability of Vortec's CMS™ technology for the treatment of silo residue at Fernald. The testing will employ non-radioactive surrogates which closely simulate the key chemical/physical characteristics of the actual silo residues. The test program will provide preliminary design data for a full-scale remediation facility at Fernald as well as information on the safety, reliability, implementability, cost, and schedule of such a facility.

The test program will be initiated by cold testing of the slurry injector to be used to introduce both the slurry and dry glass additives into the Vortec reactor. In addition, two short duration melting tests (6 - 8 hours), the preparation of the surrogate slurry and dry glass additives for 72 hours of operation, and a continuous 72-hour demonstration will be accomplished.

Success is measured by the ability of the CMS™ to produce a fully-reacted vitrified product which passes the Toxicity Characteristic Leaching Procedure (TCLP) for leaching of metal contaminants and the other acceptance criteria established by FDF. Samples of all streams into and out of the test control volume (defined as illustrated in Figure 4.1) will be analyzed to establish the partitioning of the heavy metal and radionuclide surrogates.

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The specific objectives of the project are to:

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1. Establish the appropriate glass chemistry which will result in a durable glass product following the vitrification in the Vortec process for the demonstration, Silo 1 and Silo 2 surrogates.
2. Modify the Vortec test facility to accommodate the testing requirements,
3. Perform one cold injector test and two short duration (six hour) melting tests in preparation for a 72-hour continuous demonstration test,
4. Process a minimum of 2,600 kg of (30 wt % solids) demonstration surrogate slurry per 24-hour period for a total of 72 hours of continuous operation,
5. Obtain sufficient data to demonstrate the capability of the Vortec CMSTTM to allow Fluor Daniel Fernald to evaluate the potential of this system to process Silos 1 and 2 residue on a full scale basis,
6. Produce glass for subsequent analysis with respect to actual composition and leachability using both present and proposed toxicity characteristic leachability limits,
7. Evaluate feedstock injector performance with respect to FDF slurried tank waste,
8. Obtain preliminary data with respect to flue gas handling requirements through stack sampling and analysis (these data are also needed to establish partitioning) and,
9. Provide experimental data for the preliminary design of a full-scale CMSTTM for the treatment of Silos 1 and 2 residue.
10. Determine best parameters to limit particulate and lead carryover into the off-gas system.
11. Determine the best parameters for sulfate destruction and eliminate or reduce and dissolve sulfate carryover with glass.
12. Determine best parameters for the separation and capture of lead and sulfate in the off-gas system. And then show plausibility of recycling particulates and lead back to the feedstream.
13. Provide analytical data and characterize secondary waste streams.

1.3 WORK PLAN SUBMITTALS

Draft A of this Work Plan was submitted to Fluor Daniel on June 25, 1998. The current draft (Draft B) of this Work Plan has been prepared by incorporating Fluor Daniel's comments and addressing various issues raised by the FDF team.

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2.0 TECHNOLOGY DESCRIPTION

The primary components of Vortec's CMS™ are a counter-rotating vortex (CRV) reactor and a cyclone melter. An artist's rendering of the basic CMS™ concept is shown in Figure 2-1. A unique feature of the process is the rapid suspension heating and oxidation of feedstock materials in the CRV reactor prior to the physical and chemical melting processes which occur within the cyclone melter. The use of the Vortec CRV reactor in conjunction with a cyclone melter distinguishes the Vortec CMS™ technology from other types of cyclone reactor systems. In the CMS™ process, granular glass-forming ingredients and other feedstocks are introduced into the top region of the CRV reactor. Air is introduced tangentially into the reactor through two inlet arms in such a manner as to create two counter-rotating flow streams. Fuel is also introduced through the inlet arms. As a result of the intense counter-rotating vortex mixing, it is possible to achieve a stable reaction in the presence of large quantities of inert particulate matter. Both convection and radiation heat transfer mechanisms contribute to the rapid heating of the feedstock materials within the CRV reactor.

Any organic contaminants in the feedstocks are also effectively oxidized. As a result of the unique features of the CRV reactor, the Vortec process is able to rapidly heat inert solids to melting temperatures at gas-to-solids mass ratios on the order of 2:1.

Gaseous products and preheated feedstock from the CRV reactor enter the cyclone melter where the solids are separated to the chamber walls and glass forming chemical reactions occur. The molten material and the gases exit the cyclone melter through a tangential channel and enter a separator/reservoir (not shown in the figure), where a pool of the vitrified material is collected. The vitrified material exits the reservoir through a bottom or side tap, and the flue gases exhaust to a recuperator for heat recovery by means of air preheating.

The flue gases exiting the recuperator are treated in an air pollution control (APC) assembly prior to being exhausted out the stack. As a result of the high thermal efficiency of the Vortec CMS™, the flue gas flow rates are relatively modest. Because the temperature and composition of the vitrified product can be closely controlled, the amount of process fuming (volatile carryover) can also be minimized. In most applications, the total amount of uncontrolled particulate carryover is less than 2% of the total mass of feedstock into the process.

High local flame temperatures (approximately 4000°F) can be achieved in the Vortec process, since preheated air at a temperature of approximately 1200°F can be used in the process. In spite of the high local flame temperatures, NO_x emissions have been demonstrated to be low; that is, typically less than 200 PPM. The NO_x control capability is due to the rapid temperature quenching by the particulate and the staged oxidation inherent in the design of the CMS™. (It should be noted that the same rapid quenching mechanism that effectively reduces the NO_x will produce a similar result on the formation of Dioxin if PCB's are present in the feedstock).

The average gas-solids suspension temperature leaving the CRV reactor chamber is typically on the order of 2000°F to 2700°F, depending on the product being vitrified. The process temperatures in the cyclone melter are typically in the range of 2000°F to 3000°F, depending on the melting characteristics of the feedstock being processed. Excess air levels are typically in the range of 5 to 20% depending on the makeup and the nature of the feedstock being processed.

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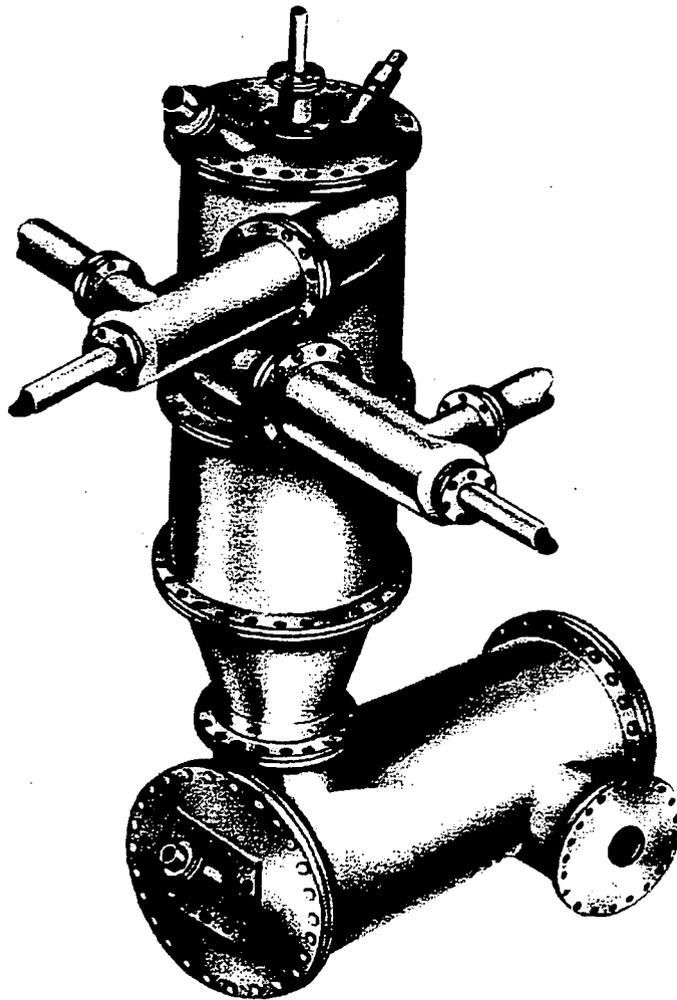


Figure 2-1. Artist Rendering of the Basic Cyclone Melting System

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3.0 PROOF-OF-PRINCIPLE TREATMENT RECIPE DEVELOPMENT

3.1 INTRODUCTION

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Batch compositions will be identified for the vitrification of the surrogate slurries to produce glasses which are acceptable by the present RCRA Toxicity Characteristic (TC) limits and the proposed RCRA Universal Treatment Standards (UTS). It is anticipated that one glass composition with minimal batch additives will be able to achieve the UTS, therefore the initial work will be directed at this target. However, Vortec will define six separate target formulations, two each of the S1, S2, and the demonstration surrogates.

The major objectives in the laboratory scale work will be to minimize the processing temperature to decrease the volatilization of lead and to maximize the waste loading to decrease the amount of material that ultimately requires storage/disposal. Since the slurry compositions in the supplied table contains relatively high concentrations of glass network forming oxides (SiO_2) or network forming oxide producing compounds (PbCO_3), the initial vitrification recipe will contain slurry without batch additions. Additional glasses will be prepared with the addition of boric acid and nepheline syenite to reduce the glass melting temperature and potentially increase the durability of the glass. These additions will bring the composition of the vitrified product close to the composition of the chemically durable borosilicate glasses chosen for vitrification of high level radioactive waste. Preliminary calculations indicate the vitrification batches containing 85% slurry (at 70% water) with 15% additions should be sufficient to achieve this goal. Approximately 70 percent of the oxides in the final vitrified product will be derived from the waste.

The laboratory work performed during the treatment recipe development will be carried out in accordance with Vortec's Quality Assurance Plan. Standard operating procedures will be followed that are based on the ASTM methods required by FDF or sound laboratory practices.

3.2 PROCUREMENT OF SURROGATE INGREDIENTS

Prior to completion and acceptance of the Work Plan, Vortec will purchase the necessary compounds (ingredients) for the preparation of the surrogate silo slurries. Small batches of the slurries will be prepared according to the instructions provided in the Contract, and the characteristics of the slurry will be established.

3.3 RAW MATERIALS SPECIFICATION

Certifications, assays, and MSDS sheets will be obtained with each shipment of material from the supplier. Only sources that are able to supply this information will be considered. Exceptions to this case may be the sources for the feldspar and diatomaceous earth. Sieve testing will follow ASTM Method D422, and moisture associated with the samples will be determined according to ASTM Method D2216. The resulting assays and moisture content will be used to formulate the slurry recipes for the vitrification testing. The non-water soluble compounds will be characterized by a sieve analysis to insure that the particle size and distribution of particle size

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are required. This test will verify the data provided by supplies on product data sheets used in the selection of the materials. The water soluble compounds will be assumed to dissolve in the slurry thus their particle size is irrelevant. Copies of the assays, certifications, and particle size analysis will be provided to FDF as requested.

3.4 SURROGATE COMPOSITION VALIDATION

Samples of the surrogates containing 30 wt % moisture will be prepared from the chemical compounds purchased and characterized to insure that the prepared surrogates have similar chemical characteristics to the batches of surrogates prepared during FDF development of the formulas.

Samples of the surrogates will be prepared (1.5 kg) in Vortec Corporation's laboratory. The formulas for the surrogates will be determined from the desired surrogates chemical compositions provided by FDF and the moisture content of the raw materials as determined during the raw materials evaluation. The total moisture content of the raw materials will be taken into account so that the moisture of the surrogates is 30 wt %. A description of the surrogate preparation and characterization methods is given below. The surrogates will be characterized by moisture, insitu density, plasticity, pH, sieve analysis and TCLP for lead. If the desired surrogate properties are not achieved during the small scale surrogate preparation, Vortec will inform FDF and together modifications will be made as needed. Additional surrogate preparations will be performed until the desired surrogate properties are achieved.

Once acceptable surrogates are produced, 3 liter samples of the surrogates will be provided to FDF for validation of the surrogate characteristics.

3.5 SURROGATE PREPARATION AND CHARACTERIZATION

The preparation of the surrogates will be performed according to the Statement of Work in the Contract.

1. Weigh out the dry chemicals and place in a suitably sized container.
2. When all powdered chemicals, other than the organics, have been added, blend well. Break up all lumps so that no lump is larger than that of the coarsest particle, i.e., the course silica.
3. Add the organics and continue blending. Ensure that the organics are completely mixed with the dry chemicals and absorbed by them.
4. Add the amount of water necessary to result in a 30% moisture mixture. The finished product should ball up like clay at this moisture content. A sheen of organics on the surface of the mixture is typical.

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A sample of the dry blended ingredients, after step 2, will be tested for particle size according to ASTM Method D422. In this analysis, the mesh sizes used shall be US Sieves 80, 120, 140, 170, 200.

When the slurry becomes too thick to stir with a stirring rod, other mechanical means will be utilized. Once completely mixed, the slurry will be allowed to age for at least 24 hours prior to characterization so that the compounds are allowed to hydrolyze and come into equilibrium.

The moisture content of the surrogate containing 30 wt % moisture will be determined by a weight loss on drying at 105°C for 24 hours in an oven (ASTM Standard D 2216). The moisture content of the surrogates will be controlled to 30 ± 2 weight percent. If this criterion is not achieved, then the moisture content of the slurry will be adjusted through the addition of water or drying.

The density of the surrogate will be determined using the Corp of Engineers method of insitu density measurements specified by FDF on August 14, 1998. If the surrogate density is not within the required range, then the chemical weights into the batch and the particle size of the materials will be verified. If revising these amounts or the particle size of the materials does not correct the density, further guidance from FDF will be sought.

The pH of the surrogate will be determined with a pH meter. If the pH of the surrogate (where 5 grams is mixed with 95 grams of water to obtain the first pH) is outside of the range of 9 to 10 then FDF will be contacted for additional information.

The plasticity of the surrogate will be characterized by the plastic limit as determined according ASTM D4318 "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils." The desired plastic limit for the surrogate should be in the range of 45 to 55% moisture by dry weight. If the plastic limit is not in this range, then the amount of silica fume will be increased while the amount of 200-mesh silica decreased.

The leaching behavior of lead in the surrogate will be characterized by TCLP analysis. If the lead concentration in the leachate is not in the specified range of 650 to 850 mg/l, then FDF will be contacted to determine the appropriate action.

3.6 GLASS RECIPES

Batch compositions will be identified for the vitrification of the surrogates to produce glasses which are acceptable by the present RCRA Toxicity Characteristic (TC) limits and the proposed RCRA Universal Treatment Standards (UTS). It is anticipated that six glass compositions with minimal batch additives will be able to achieve the UTS, therefore the initial work will be directed at this target. After completion of this phase of formulas development, Vortec plans to pursue a single robust formulation to treat all six surrogates.

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The major objectives in the laboratory scale work will be to minimize the processing temperature with destruction of the sulfate phases. This will decrease the volatilization of lead and maximize the waste loading in order to decrease the amount of material that ultimately requires storage/disposal. Since the slurry compositions in the FDF supplied recipes (see Appendix A for these data) contain relatively high concentrations of glass network forming oxides (SiO_2) or network forming oxide producing compounds (PbCO_3), the initial vitrification recipe will contain slurry without batch glass conditioning additions. Target temperature reductions are in the order of 200°C .

Additional glasses will be prepared with the goals of reducing the glass melt temperature, obtaining a chemically durable glass, and destroying the sulfates. The glass melt temperature will be reduced with the addition of fluxes to the surrogates. Alkali metal oxides such as Na_2O and Li_2O , and B_2O_3 act as fluxes. The alkali metal oxides tend to decrease the durability of the glass with Na_2O having the greatest negative effect on the durability. B_2O_3 reduces the melt temperature without a large effect on the glass durability. One disadvantage with the B_2O_3 containing glasses is there tends to be a compositional region of phase separation. During the laboratory testing and review of the literature attention will be given to observing such phase separation. The potential raw material sources for these oxides in the glass recipes include nepheline syenite (a source of Na_2O), lithium silicates, and boric acid. These additions will bring the composition of the vitrified product close to the composition of chemically durable borosilicate glasses chosen for vitrification of high level radioactive waste and glasses reported in the literature for the vitrification of the K-65 silo wastes. Preliminary calculations indicate the vitrification batches containing 85% slurry (30% solids and 70% water) with 15% additions should be sufficient to achieve this goal. Approximately 70% of the oxides in the final vitrified product will be derived from the waste.

During the preparation of the laboratory crucible glass melts, there is a potential for the sulfates to segregate into a sodium rich liquid phase at the top of the glass melt. To control the formation of this sulfate phase, the addition of reducing agents to the glass recipe and higher melting temperature will be utilized. Based on Vortec's previous experience, during pilot scale operations, with high sulfate feeds, it is not anticipated that reducing agent additions to the batch will be required to eliminate the sulfate phase.

3.7 LABORATORY VITRIFICATION TESTS

The laboratory vitrification tests will occur in two phases. During the first phase, 300 g batches of glass will be prepared to determine the most suitable vitrification recipe for each of the three slurries to meet the TC and UTS standards. The resulting glasses will be characterized to determine the chemical composition and the leaching behavior. Additionally, the glass transition temperature of the vitrified product will be determined through differential thermal analysis (DTA). Based on the glasses prepared during the first phase, the most suitable glasses for the vitrification technology will be selected for the second stage of the laboratory vitrification tests.

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During the second phase, larger glass batches will be prepared, approximately 15 kg, to produce the multiple samples which are desired by FDF.

Based on the corrected slurry recipes determined during the surrogate validation, six slurry batches ((2) demonstration, (2) silo 1, and (2) silo 2) will be prepared according to the procedure defined in section 3.5 of this document.

For the laboratory vitrification tests, approximately 140 kg of each surrogate will be prepared. These slurries will be used for the preparation of the trial glasses (Phase 1) and final laboratory samples (Phase 2).

During Phase I of the laboratory testing, the glass recipe for the surrogates will be developed. The initial set of glass recipes will include melting the surrogate without additives, surrogate with varying amounts of nepheline syentite, lithium silicate or carbonate, boric acid, and combinations of these additives. Ten to twenty glass recipes will be prepared during these initial tests. The glass samples will be prepared by placing a measured amount of batch materials into an aluminum crucible for melting. The alumina crucible will be loaded into an electrically heated box furnace at room temperature. The furnace will then be heated to 1,100°C and the melt checked. The melt will be checked for complete melting and viscosity as well as for the presence of a second liquid sulfate phase. The temperature of the melt will be determined by a type S thermocouple in close proximity to the crucible containing the glass melt. If it is determined that the glass is too viscous, then the temperature of the furnace will be increased by 50°C and the melt checked again. If a second phase is detected, it will be analyzed to determine the chemical composition and adjustments will be made to the batch recipe and/or temperature to eliminate the second liquid phase. Once the viscosity is low enough for pouring, the furnace temperature will be recorded as the melt temperature. The glass will be held at the melt temperature for one hour, removed from the furnace, poured onto a steel plate, and crushed for further characterization.

The glasses produced will be sent to a laboratory to determine their chemical composition. The glass transition will be determined by differential thermal analysis. The density of the vitrified product will be determined with the use of a picnometer.

The waste loading for the vitrified product (i.e., treated surrogate) will be calculated from the vitrified product using batch ingredients and the recipe selected for vitrification with the formula:

$$\text{Waste Loading} = \frac{WDW}{WDW + \text{Water} + \text{Additives} + \text{etc} - DG} \times 100$$

where

WDW = Waste Dry Weight

= Dry Surrogate + Dry Bentonite Weights

DG = Decomposition Gases produced in heat treatment technologies.

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The bulking factor, BF, will be determined by the resulting treated surrogate volume (representing the volume of the treated silo residues) divided by the corresponding volume of the untreated surrogate (representing the insitu volume of silo residues). The volume of the untreated surrogate will be determined using the previously determined insitu density, P_i . The bulking will be calculated as follows:

$$V_i = 0.30 \times M_{si} \div p_i \qquad BF = (V_f \div V_i) \times 100\%$$

Where:

BF = Bulking Factor

V_i = Specific volume of the 70 wt% solids surrogate slurry mixture.

V_f = Specific volume of treated surrogate

P_i = Insitu density (previously) determined

M_{si} = Mass of the 70 wt% water slurry before treatment

The volume of the final product will be determined from the density of the vitrified product prepared in the laboratory phase of the project.

The leaching behavior will be investigated with a standard TCLP test for the RCRA metals and other metals listed. Prior to the TCLP test, the glasses will be crushed and sized to between 100 and 140 mesh and rinsed with isopropyl alcohol to obtain material with a uniform surface area and free of fine particles for the TCLP. The 100-140 mesh sized particles are prepared for the TCLP to obtain a constant surface area so that the variations in leachate concentrations can be attributed to differences in the glass compositions and not variations in surface area of irregularly shaped large particles. The results from the TCLP tests, the melting behavior of the glasses, and the waste loading will be used to determine the most suitable glass for the three slurries and the implications on obtaining the desired leach rates.

From the results obtained during the first phase of laboratory testing, additional glass recipes will be developed. Specifically, this work will target obtaining a high waste loading while achieving the less than 0.75 mg/l of Pb (the UTS Pb limit) in the TCLP test. To compare the results from phase I, the Pb leach results will be normalized as a function of the Pb content of the glasses to determine if a given glass matrix is more suitable for immobilizing the Pb. If it is determined that the Pb leaching level is independent of the glass compositions selected, then the approach of setting the PbO concentration to that required to obtain the desired Pb leaching level will be taken.

During the second phase of laboratory melting tests, vitrification batches which result in 15 kg of the selected glasses will be prepared. From the molten glass, 24, 4-5 oz patties will be poured from the molten glass to provide the samples required by FDF for the leach immersion and shrinking unreacted core testing, and archive samples. The patties will be cooled in metal containers to contain the pieces which will form during cooling due to fracture. The patty pieces will be packaged in individually labeled containers. 150 oz of the molten glass will be poured into water to prepare the 36, 4 oz FDF archive samples. After the glass is poured into the water,

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it will be removed from the water, dried, and packaged into individual containers. Representative samples of the glasses will be collected for chemical analysis and leach testing.

After the completion of melting and characterization of the glasses, a report will be generated to summarize the laboratory work. Included in this report will be a comparison of the glasses prepared to address each waste stream, the methodology for selecting the most suitable vitrification batch for each slurry, and the leaching behavior and chemical analysis of the selected glasses produced on a large scale.

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4.0 TESTING AND DATA RATIONALE

This section will describe the testing procedures normally followed in the Vortec High Temperature Test Facility to conduct treatability tests. Treatability tests require sampling of all influent and effluent streams to provide data for the heat and mass balance around the CMS™ control volume. These data establish the effectiveness of the CMS™ at capturing the contaminants and incorporating them into the glass final waste form. Vortec plans to prepare ten separate populations of slurried surrogate and run them continuously in series of seven hours each (7x 10) approximately 72 hours.

4.1 SAMPLING POINTS AND SAMPLING FREQUENCY

Figure 4-1 is a process flow diagram for the Vortec pilot plant which shows the sampling locations for the process. The control volume for the Vortec process is drawn around the following CMS™ components: CRV reactor, cyclone melter, separator reservoir, and evaporative cooler. The inputs to this system include the surrogate slurry to be treated, the dry additives required to produce the design glass composition, fuel (natural gas in this case), preheated reactor air, batch atomization/transport air, and water for flue gas cooling. The outputs from this control volume are the glass product and the flue gas.

The mass flow rates of all of the above listed inputs and outputs are measured along with their associated temperatures and pressures as well as reactor and melter temperatures. Most of this data is logged into the computer based data acquisition system. Manual data logs are generated based on the frequency called for in the Data and Sampling Schedule, Table 4-1.

The data obtained from process measurements and subsequent analysis of physical samples will be used to support heat and materials balance calculations. These balances will be the basis for evaluating the performance of the Vortec process with respect to its ability to treat the silo residues, show how the elements partition in the process and establish feedstock additive, utility and energy requirements, and data for scale-up.

Data will be logged into the data acquisition system once every second and later reduced to five minute averages. Physical sample frequency is based on defined population size to be established for the continuous Vortec process when the Test Plan is developed. The Test Plan will be provided to FDF for information only.

Sampling Points and Data Requirements

The CMS™ process is to be evaluated based on the conversion of the surrogates into a glass form which is chemically durable with respect to leachability of contaminants and dissolution of the glass proper. In addition, the destruction of organic contaminants must be at or above regulatory requirements. In order to quantify the ability of the process to meet these objectives, a number of process variables must be measured and samples of input and output streams must be obtained for analysis. To limit the sampling and measurement requirements to a reasonable level, a

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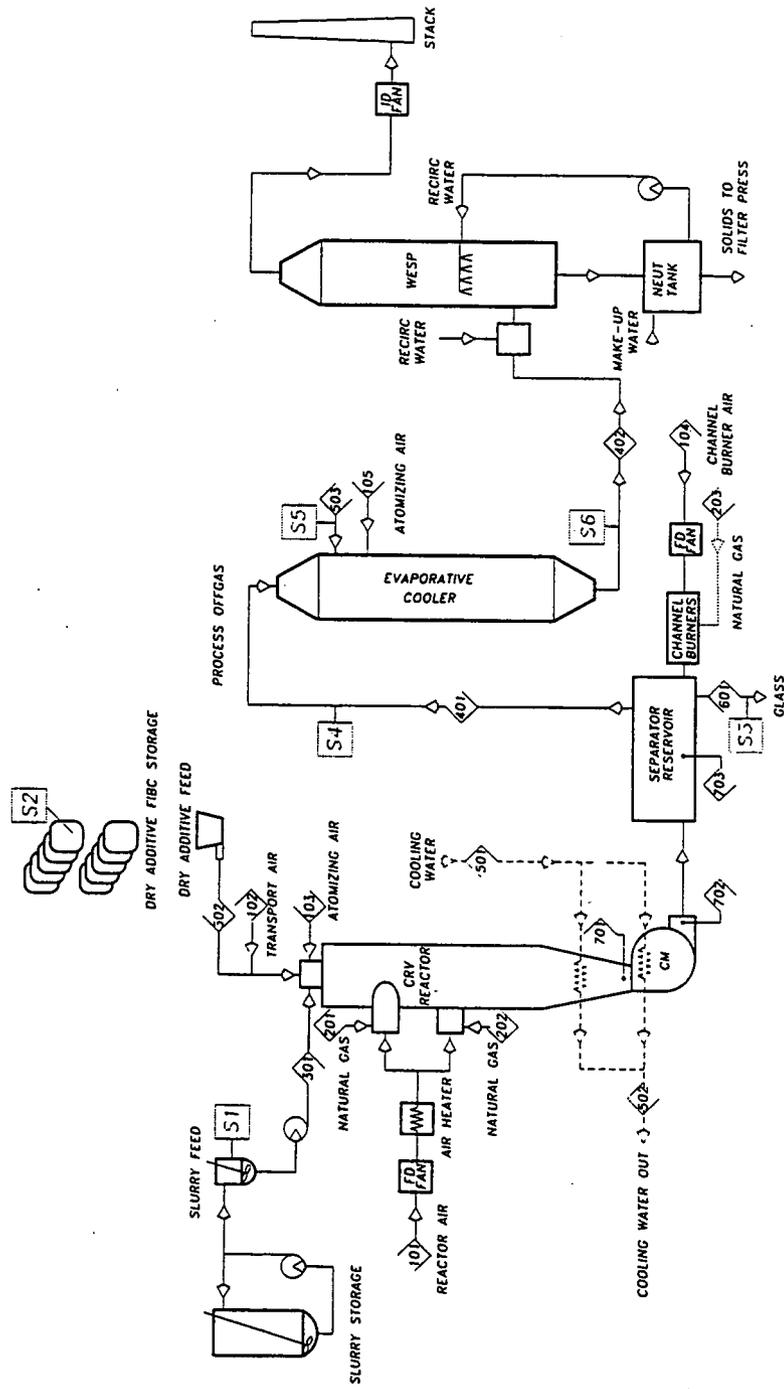


Figure 4.1. System Schematic

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Table 4-1. System Performance Sampling Matrix

Sampled Material	Sampling Frequency	# of Samples per population	Sampling Point
Slurry Batch	One composite per population	1	S1
Dry Batch	One composite per population	1	S2
Glass Patty	1 sample every 30 minutes	12	S3
	1 liter sample every 1 hour	6	S3
Evaporative Cooler Water	Once per test	1	S5
Flue Gas Particulate	Once per test	1	S6
Flue Gas Composition	Continuous	Continuous	S4
Sample from Separator Res.	Once at end of test	NA	703

comprehensive sampling matrix has been designed in accordance with the Test Plan. It will be used to define all aspects of the sampling process. The type of material, sampling frequency, and point of sampling are formally outlined in the table and will be followed during the surrogate testing. Assuming each test will take seven hours, sampling has been designed to take place during six hours so that the samples are representative of the test run. Figure 4-1 is a process schematic of the Vortec pilot test facility which includes the sampling point numerical designators. The sampling locations are the process inlet and exit points for the flow streams which require chemical analysis. The analysis of the batch is the starting point for verification of the batch composition and quantification of contaminants. The partitioning of the elements of interest among the various outlet streams is determined through chemical analysis of the outlet stream samples and the mass flows measured during the test sampling period.

In each of the following sections, a description is given of the method to be used in obtaining the various required samples. Vortec (or its subcontractor) will be fully prepared for sampling before initiation of the 72-hour test. Preparation for sampling includes the acquisition of all necessary sampling equipment and site-specific information, such as flow rates, to perform the required sampling.

Vortec (or its subcontractor) will supply pre-labeled sample containers (glass and polypropylene) and any necessary preservatives. The Vortec QA Manager will instruct all test personnel on the sampling procedures to be followed. The Vortec Laboratory Coordinator will verify that all of the sampling containers needed for shipping the samples to the analytical laboratory are available prior to the test initiation. Samples requiring refrigeration for preservation will be immediately transferred to coolers packed with ice or ice packs.

1. Slurry Batch

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The slurry batch will be prepared in a nominal 2000 gallon capacity mix tank in accordance with the Statement of Work of the Contract as follows:

1. Add the desired amount of water into the mix tank.
2. Turn on the mix tank agitator.
3. Add the bentonite while stirring/agitating.
4. Blend at high-speed until the contents are well mixed.
5. Maintain the stirring for 24 hours to allow the bentonite to fully hydrate.
6. In a separate container, add the organics to the fine silica.
7. Allow the silica to absorb the organics.
8. Weigh the dry chemicals and add to the bentonite/water mixture with sufficient agitation to keep all chemicals suspended.
9. Add the organics/silica mixture and continue blending for 24 hours.

Quantities sufficient for each sample population will be pumped into one of two 200 gallon feed tanks. Composite samples to represent each sample population will be collected from these feed tanks. Samples will be sent to FDF for evaluation, as mentioned in Section 4.3.1.1. A composite slurry sample will be obtained from each slurry population or 1/10 of total batch as per ASTM E 300 sections 35 through 38. The sampling point is designated S1 in Table 4-1.

2. Dry Batch

The dry batch materials, for the entire 72-hour test, will be transported to the batch blending tank from separate storage compartments. The dry batch will then be pneumatically blended and transferred into ten separate "Supersacks", one for each population. A representative sample of the blended batch will be taken out of each "Supersack" using a thief sampler in accordance with ASTM E 300 Sections 27 through 34. This sampling point is designated S2. The samples will be stored in laboratory prepared sample containers. After sampling, the contents of the "Supersack" will be emptied into a hopper above the CMSTM and introduced to the system via a screw feeder.

3. Glass Patty and Frit Samples

There are no formal ASTM procedures for sampling the treated surrogate (glass), so the following methodology will be utilized to standardize the process. The glass patty samples will be obtained from the stream of molten glass at sampling site S3. Twenty-four different patty samples will be taken for each test run. Each patty will be formed by using a steel ladle to catch the glass stream for exactly one minute every 30 minutes. The ladle will be cooled in water by immersion and rinsed with distilled water between samples to reduce the chance of contamination. The samples will be placed in steel containers to air cool and allowed to fracture. Four ounce portions of the samples will be collected, placed in air tight containers to form a sample, and then adequately labeled as per the chain of custody format. Twenty-four glass patty

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samples will be generated for each of the ten populations being processed. Additionally, patty samples will be collected for the analytical work to be performed on the glass by Vortec Corporation.

Glass frit samples will be collected on regular intervals by placing a slotted scoop in the glass quench water below the molten glass stream. After approximately one liter of glass frit has been collected, the scoop is removed, the water drained, and the sample spread on a clean surface and allowed to dry. The dried samples will be placed in air tight containers and labeled. Four glass frit samples will be collected for each of the ten populations.

Table 4.2 designates the sampling schedule. FDF and Vortec have chosen Batches 2, 5 and 9 on a random basis to provide glass samples for analysis.

Table 4.2. FDF Requested Glass Sample Schedule

	Leach Immersion (4 oz.)	Shrinking Unreated Core (4 oz.)	Archive (4 oz.)	Archive (4 oz.)	Archive Final Form
Silo 1 Surrogate TC (LAB)	6 Patties	6 Patties	12 Patties	36 (4 oz.) Frit	N/A
Silo 1 Surrogate UTS (LAB)	6 Patties	6 Patties	12 Patties	36 (4 oz.) Frit	N/A
Silo 2 Surrogate TC (LAB)	6 Patties	6 Patties	12 Patties	36 (4 oz.) Frit	N/A
Silo 2 Surrogate UTS (LAB)	6 Patties	6 Patties	12 Patties	36 (4 oz.) Frit	N/A
Demonstration Surrogate TC (LAB)	6 Patties	6 Patties	12 Patties	36 (4 oz.) Frit	N/A
72-Hour Batch 2	6 Patties	6 Patties	12 Patties	1 Liter of Frit	3 Liters of Frit
72-Hour Batch 5	6 Patties	6 Patties	12 Patties	1 Liter of Frit	3 Liters of Frit
72-Hour Batch 9	6 Patties	6 Patties	12 Patties	1 Liter of Frit	3 Liters of Frit
72-Hour Batches 1, 3, 4, 6, 7, 8, 10	1 Liter of Frit	1 Liter of Frit	1 Liter of Frit	1 Liter of Frit	3 Liters of Frit

5. Evaporative Cooler Water

One composite evaporative cooler water sample will be obtained from a bleed-valve off from municipal water input to the cooler system at Sampling Site S5. The purpose of collecting the sample is to determine if there is any metal contamination in the water which would increase the concentrations in the flue gas particulate. The water sample will be analyzed for Si, Al, Ca, Mg, Na, K, Fe, B, Ba, Zn, Ni, Pb, Cr, V, P, As, Se, and total solids.

6. Flue Gas Particulate

The quantity of flue gas particulate will be sampled by EPA Method 5 as described in 40 CFR, Part 60 by Comprehensive Safety Compliance, Inc. (CSC) at sampling site S6, Figure 4.1. A bulk flue gas particulate sample will also be collected for chemical analysis. CSC will be

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responsible for obtaining this material in accordance with the regulations. The particulate samples which correspond with the three random glass sampling events will be sent out for chemical analysis.

7. Flue Gas Composition

A Vortec managed flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, will provide for on-line continuous measurement of CO, O₂, SO₂, and NO/NO_x at sampling site S4. A continuous hydrocarbon analyzer, run by CSC, will also be used to determine the hydrocarbon destruction of the kerosene in the slurry. Furthermore, the measurement of specific feedstock contaminants, or other chemical species, may also be performed. CSC will sample the flue gas for SO_x at sample site S6.

8. Secondary Wastes

The small quantities of secondary wastes produced during the 72-hour test, primarily filter cake from the WESP, will be analyzed for hazardous characteristics and then disposed of accordingly.

4.2 IDENTIFICATION OF ANALYTICAL PROCEDURES

In addition to the system performance data described in Section 4.1 that will be provided by the heat and mass calculations described above, there is a requirement for glass and feedstock samples. These samples will be collected as described in Section 4.1 and will be analyzed by the certified laboratories.

Analytical Laboratory Testing of Samples From 72-Hour Test

Table 4-3 lists the influent and effluent streams to be tested from the 72-hour test. It describes which streams are to be tested for total metals and which are to be tested for leachable metals. The leaching tests will be conducted on the 8-RCRA metals, as well as Sb, Be, Ni, Tl, V, and Zn. The leaching results will be evaluated for their compliance with current TCLP regulations and potential UTS standards.

Table 4-3. Analysis of Samples From Proof-of-Principle Test

Stream	Metals Concentration	Leachability
Feedstock Slurry	yes	NA
Dry Glass Additives	yes	NA
Glass	yes	TCLP/UTS
Evaporative Cooler Water	yes	NA
Flue Gas Particulate	yes	NA

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Testing of the slurry, dry batch, evaporative cooler water, particulate, and glass-leaching will be completed by Quanterra Environmental Services as specified by FDF. Analysis of the composition of the glass will be performed by Corning Engineering Laboratory Services (CELS).

Analytical Laboratory Procedures

The appropriate analytical methods for chemical evaluation of the glass, dry batch, slurry batch, water, and flue gas particulate has been left to the discretion of the laboratory testing the materials. Quanterra will use two sets of methods to analyze the materials designated to their facility. SW 6010/7470 will be used to analyze the total metals and SW 1311/6010/7470 for the TCLP testing. It is assumed that all metals detected are in the oxide form and thus will be converted for the purposes of percent weight distribution. Corning will analyze the glass via Corning-derived methods which utilize plasma/emission spectroscopy and flame emission spectroscopy techniques. All data analysis packages will be included in the Proof-of-Principle report.

Physical samples collected during the Proof-of-Principle Test must be analyzed to obtain the data required to support heat and mass balance calculations. These analyses include elemental chemical analyses of the feedstock, the glass product, and the flue gas (both solid and gas phases). See Section 7.0 for further description of the analytical procedures. It should be noted that the Quanterra Laboratory has been certified by FDF as complying with their QA standards.

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5.0 PROCESS DESIGN AND TESTING PROCEDURES

This section discusses the implementation of the Vortec vitrification technology for processing Fernald Silo Surrogate and describes in detail the procedures to be followed in the Proof-of-Principle Demonstration Testing.

5.1 DISCUSSION OF DESIGN/CONFIGURATION OF THE TEST FACILITY

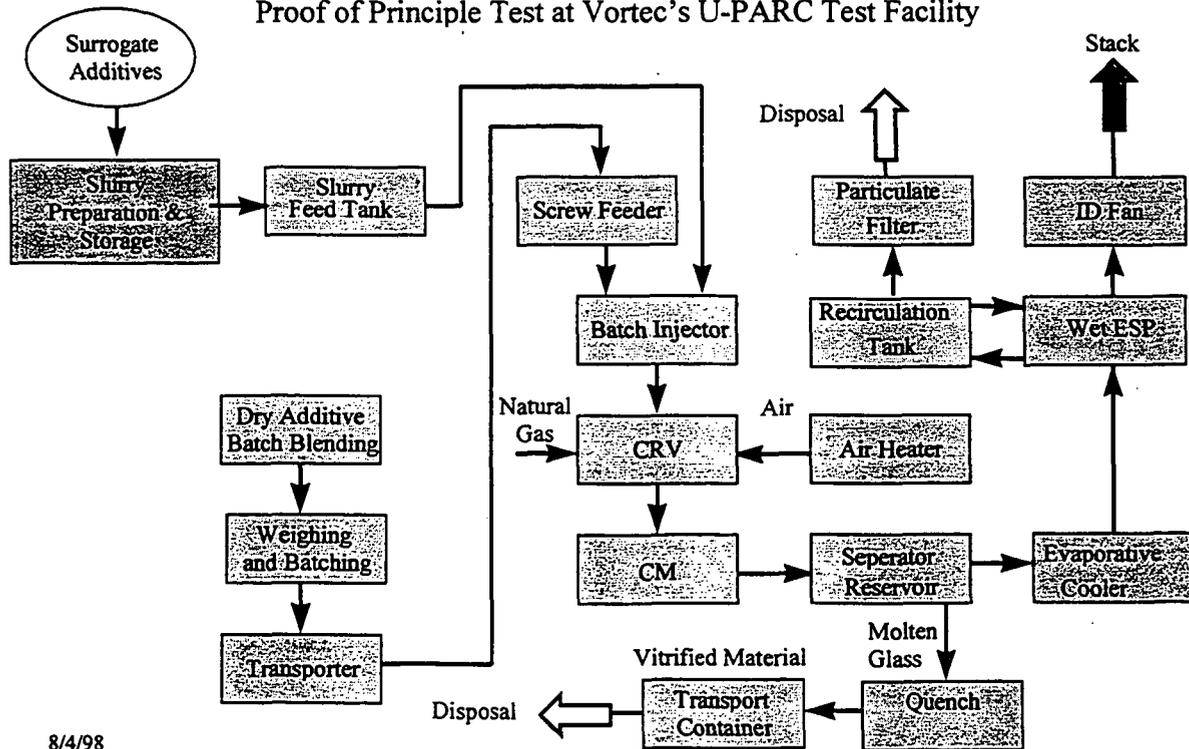
This section describes the Vortec Test Facility and its operational procedure.

5.1.1 Description of Operations and Equipment

Figure 5-1 is a block diagram of the Vortec test facility at U-PARC. The system is capable of processing nominally 10-15 tons/day of dry material at 2500°F (1371°C), depending on the feedstock. The test unit has a maximum thermal input of about 5 MM BTU/Hr constrained by the facility gas supply pressure; therefore, liquid additions will derate unit throughput as a function of the evaporation heating load, while operation at lower temperatures will reduce the solids heating load and allow increases in processing rate.

Block Flow Diagram, Fernald Surrogate

Proof of Principle Test at Vortec's U-PARC Test Facility



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Figure 5-1. Top Level Block Diagram for the Vortec U-PARC Test Facility

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The CMS™ based glass melting system consists of a batch feeding and injection subsystem (which may be dense-phase pneumatic, mechanical, or liquid atomization), an indirectly heated air preheating subsystem, a reaction and melting subsystem which includes the CRV preheater/reactor, cyclone glass melter, and glass/gas separator-reservoir, an APC subsystem, a vitrified product handing subsystem, and an instrumentation and control system. A flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provides for on-line continuous measurement of CO, O₂, SO₂, and NO/NO_x. In addition, the exhaust ductwork has ports to allow EPA Methods to be performed for the measurement of particulate emissions, specific gases, and total hydrocarbons. The instrumentation and control system is PLC based and utilizes a PC for the graphical user interface. Data logging is provided for all temperature, pressure, and flow measurements made in the course of a typical test run.

The test system is installed in a High Bay Area, with plan dimensions of 40' x 100', and a height of 64 ft., at the University of Pittsburgh Applied Research Center in Harmarville, PA. This area includes a tower for support of test equipment, and a 5-ton bridge crane.

Summary descriptions of each test facility subsystem are provided in the following sub-sections.

Batch Feeding and Injection Subsystem

There are two feed streams which are introduced into the Vortec CMS by means of a specially designed injector; the 30% solids demonstration slurry and the dry additives required to achieve the design glass chemistry. The dry solids are fed through the center of the injector while the slurry is fed through an annulus which surrounds the dry feed tube. Near the outlet of the injector, the slurry passes through holes in the dry feed tube. The two streams mix and are atomized at the exit plane of the injector by an atomizing air stream. Vortec will design and fabricate an suitably sized injector for this test. In addition to the injector, it will be necessary to add a slurry mixing and storage tank and two slurry feed tanks. The slurry mixing and storage tank will be equipped with an agitator and a circulation pump to keep the slurry solids in suspension. The circulation pump will also be used to transfer slurry to the feed tanks. Each feed tank will maintain one tenth of the total slurry (one population) which will be sampled prior to feeding. While tank "A" is delivering slurry to the CMS, tank "B" will be filled and sampled. A metering pump will be selected and purchased to pump the simulated slurry to the injector. A control signal from the pump will be fed to the PLC control system to provide the slurry feedrate into the system. Redundant pumps will be installed for the 72-hour Proof-of-Principle test.

Dry feeding is accomplished utilizing a gravity feed system consisting of a blending and storage tank, a flexible conveyor, a screw conveyor, weigh cells, and a flow valve. The dry ingredients for the 72-hour Proof-of-Principle Test will be air blended in a 150 cu ft blend tank. The prepared dry ingredients will then be loaded into ten flexible bulk bags (10 populations) for subsequent sampling. As each population is required throughout the test, it will be fed into the system through the blend tank to the flexible conveyor which feeds the storage hopper of the screw feeder. The system storage volumes will allow continuous feeding of the dry ingredients as the transfer conveyor can rapidly move the next population from the blend tank into the screw feeder hopper.

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The screw feeder sits on weigh cells which send a weight signal to the control system where feedrate is calculated. From the outlet of the screw feeder, the dry batch is fed through a flow valve where transport air is introduced to move the material into the slurry injector.

Reactor Air System

The reactor air system consists of a forced draft blower and separately natural gas fired air heater to simulate preheated reactor air as would be supplied through a heat recovery device such as a recuperator. The reactor air leaves the forced draft fan and passes through the air heater where it is preheated to nominally 1100°F (593°C). Stainless steel balance valves in the inlet piping adjust the air flow at the entrance to the CRV.

Reactor and Melting System

The Vortec CMS™ consists of three major components: the CRV reactor, the cyclone melter, and the separator-reservoir. The liquid feedstock is axially injected and atomized at the top of the CRV reactor. Natural gas and pre-heated reactor air are introduced co-currently with the feed injector and tangentially into the reactor through two inlet arms in such a manner as to create two counter-rotating flow streams. As a result of the intense counter-rotating vortex mixing, it is possible to achieve reaction stability in the presence of large quantities of inert particulate matter. Both convection and radiation heat transfer mechanisms contribute to the rapid evaporation of the liquid phase and subsequent heating of the solid phase within the CRV reactor. The heated feedstock flows from the CRV into the cyclone melter where glass reactions are completed and the product is separated from the gas stream. The separator reservoir has a floor tap to deliver glass from the cyclone melter (alternatively, a bath of molten glass can be maintained) and routes the separated flue gas to the flue gas handling system. Descriptions of these items follow:

CRV Reactor Assembly

The preheated reaction air and natural gas enters the CRV reactor via the lid and the inlet arms. Initial heating occurs in a pre-reactor stage between the lid and the inlet arms. At the inlet arm stage, the high inlet velocities provide a well stirred upper section for flame stability and effective oxidation of organics and batch heating. The CRV is a refractory lined, carbon steel, water cooled vessel. Water cooling maintains the metal surfaces of the vessel below 125°F. The vessel includes interconnecting tubing between water jacket segments and fittings for view ports, thermocouples, pilot burners, and flame safety devices.

Cyclone Melter Assembly

Hot gases and preheated batch materials exit the CRV and enter the cyclone melter where the glass melting is completed. The cyclone melter is a horizontal cylinder with a vertical tangential entrance at one end and a horizontal tangential exit at the floor of the melter at the other end. Gas dynamics within the melter separate the glass from the gas products. The glass flows through the cyclone melter in a thin layer, principally along the floor of the horizontal cylinder. The gas and the glass exit together through the tangential exit with the glass remaining on the

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floor and continuing on into the separator reservoir. The melter is a refractory lined, carbon steel, water cooled vessel. Water cooling maintains the metal surfaces of the vessel below 125°F (52°C).

Separator/Reservoir

The separator/reservoir is a refractory lined chamber which completes the separation of the glass from the reaction products and provides the ability to maintain a pool of glass if required for dissolution or homogeneity. For the initial hot feasibility tests, the glass will be allowed to flow directly out of the tap hole in the floor of the separator rather than maintain a pool of glass. This allows an assessment of the glass having a residence time on the order of minutes and is recommended for initial test work so that process changes can be implemented quickly as needed. Alternatively, up to an hour of residence time can be achieved by using an overflow weir instead of the floor tap. The incorporation of a pool for the 72-hour test will be based on the results of the hot testing. The hot gases are directed from the separation chamber to the evaporative cooler inlet duct.

Flue Gas Treatment System

The flue gas is conditioned first by an evaporative cooler to reduce the temperature to 450°F (232°C) to allow for flue gas sampling and for ease of handling to the wet electrostatic precipitator (WESP).

The primary stage of the WESP is a rod deck venturi scrubber which handles large particulate removal and saturates the flue gas prior to entering the WESP. Final particulate removal occurs in the WESP. The WESP water is recirculated through storage tanks where make-up water is added and the pH is adjusted in the range of 5 to 8. Emission testing is performed to characterize the uncontrolled emissions upstream of the WESP in support of the design of an appropriate commercial flue gas handling system. At the conclusion of a test, the WESP water is run through a filter press to remove the solids. The solids and the liquid are disposed of as required.

5.1.2 Pre-Treatment Requirements

No pretreatment of the simulated slurry is required for the Proof-of-Principle Test. However, Vortec is aware that the actual material taken from Silos 1 and 2 could be up to a quarter inch in size and will need some sort of grinding operation to produce the size range needed to make a good quality glass.

5.1.3 Testing Methodology

This section describes the procedure to be followed in conducting the Proof-of-Principle Test in the Vortec Facility.

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Procure Surrogate Ingredients

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Vortec will procure the surrogate ingredients as specified in Appendix A of this Work Plan. Vortec will sample the as received ingredients and obtain certification from the laboratory, one week prior to the test, that the materials purchased are 95% pure with particle size distribution as specified.

Surrogate Ingredients Preparation

Upon acceptance of the Work Plan by FDF, Vortec will proceed with the laboratory development of the surrogates representative of the Silos 1 and 2 chemical characteristics and for the demonstration slurry. The FDF supplied slurry preparation procedure will be tested in the Vortec Colledgeville Laboratory to establish its effectiveness.

Surrogate-Glass Testing

Vortec will invite FDF to witness the preparation and sampling of the laboratory scale surrogates and feedstock. Samples will be taken and submitted to FDF for analysis. Once FDF has approved these samples (within seven working days upon receipt of samples at the analytical laboratory), glass melting using each slurry will proceed. The melting procedure may be conducted at Vortec's Colledgeville Laboratory or at a specified Glass Analysis Laboratory, such as Corning. Samples of the glass will be sent to the FDF approved laboratory for analysis. Data from the testing of the compound for purity and compliance with specifications, prepared slurried feedstock, and glass samples will be documented and provided to FDF.

Test Facility Modification

Slurry Feedstock Preparation, Delivery, and Injection Subsystem Design

Vortec will design, fabricate, and install a feedstock preparation, delivery, and injection system to mix the slurry simulant feedstock, deliver slurry simulant and dry additives to the injector at the desired feed rates, and inject and atomize the combined feedstocks into the CRV reactor. The basis for the feed system will be the capability of delivering from 300 to 500 lb/hr of total batch feed (slurry plus additives).

Slurry Feed System Installation at the Pilot Facility

Vortec will review, redesign if necessary, and modify its U-PARC facility to feed the demonstration test slurry and the specified glass making additives, developed in Task 2, to the CMS™ process. Tanks and equipment will be required to prepare the demonstration feedstock and to maintain the solids in suspension. In addition, modifications to the tanks and transport system for the feedstock will be required to meet with the requirement of the Vortec Health and Safety procedures.

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Injector Cold Test

Vortec will conduct cold flow tests of the installed feedstock preparation and delivery system. These tests will assure that the system is capable of delivering slurried material at the design rate and will evaluate atomization quality before the actual demonstration slurry is introduced into the system.

Injector Hot Test

Vortec will perform two short duration melting trials of approximately six hours duration each using the simulated slurry mixture to assure that the injector feed delivery and injector systems are operating properly. For each test, approximately 150 gallons of slurry will be prepared.

After stable operation has been attained, and depending on the required thermal input and other operating parameters, the batch flow rate will be increased to evaluate maximum system input capability for commercial design scale-up. Steady state operation at this condition will be maintained for a minimum of one hour to obtain data for the calculation of an accurate heat and mass balance.

The results of the short duration tests will be evaluated and any modifications required to the CMS™ will be made in preparation for the 72-hour demonstration run.

Proof-of-Principle Test

Preparation of the Feedstock

Vortec will prepare the simulated slurry composition for pilot testing as specified in the Contract and provide a sample for approval by FDF. At 30 wt% solids, 18,360 lb. of slurry (1,836 gal at 10 lb./gal) will be prepared for processing during the 72-hour test. This slurry will be stored in a single 2000 gallon tank with an agitator.

The prepared batch will be pumped to one of two 200 gallon feed tanks, each of which represents a sample population. Samples of the populations will be taken as required by the FDF approved Work Plan.

The dry additives will be premixed and maintained in flexible intermediate bulk containers (FIBC's). The dry additives are 15 wt % of the final feedstock delivered to the process; therefore, 3,240 lbs. of additives will be prepared in Vortec's air blending system and stored in 10 FIBC's each containing 324 lbs. and representing ten sample populations. Sampling by thief per ASTM specifications will be performed to obtain representative samples of each population. The dry feed system will have the capacity to receive the entire contents of one FIBC.

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Seventy-two Hour Test

The Proof-of Principle Test will be conducted at Vortec's U-PARC Test Facility. This facility is capable of processing 500 pounds per hour of the demonstration slurry, and for this test will be operated at 300 pounds per hour.

Sampling

Vortec will conduct the Proof-of Principle Test as defined in the Work Plan Section. The plan calls for sampling of the slurry feedstock entering the CMS™, the dry additives entering the CMS™, the flue gas leaving the evaporative cooler, and vitrified product as it exits the separator reservoir. These four sampling points are sufficient to produce the heat and mass balance around the principal unit operation, the CMS™ reactor, melter, separator-reservoir, and evaporative cooler.

The samples will be taken using the ASTM Protocols. However, sampling of the flue gas will use the appropriate EPA Methods found in CFR 40, Part 60.

5.1.4 Disposal of Product

At the conclusion of the test, Vortec will have the vitrified product tested to assure that it passes TCLP requirements. This testing will be done independent of the sampling being conducted for FDF and will be used to confirm that the entire batch of vitrified product (approximately three tons) remaining after the test is complete can be disposed of properly.

Vortec will obtain permission from the Allegheny County Department of Air Pollution Control to conduct this test. Allegheny County Department of Air Pollution considers the Vortec Test Facility to be a minor source and only requires notification of test to be run. Vortec will make a presentation to the Allegheny County Department of Air Pollution Control to inform them of the nature of the test.

Water contained in the WESP holding tanks will be controlled to pH levels between 5.0 and 8.0 standard units with NaOH additions throughout the test period and its volume maintained with make-up water as required. At the conclusion of the tests, the solids will be filtered out and samples of both the solids and the water will be tested to determine the appropriate course for disposal.

5.2 TEST PROCEDURES

The facility operating procedure to be used when conducting Proof-of-Principle Tests is given in Appendix B.

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5.3 PROCESS CONTROL PLAN

The CMS™ facility is controlled and monitored using Allen Bradley SLC5/04 and SLC 500 programmable logic controllers (PLC's). A personal computer provides the graphical user interface (GUI) to monitor and display approximately 75 process variables (temperature, pressure and flow rate at selected locations) during pilot operations. Rockwell RS Links software is utilized to exchange data between the PLC's and the PC. The data is displayed using Rockwell RS View. The computer is also utilized to acquire the data for trending and history logs utilizing the Rockwell software package RS Trend. Written test logs are maintained in the control room by the operator. For the FDF Proof-of-Principle Test, video tapes will be taken of critical operations.

5.3.1 Instrument Monitoring, Data Acquisition, and Control System

The Vortec demonstration facility is extensively instrumented. The facility uses a PLC-based 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 O₂, CO, SO₂ and NO_x in the flue gas are logged based on periodic sampling and measurement.

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. Programmable Logic Controller

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.

The calibration procedure for each sensor type is described in the following sections. For the 72-hour Proof-of Principle Test, instrument calibration will be performed by subcontractors. The Beckman analyzers will be serviced and calibrated by Jeff Wadas Instrument Services, the scales and weigh cells by Fairbanks Scales, and the pressure/differential pressure transmitters by TBD.

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5.3.1.1 Pressure/Differential Pressure

Each pressure measuring channel is calibrated using a two-step procedure as follows. A pneumatic micro manometer is used to apply a known pressure into the pressure transmitter/transducer. The output is measured using a digital multimeter and checked for zero, span, and linearity. The transmitter/transducer output signal, normally connected to the analog-to-digital interface, is replaced with a digital calibrator. The digital calibrator generates a known signal that is then monitored in the control room to assure that the data channel is reading accurately. At selected intervals, usually at the beginning of a test program, the system is calibrated by applying a known pressure to the transducer and monitoring the output at the computer. The system is checked for zero, span, and linearity.

5.3.1.2 Temperature

When the thermocouple circuits are first installed, the EMF output from the individual thermocouples is simulated using a known millivolt input signal connected to the analog-to-digital interface. The five-point calibration procedure, described above, is used and the actual values are recorded in the computer in the control room. The system is checked for zero, span, and linearity. At selected intervals, usually at the beginning of a test program, the system is calibrated by disconnecting the thermocouple at their connectors and applying a known millivolt signal to the thermocouple leads. The output is monitored at the control-room computer.

5.3.1.3 Batch Tank Weights and Batch Flow Rates

The batch tank weighing system uses the main PLC in conjunction with strain-gage load cells. The PLC accepts the millivolt signals from the load cells and digitizes them for input to the feeding system logic. The system is initially calibrated by suspending known weights, traceable to the NBS standards, from the tank itself. The system is checked for zero, span, and linearity by varying the weights attached over the working range of the load cells.

The calibration of the weighing system is checked when adding known amounts of feedstock material and checking for agreement. If the difference is greater than 2 wt %, the system will be recalibrated.

The time history of the batch tank weight, as recorded by the data acquisition system, will be used to generate flow rates for the feedstock.

5.3.1.4 Gas Analyzers

The portable gas analyzers are calibrated before and during the tests according to the manufacturer's procedure, which requires the use of high-purity bottled calibration gases. The sample gas is delivered to the instrument and the instrument is adjusted to read the sample concentration. Sample gas concentrations are selected to allow high span and low span for each instrument.

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5.3.1.5 Gas Flow Rates

Gas flow rates are measured using orifice plates or annubars in the air and gas supply lines. These measurements rely on the difference of an upstream and downstream pressure measurement. The installation of the plate follows the standard ASME procedures for the location of the pressure taps, and the calibration of the pressure-measuring system has been described above.

Orifice plates are purchased for specific flow conditions:

1. F_1 = Design flow rate (Lb/Hr),
2. P_1 = Design pressure (Lb/In²),
3. T_1 = Design temperature (Degrees Rankine).

These conditions will produce a design differential pressure of ΔP_1 inches of water. To find the actual flow rate, the following relation is used:

$$F_2 = F_1 (\Delta P_2 / \Delta P_1 * P_2 / P_1 * T_1 / T_2)^{0.5}$$

where

F_2 = New flow (Lb/Hr)

ΔP_2 = New differential Pressure (Inches of Water)

P_2 = New design pressure (Lb/ In²),

T_2 = New temperature (Degrees Rankine)

The flow rate's accuracy has been determined to be within 1/2% at the low end of the flow range.

5.4 TEST LOGS

Standard operating procedure at the Vortec High Temperature Test Facility requires the maintenance of a test log by the facility operator during each test. This test log is maintained as a permanent part of each test. Included with the test log will be a disk of the computer recorded temperatures, pressures and flow rate as a function of time. These data are printed in hard copy and retained as a part of the permanent record.

5.5 VIDEO TAPES

Vortec will video tape selected portions of the 72-hour demonstration test. Vortec and FDF will establish the information to be recorded and the frequency with which it will be obtained. Video tapes will be provided in color and high resolution on standard VHS.

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6.0 EQUIPMENT AND MATERIALS

For a discussion of the facility and the materials being used, see Section 2.0 Technology Description and Section 3 Recipe Development.

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7.0 SAMPLING, DATA COLLECTION AND ANALYSIS

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Quanterra's Laboratory has already passed the Quality Audit that FDF has conducted and will therefore be applying the prescribed methods for analyzing the samples according to the FDF accepted methods and procedures. Horizon Environmental has been selected as the sampling subcontractor and Comprehensive Safety and Compliance Corporation has been selected to perform the flue gas particulate and composition analysis.

7.1 PERFORMANCE DATA COLLECTION POINTS

Figure 7-1 is a process schematic of the Vortec demonstration facility. Included, with numerical designators, are the locations of the instruments used to control and assess the thermodynamic performance of the system.

The CMS™ process is to be evaluated based on the conversion of the silo residue into a glass waste form which is chemically durable with respect to leachability of contaminants and dissolution of the glass proper. In addition, the destruction of organic contaminants must be at or above regulatory requirements. In order to quantify the ability of the process to meet these objectives, a number of process variables must be measured and samples of input and output streams must be obtained for analysis. In order to limit the sampling and measurement requirements to a reasonable level, a process control volume will be defined so that the influent and effluent streams are as follows:

Input points for mass flow and temperature measurement:

- Slurry Feedstock
- Atomization Air
- Dry Additives
- Transport Air
- Fuel
- CRV Reactor Air
- Evaporative Cooler Water
- Inlet CRV & CM Cooling Water

Output points for mass flow and temperature measurement:

- Glass
- Flue Gas Leaving the Evaporative Cooler
- Outlet CRV & CM Cooling Water

Sample points for chemical analysis/composition:

- Fuel
- Simulated Slurry
- Dry Additives
- Glass Product
- Particulate in off-gas

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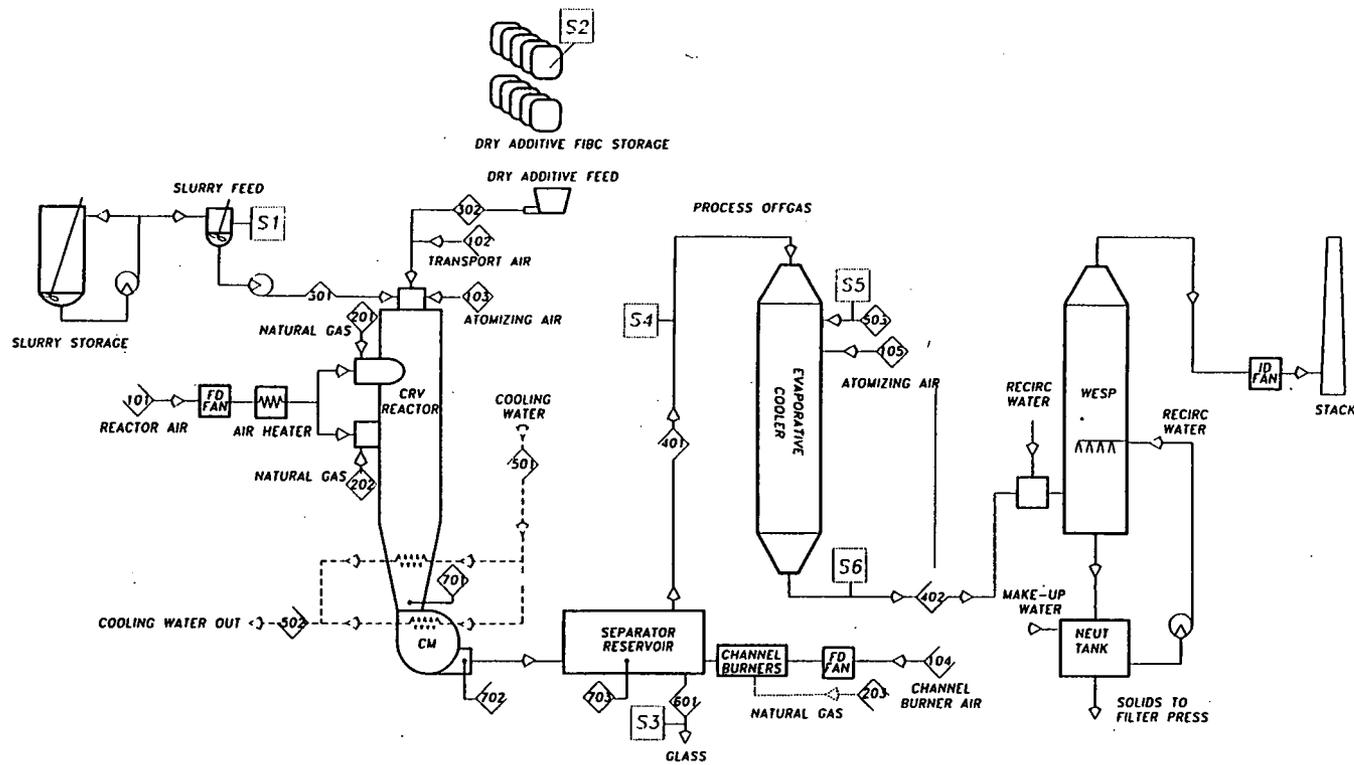


Figure 7-1. Test Facility Process Schematic

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The sampling site locations are indicated on Figure 7-1 with the designators S1, S2, S3, S4, S5, and S6. These locations are the process inlet and exit points crossing the process envelope for flow streams which require post test analysis. The analysis of the batch is the starting point for verification of the batch composition and quantification of contaminants. Additionally a chemical assay of the natural gas used as fuel during the test will be checked to determine the constituents of concern added through this route. The partitioning of the elements of interest among the various outlet streams is determined through chemical analysis of the outlet stream samples and the mass flows measured during the test sampling period. The sample points are as follows:

Flue Gas Sampling

Gaseous Products

A flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provides for on-line continuous measurement of CO, O₂, SO₂, and NO/NO_x at sample site S4. In addition, the exhaust ductwork has ports to allow EPA Methods 1 - 5 to be performed for the measurement of particulate emissions.

The flue gas sample will be analyzed for O₂, CO, and NO/NO_x. Measurement of specific feedstock contaminants, total hydrocarbons, or other chemical species may also be performed depending upon the objectives of the test.

Particulate

The uncontrolled particulate in the flue gas leaving the process is sampled during the test by the EPA Method 5 Test Procedure as described in CFR 40, Part 60 at sample site S6. It is planned to have an outside emission testing company conduct all of the particulate sampling.

Feedstock and Vitrified Product Streams Sampling

The demonstration plant will provide access for sampling feedstock materials and vitrified products. Feedstock and vitrified product samples will be collected in appropriate vessels (e.g., glass, polypropylene, polyethylene, stainless steel).

In each of the following sections, a description is given of the method to be used in obtaining each sample at the locations where the slurry is introduced into the vitrification process and where the product is removed. Preparation for sampling includes the acquisition of all necessary sampling equipment and site-specific information to perform the required sampling.

Vortec (or its subcontractor) will supply pre-labeled sample containers containing any necessary preservatives. The Vortec Laboratory Coordinator will verify that all of the sampling containers needed for shipping the samples to the analytical laboratory are available prior to the test initiation.

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Slurry Sampling of Batch Materials - Points S1 & S2

The slurry and glass additives will be introduced separately into the process and are mixed within the CRV reactor by means of a special injector. A sample of the surrogate for a given population will be taken from the 200 gallon feed tank prior to the initiation of testing for the population. A representative sample of the blended dry glass forming additives will be taken out of each population's FIBC using a thief sampler in accordance with ASTM E 300 Sections 27 through 34 at sampling point S2. The collected samples will be placed in suitable laboratory containers and appropriately labeled.

Table 7-1 lists the frequency with which samples will be taken from the input stream during the vitrification process.

Bulk Sampling of Vitrified Product - Point S3

Table 7-1 lists the frequency with which samples will be taken of the vitrified product that is being produced by the Vortec CMS™. This material will be sampled at location S3 as a solid. Both patty (air cooled) and frit (water cooled) samples will be obtained per Table 4.1. Sample geometry will conform to Table 7-1. The glass samples will be stored in laboratory prepared sample containers.

Post Sampling Procedures

The purpose of the laboratory testing listed in Table 7-2 is to determine the partitioning of the RCRA metals and the metals involved with forming the glass oxide network. The RCRA metals to be analyzed for include Ba, Cr, Pb, Cd, Hg, Ag, As, and Se when present in the feedstock. In addition, other heavy metals such as Ni, V, Ti and Zn will be analyzed for as they will be in the feedstock and are part of the proposed UTS Regulatory Limit. The analysis of the metals involved with forming the glass oxide network will determine how effectively the glass forming additives are being incorporated into the glass melt. These metals include Si, Al, Mg, Ca, Na, K, and Fe. From the concentration of these metals, the oxide composition of the glass can be determined.

An EPA Method 18 will be employed to determine hydrocarbon destruction based on the presence of kerosene in the slurry.

Vortec will supply pre-labeled sample containers containing any required preservatives. Immediately after collection, samples will be transferred to properly labeled sample containers with any necessary preservatives added. Samples requiring refrigeration for preservation will be immediately transferred to coolers packed with ice or ice packs.

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Table 7-1. Data Collection Schedule

Measurement	Sample Site	Frequency	Remarks
Slurry Flow Rate	CRV Inlet (S1)	Continuous	Calibrated Metering Pump
Dry Additive Flow Rate	CRV Inlet(S2)	Continuous	Loss-in-weight Feeder
Slurry Composition	Slurry Feed Tank (S1)	10 Populations	Sampled from feed tank
Dry Additive Composition	FIBC (S2)	10 Populations	Sampled from FIBC
Glass Composition	Separator Reservoir Drain (S3)	See Table 4.1	
Flue Gas Flowrate	Downstream of Evaporative Cooler (S6)	10 EPA Method 5 Test Once per Population, 1 Hour Duration Each	EPA/530-91-010
Flue Gas Particulate Flowrate	Downstream of Evaporative Cooler (S6)	10 EPA Method 5 Test Once per Population, 1 Hour Duration Each	EPA/530-91-010
Flue Gas Composition O ₂ , CO, SO ₂ , NO _x	Upstream of Evaporative Cooler (S4)	Continuous	On-line analyzer
Flue Gas Composition SO _x	Downstream of Evaporative Cooler (S6)	10 EPA Method 6 Test Once per Population, 1 Hour Duration Each	TBD
System Parameters: Temperature, Pressure, Flow	See Figure 7-1	Continuous	Monitored by SCADA

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Table 7-2. Analytical Laboratory Tests Required

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72-Hour Test		Number of
Sample	Compounds	Samples
Slurry Batch	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃ , B ₂ O ₃ , BaO, ZnO, NiO, PbO, CrO ₃ , V ₂ O ₅ , P ₂ O ₅ , As ₂ O ₅ , SeO ₃ , SO ₂ , H ₂ O, CO ₂	3
Dry Batch	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃ , B ₂ O ₃ , BaO, ZnO, NiO, PbO, CrO ₃ , V ₂ O ₅ , P ₂ O ₅ , As ₂ O ₅ , SeO ₂ , SO ₃ , H ₂ O, CO ₂	3
Glass-Chemistry	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃ , B ₂ O ₃ , BaO, ZnO, NiO, PbO, CrO ₃ , V ₂ O ₅ , P ₂ O ₅ , As ₂ O ₅ , SeO ₂ , SO ₃	3
Glass-TCLP	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, Sb, Be, Ni, Tl, V, Zn	3
Evap. Cooler Water	Si, Al, Ca, Mg, Na, K, Fe, B, Ba, Zn, Ni, Pb, Cr, V, P, As, Se, Total Solids	3
Flue Gas Sampling	EPA Methods 1-5, Bulk Sample, Total Hydrocarbons, SO _x	10
Flue Gas Particulate	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, Sb, Be, Ni, Tl, V, Zn, SO ₄	3

Lab-Scale Test		Number of
Parameter	Chemicals	Samples
Slurry Batch	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃ , B ₂ O ₃ , BaO, ZnO, NiO, PbO, CrO ₃ , V ₂ O ₅ , P ₂ O ₅ , As ₂ O ₅ , SeO ₂ , SO ₃ , H ₂ O, CO ₂	3
Glass Chemistry	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃ , B ₂ O ₃ , BaO, ZnO, NiO, PbO, CrO ₃ , V ₂ O ₅ , P ₂ O ₅ , As ₂ O ₅ , SeO ₂ , SO ₃	12
Glass-TCLP	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, Sb, Be, Ni, Tl, V, Zn	15

Pre-Test		Number of
Parameter	Chemicals	Samples
Glass Chemistry	SiO ₂ , Al ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, Fe ₂ O ₃	2
Glass-TCLP	As, Ba, Cd, Cr, Pb, Hg, Se, Ag	2

Post Test		Number of
Parameter	Analysis	Samples
Scrubber Water	8 RCRA metals and Se and V	1
Filter Cake	8 RCRA metals and Se and V	1

7.2 SAMPLING LOGS

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This section discusses the sample containerization, preservation, and holding times requirements and the sample handling and shipment procedures that the Vortec sampling team will follow for the demonstration. These requirements and procedures were developed in accordance with NRMRL guidance (EPA 1991), SW-846 criteria (EPA 1996), and Quanterra standard operating procedures (Quanterra 1998).

Sample Containerization, Preservation, and Holding Times

Table 7-3 presents the sample containerization, preservation, and holding time requirements for each analytical parameter. Quanterra will provide all sample containers. All sample containers will be obtained from a commercial supplier and will be certified clean. Quanterra also will provide all preservatives required. The Vortec sampling team will be responsible for providing stack sampling equipment and preserving all samples. Preservatives will be added to sample containers before or as soon as possible after collecting the samples. Sample containers will be placed in ice-filled coolers after collecting the samples.

Sample Handling and Shipment

The Vortec sampling team will follow standard EPA chain-of-custody procedures for each sample as it is collected. Samples will be retained in the field crew's custody at all times. Samples will be preserved as indicated in Table 7-3 and protected from direct sunlight.

The Vortec sampling team will ship samples to Quanterra at the end of each day's activities. Analyses of solid matrices for RCRA-TCLP and TAL minor metals and wastewater general characterization analyses will be performed by the Denver, Colorado Laboratory. Metals and particulate matter filters from the Method 5 sampling train will be analyzed by the Knoxville, Tennessee Laboratory. All laboratory samples will be shipped by overnight carrier.

Each sample container will be labeled with a unique sample identification number. The sample label also will identify the project number; sampling location, date, and time; preservatives added; sampler's initials; and analysis to be performed. A typical sample label is shown in Figure 7-2.

A unique 10 or 12 character number identifying the name of the project, pilot scale test, sampling location, sample type, and sample event will be assigned to each sample as follows:

The present project will be designated by the characters "FDF1".

The pilot scale tests will be designated as "FDF1", "S-2", ... for the test prior to the 72-hour demonstration test and "D72" for the demonstration test.

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Table 7-3. Sample Containerization, Preservation, and Holding Times

Parameter	Media	Sample Volume (mL) ^a	Container ^b	Preservative ^c	Holding Time ^d
Solids	RCRA Metals - TCLP	1,000	G	Cool to 4°C	180 days to analysis
	Mercury - TCLP	1,000	G	Cool to 4°C	28 days to analysis
Stack Gas	Metals	1,000	G	HNO ₃ pH 2	180 days to analysis
	Mercury	1,000	G	HNO ₃ pH 2	28 days to analysis
	Particulate	Filter	G	None	*
Wastewater Effluent	TAL metals	1,000	G	HNO ₃ pH 2	180 days to analysis
	Mercury	1,000	G	HNO ₃ pH 2	28 days to analysis
	Temperature (field)	200	P	None	Analyzed immediately in field
	Oil and Grease	250	P	Cool to 4°C	180 days to analysis

Notes:

- a For aqueous samples selected for MS/MSD analyses, three samples of equal volume will be required. Solid sample containers provide enough volume for MS/MSD analyses. For field/field duplicate (F/FD) analyses, two samples of equal volume will be required.
- b Container types include the following:
- G - Glass
 - P - polyethylene container
- c The Vortec sampling team will ensure that the pH of the samples is less than or equal to 2 by testing samples with pH paper. Extra samples will be collected, HCl or HNO₃ acid will be added to preserve the samples, the pH of the samples will be tested using pH paper, and the volume of the acid added will be recorded. After the required volume of HCl and HNO₃ is determined, the regular samples will be preserved before being sent to Quanterra.
- d Holding times are measured from the time of sample collection.
- * None, but analyze in timely manner.

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Figure 7-2. Sample Label

Vortec Corporation 3770 Ridge Pike Collegeville PA 19426 (610) 489-2255	Project No. 4200 Contract No. 98WO002241
Project Name: Vortec Proof-of-Principle Demonstration	
Batch No. _____	Date _____
Sampling Location _____	Time _____
Sampling ID No. _____	Initials of Sampler _____
Preservatives _____	
Analysis _____	

The sample location will be designated by the following characters:

- DS- Demonstration slurry
- DA- Dry additives
- VP - Vitrified product
- WE - Wastewater effluent
- PS - Process off-gas stack
- XX - Samples not associated with a specific location in the Vortec system, such as temperature blanks, which are discussed in footnote "b" of Table 7-3.

The following characters will designate sample type:

- S Sample
- FD - Field duplicate
- MS - Matrix spike
- MSD - Matrix spike duplicate
- FB - Field blank
- AB - Air Blank
- F - Filter
- IS - Impinger solution
- XB - Temperature blank

Consecutive numbers starting at "1" will designate the event number for each pilot test, sampling location, and sample type.

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7.3 SAMPLE CUSTODY

Sample custody will begin when samples are collected and placed into a cooler or other appropriate container in the possession of the designated field sample custodian. The field chain-of-custody form will be completed and initialed by the field samplers or field sample custodian. The following information will be provided on the chain-of-custody form:

<u>Project Name</u>	Vortec Proof-of-Principle Demonstration
<u>Project No.</u>	4200
<u>Contract No.</u>	98WO002241
<u>Project Manager</u>	John Patten
<u>Phone No.</u>	(610) 489-2255
<u>Samplers</u>	Each sampler's printed name, initials, and signature
<u>Laboratory Identification No.</u>	Unique sample identification number assigned by laboratory
<u>Matrix</u>	Sample matrix
<u>Sample Identification No.</u>	CMS™ Proof-of-Principle Program assigned number
<u>Date</u>	Date of sample collection
<u>Time</u>	Time of sample collection
<u>Location</u>	Description of sampling location
<u>Requested Analyses</u>	The analyses required to be performed on a sample.
<u>Total No. of Containers</u>	The total number of sample containers for a given location
<u>Date Shipped</u>	Date of sample shipment
<u>Carrier</u>	Type of carrier
<u>Airbill No.</u>	Airbill number, if applicable
<u>Relinquished by</u>	Signature of person who turns over the sample carrier
<u>Received by</u>	Signature of person from carrier receiving sample

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When all line items are completed, the field sample custodian will sign and date the chain-of-custody form and confirm the completeness of all descriptive information on the form. Each individual who subsequently assumes responsibility for the samples will sign the chain-of-custody form and give the reason for assuming custody. However, the courier service will not sign the chain-of-custody form. The airbill will serve as part of the chain-of-custody documentation. Use of the field chain-of-custody form will terminate when the laboratory receives the samples. The Vortec Field Manager will retain the pink copies of the chain-of-custody forms for the project files.

All samples will be packaged and labeled for shipment in compliance with current Department of Transportation (DOT) and International Air Transport Association (IATA) regulations for dangerous materials. Only metal or plastic ice chests will be used for shipping hazardous waste samples. Each ice chest will be lined with two 6-mil plastic bags. Styrofoam, bubble wrap, or "snakeskin" wrap will be used in the ice chest to absorb shock.

After the sample containers are packaged, the inner 6-mil plastic bag around the samples will be sealed by twisting the top and securely taping the bag closed to prevent leaks. To meet preservation requirements, ice will be placed between the inside plastic bag and the outside one, and the outside bag will be taped shut. The white and yellow copies of the chain-of-custody forms will accompany each shipment. These forms will be enclosed in a waterproof plastic bag that will be taped to the underside of the ice chest lid.

Each ice chest prepared for shipment will be securely taped shut. Reinforced or other suitable tape (such as duct tape) will be used and wrapped at least twice around the ice chest near each end where the hinges are located. Sample custody seals will be placed on the front and back of each ice chest to protect against unauthorized tampering with samples before analysis. The custody seals will be affixed and signed by the person who relinquishes sample custody to the courier service; the custody seal numbers will be noted on the chain-of-custody form.

In addition to a complete mailing addresses, each ice chest will clearly display "This End Up" arrows on all four sides, a label on each side indicating the proper shipping name for the samples, a sticker containing the originator's address, and any additional DOT or IATA signature required for shipment.

When selecting means of shipment, field personnel will ensure that the samples will not exceed allowable holding times. When commercial common carriers are used to ship samples, all samples will be shipped "Priority One/Overnight." Air bills will be completed and attached to the exterior lids of the ice chests. Multiple shipment labels will be used when more than one ice chest is shipped.

The Quanterra sample custodians or their designated alternatives will receive samples and assume custody of them until the samples have been properly logged in the laboratories and stored in secured areas. Sample custodians will be assigned at a later date, since the Vortec site demonstration is not scheduled to begin until September 1998.

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When a sample shipment is received, the ice chest will be inspected for warning labels and security breaches before it is opened. The ice chest will be placed under a chemical fume hood before it is opened. The sample custodian will open the container and carefully check the contents for evidence of breakage or leaking. The presence of ice will be noted, and the contents of the ice chest will be inspected for chain-of-custody forms and other information or instructions. The temperature of the temperature blank will be noted on the chain-of-custody form, along with the date and the signature of the person making the entry. The sample custodian will verify that all information on the sample bottle labels is correct and consistent with the information on the chain-of-custody form prior to signing the receipt. In order to verify sample receipt, a copy of the chain-of-custody form will be retained in each laboratory's project file, and the white copy will be returned to Vortec after each laboratory assigns its own sample identification numbers.

Any discrepancy between the sample bottle labels and the chain-of-custody form information, any broken or leaking sample bottles, or any other abnormal situation will be reported to the Laboratory Project Manager. The Laboratory Project Manager will inform the Vortec Field Manager of any such problem, and corrective action options will be discussed and implemented. The problem and its resolution will be noted on a corrective action form, which will be initialed and dated by the Laboratory Project Manager.

Each shipment of samples received at Quanterra will be assigned a work order number. Each sample bottle in the shipment will be assigned a unique sample number that includes the work order number and an identifying code. A laboratory sample label specifying the unique sample number will be attached to each bottle. The work order will specify the samples to be analyzed, the analyses to be performed, the level of QC for the project, and any other necessary information. The work order will specify the samples to be analyzed, the analyses to be performed, the level of QC for the project, and any other necessary information. The work order, accompanied by a copy of the chain-of-custody form, will be given to the laboratory group leader, who will schedule the digestion, extractions, and analyses to meet applicable holding times and project schedules. Bench sheets initiated at the first point of sample preparation will accompany the samples throughout the analytical sequence.

Samples will be stored in designated, secured, refrigerated areas according to the analyses to be performed. A logbook will be maintained for each refrigerator, and the refrigerator's temperature will be recorded each working day. A sample storage logbook or form will be used to document each time a sample is removed from or replaced in the secured storage area.

Field Notes and Logbooks

The Vortec Field Manager will record all information pertinent to the sampling program in field logbooks, which will be bound and have consecutively numbered pages. All data will be entered using black or blue indelible ink. Each page will be dated and signed by the person making the entries. Logbooks are accountable field documents and serve as a chronological representation of the sampling and measurement program. Sufficient detail will be included in the logbook to

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summarize the sampling and measurement activities. At a minimum, the logbook will contain the following information: (1) name and address of site where sampling was performed; (2) weather conditions; (3) project name and number; (4) measurements (such as pH and temperature), and (5) field equipment calibration data. Any required corrections will be made by drawing a single, straight line through the incorrect entry; initialing and dating the line; entering correct information clearly and legibly; and initialing and dating the correction.

For stack gas samples, sample data sheets required by the methods will be completed in the field. These data sheets will be used to record the physical data collected during gas sampling, such as stack temperature and pressure, gas meter readings, and differential pressure.

7.4 ANALYTICAL LABORATORY PROCEDURES

Solids, vitrified product, treated wastewater, and stack gas samples will be analyzed for the required parameters by the methods summarized in Table 7-4. The following sections describe the selection of analytical methods for all parameters, equipment calibration, and sample storage and disposal. It should be noted that Quanterra Laboratory, Earth City, MO has been designated by FDF as the qualified laboratory for the analysis of the samples taken during the Proof-of-Principle Test. (The exception will be Corning's Engineering Laboratory Services (CELS) for the analysis of glass.) Quanterra's laboratory has already passed the Quality Audit that FDF has conducted and will therefore be applying the prescribed methods for analyzing the samples according to the FDF accepted methods and procedures.

7.4.1 Selection of Analytical Methods

In selecting appropriate analytical methods for preparing and analyzing the samples collected from the CMS™ system, Vortec has taken into account the specific analytes of interest, the sample matrices, and the minimum detectable concentrations needed to evaluate the treatment system. The selection process was based on the following hierarchy of references:

1. EPA-approved methods described in the following documents:
 - a. EPA. 1996. *Test Methods for Evaluating Solid Waste*. Volumes 1A through 1C, SW-846, Third Edition (SW-846). Update III. Office of Solid Waste and Emergency Response. Washington D.C. December.
 - b. EPA. 1983. *Methods for the Chemical Analysis of Water and Wastes (MCAWW)*. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio. EPA-600/4-79-020. March.
 - c. 40 CFR 60, Appendix A. 1996. *Code of Federal Regulations, Title 40, Part 60*. National Archives and Records Administration, Office of the Federal Register, Washington, D.C.
2. Approved standard methods such as the following reference: Annual Book of American Society for Testing Material (ASTM) Standards, Philadelphia, Pennsylvania.

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Table 7-4 summarizes the analytical methods chosen. Many of the compounds will be analyzed using EPA-approved methods or standard methods. These methods are commonly used and easily obtained; therefore, they are not discussed in detail in this section.

7.4.1.1 Stack Sampling Equipment

The Method 5 and 6 sampling train components will be calibrated as indicated by the EPA's "Quality Assurance Handbook of Air Pollution Measurement Systems" (EPA-600/4-77-027b). The activity matrices for calibrating the equipment and apparatus are shown in Table 7-5.

7.4.2 Calibration Procedures, Frequencies, and Acceptance Criteria

This section describes the calibration procedures, the continuing calibration verification, and the criteria for evaluating and accepting calibration data. Detailed calibration procedures, the frequency of continuing calibration verification, and criteria for evaluating the calibration data are described in the analytical methods. Calibration data will be recorded in the instrument logbook and referenced to the standards preparation log to identify the source and method of preparation of the standard solutions used. The frequencies, acceptance criteria, and corrective actions required for initial and continuing calibration for laboratory analytical monitoring equipment are outlined in Table 7-6.

Process Monitoring Equipment

Process monitoring equipment, used to collect demonstration data, will be calibrated prior to the test, as required by the manufacturer. Inspection and maintenance procedures for process instruments will be conducted in accordance with each manufacturer's requirements. These instruments will include flow meters, weigh scales, thermocouples, pressure-sensing devices, and pH instrumentation. The pH electrodes will be calibrated using a two-point reference calibration spanning the expected test pH. All calibration data for each instrument will be documented and will include the calibration procedures implemented, if different from the procedures recommended by manufacturers, as well as the following information:

- Device being calibrated
- Identification number (serial number or tag number)
- Reference device
- Date of reference device's last calibration
- Identification of reference device (such as serial number or lot number)
- Date of the performance of calibration
- Name of primary technician performing calibration

7.5 SAMPLE STORAGE AND DISPOSAL

The laboratory will store all residual samples and sample extracts until disposal is authorized by FDF. For the first 60 days after extraction and analysis, the laboratory will store the samples and sample extracts in a refrigerator at 4°C. After that time, samples may be stored at room temperature.

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Table 7-4. Summary of Analytical Methods and Procedures

Matrix	Parameter	Method	Procedure Description	Lab	Location
Solid and Liquid	Glass Comp.	Proprietary ^a	Fusion, acid digestion, and ICP	CELS	Corning, NY
	Metals	SW-3050 ^b /3051 ^c / 6010 ^d	Acid digestion and ICP	Quanterra	Denver
	Mercury	SW-3050 ^b /3051 ^c / 7470 ^e	Acid digestion and CVAA	Quanterra	Denver
	TCLP	SW-1311 ^f	Toxicity Characteristic Leaching Procedure	Quanterra	Denver
Air	Metals	SW-0060 ^g /6010 ^d	Acid digestion and ICP	Quanterra	Knoxville
	Mercury	SW-0060 ^g /7470 ^e	Acid digestion and CVAA	Quanterra	Knoxville
	Particulate	SW-0060 ^g Method 5 ^h	Gravimetric, replicate weighing	Quanterra	Knoxville
	HCl/Cl ₂	SW-9056 ⁱ /9057 ^j	IC	Quanterra	Knoxville
Liquid	VOCs	SW-8260 ^k	Purge and trap, GC/MS	Quanterra	Denver
	SVOCs	SW-3510 ^l /8270 ^m	Liquid-liquid extraction, GC/MS	Quanterra	Denver
	TSS	MCAWW 160 ⁿ	Residue, Nonfilterable	Quanterra	Denver
	Chlorine	MCAWW 330 ^o	Chlorine, Total Residual (Titrimetric, Iodometric)	Quanterra	Denver
	Oil and Grease	MCAWW 413 ^o	Oil and Grease Liquid-Liquid Extraction/IR Analysis	Quanterra	Denver
	pH (field)	MCAWW 150 ^o	pH electrometric measurement	Quanterra	On-site
	Temperature (field)	MCAWW 170 ^o	Thermometric Method	Quanterra	On-site

Notes:

- a. Quanterra Environmental Services Radiochemical Analyses. Taken from *Quality Assurance Management Plan for Environmental Services*. Revision 2, June 30, 1997.
- b. "Method 3050 - Acid Digestion of Sediments, Sludges, and Soils." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-3050, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- c. "Method 3051 - Microwave Assisted Acid Digestion of Sediments, Sludges, Soils, and Oils." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-3051, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- d. "Method 6010 - Inductively Coupled Plasma-Atomic Emission Spectroscopy." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-6010, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- e. "Method 7470 - Mercury in Liquid Waste (Manual Cold-Vapor Technique)." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-7470, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.

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- f. "Method 1311- Toxicity Characteristic Leaching Procedure." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-7470, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- g. "Method 0060 - Determination of Metals in Stack Emissions." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method 0060, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- h. "Method 5 - Determination of Particulate Emissions from Stationary Sources." 40 CFR 60 Appendix A, Method 5, July 1990. "Method 160.2 - Residue, Non-filterable (Gravimetric, Dried at 103°C to 105°C). Taken from *Methods for Chemical Analysis of Water and Waste*. EPA-600/4-79-020. EPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1979.
- i. "Method 9056 - Determination of Inorganic Anions by Ion Chromatography." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method 9056, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- j. "Method 9057 - Determination of Chloride from HCl/Cl₂ Emission Sampling Train (Methods 0050 and 0051) by Anion Chromatography." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-9057, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- k. "Method 8260 - Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-8260, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- l. "Method 3510 - Separatory Funnel Liquid-Liquid Extraction." Taken from *SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-3510, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- m. "Method 8270 - Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-8270, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- n. "Method 160.1 - Residue, Filterable (Gravimetric, Dried at 180 °C), Method 160.2 - Residue, Non-filterable (Gravimetric, Dried at 103°C to 105°C), and Method 160.3 - Residue, Total (Gravimetric, Dried at 103 C to 105°C)." EPA 600 - Method 160. Taken from *Methods for Chemical Analysis of Water and Waste*. EPA-600/4-79-020. EPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1979.
- o. EPA. 1983. *Methods for the Chemical Analysis of Water and Wastes (MCAWW)*. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio. EPA-600/4-79-020. March.

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Table 7-5. Summary of Calibration Activities for Stack Sampling Equipment

Equipment	Acceptance Limits	Frequency and Method of Measurements	Action if Requirements Are Not Met
Dry gas meter	$Y_i = Y \pm 0.02 Y$	Calibration versus wet test meter: Initially and when post-check exceeds $Y \pm 0.05$	Repair or replace, and then calibrate
Thermometers (stack gas meters and final impinger)	Impinger thermometer $\pm 1^\circ\text{C}$ (2°F); Dry gas thermometer $\pm 3^\circ\text{C}$ (5.4°F) over range; Stack temperature sensor ± 1.5 percent of absolute temperature	Calibration prior to test against a mercury-in-glass thermometer	Adjust, determine a constant correction factor, or reject
Probe heating system (Isokinetic trains)	Capable of maintaining $120^\circ\text{C} \pm 14^\circ\text{C}$ ($248^\circ \pm 25^\circ\text{F}$) at a flow of 21 L/min (0.71 ft ³ /min)	Calibration of component initially by APTD-0576(11); If constructed calibration by APTD-0581(10) or using published calibration curves	Repair or replace, and then reverify the calibration
Barometer	± 2.5 mm (0.1 in.) mercury of mercury-in-glass barometer	Calibration initially against a mercury-in-glass barometer: checks before and after field test	Adjust to agree with a certified barometer
Probe nozzle	Average of three ID measurements of nozzle; Difference between high and low < 0.1 mm (0.004 in.)	Measurement by micrometer to nearest 0.025 mm (0.001 in.): checks before and after field test	Recalibrate, reshape, and sharpen when nozzle becomes nicked, dented, or corroded
Analytical balance (moisture)	± 1 mg of Class-S weights	Checks with Class-S weights upon receipt and daily	Adjust or repair
Type-S pitot tube or probe assembly or both	All dimension specifications met	Calibration prior to test and visually inspected after each field test	Use pitot tubes that meet face opening specifications, repair or replace, as required
Stack gas temperature measurement system	Capable of measuring within 1.5 percent of minimum stack temperature	Calibration prior to test and after each field use	Adjust to agree with mercury bulb thermometer, construct calibration curve, correct readings
Differential pressure gauge (excludes inclined manometer)	Agree within ± 5 percent of inclined manometers	Calibration prior to and after field use	Adjust to agree with mercury bulb thermometer, construct calibration curve, correct readings

Notes:

ft³/min = Cubic feet per minute
 in. = Inch
 L/min = Liter per minute

< = Less than
 \pm = Plus or minus
 mm = Millimeter

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Table 7-6. Summary of Laboratory Calibration Requirements

Parameter	Method	Calibration	Frequency	Acceptance Criteria	Corrective Action
VOCs	SW-846 8260 ^f	GC/MS tune using BFB	Before sample analysis and every 12 hours	Refer to mass-intensity specifications in method	1. Retune instrument 2. Repeat tune check
		Initial (five point) calibration	Before sample analysis and as needed based on calibration verification	For each CCC, %RSD <30 RF from five calibration standards; see Note c for SPCC criteria	Evaluate system
		Calibration verification (single-point)	Every 12 hours after tuning	See Note c for SPCC criteria	Evaluate system
				For each CCC, single-point RF within 30% of average RF from initial calibration	Repeat initial calibration
SVOCs	SW-846 8270 ^d	GC/MS tune using DFTPP Initial (five point) calibration	Before sample analysis and every 12 hours Before sample analysis and as needed based on calibration verification	Refer to key ions and ion abundance criteria in method For each CCC, %RSD ≤30 RF from five calibration standards; SPCC RF >0.050	1. Retune instrument 2. Repeat tune check Evaluate system
		Calibration verification (single-point) - mid-level	Every 12 hours after tuning	For each SPCC RF >0.050	Evaluate system
				For each CCC, %D <20% between RF from standard and average RF from initial	Repeat initial calibration
Metals (excluding Hg)	SW 846 6010 ^f (ICP-metals)	Initial (one point) calibration and standards/high point	Prior to sample analysis	Verify quantitation at ±5% of true value	1. Inspect instrument 2. Correct as necessary 3. Recalibrate
		Continuing calibration and standards/mid-level	Every 10 samples and at end of run	Verify quantitation at ±10% of true value	1. Repeat with fresh standard 2. Check for contamination 3. Repeat initial calibration
Mercury	SW-846 7470 ^f (CVAA-mercury)	Initial (five point) plus blank	Prior to sample analyses	ICV ±10% of true value Correlation coefficient ≥0.995	1. Inspect instrument 2. Correct as necessary 3. Recalibrate
		Continuing calibration	Every 10 samples	Verify quantitation at ±20% of true value	1. Repeat with fresh standard 2. Check for contamination 3. Repeat initial calibration
			End of run	Verify quantitation at ±20% of original prepared standard	1. Repeat with fresh standard 2. Check for contamination 3. Repeat initial calibration
Chlorine	MCAWW 330 ^f	Initial (three point) calibration plus blank	Prior to sample analysis	Measured to response within ± 10% of true value	1. Retune instrument 2. Repeat tune check
		Continuing calibration	One per batch of 20 samples	Measured to response within ± 10% of true value	Evaluate system ^g
TSS	MCAWW 160 ^f	Calibration check for the balance	Daily	± 1% of certified class S weights	1. Repeat calibration 2. Use another balance
pH	MCAWW 150 ^f	Initial (two-point) calibration	Daily	Within 0.1 pH unit of buffer solution values	1. Repeat check with fresh standard 2. Repeat initial calibration
Temperature	MCAWW 170 ^f	NA	NA	NA	NA
Oil and Grease	MCAWW 413 ^f	NA	NA	NA	NA

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Notes to Table 7-6. Summary of Laboratory Calibration Requirements (Continued)

Notes:

- a. System evaluation includes (1) checking for leaks, (2) checking septum, (3) correcting system problems, and (4) repeating initial calibration.
- b. Instrument performance checks will be performed to verify that spectrometer performance has not changed significantly from that established at the last calibration. To test the constancy of the energy and efficiency calibrations, the following parameters associated with a designated radioactive source will be trended over time: peak centroid, peak energy, and nuclide activity at low, medium, and high photopeak energies. Individual gamma detector backgrounds will be measured and trended over time. Preliminary control limits may be established based upon ten counts. Control limits for nuclide activity and background count rate will be established at 3 sigma from the mean of the experimental data. The upper and lower control limits for the peak centroid and peak energy set at 1.5 channels and 0.75 keV from the established peak centroid and energy. Update calibrations will be performed quarterly. A QC instrument performance check will be performed following a calibration and must pass the performance criteria before proceeding with the batch sample counting routine. A QC instrument performance check will be performed daily.
- c. "Method 8260 - Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-8260, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- d. "Method 8270 - Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-8270, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- e. "Method 6010 - Inductively Coupled Plasma-Atomic Emission Spectroscopy." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-6010, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- f. "Method 7470 - Mercury in Liquid Waste (Manual Cold-Vapor Technique)." Taken from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. SW-846 Method SW-7470, Third Edition, September 1986. Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996). EPA, OSWER, Washington, D.C. 20460.
- g. EPA. 1983. *Methods for the Chemical Analysis of Water and Wastes (MCAWW)*. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio. EPA-600/4-79-020. March.
- h. "Method 160.2 - Residue, Non-filterable (Gravimetric, Dried at 103 °C to 105 °C). Taken from *Methods for Chemical Analysis of Water and Waste*. EPA-600/4-79-020. EPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1979.
- i. Quanterra Environmental Services Radiochemical Analyses. Taken from *Quality Assurance Management Plan for Environmental Services*. Revision 2, June 30, 1997.

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8.0 DATA MANAGEMENT PLAN

The Vortec Data Management System consists of software as well as data in both electronic and hard copy forms. The Data Management Plan will refine the data categories, Figure 8-1, functional requirements (discussed below), data constraints, and interfaces, as well defining the data controls.

Figure 8-1 shows the functional categories of data needs with representative data items.

The functional parameters, values, and sampling procedures will be directed to meeting the Proof-of-Principle Testing objective. The major functional requirements of the system are:

1. The system ensures data integrity during the contract period and when later archived.
2. The system provides multilevel security for authorized personnel to read, enter, and change data.
3. The system has an audit trail.
4. The system has the capability to respond to ad hoc queries, generate standard reports, and generate ad hoc reports.
5. The system has the capability to rapidly access the data; that is, a minimum number of screens will be required to go from logon to the data or information desired.
6. The system is menu driven when entering data, making queries, generating reports, or generating new forms.
7. Data entry may be manual, automatic, electronic connection, over a network, or by scanning.
8. The user interface is designed with ease of use as a primary consideration.
9. Data integrity assurance, data verification and data validation.

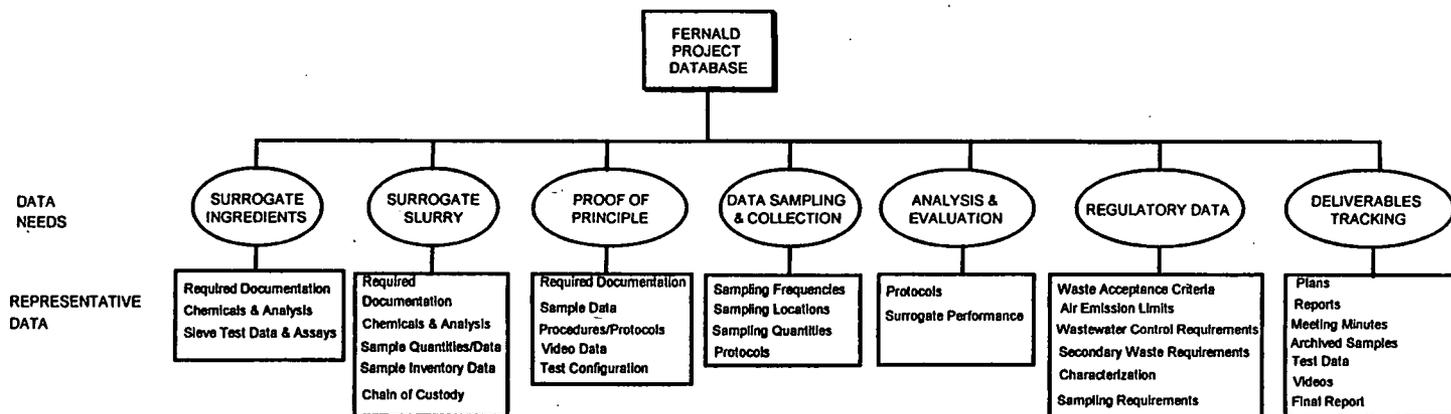


Figure 8-1. Vortec Fernald Project Functional Data Needs

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9.0 DATA ANALYSIS, EVALUATION, AND INTERPRETATION

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9.1 MASS AND ENERGY BALANCE - PRIMARY WASTE STREAM

As described in the previous sections, heat and mass balance evaluations will be performed based on the measured data from the proof of performance testing. A preliminary heat and mass balance for the pilot scale test was provided in Appendix C. The pilot facility is sufficiently instrumented through the use of both stationary elements and sampling probes to allow input and output state point data to be collected and used to establish the mass flow and enthalpy of all input and output streams.

System performance data will be available through the entire 72-hour Proof-of-Principle Test. However, once FDF selected the three populations of interest, only the three time periods will be reduced and presented in the final report. Figure 9-1 again indicates the state point locations and the CMS™ configuration for which a heat and mass balance will be prepared.

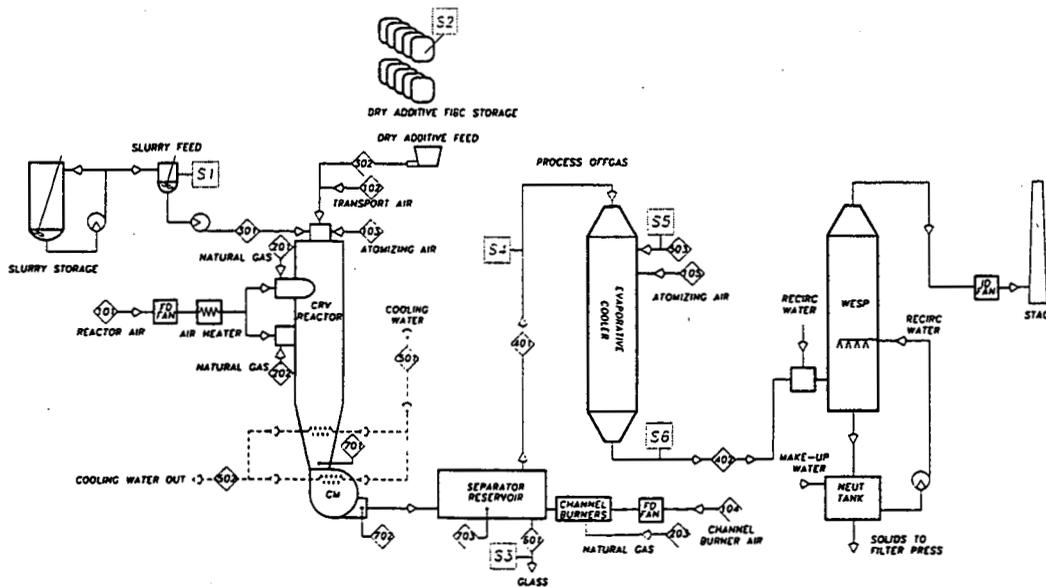


Figure 9-1. Configuration of the CMS™ for the Proof-of-Principle Test Heat and Mass Balance to be Presented in the Final Report

9.2 DATA EVALUATION

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To evaluate the test data, a complete heat and mass balance of the system, based on chemistry and thermodynamics, is performed for each test using a proprietary computer program developed by Vortec. This test-data analysis program is used to validate the data measured and to identify any possible unaccounted heat and/or mass. The data analysis is also able to provide information with regard to the composition of the flue gas and the volume and enthalpy associated with each of the species. The test data will also be used to determine the distribution of the heavy metals and radionuclide surrogates between the flue gas and glass.

Based on the test data, the fluid dynamic characteristics of the CMS™ are analyzed for both the gaseous phase and the liquid glass phase. As a result, the velocity and residence time of the gases at different locations in the CMS™ are determined

9.3 DATA INTERPRETATION

Data obtained from the Proof-of-Principle Test will be reduced and used to evaluate the effectiveness of the Vortec CMS™ to treat Silo 1 and 2 residue in accordance with the FDF approved Work Plan. Based on the glass product samples selected for TCLP analysis, the balance of the physical samples obtained for the same populations will be submitted for analysis. In addition, the process data for the time periods corresponding to these populations will be reduced to average values and used to establish that and mass balance data for these populations. The results from the chemical analyses of the samples will be utilized in the mass balances to establish the partitioning of each element of concern from the waste to the product. This data, coupled with the TCLP values will provide a means of judging the effectiveness of vitrification to move a given waste constituent into the glass product and maintain it in that structure. In addition, destruction of organic constituents will be measured for evaluation of this attribute of the treatment process.

Vortec will compare the results of the glass analysis with the prescribed waste form characteristics established by FDF; namely, appearance, compressive strength, liquid content, TCLP results, dusting characteristics, and durability.

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10.0 HEALTH AND SAFETY REQUIREMENTS FOR THE PROOF-OF-PRINCIPLE TESTING

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Vortec Corporation has been operating its U-PARC facility for ten years under the direction of the Vortec corporate Health and Safety Policy and Procedures. Approximately 100 tests have been performed to date in the pilot plant. Recent tests have been conducted using hazardous waste surrogates and in addition several treatability studies have been using K088, a listed hazardous waste. All testing has been performed without accident or incident and in conformity with the required regulations. The July 1993 test for Westinghouse Hanford required that the entire U-PARC facility be prepared to safely handle the highly caustic LLTW simulant prepared for that test. New regulations, recently imposed throughout the state of Pennsylvania, will require increased preparedness at the test facility. Prior to the test, Vortec will again ready the facility to safely handle the simulant and comply with all applicable health, safety, and environmental regulations.

Vortec has conducted tests at U-PARC that require approval from the appropriate local regulators. When conducting treatability tests, both the Environmental Protection Agency Region III and Pennsylvania Department of Environmental Resources have deferred to the Allegheny County Air Pollution Control Board to issue permission to test. This is the same procedure that was required by the regulatory authority for this LLTW tank test. The Allegheny County Air Pollution Control Board has been informed of the Vortec's intent to run a 72-hour test using the surrogate materials for Silo 1 and 2. Allegheny County Air Pollution Control Board is reviewing detailed information provided by Vortec regarding this Proof-of-Principle Test.

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11.0 WASTE STREAM MANAGEMENT

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The majority of the effluent from the test will be glass that will be tested using the TCLP determination for hazardous material. Since the feedstock is a manufactured product and not a waste the vitrified product, when it passes TCLP, is not considered a hazardous waste and can be disposed of using commercial waste disposal contractors. The remaining effluents, particulate matter and water from the WESP will be tested using TCLP to determine if they are hazardous. If these materials are determined to be hazardous, then a hazardous waste disposal company will be contacted for disposal of these materials.

11.1 REGULATORY ISSUES SPECIFIC TO TESTING FACILITY

Vortec has conducted tests at U-PARC that require approval from the appropriate local regulators. When conducting a treatability test, both the Environmental Protection Agency Region III and Pennsylvania Department of Environmental Resources have deferred to the Allegheny County Air Pollution Control Board to issue permission to test. This is the same procedure that was required by the regulatory authority for the LLTW tank test. The letter sent to the Allegheny County Air Pollution Control Board during the development of the proposal to FDF is presented in Appendix C. As indicated above Allegheny County Air Pollution Control Board is reviewing specific data regarding this test. Since Vortec has conducted similar tests in the past, no problems are foreseen with conducting this test with the approval of the cognizant authority.

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12.0 REPORTS

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Consistent with the program schedule provided in Section 7, Vortec will provide the deliverables listed in Table 12-1. Reports will be made to the FDF Program Manager on a weekly basis via telephone and at any other time that it is necessary to provide or seek information. The existing Vortec Test and Q/A Plans will be modified to comply with the outlines provided in the Contract. These documents will be completed and provided to FDF for review within three weeks of the start of contract. The assays and sieve tests for the compounds that are being used to form the laboratory test surrogates for glass recipes will be provided to FDF no later than two weeks prior to the test. In the case of the laboratory scale test, this is expected to occur during week 13 after the start of contract. Samples of the Demonstration test surrogate then will be provided during week 14.

The 72-hour demonstration test is scheduled for week 16, however, the time required for the analysis of the data shipped to the analytical laboratory and the simultaneous reduction and analysis of the system's performance data will required approximately 20 weeks with the final report not scheduled for review by FDF until week 42, the start of contract. Video tapes of the test will be available at the end of the test period.

Table 12-1. Proof-of-Principle Project Deliverables

Activity	Document Required	Due Date
Weekly Reports (By Phone)	Weekly, within three days of the end of the testing week	
Work Plan	3 Weeks after start	6/25/98
QA/QC Plan	3 Weeks after start	6/25/98
Revised Work Plan (Draft B)	1 Week after comments received	8/21/98
Revised QA Plan (Draft B)	1 Week after comments received	8/21/98
Compound Assays	Two week prior to the test	8/23/98
Sieve Test Results	Two week prior to the test	8/23/98
Proof-of-Principle Test Documentation	38 weeks after award	2/19/99
Analytical Data Package	38 weeks after award	2/19/99
Archival Samples	38 weeks after award	2/19/99
Prepare Draft Final Report w/Testing Documentation and Analytical Data Packages	38 weeks after award	2/19/99
FDF Review and of Draft Final Report	42 weeks after award	3/19/99
Submit Final Report w/Archived Samples	44 weeks after award	4/2/99
Perform Presentation of Final Report	44 weeks after award	4/16/99
Telephone Conversations	As required	
Video	As required	

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13.0 SCHEDULE

The Proof-of-Principle Test schedule is presented in Figure 13-1.

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13.1 MILESTONES

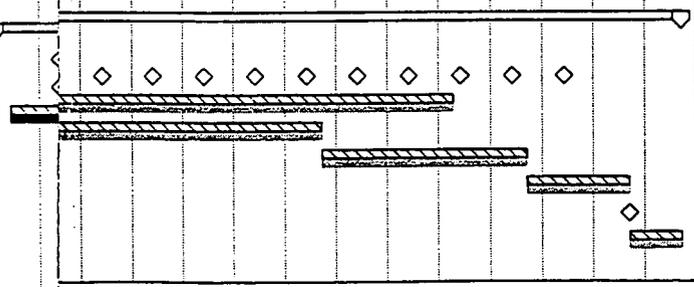
The project schedule identifies each task with sub-task. The project schedule has a duration of 45 weeks as shown in Figure 13-1. As requested in the Contract, Table 13-1 is provided showing the Proof-of-Principle milestones and their relation to the initiation of the contract. The schedule is based on a standard 40 hour work week for all activities.

Table 13-1. Proof-of-Principle Project Key Milestones

Activity	Activity Duration (Weeks)	Project Duration (Weeks)
Award Contract	0	0
Prepare Work Plan and QA/QC Plan	3	3
FDF Review and Comment on Work Plan and QA/QC Plan	4	.7
Address FDF Comments on Work Plan and QA/QC Plan	1	8
FDF Review and Comment on Re-submitted Work Plan and QA/QC Plan	2	10
Address Final Comments	1	11
FDF Reviews and Approves Work Plan and QA/QC Plan	2	13
Perform Proof-of-Principle Testing	7	21
Prepare Draft Final Report w/Testing Documentation and Analytical Data Packages	6	38
FDF Review and of Draft Final Report	4	42
Address FDF Comments on Draft Final Report	2	44
Submit Final Report w/Archived Samples	0	44
Perform Presentation of Final Report	2	45

ID	Task Name	W1	W2	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47
		S 5/31	S 6/7	S 1/24	S 1/31	S 2/7	S 2/14	S 2/21	S 2/28	S 3/7	S 3/14	S 3/21	S 3/28	S 4/4	S 4/11	S 4/18
1	Silos 1&2 Fernald Contract Award															
2																
3	Task 1 Pre-Performance															
4	Sub-Task 1.1 Prepare & Review Work Plan															
5	Sub-Task 1.2 Prepare & Review Test QA/QC Plan															
6	FDF Review of Draft WP & QA Plans															
7	Incorporate FDF Comments into WP & QA Plans															
8	FDF Review of Re-submitted WP & QA Plans															
9	FDF Final Comments Inc into WP & QA Plans															
10	FDF Final Approval of WP & QA Plans															
11	Sub-Task 1.3 Procure Surrogate Ingredients															
12																
13	Task 2 Surrogate TEST Activities															
14	Sub-Task 2.1 Surrogate Ingredients Preparation															
15	Sub-Task 2.2 Develop Treatment Recipes															
16	Sub-Task 2.3 Surrogate-Glass Testing															
17	Sub-Task 2.4 Documentation to FDF															
18																
19	Task 3 Facility Modification															
20	Sub-Task 3.1 Slurry Feedstock Prep, Delivery, and Injector Desi															
21	Sub-Task 3.2 Slurry Feed System Insulation at the Pilot Plant															
22	Sub-Task 3.3 Injector Cold Test															
23	Sub-Task 3.4 Injector Hot Test															
24																
25	Task 4 Proof of Principal Test															
26	Sub-task 4.1 Preparation of the feedstock															
27	Sample Analysis Approval by FDF															
28	Sub-Task 4.2 72- Hour Test															
29	Sub-Task 4.3 Sampling															
30	Sub-Task 4.4 Disposal of Product															
31																
32	Task 5 Post Test Analysis															
33	Sub-task 5.1 Analysis of the Samples															
34	Sub-task 5.2 Data Management															
35	Sub-task 5.3 Data (Reduction) Evaluation															
36	Sub-task 5.4 Test Mass and Energy Balance															
37	Sub-task 5.5 Test Data for Preliminary Design															
38																
39	Task 6 Full-Scale Preliminary Design															
40	Sub-task 6.0 Preliminary Discussion on Base and Alternate Con															
41	Sub-task 6.1 Design Requirement Document															
42	Sub-task 6.2 Process Flow Diagram															
43	Sub-task 6.3 Process Description															
44	Sub-task 6.4 Process Mass and Energy Balance															
45	Sub-task 6.5 General Plant Arrangement															
46	Hardware Design															
47	Design Update															
48	Sub-task 6.6 Cost Estimate															
49	Cost Update															
50	Sub-task 6.7 Construction Schedule															
51	Sub-task 6.8 Review Regulatory Concerns															
52	Sub-task 6.9 Review Health and Safety Concerns															
53																
54	Task 7 Program Management															
55	Sub-Task 7.1 Meetings (4 Scheduled)															
60	Weekly Teleconference															
104	Sub-Task 7.2 Reports															
105	Final Report Draft															
106	FDF Review of Final Report Draft															
107	Final Report Review Corrections															
108	Final Report Submitted															
109	Final Report Presentation															
110	Sub-Task 7.3 Subcontract for Sampling															

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Project: FDF Silo 1&2.MPP
 Date: Wed 8/26/98

Task
 Progress

ed Up Baseline Milestone ◊
 ed Up Progress

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14.0 MANAGEMENT AND STAFFING

Vortec has organized the program team and selected personnel to address the key program elements through the following appointments:

- Program Manager who directed the previous Vortec's technical effort in the area of mixed-waste remediation,
- Key individuals from the support organization with significant experience in the technical area and an interest in the FDF Silo 1 and 2 remediation project.

Figure 14-1 shows the project organization and management structure for the program, with technical, supporting, and program management functions represented. As Vortec's founder, President, and owner, Dr. Hnat will provide the executive visibility to the program, thereby assuring FDF of access at the highest level.

The organization has been structured to provide executive visibility. Vortec will establish an Executive Committee which includes Vortec's President and the principal engineer from the Foster Wheeler subcontract organizations. This assures FDF direct and ready access to the top levels of each organization.

The Vortec Test Facility at U-PARC has a permanent staff that is responsible for testing and maintenance of the facility. This staff has been responsible for the facility construction and maintenance has completed over 150 separate tests over the last ten years.

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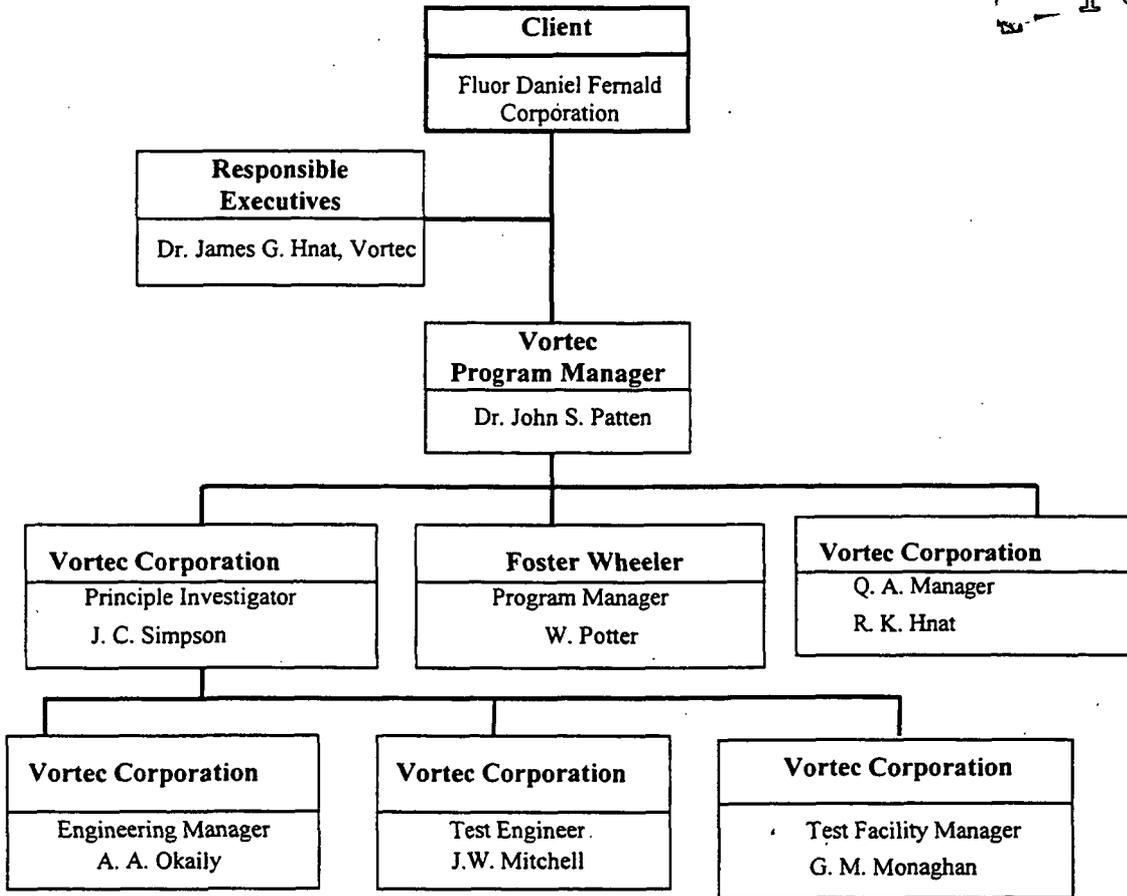


Figure 14-1. Project Organization

15.0 REGULATORY COMPLIANCE

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Vortec has conducted tests at U-PARC that require approval from the appropriate local regulators. When conducting treatability test, both the Environmental Protection Agency Region III and Pennsylvania Department of Environmental Resources have deferred to the Allegheny County Air Pollution Control Board to issue permission to test. This is the same procedure that was required by the regulatory authority for this LLTW tank test. Data are presented in Appendix B of the Proposal that document the arrangement between Vortec and Allegheny County Air Pollution Control Board. Vortec has contacted Allegheny County regarding the FDF Proof-of-Principle Test and they will review the Test Plan at the appropriated time prior to the initiation of testing.

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APPENDIX A
Surrogate Formulas

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**Table A-1. Silo 1 Surrogate Slurry
 (Basis: g/100 g dry solids)**

a Compound	b mol. wt.	c Silo 1 dry	d Silo 1 insitu	e Chemical wt % Moisture	f Surrogate Mix
BaSO ₄	233.40	10.33	7.23		10.33
Na ₂ CrO ₄	161.97	0.08	0.06	30.77	0.11
Fe ₂ O ₃	159.60	2.67	1.87		2.67
MgO	40.31	0.57	0.40		0.57
MgCO ₃	84.32	0.73	0.51	8.00	0.79
Mg ₃ (PO ₄) ₂	262.88	1.69	1.18		1.69
Na ₂ CO ₃	84.99	0.50	0.35	3.00	0.52
NiO	74.71	0.46	0.32		0.46
PbO	223.20	5.00	3.50		5.00
PbCO ₃	267.20	4.17	2.92		4.17
PbSO ₄	303.25	6.30	4.41		6.30
Na ₂ SeO ₃	173.01	0.13	0.09	34.22	0.20
SiO ₂ Mix (see below)	60.08	49.53	34.67		49.53
V ₂ O ₅	181.88	0.09	0.06		0.09
ZnO	81.37	0.01	0.01		0.01
Tributyl Phosphate		0.00	0.00		0.00
Kerosene		0.00	0.00		0.00
Diatomaceous Earth		1.47	1.03		1.47
Feldspar – (Na, K) AlSi ₃ O ₈		16.27	11.39		16.27
H ₂ O	18.00	--	30.00		--
		100.00	100.00	NA	100.18
SiO ₂ Mix	For Above				
Course SiO ₂	14.73				
Fine SiO ₂	13.50				
Fumed Silica	6.44				
Total	34.67				

Notes:

Column "c" is the one used in the surrogate recipe.

Columns "e" and "f" are given only as example. The seller must determine the moisture content of his own chemicals and make the appropriate correction for moisture in Column "e" and determine the actual chemical amounts to be used in the surrogate mix, Column "f".

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**Table A-2. Silo 2 Surrogate Slurry
 (Basis: g/100 g dry solids)**

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a Compound	b mol. wt.	c Silo 2 dry	d Silo 2 insitu	e Chemical % Moisture	f Surrogate Mix
Al ₂ O ₃	101.96	0.81	0.57		0.81
Na ₂ HAsO ₄	186.01	0.21	0.15	40.38	0.35
BaSO ₄	233.40	6.80	4.76		6.80
CaCO ₃	100.09	3.84	2.69		3.84
Na ₂ CrO ₄	161.97	0.06	0.04	30.77	0.09
Fe ₂ O ₃	159.60	6.23	4.36		6.23
KNO ₃	101.11	0.36	0.25		0.36
MgCO ₃	84.32	2.40	1.68		2.61
Mg ₃ (PO ₄) ₂	262.88	1.73	1.21		1.73
Na ₂ CO ₃	84.99	0.71	0.50		0.73
NiO	74.71	0.37	0.26		0.37
PbO	223.20	3.57	2.50		3.57
PbCO ₃	267.20	0.46	0.32		0.46
PbSO ₄	303.25	4.03	2.82		4.03
Na ₂ SeO ₃	173.01	0.10	0.07	34.22	0.13
SiO ₂ Mix (see below)	60.08	48.67	34.07		48.67
V ₂ O ₅	181.88	0.09	0.06		0.09
ZnO	81.37	0.01	0.01		0.01
Tributyl Phosphate		0.92	0.64		0.92
Kerosene		0.92	0.64		0.92
Diatomaceous Earth		4.43	3.10		4.43
Feldspar - (Na, K)AlSi ₃ O ₈		13.28	9.30		13.28
H ₂ O	18.00	--	30.00		--
		100.00	100.00	N/A	100.43
SiO ₂ Mix	For Above				
Course SiO ₂	14.79				
Fine SiO ₂	12.84				
Fumed Silica	6.44				
Total	34.07				

Notes:

Column "c" is the one used in the surrogate recipe.

Columns "e" and "f" are given only as example. The seller must determine the moisture content of his own chemicals and make the appropriate correction for moisture in Column "e" and determine the actual chemical amounts to be used in the surrogate mix, Column "f".

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Table A-3. Demonstration Surrogate
 (Basis: g/100 g dry solids)

a	b	c	d	e	f
Compound	mol. wt.	Composite Dry	Composite insitu	Chemical wt % Moisture	Surrogate Mix
Na ₂ HAsO ₄	186.01	0.17	0.12	40.38	0.17
BaSO ₄	233.40	8.18	5.73		8.18
Na ₂ CrO ₄	161.97	0.27	0.19	30.77	0.39
Fe ₂ O ₃	159.60	2.52	1.76		2.52
Mg ₃ (PO ₄) ₂	262.88	2.35	1.65		2.35
NaNO ₃	84.99	1.03	0.72	3.00	1.06
NiO	74.71	0.43	0.30		0.43
PbO	223.20	5.67	3.97		5.67
PbCO ₃	267.20	6.60	4.62		6.60
PbSO ₄	303.25	2.65	1.86		2.65
Na ₂ SeO ₃	173.01	0.10	0.07	34.22	0.15
SiO ₂ Mix (see below)	60.08	47.94	33.56		47.94
V ₂ O ₅	181.88	0.09	0.06		0.09
ZnO	149.88	0.01	0.01		0.01
Tributyl Phosphate		0.92	0.64		0.92
Kerosene		0.92	0.64		0.92
Diatomaceous Earth		1.83	1.28		1.83
Feldspar - (Na, K) AlSi ₃ O ₈		18.32	12.82		18.32
H ₂ O	18.00	--	30.00		--
		100.00	100.00	NA	100.20
SiO ₂ Mix	For Above				
Course SiO ₂	19.92				
Fine SiO ₂	18.90				
Fumed Silicia	9.12				
Total	47.94				

Notes:

Column "c" is the one used in the Surrogate recipe.

Columns "e" and "f" are given only as example. The seller must determine the moisture content of his own chemicals and make the appropriate for moisture in Column "e" and determine the actual chemical amounts to be used in the surrogate mix, Column "f".

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APPENDIX B
Operating Procedure for CMS™

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B.0 OPERATING PROCEDURES

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B.1 PURPOSE

The purpose of this document is to define the procedures for start-up, operation, and shut-down of Vortec's CMS™ test facility at the University of Pittsburgh Applied Research Center (UPARC) in Harmarville, Pennsylvania, for the performance of Proof-of-Principle testing.

B.2 SCOPE

These operating procedures include those for start-up of the CMS™ facility, operation during Proof-of-Principle testing, and shut-down of the facility after testing. They also identify the responsibilities of key personnel prior to start-up; during start-up, operation, and shut-down; and post shut-down. These procedures are generic and are to be supplemented by a test plan specific to the test being performed.

B.3 RESPONSIBILITIES

The responsibilities of key personnel with respect to operating procedures are as follows:

Program Manager

The Program Manager is responsible for developing a test plan specific to the Proof-of-Principle Test being performed. He is also responsible for ensuring that qualified personnel are assigned to perform the functions necessary for a safe and successful test. He will coordinate with the Environmental Compliance Manager (ECM) for the definition of test specific health and safety procedures and the Quality Assurance Manager (QAM) for incorporation of procedures to meet quality assurance objectives into the Test Plan.

Environmental Compliance Manager

The ECM is responsible for the definition of test specific health and safety procedures to be incorporated into the test plan by the Program Manager. He will also conduct on-site inspections during the operation of the test to ensure that defined health and safety procedures are followed.

Test Facility Manager

The Test Facility Manager is responsible for installation and maintenance of all test facility components. The Test Facility Manager will ensure that the test system is configured in accordance with the test plan and that all components of the system are operating properly. The Test Facility Manager is also responsible for start-up and shut-down of the system in accordance with the Test Plan.

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Test Engineer

The Test Engineer is responsible for supervising the test operation of the CMS™ facility in accordance with the Test Plan. The Test Engineer will coordinate the efforts of all personnel necessary for the safe and successful performance of the test. The Test Engineer will ensure that all operation logs and test data sheets are completed in accordance with the test plan.

Test Operator

The Test Operator is responsible for observing the operating conditions of the test system (critical temperatures, pressures, flowrates, etc.) and adjusting the operating conditions to maintain the system within the operating parameters as established by the test plan. The Test Operator will observe these conditions on the computer control display in the facility Control Room.

Sample Manager

The Sample Manager is responsible for supervising the collection of samples of various flow streams as defined in the Test Plan. He will insure that all protocols are followed for the collection, preservation, and custody of samples.

Data Acquisition Manager

The Data Acquisition Manager is responsible for supervising the acquisition, recording, and reduction of process data (flows, pressures, temperatures, etc.) in accordance with the test plan. The Data Acquisition Manager will ensure that the instrumentation is properly calibrated prior to the test, the computer data acquisition and recording system is operational, the proper data is recorded during the test, periodic data printouts are obtained during the test in accordance with the test procedures, and the data is collected and maintained in a safe location following the test. The Data Acquisition Manager is also responsible for the reduction and analysis of the data following the test.

Quality Assurance Manager

The QAM will assist the Program Manager in incorporating the quality control procedures into the test plan. The QAM will perform on-site supervision to assure that quality control procedures are being followed during the test, specifically with respect to collection and storage of samples.

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B.4 DEFINITIONS

CMST TM	Vortec Cyclone Melting System
CRV	Counter-Rotating-Vortex reactor component of the CMST TM
CM	Cyclone Melter component of the CMST TM
S/R	Separator/Reservoir component of the CMST TM
QAM	Quality Assurance Manager
ECM	Environmental Control Manager
WESP	Wet Electrostatic Precipitator
VF ID Fan	Variable frequency induced draft fan used to discharge the flue gas
Emhart System	The natural gas fired burners installed on the S/R to control glass temperature in the S/R
Bloom System	The natural gas fired burner system supplying additional heat to the S/R to control glass temperature the S/R
FD Fan	Forced draft fan supplying reaction air to the CMST TM
Air Heater	Natural gas fired indirect heater used to preheat the reaction air to the CMST TM
L-Valve	Aerodynamic valve for control of batch to the CRV
Evaporative Cooler	Component in the facility used to cool the flue gases, via a water spray, exiting the CMST TM prior to introduction of the gases into the WESP
Lance	Component of the evaporative cooler used to atomize the water entering the evaporative cooler and spray the water into the flue gas
Prereactor Burner	Natural gas fired burner in the lid of the CRV when the pre-reaction section of the CRV is used
Tap Hole	Orifice in the S/R from through which molted material is discharged from the CMST TM
CRV Injector	Component used to inject batch material into the CRV
Batch	Blended material used as a feedstock
Cooling Loop	Water circuits for cooling the CRV and CM
UPARC	University of Pittsburgh Applied Research Center
UPS	Uninterruptible power supply for the control system

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B.5 START-UP PROCEDURE

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1. Obtain a set of test data sheets and fill in the test definition data.
2. Obtain electric, gas, and water meter readings requested on the test data sheets.
3. If refrigeration will be needed for samples taken during the test, plug in refrigerator on loading dock and set temperature control.
4. Turn on control power and WESP power:
 - a. Control Power:
 - 1) Two toggle switches located on panel facing east on floor above control room.
 - 2) Bank of component control power toggle switches located on top of control cabinet in control room.
 - b. VF ID fan power: in breaker box on floor above control room.
 - c. WESP Powers:
 - 1) High voltage and purge air heaters in breaker box on floor above control room.
 - 2) Four purge air disconnect boxes outside on elevated WESP platform
5. Check computer date and time and erase previous test log files.
6. Open natural gas ball valves:
 - a. Main building supply valve outside, near air heater.
 - b. CMS™ main gas on 1st steel floor.
 - c. Emhart system for S/R on 1st steel floor.
 - d. Bloom system for S/R on ground floor.
 - e. If the current configuration is using the pre-reactor spool and burner above the CRV combustion air inlet piece, open valve leading to vertical gas line going up from 1st to 2nd steel floor.
7. Start VF ID Fan.
 - a. Select low speed initially, about 20 %, to avoid excessive suction on the S/R. Leave controller on 'manual' for first part of start up, and later switch to 'auto' with a slightly positive S/R pressure setpoint.
8. Start FD Fan.
 - a. Typically an airflow of 2500 – 3000 lb/hr is used.
9. Start Air Heater.
 - a. Turn air heater panel power on, push blower start button, wait for all limit lights to come on, push burner start button. There will be a delay of about 90 seconds before 'burner lit' light comes on. It may fail to light several times before all air is purged from gas line.
 - b. Set control to 'auto' and setpoint to 500 deg. F.

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10. Turn on outdoor lights over WESP area and over loading dock. In cold weather, verify that heat tapes for WESP water lines have been turned on.
11. Activate pond water cooling:
 - a. Open pond water cooling loops.
 - 1) One 6" gate valve with hand wheel on green supply line on ground floor.
 - 2) Two 6" butterfly valves with levers on green supply line on ground floor.
 - 3) Two 3" ball valves on loop supply and return manifolds on 2nd floor.
 - b. Turn on pond water booster pump on mezzanine above 6" supply line.
 - 1) Turn down globe valve on pump outlet.
 - 2) Turn on pump.
 - 3) Open globe valve again slowly to give time for the pressure regulating valve on the low pressure line to respond.
 - c. Check for sufficient and steady flow in the rotometers for each component. Adjust individual globe valve and bleed air from petcocks on high points of loop if a loop's flow is unsteady or not responding to valve adjustment. Note that there may be two banks of rotometers, one for loops 1 to 30 (low pressure) and another for loops 50 to 55 (high pressure).
12. Open city water cooling flows:
 - a. Coils around CRV and CM viewports.
 - b. Tap hole coil.
 - c. Flue gas sampling probes.
 - d. City water back-up to pond water system. Open two ball valves around backflow prevention valve on ground floor. Note that there is a sequence given on tags on each ball valve indicating which valve should be opened (or closed) first.
 - e. Special cooling for internal injection components of CRV burner, if present.
13. Open city water make-up flows:
 - a. Evaporative cooler feed tank.
 - b. Ball valve in high bay on line to WESP recirculation tank in pump house. Check inside pump house that the WESP tanks are, or are not, filling as desired.
14. Open cooling air flows:
 - a. CRV, CM, and S/R viewport purge air.
 - b. CRV pilot and flame detector purge airs.
 - c. Special cooling or purging for internal injection components of CRV burner, if present.
 - d. Feed system airs:
 - 1) L-valve batch moving air and purge airs, if in use.
 - 2) Nol-Tec transport air, if in use.
 - e. Gas sampling system pump cooling air.

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15. Start WESP water system:

- a. If WESP shell is empty of water, fill one recirculation tank to top.
- b. Position system valves for start up:
- 1) 4" ball valve from tank to a supply pump – OPEN.
 - 2) 3" ball valve on supply pump outlet – CLOSED (to avoid shocking flow sensor).
 - 3) Ball valves to fog nozzles and both duct sprays – OPEN.
 - 4) Ball valve to wash spray – CLOSED.
 - 5) Throttle valves to fog nozzles and both duct sprays – OPEN PARTIALLY.
- c. Put both return pumps on 'auto'.
- d. Start the supply pump and slowly open the ball valve on its outlet so as to not shock the flow sensor.
- e. Then immediately and simultaneously:
- 1) Watch level in recirc tank and add only enough water to keep level above low-low alarm level.
 - 2) Watch level sensor on WESP shell to verify that it turns on a return pump at the 2nd point up and turns it off at the 1st or bottom point.
- f. Open ball valve on city water make-up line in pump house, and verify that another in high bay area is open from a previous step. Watch to see that the make up water is cycling properly to hold the tank water level in its proper range.
- g. Adjust throttle valves on fog nozzle and both duct spray lines to give the specified line pressures. These pressure specifications are indicated on the side of the WESP shell, and (including other data for reference) are:

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1 st duct spray = rod deck scrubber	18 psi 45 gpm
2 nd duct spray = one big nozzle	18 psi 30 gpm
fog nozzles	20 psi 30 gpm
wash nozzles	25 psi 80 gpm.

- h. 18 psi for rod deck spray, 20 psi for 2nd inlet duct spray, and 18 psi for fog spray.
- i. Check that the sump pump in the ID fan drain sump is on and working. In cold weather, check that the thermostatic heating circuit for the sump is working.

16. Turn on WESP high voltage. The voltage typically starts out in the 15-20 kV range and may take several hours or the initiation of batch flow to attain the desired 30-35 kV range.

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17. Activate the evaporative cooler water sprays.
 - a. Set the setpoint for cooler exit temperature at the desired value (450 – 800 °F).
 - b. Verify that the city water make-up flow to tank on ground floor is open from previous step.
 - c. Open ball valves for water flow to lance in the pump circuit.
 - 1) On north wall by stairs between ground floor and 1st steel floor.
 - 2) Before and after throttle valve on 2nd steel floor.
 - 3) Before globe valve at lance to be used.
 - d. Open ball valves on north wall on 2nd steel floor for emergency city water backup flow to lance.
 - e. Open the plant air to lance. If there is more use of plant air than normal, Vortec's auxiliary air compressor may be brought on line to ensure sufficient air capacity.
 - f. Open globe valves for water and air to lance at lance to be used.
 - g. Verify that ball valves in flow meter and throttle valve bypass line in pump water and air circuits are closed.
 - h. Verify that ball valves at lance that is not being used are closed.
 - i. Turn on water pump. Pump outlet pressure should be 120 psi and recirculation loop should be returning water back to tank. Low pump outlet pressure may be caused by a dirty strainer.
18. Ramp up air heater setpoint (aggressively) to 1200°F to produce a heat up rate of 150 °F/hr at CM exit (or CRV lid) temperature. Plot temperature vs. time to monitor rate and to foresee needed setpoint changes.
19. Set VF ID fan control to 'auto' with S/R pressure setpoint of .05" H₂O.
20. Light the CRV lid pilot light.
 - a. Turn down cooling air to rear of pilot.
 - b. Either turn up FD fan some or trim down butterfly valve on air line outside on top of air heater to give 4" H₂O or more pressure in Lamson air line as indicated on Magnehelic pressure gauge in control room. Note, however, that it is possible for the Lamson air flow to be too high for the pilot to light.
 - c. Turn on power to main gas flame safety and control panel.
 - d. Light pilot with the following sequence:
 - 1) Slowly rotate switch from 'off' through 'on' to 'light'.
 - 2) Hold 'on' (red light come on) hold for 5 seconds, then release to 'off'.
 - 3) If yellow 'lit' light came on, pilot was lit. If not, repeat sequence a dozen times or more to remove air from gas line.
 - 4) If a click was heard from behind the panel then the pilot switch was held on 'light' too long. The relay behind the control panel must be reset by pushing in the red reset button after allowing a minute or so for the relay to cool.
 - e. Restore sufficient cooling air to pilot.
 - f. The heat input from the pilot might be worth about 5-10 minutes of ramping.

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21. If the current configuration is without the pre-reactor spool and burner above the CRV combustion air inlet piece, then jump to 'light the CRV main gas'. If the current configuration is with the pre-reactor spool and burner, then light the pre-reactor burner before lighting the CRV main gas.
22. Light the pre-reactor burner:
 - a. Close the one large or the two small ball valves on main gas line to CRV inlet arms.
 - b. Open throttle valve on air line to pre-reactor burner fully.
 - c. Close throttle valve on gas line to pre-reactor burner.
 - d. Open ball valve on gas line to pre-reactor burner.
 - e. Open throttle valve on gas line to pre-reactor burner about ¼ turn.
 - f. Push 'start' button on gas control panel, look for the green 'gas TRV open' light to come on immediately, and the yellow 'main gas lit' light to come on within a few seconds. Repeat as many as a dozen times if necessary to clear air from the gas line. The two Maxon gas shutoff valves on the 2nd floor will stay open only when the flame is detected.
 - g. The heat input from the pre-reactor burner at this idle position might be worth about 30 minutes of ramping.
23. Continue ramping up at the 150 °F/hr by opening gas to pre-reactor burner until the CRV lid temperature is above 1,500°F.
24. Light main gas to CRV as follows:
 - a. If the current configuration is without the pre-reactor spool and burner, the CRV pilot will ignite the main gas to the CRV inlet arms. Push 'start' button on gas control panel, look for green 'gas TRV open' light to come on immediately, and yellow 'main gas lit' light to come on within a few seconds. Repeat as many as a dozen times if necessary to clear air from the gas line. The two Maxon gas shutoff valves on the 2nd floor will stay open only when the flame is detected.
 - b. If the current configuration is with the pre-reactor spool, the pre-reactor burner must be putting out a long flame, 2-3 ft and visible through the viewport, to ignite the CRV main gas to the arms. Simply open the gas to the arms and verify that the gas is lit by watching for a rise in CM exit gas temperature. First close down the main gas throttle valve, then verify that the large ball valve is fully open and the two smaller ball valves to each arm are open either fully or partially for controlled distribution, then slowly open the main valve.
25. Continue ramping up at the 150 °F/hr by opening main gas and gas to pre-reactor burner.
26. Turn on roof exhaust fan – breaker 13 in electrical box on west wall of closet in hall east of water fountain.

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27. Turn on Bloom burner in S/R reservoir. E-1722
- Verify that VF ID fan control is on 'auto'.
 - Turn on power switch on Bloom skid control panel.
 - Turn on blower (press blower button).
 - When 'purge complete' light comes on, turn burner start/stop switch to 'start', watch for 'flame on' light.
 - If 'flame fail' light comes on, repeat step 'd' until burner lights.
 - Once burner is lit, set output to 35% (which is just coming off of idle).
 - Ramp S/R reservoir temperature up at about 300 °F/hr. Emhart burners in S/R reservoir should be turned on when S/R temperatures get to 1500 °F.
28. Turn on Emhart burner system in S/R when S/R temperature gets in range 1500-1600 °F.
- Observe S/R temperatures for step d. below.
 - Turn on the Eclipse blower.
 - A click in the green gas shut off box on the S/R gas line will be heard when the air line pressure switch senses sufficient pressure. Throw the lever on the box to the right to send gas to the burners. The three flow control dial valves should always be left in their full open position.
 - Light the three Bunsen burners under the west end of the S/R and observe flame quality. A blue flame with a little bit of orange color is fine.
 - Ignition of the Emhart gas is indicated by an alarm caused by a pulse in S/R pressure and by a slight (25 °F) jump in S/R temperature.
29. Continue ramping up CRV main gas, pre-reactor burner gas, and Bloom system until desired temperatures are attained.
30. Ignite tap hole burner:
- Open ball valves on air and gas lines. The air is FD fan air and the pipe line traces up through a second ball valve on the second steel level.
 - Ignite burner with a hand held propane soldering torch. If burner does not light, read indicator on air line pressure switch to verify that solenoid valve on gas line is being energized
31. Place cullet cart or crucible under the center drain tap hole and, if used, the S/R long leg weir opening.
- Install city water supply line and fill each with water.
 - If needed, rig up appropriate drain system, either a hose to floor drain, or a pump and line to tank or drums for storage.
 - If needed (when the test batch is over 2,000 lbs or the test feed rate will be high) turn on the pond water to the crucible water jacket.
32. Open center drain tap hole to allow glass remaining from previous test to drain out into cullet cart or crucible filled with water.

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33. Items to watch during the warm up period, and all operation as well, are:
- Pond water cooling loop flows and temperatures – flows drifting downwards and air bubbles in line.
 - Evaporative cooler pump outlet pressure – plugging of inlet strainer.
 - WESP recirculation tank level – maladjusted float level on make up water.
 - WESP shell water level switch action – sticking.
 - WESP fog nozzles, rod deck, and duct spray pressures – drifting downwards.
 - WESP supply pump pressure – plugging of inlet strainer.
 - Check that the CRV injector is being cooled sufficiently.

B.6 TEST OPERATION PROCEDURE

General procedures are presented here that should be exercised as appropriate for the particular test objectives and system configuration at the time. Specific procedures required by and unique to a particular test are to be provided by a specific test plan.

Before Start of Test:

- Activate the gas sampling system:
 - Turn on refrigerator.
 - Turn on heated cable.
 - Calibrate analyzers as per manual.
 - Turn on cooling air to pump.
 - Turn on pump.
 - Open drying N₂ to dryer.
 - Clean filter.
 - Set up sampling system log book for running entries during each test.
- Bring the system to the specified temperatures, and hold at steady state for at least ½ hour.
- Check zero point adjustment of S/R pressure transmitter:
 - At the transmitter, disconnect the line from pressure tap in the S/R roof.
 - Read pressure on monitor. If needed, turn the 'zero' screw underneath the transmitter until the deviation from zero is no more than 0.01" H₂O.
 - Reconnect line from pressure tap.
- Observe critical system thermocouple readouts, CRV lid, CM exit, S/R wall, S/R glass, for steadiness and relative consistency to determine if any need to be replaced or inserted differently. To prolong its life, the S/R glass thermocouple is best kept withdrawn from the S/R until a point in the test when it is most needed.

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5. Walk down the system to check for proper condition of:
 - a. Pond water cooling loops, both flow and temperature (both banks of rotometers).
 - b. Evaporative cooler pump pressure (120 psi).
 - c. WESP tank level and spray pressures.
 - d. WESP tank water pH. Either neutral or as called for in specific test plan.
 - e. WESP high voltage.
6. If not done previously, obtain a set of test data sheets and fill in the test definition data.
7. Obtain start of test electric, gas, and water meter readings requested on the test data sheets.
8. Check computer time and date and correct if necessary.
9. Activate computer test logging.

During Test:

10. The general test procedure consists of the following steps:
 - a. Hold system at the desired temperatures with the air flow needed for the test until steady state conditions are attained. Balance the fuel to the lid burner, fuel to the inlet arms, and Bloom burner to give the desired temperatures in each.
 - b. Initiate batch feed at a low rate.
 - c. Quickly adjust fuel input to what is expected for the temperatures desired.
 - d. Continually adjust fuel and other parameters as needed to attain and hold steady at the desired temperatures.
 - e. Observe results and take batch and glass samples as needed.
 - f. Either increase batch feed rate or alter system temperatures for a new operating point.
 - g. Attain steady state and hold it for flue gas testing.
 - h. Initiate the sampling plan.
11. Record test data by the following means:
 - a. Handwriting on log forms:
 - 1) Log sheet – record test start and end times and dates; operating data for special equipment that is not part of the regular system or otherwise not integrated into the routine data logging; and other test conditions, observations, results, problems, and events.
 - 2) Batch feed sheet – feed rate data for manual feeding methods not fully integrated into the computer data logging.
 - 3) Cooling loop sheet – manual reading of rotometers and dial thermometers for pond water cooling loops. Include also total flow meter readings for both water lines. Record once per test or as called for in the specific test plan.

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- 4) Gas sampling system log book – notes on calibration and functional problems both before and during testing.
 - b. Computer log files on hard disk of all significant data input to and calculated by the computer. Includes all system temperature, pressure, and flow data input to or calculated by the computer. A full set of data is to be entered into the log file every minute.
 - c. Computer screen printout. Print the main system condition screen and a special data dump screen that serves as a hardcopy back up to the data files.
 - d. Special notes taken as appropriate to test objectives.
12. Collect samples of test materials:
- a. Samples of influent and effluent streams will be collected at frequency intervals as specified in the test plan as appropriate to satisfy stated test objectives. Samples will be stored in preservatives and at temperature conditions appropriate for the type of sample in accordance with the test plan. Sample storage containers will be marked identifying the sample material, test number, date and time sampled, preservative, and collector. When required, custodial tracking forms will be used to identify the name, date, and time of custodial transfer. The following materials are generally sampled during a proof-of-principle test:
 - 1) Batch material – the individual ingredients which make up the batch are generally sampled from bulk containers prior to the test.
 - 2) Blended batch – samples of blended batch material are generally collected from bulk containers after blending prior to the test. Samples are also generally collected from the batch feed line at periodic intervals during the period of time when flue gas sampling is being performed.
 - 3) Glass – samples of quenched and unquenched glass are generally collected at periodic intervals during the test. The unquenched samples are collected as the molten material discharges from the S/R component of the system. The quenched samples are collected from the cullet cart.
 - 4) Flue gas -
 - a) At exit of S/R – continuous monitoring for O₂, CO, NO_x, and SO₂ content with the gas sampling system. Also special sampling for gas constituents if required.
 - b) At entrance to WESP – periodic timed measurements of emission species and collection of particulate samples, generally done to EPA standards (typically Method 5) by certified contractors.
 - c) At exit of WESP – same as at entrance, but not usually required.
 - 5) Cullet cart water – samples are generally taken at periodic intervals when flue gas sampling is being conducted and, in the case of hazardous waste testing, after the test prior to disposal.
 - 6) WESP water – generally collected at the end of test and/or prior to disposal.
 - 7) City water samples – samples generally taken prior to test.
 - d) When called for in the specific test plan, refrigeration of the samples may be accomplished in the refrigerator on the loading dock or with ice packs and a cooler.

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B.7 SHUT-DOWN PROCEDURE

The shut-down for the UPARC system is not a controlled temperature ramp down, but rather a quick shut off and button up of the system.

1. After the test, continue running system at the test conditions to keep the S/R hot while it drains.
2. Turn off computer data logging.
3. Put WESP in wash down mode:
4. Turn off High voltage.
5. Close ball valve on fog nozzle spray, but leave both inlet duct sprays on.
6. Open ball valve to wash nozzles on top of WESP.
7. Check adjustment of globe valve to give the specified pressure, 25 psi, in the wash nozzle line. This spec is recorded along with the specs for the other sprays on the side of the WESP shell.
8. Let it wash while shut down proceeds or for a minimum of 20 minutes.
9. Drain glass from S/R:
10. Turn on center drain tap hole burner. If acceptable, this should be done several hours before the end of the test.
11. Continue running system at the test conditions to keep S/R hot.
12. If glass flow had been out the long end, the center drain tap hole must be heated and opened to drain out the large bulk of glass. Place a fresh and large (3 cu ft) cullet cart or crucible full of water under the hole. Burn up through the plug in the hole with slice rods.
13. Drain system for about an hour until glass flow is clearly intermittent.
14. Turn off gas sampling system.
15. When glass flow is small enough, shut down all the following combustion flows in quick succession:
16. Tap Hole burner – close both gas and air valves upstream of pressure regulators.
17. Bloom burner - turn power switch to off.
18. Emhart burners - turn off Eclipse blower and watch for the lever on the gas shut off box on the gas line overhead to flip to off position.
19. Air heater - push off button on control panel.
20. CRV pilot burner – rotate switch to off.
21. CRV main gas – push off button on flame safety panel. Turn panel power off.

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22. FD fan (Lamson).
23. ID fan – push off button twice. Power to VF controller will be shut off in a step below.
24. Shut down evaporative cooler lance spray:
25. Turn off water pump.
26. Close ball valve for make up water to tank.
27. Turn off air compressor if running, and close valves to isolate compressor from plant air line.
28. On 2nd steel level, close ball valves on water lines to lance, both the pump circuit and the city water back up circuit.
29. On 2nd steel level, close ball valves on air lines to lance.
30. Turn off all cooling air flows:
31. CRV, CM, and S/R viewport purge air.
32. CRV pilot and flame detector purge airs.
33. Special cooling or purging for internal injection components of CRV burner, if present.
34. Feed system airs:
35. L-valve batch moving air and purge airs, if in use.
36. Noltec transport air, if in use.
37. Gas sampling system pump cooling air.
38. Shut off city water to cullet cart and/or crucible. Leave all other city water cooling flows on for 2 or more days.
39. Turn off pond water booster pump. Shut off pond water to crucible jacket. Leave on all other pond water cooling flows for 2 or more days.
40. Shut down WESP waters:
41. Close ball valve in high bay on city water make up line to WESP tank.
42. Close ball valve in pump house on city water make up line to WESP tank.
43. Turn off supply pump in pump house.
44. Run return pump at WESP in 'manual' to drain water from WESP shell. Avoid over flowing the one tank by diverting returning water to the other tank.
45. Check to see that the sump pump under the ID fan has switched off.
46. In warm weather, close the ball valve on the wash line and open the ball valve on the fog line to be ready for the next test.
47. In cold weather, drain all water from the supply line, the return line, and the city water make up line.

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48. On floor above control room:
49. Disconnect power to VF controller in breaker box.
50. Disconnect power to WESP high voltage in breaker box.
51. Disconnect power to WESP purge air heaters in breaker box.
52. Turn off two control power toggle switches on panel facing east.
53. In the control room, turn off the bank of component control power toggle switches on top of main control cabinet, *all but the UPS switch which should always be left on.*
54. Close natural gas ball valves:
55. Main building supply valve outside near air heater.
56. CMS main gas line on 1st steel floor.
57. Vertical gas line from 1st to 2nd steel floor.
58. Emhart gas line on 1st steel floor.
59. Bloom skid line on ground floor.
60. Turn off the outdoor lights over the WESP and loading dock.
61. Turn off roof exhaust fan – breaker 13 in electrical box on west wall of closet in hall east of water fountain.
62. Turn off bag house, if in use.
63. After a couple of days when all water cooled components are below 200°F, turn off cooling waters:
64. City water:
Coils around CRV and CM viewports.
Tap hole coil.
Flue gas sampling probes.
City water back-up to pond water system. Close two ball valves around backflow prevention valve on ground floor. Note that there is a sequence given on tags on each ball valve indicating which valve should be closed (or opened) first.
65. Special cooling for internal injection components of CRV burner, if present.
66. Pond water:
The 6" butterfly valve with lever down stream of the meter on the green supply line on ground floor.
Two 3" ball valves on the component supply and return manifolds on 2nd floor.
67. Complete final meter readings on test data sheets.

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68. Copy computer test data log files onto floppy disk. Make two copies, one to keep at UPARC and to send to Collegeville. Check fidelity of copies before erasing hard disk files.
69. Cullet cart water is to be retained for use in the WESP (or elsewhere) or disposed of as called out in the specific test plan.
70. Label and store, dispose of, or process vitrified product as called for in the specific test plan.
71. Remove particulate from WESP tanks:
72. Begin agitating water with mixer to put particulate into suspension.
73. Check and bring pH of water to neutral early in the agitation process.
74. Run water through filter press.
75. Obtain and label sample of filter cake as called for in the specific test plan.
76. Label and store or dispose of filter cake as called for in the specific test plan.
77. Turn off refrigerator on loading dock if on and no longer in use.

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APPENDIX C
Heat & Mass Balances

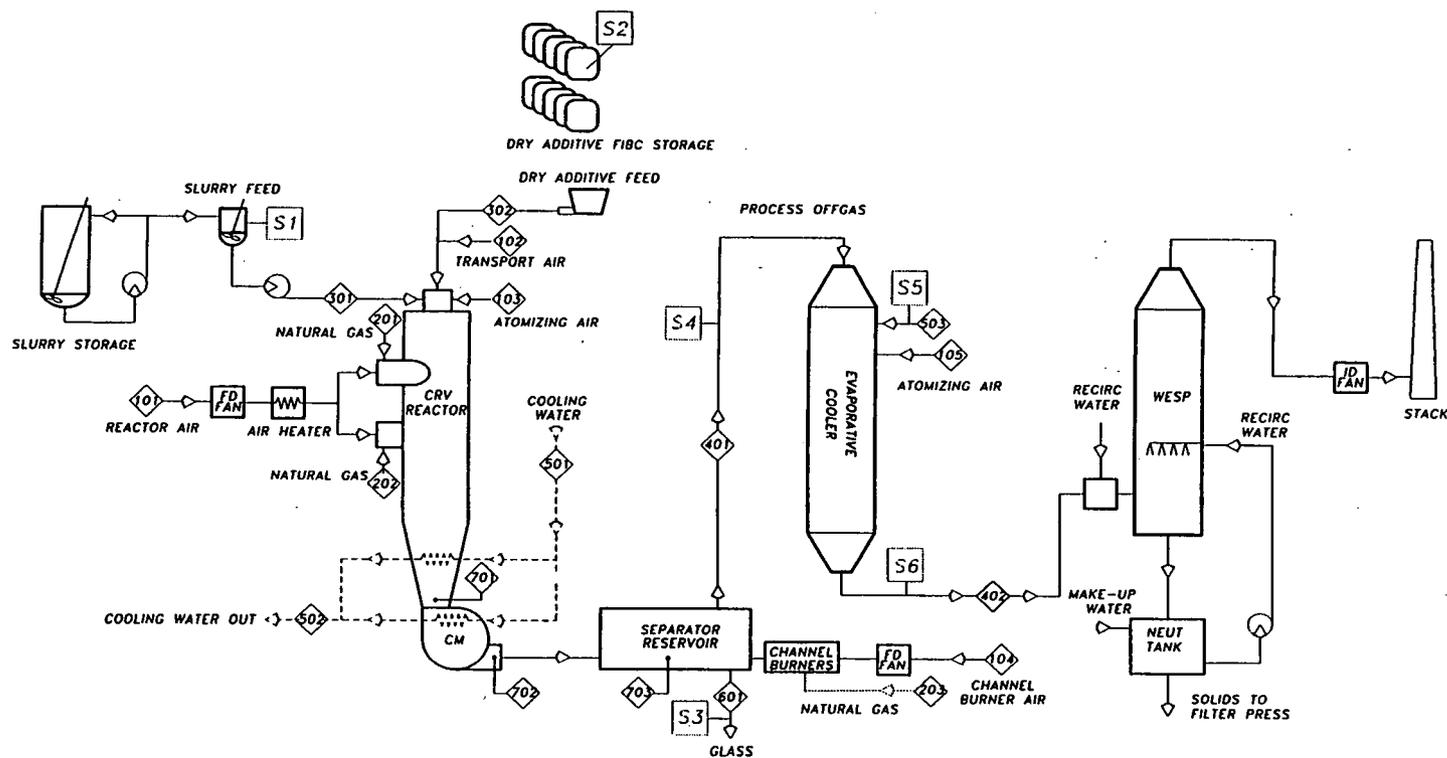


Figure C-1. Pilot Plant Process Flow Diagram for FDF Proof-of-Principle Demonstration

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Table C-1. Pilot Scale Heat & Mass Balance

TABLE CONTAINS PROPRIETARY INFORMATION-
NON-RELEASABLE

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Table C-1. Pilot Scale Heat & Mass Balance

SUBSYSTEM	AIR					NATURAL GAS			BATCH	
STATE POINT NO.	101	102	103	104	105	201	202	203	301	302
STREAM DESCRIPTION	TOTAL REACTOR AIR	DRY SOLIDS TRANSPORT AIR	SLURRY ATOMIZING AIR	SEPARATOR RESERVOIR AIR	EVAP COOLER ATOMIZING AIR	NATURAL GAS TO UPPER INLET ARMS	NATURAL GAS TO LOWER INLET ARMS	NATURAL GAS TO SEPARATOR	SLURRY INPUT	DRY SOLIDS INPUT
FLOW RATE IN ACFM (GPM)	2,055	10	3	183	37	26	26	13	(0.4)	0.0107
TEMPERATURE IN DEG F	970	70	70	70	70	70	70	70	70	70
PRESSURE IN INCHES WC (PSIG)	15	(20)	(90)	15	(90)	(5)	(5)	(5)	(90)	10
TOTAL MASS FLOW IN LB/HR	3,544	105	100	850	1,194	87	87	44	255	45
GASEOUS FLOWS IN LB/HR	3,544	105	100	850	1,194	87	87	44		
LIQUID FLOWS IN LB/HR										
SOLIDS FLOWRATES										
SLURRY									255	
SO3 in slurry									2.91	
PbO in slurry									9.27	
DRY ADDITIVES										45
GLASS										
PARTICULATE										

SUBSYSTEM	FLUE GAS		WATER			GLASS	CMS			
STATE POINT NO.	401	402	501	502	503	601	701	702	703	
STREAM DESCRIPTION	FLUE GAS LEAVING SEPARATOR RESERVOIR	FLUE GAS LEAVING EVAPORATIVE COOLER	TOTAL INLET COOLING WATER	TOTAL OUTLET COOLING WATER	EVAPORATIVE COOLER WATER	MOLTEN GLASS OUTPUT	CRV REACTOR	CYCLONE MELTER	SEPARATOR RESERVOIR	
FLOW RATE IN ACFM (GPM)	6,563	4,308	(70.2)	(70.2)	(4.8)	0.0108	5,262	5,378	6,563	
TEMPERATURE IN DEG F	2,450	500	70	105	70	2,350	2,450	2,450	2,450	
PRESSURE IN INCHES WC (PSIG)	-0.1	-1	(50)	(45)	(50)	0	10	1	-0.1	
TOTAL MASS FLOW IN LB/HR	5,026	8,608	35,124	35,124	2,388	91	4,223	4,223	5,117	
GASEOUS FLOWS IN LB/HR	5,014	8,596					4,120	4,120	5,014	
SO2 in flue gas	2.32	2.32					2.32	2.32	2.32	
PbO in flue gas	3.71	3.71					3.71	3.71	3.71	
LIQUID FLOWS IN LB/HR			35,124	35,124	2,388					
SOLIDS FLOWRATES										
SLURRY										
DRY ADDITIVES										
GLASS						91	91	91	91	
PARTICULATE	12	12					12	12	12	

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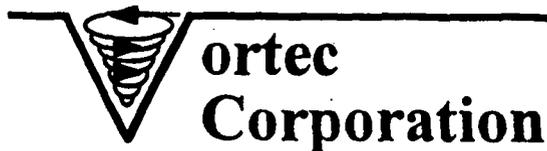
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APPENDIX D

Letter to Allegheny County Air Pollution Control Board

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3770 Ridge Pike
Collegeville, PA 19426-3158 U.S.A.
(610)489-2255 • FAX: (610)489-3185

March 27, 1998

Ms. Sandra Etzel
Chief Engineer
Allegheny County Health Department
Bureau of Air Pollution Control
301 39th Street, Bldg. 7
Pittsburgh, PA 15201

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Dear Ms. Etzel:

As per your conversation with Chris Holdridge last week regarding the status of Vortec's air permit exemption, the following is a brief explanation of Vortec's test facility located in Harmarville, PA. Vortec Corporation is a research and development company headquartered in Collegeville, PA specializing in the recycling of industrial wastes into valuable commercial products. Our patented Cyclone Melting System (CMS™) transforms industrial wastes into a "vitrified" glass product which possesses long-term stability and consistently passes leaching criteria.

Vortec's pilot test facility performs vitrification tests for short periods of time at relatively low flow rates. We typically only run for 8-12 hours one or two days every few months, but sometimes do run continuously for two or three day periods in order to prove the integrity of our system to various clients. To date, Vortec's longest test run has been 100 continuous hours. The facility is fired by natural gas provided by a public utility at a load of no more than 5,000,000 BTU per hour. The gasses emitted from the system are therefore primarily due to the processing of the industrial wastes being tested. Vortec runs both hazardous and non-hazardous materials through the system. Hazardous materials require treatability study approval from PADEP, which limits the amount Vortec may recycle to 1,000 kg per study at no more than 250 kg/day. Our facility is capable of handling a wide variety of wastes including spent potliner (SPL), municipal solid waste (MSW) ash, coal fired boiler ash, auto shredder residue, and other industrial wastes. The waste materials are combined with glass forming additives and melted in the CMS™ to form a glass product.

The flue gas from the system is cooled by an evaporative cooler and then continuously analyzed for CO, O₂, SO₂, and NO/NO_x concentrations by a series of four Rosemount Analytical/Beckman analyzers. This set of instrumentation allows us to adjust the fuel to air ratio in order to obtain the greatest level of efficiency from the system. After analysis, the flue gas is run through a wet electrostatic precipitator (WESP) with a design efficiency of 99.425%. The WESP primarily functions to remove particulate from the flue gas and also serves to some degree as a wet scrubber. The highest SO₂ and NO_x levels Vortec has measured before the WESP, while running at 5 million BTUs per hour, are 9.4 lbs/hr and 9.4 lbs/hr, respectively. No data has been obtained for rates after the WESP, but it is assumed that these levels are somewhat lower, despite the fact that the WESP is not an acid scrubber.

A total of six letters from the Allegheny County Health Department exempting Vortec from air permit requirements have been received by Vortec over the years. As requested, these letters, and some of the most recent letters Vortec has sent to the department, are enclosed for your review. The letters are dated from 1992 to 1994 and were approved based on the

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fact that the pilot facility is used for research and has limited operating hours and minimal emission rates. Furthermore, sulfur emission is rare and limited to recycling of MSW ash, which represents only one of the several different types of waste we process.

Vortec would like to confirm our air permit exemption status. I understand that natural gas-burning equipment with net load ratings of 10 million BTUs per hour or less are exempt from applying for air permits as long as they meet the sulfur dioxide requirements of 2104.03 Air Pollution Control Regulations. Since most of Vortec's wastes are low sulfur, we do meet these standards, with the possible exception of emissions resulting from occasional MSW ash tests. We request that your office confirm that Vortec is still exempt from the regulations considering our low emissions and limited use. Vortec would be happy to provide you with any other additional information.

Currently, we are planning on conducting one day of testing tentatively set for sometime within the month of April. The testing will consist of two runs, each recycling 3,000 lbs of MSW ash into a glass, and will last for eight hours or less. This would be a good time for Vortec to obtain any additional information your office may require.

Vortec is also entertaining other vitrification studies which may be desired towards the end of the year. One such test will be a continuous 72 hour test for proof of principle testing for a DOE project. This test will consist of running a non-hazardous simulation of a multi-component waste. The test material will be spiked with a combination of heavy metals in order to track their mass balance. Based on our experience with similar tests, the majority of the metals (90%) will be integrated into the glass, while the remainder will be retained by the WESP (98-99%). A spreadsheet indicating estimated emissions based on these removal efficiencies is attached. The entire test will only result in approximately 2 pounds of heavy metal emission from the stack, with PbO contributing the majority. Vortec would like to know what may be required from your department before such testing is conducted.

Please address all questions requiring further information to Christopher Holdridge, Vortec's Environmental Compliance Engineer at 610-489-2255.

Sincerely,

James G. Hnat
James G. Hnat, Ph.D.
President

Heavy Metals from DOE Testing

Batch Flow: 255 lb/hr

(72 hour)

Metal	% in Batch	Input Quantity (lb/hr)	Captured In Glass (lb/hr)	Captured By WESP (lb/hr)	Stack Emissions (lb/hr)	Total Emission (lb)
BaO	1.78	4.539	4.0851	0.444822	0.009078	0.653616
ZnO	0.01	0.0255	0.02295	0.002499	5.1E-05	0.003672
NiO	0.13	0.3315	0.29835	0.032487	0.000663	0.047736
PbO	3.64	9.282	8.3538	0.909636	0.018564	1.336608
CrO3	0.09	0.2295	0.20655	0.022491	0.000459	0.033048
V2O5	0.03	0.0765	0.06885	0.007497	0.000153	0.011016
As2O5	0.06	0.153	0.1377	0.014994	0.000306	0.022032
SeO2	0.09	0.2295	0.20655	0.022491	0.000459	0.033048

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