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Process Technology	Waste Product Technology	Date 05/23/95
Project Title/Work Order LLW Vitrification Technology Development/GTSD Test Plan (PO MMI-SVV-384215 GTSD)		EDT No. 611406 **[WHC-SD-WM-VI-020, Rev. 0]** ECN No.

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16. KEY

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This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Chris Willingham

C. Willingham 6/14/95

SUPPORTING DOCUMENT

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Vendor. Radioactive. LLW. Waste. Vitrification. Glass. Melter. Testing. Hanford. Sodium.	Name: W. C. Eaton, ed. Signature Organization/Charge Code 74610/D42AN

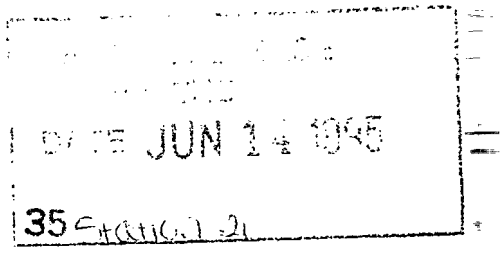
7. Abstract

This document provides a test plan for the conduct of vitrification testing by a vendor in support of the Hanford Tank Waste Remediation System (TWRS) Low-Level Waste (LLW) Vitrification Program. The vendor providing this test plan and conducting the work detailed within it [one of seven selected for glass melter testing under Purchase Order MMI-SVV-384215] is GTS Duratek, Inc., Columbia, Maryland.

The GTS Duratek project manager for this work is J. Ruller.

This test plan is for Phase I activities described in the above Purchase Order. Test conduct includes melting of glass with Hanford LLW Double-Shell Slurry Feed waste simulant in a DuraMelter™ vitrification system.

8. RELEASE STAMP



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TP3102WHC
Rev. 1

Test Plan
Phase 1 Hanford LLW Melter Tests

GTS Duratek, Inc.
Columbia, Maryland

September 1994

Approved :

J. Ruller
Project Manager
GTS Duratek

2/10/95
Date

Approved:

W. Eaton
Cognizant Engineer
Westinghouse Hanford Company

3/2/95
Date

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List of Acronyms

CAA	-	Clean Air Act
CEM	-	Continuous Emissions Monitor
CFR	-	Code of Federal Regulations
CUA-VSL	-	The Catholic University of America, Vitreous State Laboratory
DC	-	District of Columbia
DF	-	Decontamination Factor
EPA	-	Environmental Protection Agency
ES	-	Engineering Science, Inc.
HEPA	-	High Efficiency Particulate Arrestor
LLW	-	Low-Level Waste
OEM	-	Original Equipment Manufacturer
PC	-	Personal Computer
PCT	-	Product Consistency Test
PLC	-	Programmable Logic Controller
QA	-	Quality Assurance
SCR	-	Silicon Controlled Rectifier
THC	-	Total Hydrocarbons
WHC	-	Westinghouse Hanford Company

TEST PLAN FOR GTS DURATEK PHASE I LLW MELTER TESTS

1.0 INTRODUCTION

This Test Plan provides an outline of the test objectives, system description, test monitoring and sampling, and planned schedule for Phase I Hanford LLW melter tests to be conducted by GTS Duratek, Inc. on DuraMelter™ vitrification systems installed at the Vitreous State Laboratory of The Catholic University of America (CUA-VSL).

1.1 Test Objectives

The primary objectives of this test are:

- Conduct "proof-of-principle" tests to demonstrate that the DuraMelter™ vitrification system can process a simulated, highly alkaline, high nitrate/nitrite, LLW feed and produce a glass of consistent quality.
- Demonstrate a practical and reliable feed system capable of consistent mixing and delivery of LLW simulant and glass former feed materials to the melter, and providing control of product glass composition.
- Demonstrate ability to produce a durable, consistent, homogeneous glass with a target composition (product quality).
- Determine any specific requirements for feed preparation, secondary waste, and off-gas treatment systems.
- Provide a descriptive chronology of events during the tests.
- Describe general operating behavior during the tests including upsets and operating problems.
- Determine quantity of feed processed and processing rates.
- Collect mass balance data across the melter for potentially volatile components such as Cs, Na, B, Mo, SO_x, F, I, and Cl to determine partitioning of these components between the glass, condensed deposits, off-gas entrained particulates, and scrub solutions. Mass balance data are also needed for elements of radiological interest, including Cs, Sr, I, and Tc (Mo will stand in for Tc).

- Make off-gas measurements of NO_x and SO_x concentrations, flow rates, and quantities and composition of entrained particulates.

- Collect data to assess melt characteristics including phase separation, foaming events, cold-cap behavior, etc.

- Collect samples of glass product throughout the tests for assessment of glass composition consistency and uniformity as well as leach resistance testing.

- Perform pre-test and post-test inspection of the equipment. To the extent possible, inspection will identify solids buildup, deposits, plugging, corrosion, erosion, refractory wear, electrode wear, and equipment damage.

- Provide samples collected according to the sampling plan described below to WHC and/or WHC-designated laboratories for analysis and archiving. Feed, product glass, off-gas scrub solutions, and off-gas sampling will be done approximately every 4 hours after reaching steady-state operation.

- The test will be of sufficient duration to achieve the test objectives stated in this Plan, and at a minimum, will be of sufficient duration to process at least three times the melter system glass inventory. In no event will the test duration be less than 24 hours continuous processing time.

1.2 Scope of Testing

This effort will include pretest work, one test on the DuraMelter™ 100 vitrification system, and one test on the DuraMelter™ 1000 vitrification system, as described below.

The operation of the DuraMelter™ 100 will provide the following information which will be useful in optimizing the operation of the DuraMelter™ 1000. In general, the smaller size of the DuraMelter™ 100 allows the testing of various operating conditions at a minimal cost compared to that for the DuraMelter™ 1000. Experience has shown that it is large enough that general behavior is similar to the larger system and to a great extent is scalable. Therefore, what we learn from the smaller system is directly applicable to the larger system.

We will be able to test the operation of the melter with a slurry feed and get a good idea of its suitability for scale up as an option for the larger system. We will test several additives during the turnover stage with respect to their effects on emissions. We will have the opportunity to observe any unexpected behavior such as foaming, excessive dusting or volatile carryover in the off-gas, and development of secondary phases. All

of these tests and potential problems can be handled more easily and at lower cost in the smaller melter. If corrective action is required it is easier to test solutions using the smaller system.

If there are any unexpected corrosion effects, it is much preferred to discover them before proceeding to the larger melter. We do not anticipate any problems but if they are discovered in the smaller melter it can prevent costly results in the larger melter.

Although the two melters are very similar in design, the power supply for the smaller melter has greater connected power relative to melter volume than the power supply for the larger system. This will allow us to push the production rate in the smaller system to an extent not possible in the larger system when connected power is the controlling factor. This will add additional information on production rates not available from the DuraMelter™ 1000 alone.

1.2.1 Pretest Work

Pretest work will include glass formulation development based on the composition of the LLW simulant. A series of crucible melts will be made and characterized for key processing characteristics relevant to the DuraMelter™ systems (including melt viscosity, electrical conductivity and liquidus temperature).

PCT leach tests will also be conducted to ensure that the selected composition meets the WHC requirement for a normalized sodium release of below 1 $g/m^2/d$. As of this writing, this work has been completed and the selected glass composition and relevant properties are given below. Independent confirmatory measurements will be made at PNL.

Other pretest work will include procurement and modifications that are necessary (primarily to the feed systems) to ensure that the systems will meet the specific requirements for these tests. Limited scoping testing may be performed on a DuraMelter™ 10 system to obtain preliminary information on feed behavior and processing characteristics prior to the actual tests. Limited start-up testing will be performed, as deemed necessary, on the DuraMelter™ 100 and 1000 systems in order to debug any system modifications or changes made for these tests prior to commencement of the tests themselves.

1.2.2 DuraMelter™ 100 Test

The smaller size of the DuraMelter™ 100 system together with the fact that the feed system is already configured for a slurry feed make rapid initiation of testing viable. Data from this test will provide a valuable basis for the larger scale (and more costly)

test on the DuraMelter™ 1000 system to ensure that maximum benefit from that test is obtained. The DuraMelter™ 100 test is expected to be of about six days duration based on the nominal glass production rate of 100 kg/d. This would allow a three-melter-volume turnover of glass to reach the target composition followed by a further three-melter-volume turnover at steady-state which would constitute the body of the test. The conversion of turnover to feeding time obviously depends on the feed rate; if higher feed rates prove possible the test duration will be shorter but, in any event, the quantity of glass produced will be sufficient to achieve a total of six melter-volume turnovers. Note that the basis for the nominal production rate of the DuraMelter™ 100 is based on a typical borosilicate glass slurry feed producing about 400 g glass per liter of feed. We expect that production rates in excess of this should be possible with the Hanford LLW feed.

A limited number of samples from this test (sample splits) will be analyzed at CUA-VSL since a rapid turnaround time is available. This will allow us to make maximum use of the results from the DuraMelter™ 100 system test in the final detailed planning of the DuraMelter™ 1000 test.

1.2.3 DuraMelter™ 1000 Test

The same basic approach will be used for the DuraMelter™ 1000 tests, i.e. the steady state portion of the test will follow a turnover period corresponding to three melter volumes of glass. While for the DuraMelter™ 100 system the glass inventory in the melter is approximately equal to the nominal daily production rate (~ 100 kg), for the DuraMelter™ 1000 it is considerably larger: the approximate inventory is about 2600 kg and the nominal daily production rate is about 1000 kg. Three turnovers at the nominal production rate will therefore take about eight days; again, this may be shorter if faster production rates prove possible with this feed. The steady state portion of the test will consist of a further four day period. Note that the basis for the nominal production rate of the DuraMelter™ 1000 is based on a typical borosilicate glass slurry feed producing about 400 g glass per liter of feed. We expect that production rates in excess of this should be possible with the Hanford LLW feed.

2.0 MELTER SYSTEM DESCRIPTION

Tests will be performed using two melters at the VSL which are similar in basic design but approximately a factor of ten different in size and nominal capacity. The two melters are the DuraMelter™ 100 and DuraMelter™ 1000. The basic features of the melters are described below.

2.1 Feed System

We expect that a slurry feed system will be employed for the runs on the

DuraMelter 100™ and the DuraMelter 1000™ systems although dry-feed options are held as alternatives for the larger system. The DuraMelter 100™ is currently equipped with a liquid slurry feed nozzle while the DuraMelter 1000™ is equipped with a chute to accommodate bagged, solid feed.

2.1.1 DuraMelter 100™

This melter and its associated glove box feed system are radioactive and therefore a new feed system will be installed to minimize contamination. The slurry feed method will be employed according to the following sequence:

a. The 55-gallon drums containing waste simulant will be stirred or agitated as necessary to minimize possibility of gelation or precipitation (at least weekly).

b. One drum of simulant at a time will be placed in the DuraMelter 100™ feed preparation area, fitted with a stirrer and drum cover and, after thorough stirring, the requisite quantity of simulant pumped into the mixing tank.

c. In the mixing tank the simulant will be combined (stirred) with chemical additives to yield a final feed slurry containing up to about 75% total solids (i.e., soluble plus insoluble solids); pretests have shown that this material can be pumped without any additional water. The chemical additives will be pre-weighed and mixed in ~30 kg batches, each contained in a plastic bag. One bag of additives will be added to the hopper of a vibratory feeder for every 20 liters of simulant transferred. The entire contents of the hopper will then be added gradually to the mix tank while stirring constantly. After mixing thoroughly, the feed will be pumped into the continuously-agitated feed tank. Knowing the amount and the composition of the simulant and the amounts and purities of the chemical additives will provide a sufficient control over feed composition without a need for further analysis. The requisite quantity of any selected reductants will be added to either the mix tank (pretests) or the feed tank (steady-state).

d. The feed will be metered from the feed tank into the melter by means of a progressive cavity pump, through a water-cooled nozzle mounted on the top of the melter. The inlet to this pump will be connected to a recycle line through which feed flows rapidly in a loop from the feed tank, through a recycle pump to the feed pump (mounted on top of the melter), and back to the feed tank. The feed rate will be controlled by monitoring

of the sludge level in the feed tank and adjusting the rotation of the pump accordingly. The level of the feed will be measured periodically to obtain average feed rates over intervals of about 4 hours. In addition, the speed setting on the feed pump will be calibrated to actual measured flow rate (volume delivered in a timed interval) to permit real-time adjustments to be made.

2.1.2 DuraMelter 1000™

This melter is not presently equipped with a liquid feed facility and modification is required to provide one. A slurry feed system similar to the one described above is the preferred option, but other alternatives will also be evaluated. In these options, the additives would be fed as solids following one of the strategies outlined below. In either case, the waste simulant would be distributed into the melter plenum directly from 55-gallon drums using a drum metering pump (piston or diaphragm) connected on the top of the melter to appropriate water cooled nozzles.

Feed Alternative 1:

This slurry-feed option would closely parallel the approach used for the DuraMelter™ 100 system. The major differences would be in the batch size that is used (the 55-gallon drums would be replaced by 500-gallon tanks) and the method of delivering the dry chemicals to the mix tank (a hopper with either a vibratory or screw feed system would be used). The contents of the mix tank and the feed tank would be continuously agitated. A recycle loop to a feed pump at the top of the melter would be used in a similar fashion to that described for the DuraMelter™ 100 system.

Feed Alternative 2:

(Assumption: Pre-mixed chemical additives can be obtained from commercial vendor contained within 40-50 lb bags made of fiberglass or other inorganic fibrous material.)

Pre-mixed chemical additives packed in fiberglass bags will be loaded into the melter plenum using an existing, double air-lock chute. This is a method which would utilize procedures previously developed for feeding of asbestos containing materials. The bag material will be E-glass fiber which has a softening temperature of about 830°C. The bag feed rate will be time-averaged to provide as uniform a bag feed rate as possible. Delivery of liquid waste simulant will be continuous at the appropriate

feed rate.

Feed Alternative 3:

(Requirement: Two vertical helix feeder systems with access doors, water-cooled nozzle adapters and double air-lock vibrating hoppers are to be erected on the top of the melter, utilizing existing through ports.)

Pre-mixed chemical additives packed in bags will be crane-lifted, loaded into the air-locked hoppers and then screw-fed into the melter plenum. The exact procedures shall be developed after construction of feeders is completed. The feed rate shall be time-averaged with delivery of liquid waste simulant. Off-gas entrainment is a consideration with this technique although it may be possible to mitigate this with the use of a pelletized form of the chemical additives.

Data from the DuraMelter™ 100 runs will be used as a basis for selection of the feed system that will be used for the DuraMelter™ 1000 runs. In addition, one or more alternatives may be tested for short periods of time (about one day) during the turnover phase before the steady state tests begin. These pretests will be conducted in order to provide a comparative evaluation of alternative viable feeds systems to maximize the information obtained from these tests. This should provide additional data for scale up.

2.2 Melter Systems

2.2.1 DuraMelter™ 100

The DuraMelter™ 100 is a Joule-heated ceramic-lined melter with a nominal glass melting rate of 100 kg/day. The actual melting rate depends on the type of feed supplied, the properties of the resultant glass, the melter temperature, the rate of bubbler-induced mixing employed, and other operational parameters chosen. A schematic diagram of the melter is shown in Figure 2.1 and will be used to explain the basic melter design.

The footprint of the melter is approximately a 3 feet by 3 feet square to which the discharge chamber, a 1.5 feet by 2 feet appendage, is added. The melter shell is about 4 feet in height and rests on an approximately 2-foot tall stand bringing the top of the melter to about 6 feet. The glass contact refractory is a Monofrax® K3 refractory which forms a 14" by 14" melt tank. The normal glass depth is maintained at about 15" and the K3 refractory extends several inches above that level. Two 1" thick flat plate Inconel 690 electrodes cover opposing walls of the melt chamber. The surface area of a single

electrode is 162 square inches. The resultant melt volume is about 2500 cubic in. (41 liters). This represents about 100 kg capacity for a typical glass specific gravity of 2.5. The melter plenum sides are lined with Zirmul® refractory and the plenum roof has an Inconel protective sheet. There is about 15" of air space between the melt surface and the plenum ceiling.

The melt refractory is held within an Inconel shell which prevents the leakage of molten glass into layers of insulating refractory fiber between the inner shell and outer stainless steel shell. The inner shell has penetrations for electrode busses, drain and discharge ports. These are designed to prevent glass leakage.

The melter has two drains that exit through the bottom. One is a direct bottom drain from the floor of the melt tank. It is sealed by frozen glass and can be activated by applying heat from a wire resistance heater. This drain is used if it is desired to completely drain the melter. A second drain exiting the bottom has a drain pipe which extends above the normal level of the glass. It can be used to drain a floating secondary phase from the glass surface. The normal glass discharge is through a side exit port to a riser and pour trough, as illustrated. This, along with an air lance, forms an air lift. The air lift discharge is activated by bubbling air through the air lance inserted in the discharge riser. Glass drains from the trough through a flanged opening to a metal container sealed to the flange.

Glass samples can be collected in a variety of ways depending on the quantity of glass desired. If a small amount of glass is desired, it may be collected by terminating the discharge riser bubbling and, as the glass flow tapers off, closing a gate valve located just above the discharge chamber flange. When the flow has stopped, the gate valve can be opened and the glass solidified on the top of the slide is collected. The gate material itself is clean (and can be cleaned before and after use), corrosion-free, and is not in contact with any grease or lubricant. If a larger sample is required, the glass can be collected in a suitable crucible within a larger container using the air lift to start and stop the glass discharge.

The melter employs air bubbling to promote mixing and to increase the melting rate. The bubbler is designed to produce a curtain of bubbles rising from the melter floor between the two electrodes. In addition to mixing, the bubbling of air tends to keep the melt well oxidized.

The heat for glass melting is provided primarily by Joule heating in the melt. The melter is equipped with resistance heaters in the plenum space for starting the melter and for increasing the plenum temperature, if desired. The melter has a large number of thermocouples in the melt, in the plenum space, in the discharge chamber and at various locations in the melter refractory.

The top of the melter is equipped with a number of ports. These provide access for feed, for viewing, for off-gas discharge etc. The normal method of feeding is slurry feeding through a water-cooled feed pipe mounted through the top of the melter. The melter will also accommodate dry feed.

The power to the melter electrodes (40 kW designed power) is controlled by a programmable process controller. It can be configured to control in several ways depending on the desired operating conditions. Normally the temperature of a thermocouple in the melt is the parameter used to control the melt process. The glass tank is small enough that the response time of the glass temperature is relatively short and temperature is a reasonable choice for process control. The output of the process controller adjusts the on-time of an SCR power controller to determine the applied electrical power. The response to changing demands due to feeding, cold cap variation etc. is automatic. The process controller is configured with alarms which alert the operator to abnormal conditions in temperature or power. The controller can be programmed to reduce the melter power to a safe level if a potentially hazardous condition exists. The upper safe operating temperature for the glass melt is about 1200°C due to the use of Inconel electrodes.

A computer-based data acquisition system is used to display and record important melter operating conditions such as melter power and temperatures at critical locations in the melter. Data is recorded on disk and periodically printed out; an example of the format is shown in Table 2.3. Manual readouts are also available for these parameters. The computer is also programmed to act as a backup process controller in case of malfunction of the dedicated controller.

Pretest Melter Conditions

The melter has been used previously to process a variety of simulated and actual low-level radioactive wastes. Prior to performing the melter tests on Hanford simulated wastes, the system will be in standby mode with a high-iron borosilicate glass in the tank. The approximate composition (wt%) of the glass in the DuraMelter™ 100 prior to the introduction of any Hanford LLW feed is: Al_2O_3 = 5%; B_2O_3 = 20%; CaO = 7%; Fe_2O_3 = 4%; MgO = 5%; Na_2O = 11%; SiO_2 = 44%; others = 8%. This glass will be flushed (three turnovers, as described above) with the Hanford simulated waste feed to remove the standby glass before the body of the steady-state tests. Areas of the melter plenum will be contaminated with minimal amounts of material from previous melts but this is not expected to contribute substantially to off-gas carryover. Records of previous melt feeds are available. Since none of the melter components are new, coupons will be used to determine any reactions between the Hanford feed and glass with the melter materials, including refractories and Inconel 690. Coupons will be tested in contact with the glass, in the plenum space, and at the glass air interface. The materials of

construction for the DuraMelters™ were chosen from those known from previous experience in the glass and waste vitrification industries to be highly durable. Our own experience with a large number of actual and surrogate wastes, though not documented in any comprehensive studies, is consistent with that history. It is not expected that during the short tests proposed here that anything less than the most severe signs of corrosion would be observable; consequently, lifetime predictions for melter components cannot be made reliably from such tests. We may, however, be able to observe some semiquantitative effects that would suggest areas for further study. The major objective of these tests will be to confirm that Hanford wastes are not grossly more corrosive to the melter components than other wastes we have processed.

Corrosion tests will be performed on coupons of the following melter materials: Inconel 690, Inconel 601, K3 brick, and Zirmul® brick. The Inconel 690 and K3 coupons will be of sufficient length to be exposed to the glass, the glass air interface and plenum atmosphere alone. The Inconel 601 and Zirmul® coupons will be exposed to plenum atmosphere. The Inconel coupons will be obtained form our inventory. Archive samples will be supplied which have been cut from the same stock. The brick coupons will be cut from surplus bricks remaining from melter construction. Archive samples will be provided from the identical bricks.

Prior to testing, the metal coupons will be degreased with mild detergent and rinsed with deionized water. The coupons will be weighed and their dimensions measured and recorded. The brick coupons will be cut from larger bricks. The bricks will be rinsed with deionized water and allowed to air dry. The weights and dimensions of the coupons will be recorded.

The coupons will be suspended from above at the appropriate height to expose them to the desired environment. A single 3" diameter access port will be used. The brick and Inconel 690 coupons will be suspended from a piece of Inconel 601 pipe attached to the port cover. The brick coupons will be held by open baskets made of Inconel 72 filler metal (welding rod). The Inconel 601 pipe will serve as the coupon for that material. The coupons will be put in place at the end of the turnover feeding (i.e. before commencing the steady-state runs) and be removed at the end of the steady state campaigns. The total time of exposure will be recorded.

Upon removal, the coupons will be examined for signs of severe attack. Attempts will be made to remove glass adhering to the metal coupons by mechanical means. The weights and dimensions of the coupons will be obtained and recorded. Sections of the coupons will be cut for optical and electron microscopic analysis. Microprobe analysis will be used to look for signs of surface corrosion. The brick coupons will be examined for signs of severe attack, Adhering glass cannot be readily removed so only rough dimensional information can be obtained on the bulk samples. Sections of the coupons

will be cut and the cross sectional dimensions determined if a reasonable glass-brick interface can be observed. The interface regions will be examined by microscopy and by microprobe. The results of these tests, as stated above, will be largely qualitative and not sufficient for making lifetime predictions of melter components. Archive samples of the pre- and post-test coupon materials will be provided to WHC.

2.2.2 DuraMelter™ 1000

As discussed above, the DuraMelter™ 1000 is similar in design to the DuraMelter™ 100 but is more than an order of magnitude larger in terms of size and glass production capacity. In describing the DuraMelter™ 1000, the differences from the DuraMelter™ 100 will be emphasized. The nominal glass production capacity is 1000 kg/day but may be several times higher depending on feed, glass type, and operating conditions. It is a Joule-heated melter with Inconel 690 electrodes and thus an upper operating temperature of about 1200°C. A schematic diagram of the melter is shown in Figure 2.2 and will be used to explain the basic melter design.

The footprint of the melter is approximately 6 3/4 ft by 6 3/4 ft with a 2 ft. by 4 ft. discharge chamber appended to one end. The melter shell is 9 ft. tall. The refractory design of the glass tank and plenum area is similar to that of the DuraMelter™ 100 with the exception that the plenum area walls are constructed of Monofrax® H refractory. The surface of the glass pool is about 42" on a side. The glass depth is nominally 38". The resultant melt volume is approximately 67,000 cubic in. (1100 liters). This represents more than 2.5 metric tons of glass capacity for the tank. The two opposing walls of the tank have pairs of flat plate electrodes. The bottom electrodes are 12" by 42" and the top electrodes are 10" by 42" giving an electrode area per pair of about 925 sq. in. There is about 35" of air space above the melt surface. Under normal operating conditions the melt level would be between about 1-5 inches above the top of the electrodes, but this is adjustable.

As in the DuraMelter™ 100, the refractories are contained in an inner shell with penetrations for drains and electrode busses. The melter has a bottom drain which can be used to drain the melter completely. The normal discharge is via an air lift. Discharge and sampling are accomplished in a manner similar to that of the DuraMelter™ 100. There are provisions for a surface drain to remove floating secondary phases but it is not presently installed.

There are various ports on the top plate of the melter which will accommodate a variety of feed mechanisms, as is discussed elsewhere. These ports are also used for thermocouple wells, plenum heaters, the bubbler assembly and viewing ports that are

installed. The melter is also provided with an inclined chute for feeding bulk materials such as bagged material. The chute has an inner insulated heat shield door and two air lock doors to facilitate safe charging of materials. The doors are pneumatically operated.

The power to the melter electrodes (200 kW designed power) is controlled by programmable process controllers. The thermal mass of the DuraMelter™ 1000 is relatively large and the time constants for temperature control of the melt are very long (hours). It is convenient to control the process temperature by configuring the process controller to control power and adjusting the power setpoint as needed to maintain the desired operating temperature. Alarms can be set to detect out-of-range temperatures or power in the melter. The top and bottom electrode pairs are powered from separate but same phase circuits and have independent controllers. It is possible to skew the power supplied to the top or the bottom of the melt pool by adjusting the power to each pair independently. Backup process controllers are installed to be used in case of failure of the main controllers.

A computer data acquisition system is available to record and display selected melter operating parameters in a similar fashion to the DuraMelter™ 100.

Pretest Melter Conditions

The pretest conditions of the DuraMelter™ 1000 will be similar to those of the DuraMelter™ 100 except that only non-radioactive glasses have been melted in the 1000. A list of previous feed types is available. The approximate composition (wt%) of the glass in the DuraMelter™ 1000 prior to the introduction of any Hanford LLW feed is: Al_2O_3 = 4%; B_2O_3 = 20%; CuO = 4%; Fe_2O_3 = 5%; MgO = 4%; Na_2O = 11%;SiO_2 = 44%; others = 8%. The melter will be flushed with Hanford simulated waste feed (three turnovers, as described above) to establish the starting conditions for the test. Corrosion coupons will be used to look for signs of severe attack as described above for the DuraMelter™ 100.

2.3 Off-Gas System

If the existing off-gas systems for both the DuraMelter™ 100 and DuraMelter™ 1000 are applied specifically to the process of vitrification of WHC simulated waste, they are to be considered functionally identical. Both consist of a melter exhaust film cooler, evaporative quencher, packed bed scrubber, air reheater, heated air dilution port, air-jet bag filter and HEPA filter units. Both off-gas systems have been designed to treat particulate, aerosol and acidic gaseous emissions other than NO_x. No equipment modifications are planned to provide for treatment of nitrogen oxides at this point. However, to diminish NO_x emissions, yet undetermined amounts of reducing agents may

be added to the feed. In any case, the NO_x emissions, among others, shall be monitored (for complete monitoring schedule see Section 3.0).

Both off-gas systems are operator assisted, controlled by ladder logistic alarm levels. The liquid volumes in the DuraMelter™ 100 quencher and scrubber sumps are about 250 l and 1000 l, respectively.

System monitoring will be performed in-house and verified by a qualified laboratory (Engineering-Science, Inc., 10521 Rosehaven St., Fairfax, VA 22030).

2.4 Secondary Streams

No secondary streams, other than about 0.1-2M Sodium Nitrate/Nitrite solution contaminated with small quantities of the soluble salts of other metallic contaminants (to the extent of their solubility in basic solution) are expected to be generated during operations. Only closed-loop cooling lines are incorporated in the system and provisions are in place to recycle all filtrable or solid secondary wastes.

2.5 Flowsheet

2.5.1 General Features

The tests on the DuraMelter™ 100 and 1000 systems will differ slightly due to the inherent differences in these two systems. However, many features of the overall flowsheet will be the same for both tests.

The LLW simulant will be shipped to CUA-VSL in 55-gallon drums. The material will be stored for the minimum possible time before use and during storage, the contents will be mixed at least weekly (or as deemed necessary by screening tests) to avoid precipitation and sedimentation. The LLW simulant will be used directly with no pretreatment. The material will be pumped using a drum pump/stirrer directly to the vitrification system as described below.

Glass-forming additives that will be used for these tests are listed in Table 2.1. For each of these materials, vendor data-sheets are provided in Appendix I. (Note that equivalent materials may be substituted as necessary based on cost and availability).

Table 2.1 also shows the composition of the LLW simulant on an oxide basis together with the target glass composition that will be used for these tests which is based on a 25 wt.% oxide waste loading. The glass-forming additives that are required are also shown on a wt.% oxide basis together with the chemical source of each to be used in the

feed. Table 2.2 summarizes some of the pertinent properties of the proposed target glass composition, including the melt viscosity and electrical conductivity as functions of temperature, crystallization behavior, and leach resistance as determined by the Product Consistency Test (PCT) procedure.

2.5.2 DuraMelter™ 100 System

The test conducted on the DuraMelter™ 100 system will make use of the presently configured capability to feed a slurry stream to the melter. The slurry feed will be prepared from the LLW simulant and the requisite quantities of chemical additives in the system's feed tank; the details are described in Section 2.1. The feed blend is then pumped to the melter through a water-cooled feed line. The feed rate is measured from the flow rate; an additional cumulative measure is obtained from the feed tank level and total feeding time.

The glass residence time for the DuraMelter™ 100 system is approximately 24 hrs, depending on the glass production rate. It has been established that the behavior of melters of this type is well approximated by a simple well-stirred tank model. The residence time then follows from the melter inventory (about 100 kg glass) and the glass production rate (about 100 kg/day). At higher production rates, the residence time will be correspondingly shorter; we expect a minimum residence time of about 8 hrs for this system.

The glass product will be poured directly into preweighed, unpainted steel pails (5-gallon or smaller), each of which will bear a unique identification number. The drums of glass will be allowed to cool and then be weighed. Samples for analysis and testing will be collected directly from the pour stream using the grab-sample technique described below (Table 3.2, Method D) at the intervals and in the quantities described in Section 3.3. The weight of these samples will also be recorded. Glass samples will also be collected during the turnover period in order to permit the residence time to be determined directly.

2.5.3 DuraMelter™ 1000 System

The DuraMelter™ 1000 system is better suited (and, indeed, presently configured) to accepting a dry feed. The baseline feed option on this system is a slurry feed similar to that used for the DuraMelter™ 100 system. However, limited tests will be conducted on this system will use a combination of dry-fed chemical additives and liquid-fed LLW simulant. The details of the feed system and process controls to achieve a uniform target glass composition are presented in Section 2.1.

The glass residence time for the DuraMelter™ 1000 system, again based on the well-established well-stirred tank approximation, is about 2.6 days, depending on the production rate. This estimate follows from the glass inventory (about 2600 kg) and the nominal production rate (about 1000 kg/day); we expect a minimum residence time of about 20 hrs for this system.

The glass product will be poured directly into preweighed, unpainted steel drums (55-gallon or smaller), each of which will bear a unique identification number. The drums of glass will be allowed to cool and then weighed. Samples for analysis and testing will be collected directly from the pour stream using the grab-sample technique described below (Table 3.2, Method D) at the intervals and in the quantities described in Section 3.3. The weight of the samples will also be recorded. Glass samples will also be collected during the turnover period in order to permit the residence time to be determined directly.

3.0 TEST MONITORING AND SAMPLING

3.1 General

Figures 3.1 and 3.2 show schematic diagrams of the DuraMelter™ 100 and 1000 systems indicating data and sample collection points. Table 3.1 shows the frequency of sample and data collection, the collection methods, and the sample sizes.

Samples will be stored in clean, labelled and suitably sized plastic containers with snap-on or screw on caps. Liquid sample containers will be sealed in plastic bags and overpacked in 5-gallon or 55-gallon steel drums (according to the quantity) filled with loose absorbent; solid samples will be packaged similarly. Sample containers will be grouped and segregated in labelled 4-mil plastic bags to facilitate identification. All samples will be assigned unique names (combinations of alpha-numeric characters) that will be recorded on the sample container label and in the appropriate logbook. The logbook entries will include all other pertinent sampling information (time, date, location, special conditions, operator, etc.) for that sample. Samples will be shipped per Federal, State, and Local regulations.

Pretest and post test inspections will be conducted to obtain information on electrode and refractory wear. Due to the time and expense involved in completely draining the glass from these melters and bringing them to room temperature to permit detailed inspection, alternative methods will be used. The glass will be drained to below the normal operating level to expose electrode and refractory material surfaces that will be in contact with the glass. Visual observations will be made as to the conditions of these materials and recorded both before and after the test; photography will be used to

supplement these observations. In addition, test coupons will be fabricated from each of the key electrode and refractory materials. The weight and dimensions of these coupons will be measured before and after the test. The coupons will be immersed in the molten glass pool in the melter, in the plenum space, and at the glass-air interface for the duration of the test period.

3.2 Test Monitoring

The monitoring facilities for both DuraMelter™ systems are essentially the same. Process control alarm levels are handled by the PLC (Allen-Bradley 250 family), while the critical parameters (temperature, pressure and current/voltage) are continuously monitored by sensors directly interfaced to a PC. The non-critical parameters are displayed only but can be, in most cases, easily interfaced for continuous monitoring. The emissions monitoring functions are handled by various OEM probes (ENERAC Inc., FCI Fluid Components Inc. etc.) equipped with RS232 data transmission modules. All probes are guaranteed by their manufacturers to meet all relevant requirements of 40 CFR 60 Appendices A & B. Figures 3.1 and 3.2 and Tables 3.3 and 3.4 show the complete monitoring and data acquisition schedule.

Emissions monitoring is performed in two distinctive levels: measurement of basic physical parameters and analysis. There are two methods of gaseous phase sampling employed in the system. One based on the standard isokinetic train is, exhaustively described in Appendices A and B of 40 CFR 60. The second is based upon measurements of concentration using compound specific sensors (electrochemical or Hall effect), which are commercially available from various sources. Dilution and permeation drying techniques are used for sample conditioning upstream of the sensors. Calibration will be performed according to OEM procedures and, whenever possible, cross-checked against Engineering Science data. Any deviations will be reported.

3.3 Off-Gas Monitoring Verification Data

As discussed above, the bulk of the off-gas monitoring measurements will be made in-house. However, independent verification data will also be collected by a qualified air monitoring laboratory (Engineering-Science, Inc. (ES)) in a period during the steady state operations. ES has been contracted to perform the following measurements:

Particles/Metals Source Assessment: Melter Exhaust and HEPA Filter Exhaust; and NO_x, SO_x, CO, O_2, and THC: the Melter Exhaust, Post-Quench, Post-Demister, and the HEPA Filter Exhaust.

This source assessment program will monitor the selected locations for Particles, Metals (Na, K, Ca, Cs, B, Mo, Sr, and Cr), NO_x, SO_x, CO, O_2, and THC. The sampling will be performed in one twelve-hour day.

Three Particle/Metals runs will be conducted at the Melter Exhaust and at the HEPA Filter Exhaust. These runs will be conducted by modifying EPA's Boiler and Industrial Furnace Multiple Metals Train to accommodate the physical constraints of the sample locations. The BIF train will be modified so that the exhaust gas at the Melter Exhaust can be sampled as representatively as possible. The modifications will include the substitution of a cooled inconel probe followed by an unheated filter, for the conventional heated probe/filter. This sampling will be single-point sampling with the isokinetic sampling rates selected from velocity measurement made at a single point in the HEPA outlet duct. It should be noted that the exhaust duct is not configured to allow a strict conformance with the sample point selection criteria established in 40 CFR Part 60, Appendix A, Method 1. This may impact the representativeness of the collection of particulate matter.

All four sample points (Melter Exhaust, Post-Quench, Post-Demister, HEPA Filter Exhaust) will be monitored periodically for criteria pollutants (NO_x, SO_x, CO), O_2 and THC. This will be done with the ES CEM Trailer using EPA Reference methods. Periodically, the gas stream velocity will be measured at each location.

Prior to the beginning of this test, ES will prepare a brief sampling protocol that describes the sampling and analytical methods intended for this project. ES will also provide a final report that tabulates the sample results and provides a basic description of the sampling program and deviations from the planned procedures. ES will provide the pollutant data in units of mass emission rates.

4.0 TEST SCHEDULE

The chronology of the test events for this project are shown in the schedule in Table 4.1. Immediately following the meetings of August 11 and 12th between Westinghouse Hanford, GTS Duratek, and the VSL, preparations of the QA Plan and the Test Plan commenced. At the same time, we also started crucible tests to develop a composition appropriate for this project; containing 25% surrogate tank waste loading with physical properties (conductivity, viscosity, and leachability) suitable for processing in our joule-heated system. Our intent was to have chosen the composition for the melter demonstrations for inclusion in this test plan so that Westinghouse Hanford personnel could verify that it meets their criteria. We have requested one drum of LLW simulant for these crucible tests.

The DuraMelter™ 100 campaign is scheduled for the latter part of September. Our goal is to have the system in steady state by September 29, 1994. The total duration of the campaign will be six days. The residence time of the melter is such that it will take three days to reach steady state conditions. The run will commence sometime between the 19th and the 25th of September depending on other commitments and melter readiness. Once steady state conditions are achieved, samples of the quencher sump, scrubber sump, feed, and waste form (glass) will be taken every four hours; additional samples will be taken as shown in Table 3.1. Selected samples will be sent to an outside laboratory chosen by WHC. Some analyses will be performed at the VSL to ensure that results are received well in advance of the DuraMelter™ 1000 campaign. We have requested two barrels of LLW simulant for this campaign.

The DuraMelter™ 1000 campaign is scheduled to begin after Thanksgiving. A firm date will be set as soon as WHC's schedule is finalized and we can ensure that our run will not conflict with other vendor demonstrations. Design modifications to the feed system for the DuraMelter™ 1000 are underway. Orders for long lead time items are currently being placed. The duration of this campaign will be 12 days; eight days to reach steady state and four days of operation under steady state (equilibrium) conditions to obtain samples to satisfy the statement of work. Once steady state conditions are achieved, samples of the off-gas, feed, and waste form (glass) will be taken at four hour intervals. Selected samples will be sent to an outside laboratory chosen by WHC. We have requested 36 barrels of LLW simulant for this campaign.

The schedule for written reports is shown in Table 4.1. GTS Duratek will provide a preliminary test summary report 15 days after the DuraMelter™ 100 campaign and a preliminary test summary report 15 days after the DuraMelter™ 1000 campaign. One draft full test report combining the results both the DuraMelter™ 100 and DuraMelter™ 1000 campaigns will be provided 45 days after the DuraMelter™ 1000 campaign. The final full test report will be provided 15 days after comments are received from WHC. The draft report on life expectancy and reliability of the melter system technology will be provided to WHC following Phase I testing, 30 days following the DuraMelter™ 1000 campaign. We will also prepare a report summarizing the life expectancy and reliability of the full-scale melter system using maintenance records and other pertinent data that are available. This report will be supplied to WHC 30 days after the completion of the DuraMelter™ 1000 campaign.

5.0 ENVIRONMENTAL

5.1 Emissions

Both DuraMelter™ vitrification systems are equipped with advanced off-gas treatment systems since they are routinely used for testing hazardous and/or radioactive

wastes. These treatment systems are designed to remove acid gases and particulates from the off-gas streams prior to release to the building stack. The treatment trains include wet scrubbing with sodium hydroxide solution and both baghouse and HEPA filtration. Data from previous tests have verified the effectiveness of these systems. However, these systems were not specifically designed to treat the high NO_x concentration in the off-gas stream that is expected to result from treatment of the high nitrate/nitrite LLW simulant. We therefore believe that NO_x is the only conceivable contaminant of concern with respect to these tests.

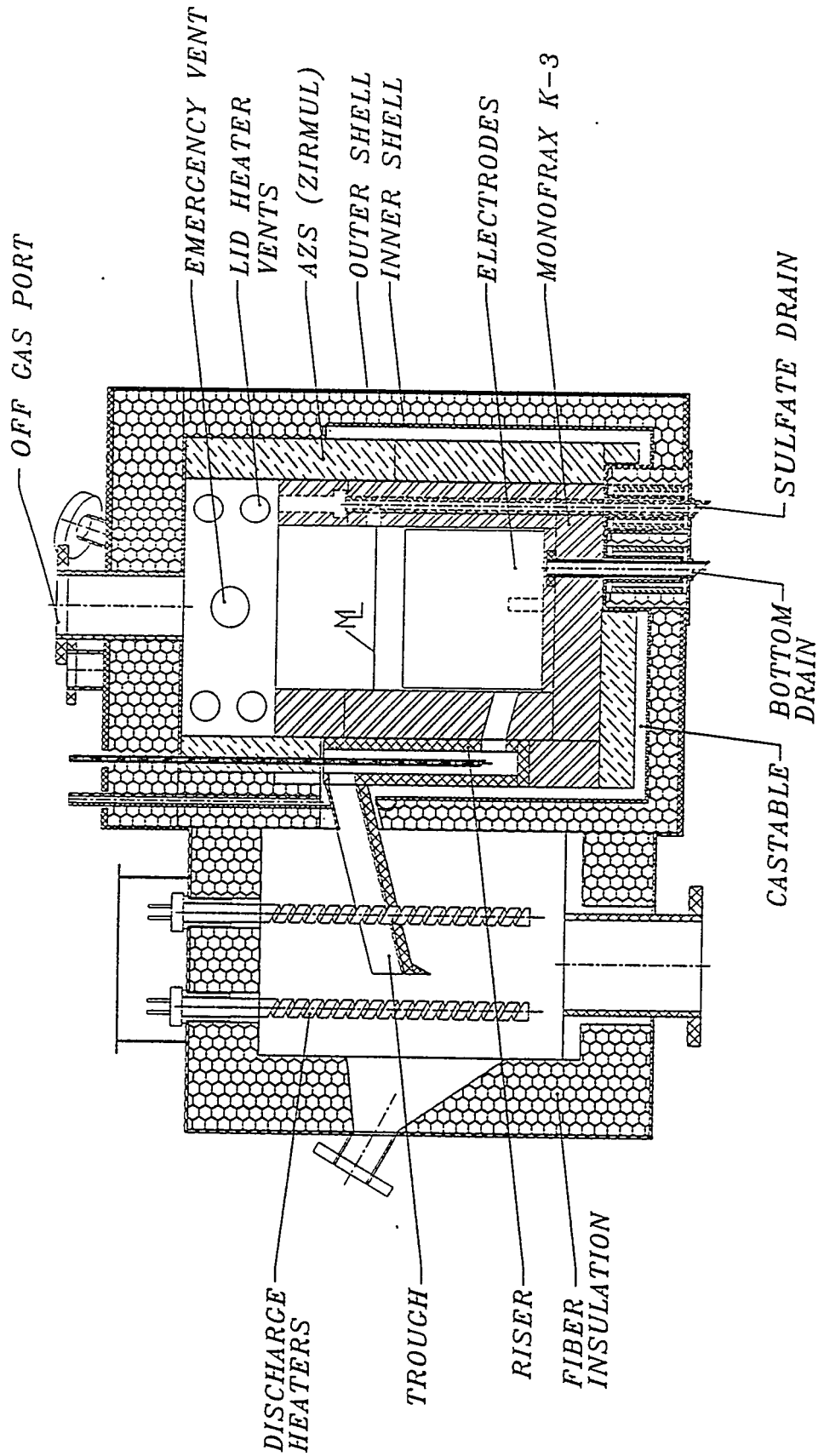
Table 5.1 shows the estimated concentrations of several contaminants assuming the nominal glass production rates, the target feed composition, and the decontamination factors (DFs) for the off-gas treatment system components shown in the table.

Relevant local regulations for these tests are those established for the District of Columbia (DCMR20); for air emissions, the Clean Air Act (CAA) standards have been adopted by DC. Electric glass melter are specifically exempted under the CAA and DCMR 20 Section 606 (Nitrogen Oxide Emissions) applies only to "fossil fuel-fired steam generating units of more than one hundred million (100,000,000) BTUs per hour heat input." We therefore believe that the estimates in Table 5.1 confirm that the planned tests will remain well within local emissions limits.

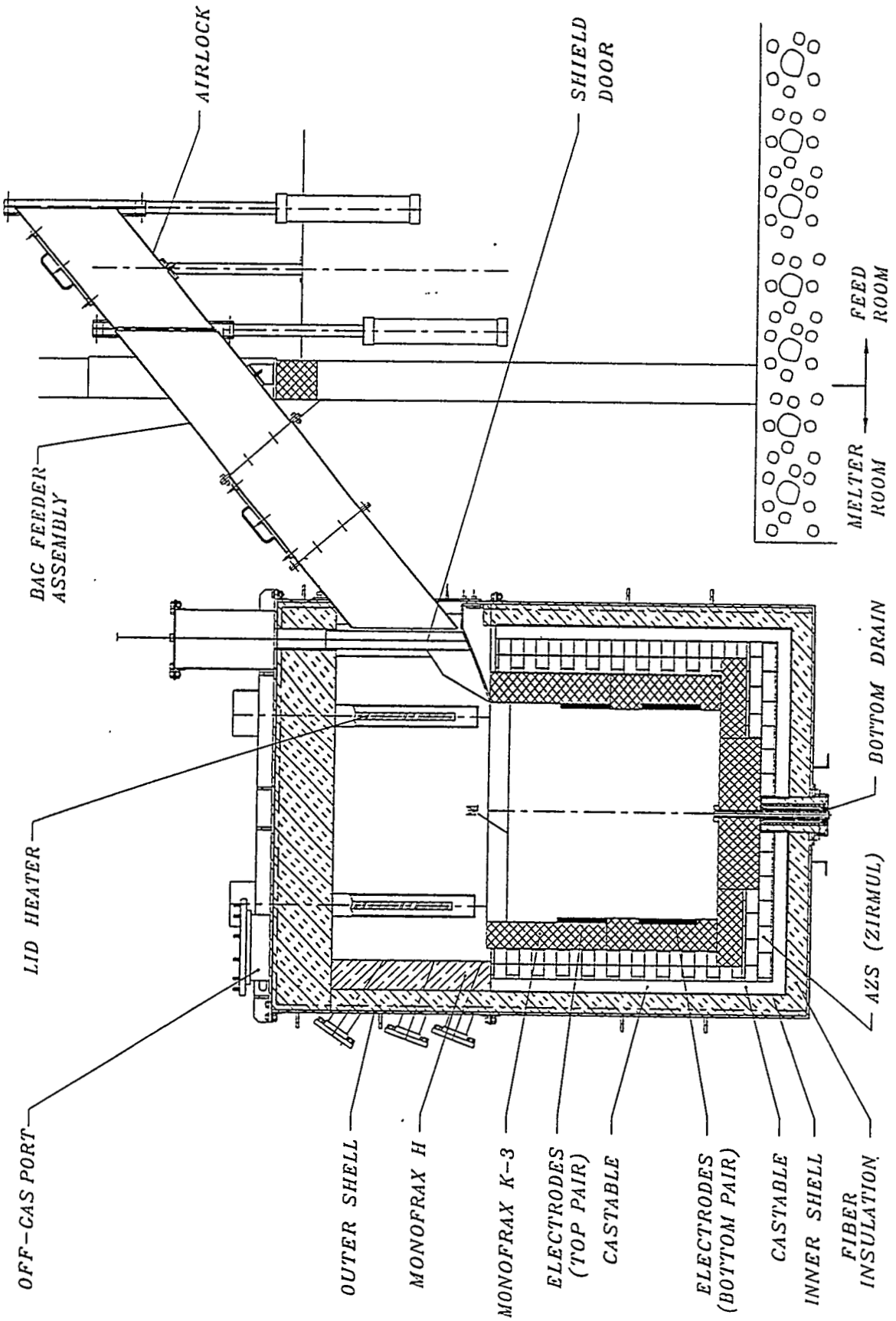
5.2 Secondary Wastes and Residues

We do not expect to have any unused feed from these tests since feeding to the melter is a convenient and logical form of disposal. The off-gas systems for both melters will be operated in the water-balanced mode (i.e. the same amount of water that is fed into the melter leaves the system as humid air from the stack) so there is no increase in the volume of the sump fluids. These fluids will remain in the off-gas sumps for use in subsequent tests on the systems. Any sediments that accumulate will also be recycled to the melter after the tests are complete. Any disposal of chemical wastes other than to the melter will be conducted in accordance with The Catholic University Chemical Materials Safety Manual and the Vitreous State Laboratory Hazardous Waste Management Program Plan, as appropriate.

Special considerations will apply to the DuraMelter™ 100 system tests since that system has been used previously for processing large quantities of radioactive materials from Fernald. The system will be decontaminated to the extent possible but, nevertheless, all work will comply with The Catholic University Radiation Safety Manual (in addition to specific operating procedures for that system). We are required to return radioactive material from that system (including glass produced from the tests) to the Fernald site.



2.1 Schematic diagram of DuraMelter™ 100



2.2 Schematic diagram of DuraMelter™ 1000

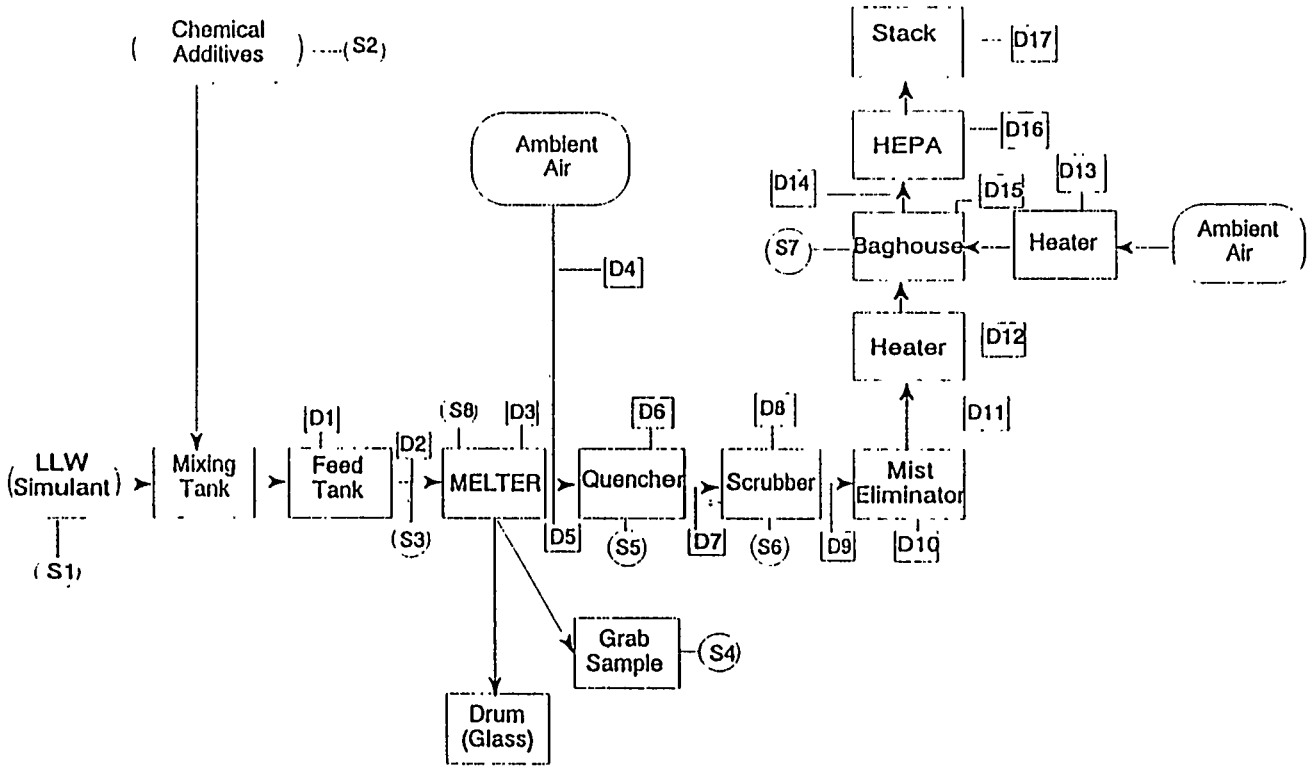


Figure 3-1
Schematic Diagram of DuraMelter™ 100 System

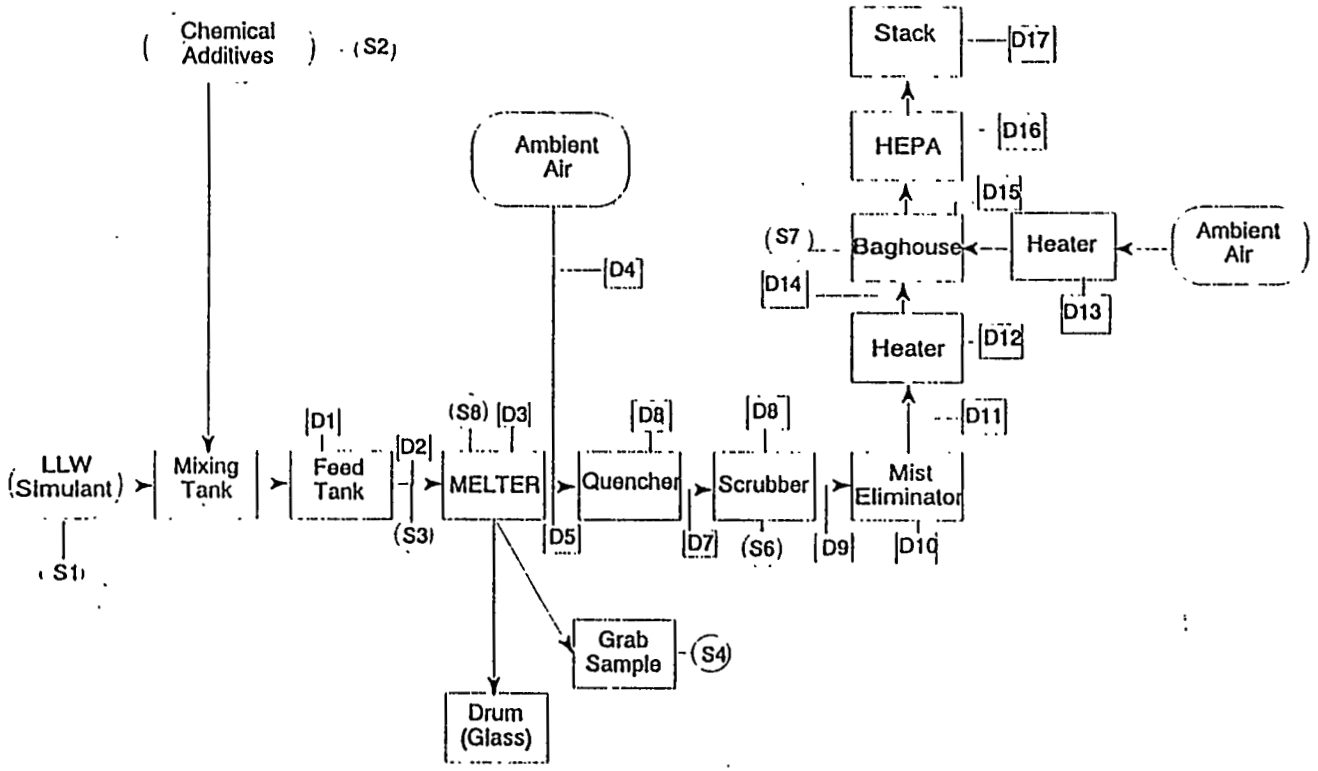


Figure 3-2
Schematic Diagram of DuraMelter™ 1000 System

Table 2.1a. Formulation of GTS Duratek target glass composition, CUA-HAW4 (based on 25% oxide waste loading)

Oxide	Tank Waste	Additives	GLASS		Source	Vendor	Purity	Oxide factor	Target Wt (Kg)**
			Target	Analyzed					
Al_2O_3	12.73	4.00	6.18	5.75	Al_2O_3	Pechiney	0.997	1	18.05
B_2O_3		8.20	6.15	6.53	H_3BO_3	US Borax	0.999	0.563	65.61
CaO	0.01	10.40	7.80	8.33	$CaCO_3$	Minerals Tech.	0.986	0.56	84.76
Cr_2O_3	0.16		0.04	N.A.					
Cs_2O	0.59		0.15	N.A.					
Fe_2O_3	0.02	9.99	7.50	7.94	Fe_2O_3 sludge	NOAH	0.995	1	45.18
K_2O	5.76	2.99	3.68	3.14	K_2CO_3	Armand	0.996	0.68	19.88
MgO	0.01		0.00	N.A.					
MnO_2	0.01		0.00	N.A.					
MoO	0.6		0.15	N.A.					
Na_2O	75.86		18.97	20.74					
P_2O_5	0.75		0.19	0.32					
SiO_2		56.30	42.23	42.42	SiO_2	US Silica	0.997	1	239.21
SO_3	0.84		0.21	N.A.					
SrO	0.43		0.11	N.A.					
TiO_2		1.33	1.00	1.08	TiO_2	RGC Minerals	0.942	1	6.34
ZrO_2		6.79	5.09	3.67*	$ZrSiO_4$	RGC Minerals	0.988	0.67	46.01
Cl	1.38		0.35	N.A.					
F	1.16		0.29	N.A.					
I	0.52		0.13	N.A.					
SUM	100.83a	100.00	100.21	100.00	Total				525.04

a.NaF, NaCl, and NaI have been converted to Na_2O and F, Cl, and I in this listing, hence the sum is greater than 100% due to the excess oxygen.
**There was some undissolved ZrO_2 in this crucible melt; we do not expect this to be the case in a melter with much longer residence time.*
NA = Not analyzed
***To produce 600 kg of glass.*

Table 2.1b. Formulation of GTS Duratek target glass composition, CUA-HAW4 (based on 25% oxide waste loading)

	Tank Waste	Additives	GLASS		Sludge	Vendor	Purity	Oxide factor	Target Wt. (Kg)**
			Target	Analysis					
Al_2O_3	12.73	4.00	6.18	5.75	Al_2O_3	Pechiney	0.997	1	481.44
B_2O_3		8.20	6.15	6.53	H_3BO_3	US Borax	0.999	0.563	1749.53
CaO	0.01	10.40	7.80	8.33	$CaCO_3$	Minerals Tech.	0.986	0.56	2260.21
Cr_2O_3	0.16		0.04	N.A.					
Cs_2O	0.59		0.15	N.A.					
Fe_2O_3	0.02	9.99	7.50	7.94	Fe_2O_3	NOAH	0.995	1	1204.82
K_2O	5.76	2.99	3.68	3.14	K_2CO_3	Armand	0.996	0.68	530.21
MgO	0.01		0.00	N.A.					
MnO_2	0.01		0.00	N.A.					
MoO	0.6		0.15	N.A.					
Na_2O	75.86		18.97	20.74					
P_2O_5	0.75		0.19	0.32					
SiO_2		56.30	42.23	42.42	SiO_2	US Silica	0.997	1	6379.03
SO_3	0.84		0.21	N.A.					
SrO	0.43		0.11	N.A.					
TiO_2		1.33	1.00	1.08	TiO_2	RGC Minerals	0.942	1	169.00
ZrO_2		6.79	5.09	3.67*	$ZrSiO_4$	RGC Minerals	0.988	0.67	1226.82
Cl	1.38		0.35	N.A.					
F	1.16		0.29	N.A.					
I	0.52		0.13	N.A.					
SUM	100.83[a]	100.00	100.08	100.00	Total				14001.08

a. NaF, NaCl, and NaI have been converted to Na_2O and F, Cl, and I in this listing, hence the sum is greater than 100% due to the excess oxygen.
** There was some undissolved ZrO_2 in this crucible melt; we do not expect this to be the case in a melter with much longer residence time.*
NA = Not analyzed
***To produce 16000 kg of glass.*

Table 2.2
Summary of Properties for the Glass CUA-HAW4
(All data obtained by CUA-VSL)

Viscosity at (°C), in Poise	CUA-HAW4	SRL-EA
1050	94.9	
1100	56.5	
1150	34.8	
1200	22.2	
Conductivity at (°C), in S/cm		
1050	0.33	
1100	0.40	
1150	0.48	
1200	0.57	
Liquidus Temperature	<1000°C	
PCT leach test conc., in ppm		
B	18	578
Na	297	1620
Si	76	850
Normalized conc., in g/l		
B	0.90	17.1
Na	1.9	13.4
Si	0.38	3.9
Normalized Leach rate in $g/m^2/d$		
B	0.064	1.2
Na	0.14	0.96
Si	0.027	0.28

Table 2.3
Example of DuraMelter™ 100 Data Acquisition File

Output file format:

DOS Text (ASCII), TAB Delimited

Date 09/23/94 Time: 14:33:11

Date	Time	BH_DP	Humidity	Flow_2	Flow_1	Htr_L_N	Htr_L_S	Htr_D_N	Htr_D_S	E_Power	E_Curr	E_Volt	Glass_T
09/23/94	14:33:16	5:53723	20:8792	1706:32	564:690	36:768	40:528	39:356	17:529	17:800	448:259	36:982	1167:570
09/23/94	14:38:20	5:48229	20:8180	1688:01	558:585	37:501	40:626	40:284	17:578	26:699	572:775	47:236	1162:231
09/23/94	14:43:24	5:50060	21:1843	1694:11	558:585	37:989	39:405	40:333	18:506	19:980	488:788	40:332	1164:518
09/23/94	14:48:28	5:53113	21:3675	1700:22	583:005	37:159	40:528	40:040	17:627	24:659	550:314	45:459	1162:993

Table 3.1.
Sampling Schedule for DuraMelter™ 100 and 1000 Tests.

POINT	DESCRIPTION	FREQUENCY	Destination/Sample Size						METHOD
			PNL	Quanterra	WHC (lab)	WHC (Archive)	USGS	VSL	
S1	LLW Simulant	1 per drum	100 ml	400 ml	250 ml	200 ml	--	200 ml	A
S2	Chemical Additives	1 per chemical	--	--	--	--	--	10 g	B
S3	Feed Line	1 per 4 hrs	100 ml	--	200 ml	200 ml	100 ml	200 ml	C
S4	Glass	1 per 4 hrs	100 g	--	--	100 g	100 g	100 g	D
S5	Quencher Sump Liquid	1 per 4 hrs	100 ml	400 ml	--	200 ml	--	200 ml	C
S6	Scrubber Sump Liquid	1 per 4 hrs	100 ml	400 ml	--	200 ml	--	200 ml	C
S7	Baghouse Dust	1 after 3 turnovers; 1 at end of test	100 g	--	--	100 g	100 g	100 g	B
S8	Glass Pool	1 per test	100 g	--	--	100 g	100 g	100 g	E

NOTE: See Table 3.2 for sampling methods.

Table 3.2
Sampling Methods Referred to in Table 3.1

Method A

After thoroughly stirring and homogenizing the contents of the drum, a clean pipette will be used to withdraw a sample of the contents. The sample will then be transferred to a clean labelled sampling vial.

Method B

A scoop sample will be taken from the freshly opened container after thoroughly mixing the contents. The sample will then be transferred to a clean labelled sampling vial.

Method C

A liquid/slurry sample will be collected by opening the appropriate valve in the sampling line, and then flushing the line with at least 3 line volumes, allowing the material to flow into a clean labelled sample container.

Method D

The glass pour stream is interrupted by closing the gate valve and allowing a small amount of glass to collect on top of the gate where it quickly solidifies. The gate is then opened after a few seconds whereupon the glass sample falls into the sample container below. The sample is then transferred to clean labelled sample container.

Method E

A metal ladle is introduced into the melt pool through one of the access ports in the melter lid to obtain a dip sample of the glass near the surface of the melt pool. The ladle is then withdrawn and allowed to cool. The glass sample is fractured from the ladle and collected in a clean labelled sample container. A similar method will be attempted to obtain a sample of the cold-cap material.

Table 3.3. Data Acquisition Schedule for DuraMelter™ 100 System

Data Point ID	Description	Parameter	Monitoring Method	Frequency*
D1	Feed Tank	Level	Manual	1 per hr
D2	Feed line to melter	Flow Rate	Manual	1 per hr
D3	Melter	Temperature Pressure (absolute) Current/Voltage Level	Auto Auto Auto Manual	1 per 30 min 1 per 30 min 1 per 30 min 1 per hr
D4	Dilution air	Temperature Flow Rate	Manual	1 per day
D5	Melter - quencher line	Temperature Pressure (absolute) Integrated Mass (Isokinetic) Concentration	Auto Auto Manual Manual	1 per 30 mins At least once every 4 hrs
D6	Quencher	Temperature Pressure (differential) Level	Auto Manual Auto-alarm	1 per 30 min
D7	Quencher - scrubber line	Temperature Concentration	Auto Manual	1 per 30 min 1 per 4 hrs
D8	Scrubber	Temperature Pressure (differential) Level	Auto Auto Auto-alarm	1 per 30 min 1 per 30 min
D9	Scrubber - M.E. line	Concentration	Manual	1 per 4 hrs
D10	Mist Eliminator (M.E.)	Pressure (differential)	Manual	
D11	M.E. - Heater Line	Temperature Pressure (absolute) Flow Rate Concentration	Auto Manual Auto Manual	 1 per 30 min 1 per 4 hrs
D12	Heater	Temperature	Auto-set point	
D13	Heater	Temperature	Auto-set point	
D14	Baghouse - HEPA line	Temperature Pressure (absolute) Flow Rate Humidity	Auto Manual Auto Auto	
D15	Baghouse	Temperature Pressure (absolute) Pressure (differential)	Auto Manual Auto	
D16	HEPA	Temperature Pressure (differential)	Auto Manual	
D17	Stack	Temperature Pressure (absolute) Flow Rate Humidity Integrated Mass (Isokinetic) Concentration	Auto Manual Auto Auto Manual Manual	 At least 3 times every 4 hrs

*Nominal frequencies, may be variable in some instances.

Table 3.4. Data Acquisition Schedule for DuraMelter™ 1000 System

Data Point ID	Description	Parameter	Monitoring Method*	Frequency*
D1	Feed Tank	Level		
D2	Feed line to melter	Flow Rate		
D3	Melter	Temperature Pressure (absolute) Current/Voltage Level		
D4	Dilution air	Temperature Flow Rate		
D5	Melter - quencher line	Temperature Pressure (absolute) Integrated Mass (Isokinetic) Concentration		
D6	Quencher	Temperature Pressure (differential) Level		
D7	Quencher - scrubber line	Temperature Concentration		
D8	Scrubber	Temperature Pressure (differential) Level		
D9	Scrubber - M.E. line	Concentration		
D10	Mist Eliminator (M.E.)	Pressure (differential)		
D11	M.E. - Heater Line	Temperature Pressure (absolute) Flow Rate Integrated Mass (Isokinetic) Concentration		
D12	Heater	Temperature		
D13	Heater	Temperature		
D14	Heater - Baghouse	Temperature Pressure (absolute) Flow Rate Humidity		
D15	Baghouse	Temperature Pressure (absolute) Pressure (differential)		
D16	HEPA	Temperature Pressure (differential)		
D17	Stack	Temperature Pressure (absolute) Flow Rate Humidity Integrated Mass (Isokinetic) Concentration		

*To be determined based on DuraMelter™ 100 test results.

Table 3.5
DuraMelter™ 100 Thermocouple Location Chart

Thermocouple Number	Melter Location	Data Point Number (Fig. 3.1)
1	South refractory thermowell, bottom	D3
2	10" above TC1	
3	Plenum, 18" into main thermowell	
4	Main thermowell, 3" above TC5	
5	Main thermowell, 3" above TC6	
6	Main thermowell, bottom	
7	West refractory thermowell, 10" above TC8	
8	West refractory thermowell, bottom	
9	Discharge thermowell	
10	Redundant with TC9	
11	Sulfate drain bottom	
12	Sulfate drain top	
13	Bottom drain bottom	
14	Bottom drain top	
15	Unused	
16	Melter containment room ceiling	---
17	Scrubber top	D8
18	Sump solution temperature after heat exchanger (R2D2 solution)	
19	Air after air heater	D12
20	Baghouse	D15
21-40	Unused	--

Table 4.1. Schedule for Deliverables

ACTIVITY	Start	Finish	Duration
QA Plan	8/12/94	9/21/94	39 days
Test Plan	8/12/94	9/21/94	39 days
Compositional Development	8/12/94	8/29/9	17 days
DuraMelter 100 Campaign	9/22/94	9/28/94	6 days
Preliminary Test Report D100	9/28/94	10/13/94	15 days
DuraMelter 1000 Campaign	11/28/94	12/13/94	12 (working days)
Preliminary Test Report D1000	12/13/94	12/28/94	15 days
Draft Full test Report (D100 & D1000)	12/13/94	1/27/95	45 days
Draft Report on Life Expectancy	12/13/94	1/12/95	30 days
Draft Report on Tech Info	12/13/94	1/12/95	30 days
Phase I Summary Meeting in Richland	2/27/95	2/28/95	2 days
Phase II Proposal	2/28/95	3/28/95	30 days

Table 5.1.
Estimate of Maximum Emissions

Table 5.1a. Melter Characteristics

		DM 100	DM 1000
Gas Flow Rate	cfm	500	1200
	g/min	17000	41000
Glass Output	kg/day	100	1000
	g/min	69	694

Table 5.1b. Contaminant Generation Rate (Maximum possible)

LLW Simulant, Oxide g/l		Generation Rate, g/kg glass	
Na_2O	296.76	Na_2O	189.6*
SO_3	3.44	SO_2	1.8
NaCl	9.36	HCl	3.7
NaF	10.5	HF	3.2
NO_3	198.4	NO_2	143
NO_2	78.2	CO_2	7.6
CO_3	16.2		

*Corresponds to 25% waste loading on oxide basis

Table 5.1c. Estimated Contaminant Concentrations.

	MIN DF	DM 100		DM 1000	
		With DF =1	With MIN DF	With DF =1	With MIN DF
SO_2	100	7 ppm	0.07 ppm	30 ppm	0.3 ppm
HCl	100	15 ppm	0.15 ppm	63 ppm	0.63 ppm
HF	100	13 ppm	0.13 ppm	64 ppm	0.64 ppm
NO_2	1	590 ppm	590 ppm	2400 ppm	2400 ppm
CO_2	1	31 ppm	31 ppm	130 ppm	130 ppm

Notes:DF = 1 column takes no credit for solubility of component in the glass or removal by off-gas treatment system. MIN DF columns are the minimum expected system values.

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APPENDIX I
VENDOR DATA SHEETS FOR CHEMICAL ADDITIVES

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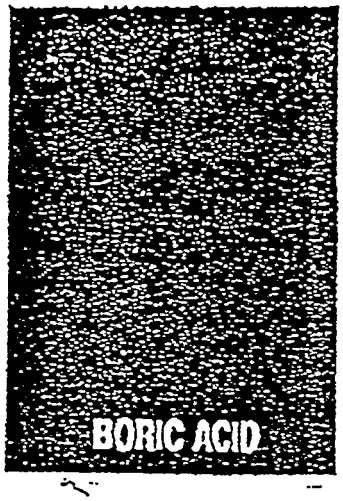
Ceramics, glass and glazes - 2

PHYSICAL ANALYSIS		AC 28	AC 34	AC 34 B4	AC 34 B5	AC 34 B6
Ultimate crystal size	µm	1,5	3,0	3,0	3,0	3,0
BET surface area	m2/g	0,3	0,7	1,4	1,2	1,0
Particle size d 50	µm	60	60	4,5	5,5	6,5
Green density		2,41	2,30	2,30	2,30	2,30
Fluid density		3,10	3,17	3,20	3,17	3,17
CHEMICAL ANALYSIS						
Al_2O_3	%	99,7	99,6	99,5	99,5	99,5
Na_2O	ppm	1000	2000	2000	2000	2000
CaO	ppm	140	100	100	100	100
SiO_2	ppm	240	80	90	90	90
Fe_2O_3	ppm	260	260	270	270	270
High voltage insulators		●	●	●	●	●
Spark plugs		●	●			
Grinding media			●	●		
Mechanical parts		●	●			

Note:
Test and analysis methods furnished upon request
Values given are typical values and may vary



TECHNICAL GRADES

Boric Acid, H_3BO_3 is available in the following forms:

TECHNICAL — GRANULAR AND POWDERED

CHEMICAL SPECIFICATIONS	Guaranteed	Typical
Boric Acid (H_3BO_3)	99.9 - 100.9%	100.4%
B_2O_3	56.3 - 56.8%	56.6%
Chloride (Cl)	0.0015% max.	0.0006%
Sulfate (SO_4)	0.045C% max.	0.025%
Iron (Fe)	0.0006% max.	0.0001%

SCREEN SPECIFICATIONS			AVG. BULK DENSITY	
			Pounds per Cubic Foot	
Mesh Designation	U.S. Standard Sieve No.	Retained	Loose Pack	Tight Pack
Granular	+ 20	2% Max.	55	68
Powdered	+200	10% Max.	37	48

Granular material has an angle of repose of approximately 55°.

CONTAINERS

Multiwall paper bags with a polyethylene free film moisture-resistant barrier, granular, 100 lbs. net and 50 lbs. net; Powdered, 50 lbs. net; or fiber drums with polyethylene liner, net weight as follows: Granular, 300 lbs., Powdered, 250 lbs. Impalpable, 225 lbs.

U.S. BORAX

TEXTILE CHEMICAL COMPANY
4501 E. Fayette Street
Baltimore, MD 21224
Telephone (410) 675-5510
FAX (410) 276-5540

Specialty Minerals Inc.
260 Columbia Street
Adams, MA 01220
Tel 413 743-0591

Mar 23, 1993

Dear Customer:

Test data obtained on the PCC USP Albaglos shipped to your location follows:

Purchase Order Number
SMI COS Number 851092
Lot Number A-3-036-25

Test Performed	Limits	Results
Loss @ 200 C, %	MAX 2.000	0.684
Acid Insolubles, %	MAX 0.20	0.05
Calcium Carbonate, %	MIN 98.00	98.59
Mg/Alkali Salts, %	MAX 1.00	0.74
Iron Content, ppm	MAX 1000	<1000
Heavy Metals, ppm	MAX 20.00	< 20.00
Lead, ppm	MAX 3.00	< 3.00
Arsenic, ppm	MAX 3.00	< 3.00
Fluoride Content, ppm	MAX 50.00	< 50.00
Ba Qualitative Test	Neg. to Test	Negative
Mercury, ppm	MAX 0.50	< 0.50
Identification Test		Passes

Based upon the test data derived above I do hereby certify that this lot complies with the requirements listed in the United States Pharmacopia for Calcium Carbonate.

Very truly yours,

J.R. Bush
Sr. Laboratory Technician

793-GLU-00005

"THIS PAPER CONTAINS SPECIALTY MINERALS INC.'S PCC"

ARMAND PRODUCTS COMPANY

Potassium Carbonate Dense Granular, Regular

Armand Products Company
469 North Harrison Street
Princeton, New Jersey 08540
(609) 6[illegible]-[illegible]
Telex: 762226

Technical Information

COMPONENT	BASIS	SALES SPECIFICATION[1]	
Total Alkalinity (as K_2CO_3)	wt. %	99.5	Min.
KOH	wt. %	0.25	Max.
KCl	wt. %	0.0125	Max.
H_2O	wt. %	0.5	Max.
Na	wt. %	0.41	Max.
K_2SO_4	ppm by wt.	75.	Max.
Fe	ppm by wt.	2.0	Max.
Ni	ppm by wt.	1.0	Max.
Hg	ppm by wt.	0.05	Max.
Heavy Metals (as Pb)	ppm by wt.	20.	Max.
As	ppm by wt.	3.	Max.

PARTICLE SIZE DISTRIBUTION	TYPICAL RANGE
	−18 mesh to +80 mesh

NOTES:

[1]Meets Food Chemicals Codex and U.S. Pharmacopeia/NF specifications.

[illegible]

Printed in U.S.A.

NOAH CHEMICAL DIV. NOAH TECHNOLOGIES CORPORATION

7001 FAIRGROUNDS PARKWAY, SAN ANTONIO, TEXAS 78238-4541., TELEPHONE 210-680-9000 FAX 210-521-3323

August 30, 1994

Catholic University
Fax Number: (202)319-4469

Attn: Isabel Muller

Dear Ms. Muller:

The following is the typical analytical data of both primary and secondary metals in the ferric oxide that we discussed. As you said that there would be no advantage to your application by using the hydrated ferric oxide, this information is not included.

The following chart was made by reviewing the typical data over the past few years:

IRON (III) OXIDE, (Ferric Oxide)

Fe_2O_3		~~99.6%~~ 99.9%
Al		0.005-0.015%
Sb		5 - 15 ppm
As		1 - 5 ppm
Cr		0.002-0.004%
Co		0.006-0.012%
Cu	<	0.001%
Mg		0.003-0.008%
Mn		0.05%
Ni		0.005-0.009%
Si		0.005-0.02%
Sr	<	0.001%
Sn		5 - 20 ppm
Zn		0.001-0.01%

Your interest in our products is greatly appreciated.If you have any questions or require further information, please do not hesitate to contact us.

Best regards,

NOAH TECHNOLOGIES CORP.

I. Bob Blumenthal

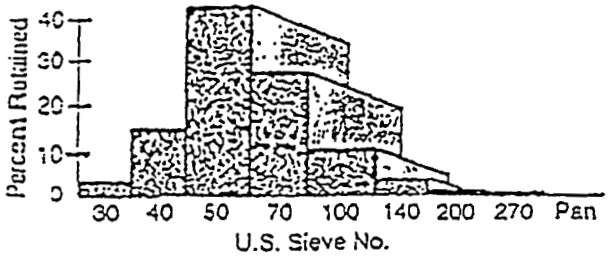
IBB:dym

SILICA

#1 DRY

Mine: Berkeley Springs, West Virginia
Form Number: 1501
Date: November, 1997

PICAL SIZE ANALYSIS:



20X Magnification

U.S. Sieve No.	Millimeter Designation	% Retained On Sieve		% Retained Cumulative	% Passing
		Mean	Range	Mean	Mean
30	.600	1.0	0-3	1.0	99.0
40	.425	15.0	9-21	16.0	84.0
50	.300	41.0	34-46	57.0	43.0
70	.212	26.0	21-31	83.0	17.0
100	.150	10.0	5-15	93.0	7.0
140	.106	4.0	2-6	97.0	3.0
200	.075	2.0	0-4	99.0	1.0
270	.053	0.8	0-2	99.9	0.1
Pan		0.2	<0.3	100.0	0

PICAL PHYSICAL PROPERTIES:

neral	Quartz	Melting Point	3100°F
lor	White	Theoretical Surface Area (cm^2/gm)	79
ain Shape	Subangular	Actual Surface Area (cm^2/gm)	123
herlcity (Krumbein)	.7-.8	Coefficient of Area	1.56
undness (Krumbein)	.5-.6	Base Permeability	180
rdness (Moh)	7.0	Moisture Content Dry (Max.)	<.1
ecific Gravity	2.65	Acid Demand (pH-7)	<2
lk Density — Compacted (lbs/ft³)	96	AFS Grain Fineness (Range)	44-55
Uncompacted (lbs/ft³)	86	pH	Neutral

PICAL CHEMICAL ANALYSIS: (Percent Reported as Oxide)

O_2 (Silicon Dioxide)	99.70	TiO_2 (Titanium Dioxide)	.02
$_2O_3$ (Iron Oxide)	.028	CaO (Calcium Oxide)	<.01
$_2O_3$ (Aluminum Oxide)	.097	MgO (Magnesium Oxide)	<.01
LOI (Loss-on-Ignition)	.16		

SEE REVERSE SIDE

RGC MINERAL SANDS LIMITED
A MEMBER OF THE RENISON GOLDFIELDS CONSOLIDATED GROUP OF COMPANIES
A.C.N. 008 750 666

GENERAL SPECIFICATION

FLORIDA ZIRCON

CHEMICAL ANALYSES

Guaranteed Chemical Analyses (% dry basis)

$ZrO_2 + HfO_2$	66.0 min
Fe_2O_3 (total iron as Fe_2O_3)	0.05 max
TiO_2	0.20 max

Special contracts covering other guarantees may be negotiated.

Typical Chemical Analyses (% dry basis)

$ZrO_2 + HfO_2$	66.4
Fe_2O_3 (total iron as Fe_2O_3)	0.04
TiO_2	0.12
Al_2O_3	0.46
SiO_2	32.4
Free Silica	0.11
U	230ppm
Th	120ppm
Moisture	0.1

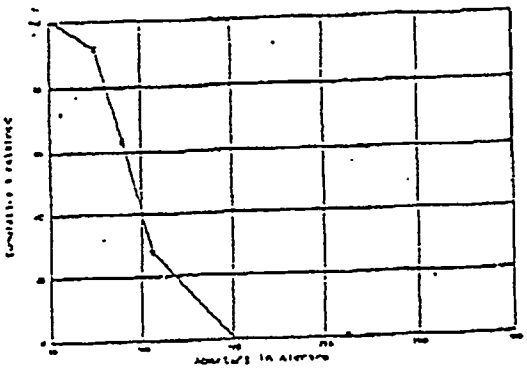
Slight variations in chemical composition of this natural product should be expected.

TYPICAL PHYSICAL PROPERTIES

Specific gravity	4.2 to 4.8
Bulk density	2850 to 2950 kg/m³
Angle of repose	30°
Hardness (MOHS)	7.5
Melting point	4000°F
Thermal Conduct.	14.5 Btu in $ft^{-2}h^{-1}°F^{-1}$
Linear Expansion	1.4×10^{-6} $°F^{-1}$
Specific Heat	0.13 Btu lb^{-1} $°F^{-1}$
Thermal Stability	No change to 3090°F
Loss on Ignition	typically 0.02%

SIZE DISTRIBUTION

Zircon sand concentrate being a natural product is subject to some size variation. The typical size distribution, although not guaranteed, can be expected to be as shown.



Typical AFS No: 129 - 140

American Standard ANSI/ASTM E-11-61

American Mesh No	Sieve Aperture (microns)	Cumulative % Retained
70	212	<1
100	150	<1
140	106	23
170	90	63
200	75	91
270	53	99
-270	pan	100

For further information contact

RGC Mineral Sands Limited
Gold Fields House, 1 Alfred Street, Sydney, Australia 2000
Ph: 61 (02) 934 8585 Tlx: AA120373
Fax: 61 (02) 934 8666
or in the USA
RGC (USA) Mineral Sands Inc
1223 Warner Road (Couriers only)
PO BOX 1036 (Correspondence only)
Green Cove Springs, Florida 32043
Ph: (904) 284 1412
Fax: (904) 284 4006

ISSUE NO: 3

RGC MINERAL SANDS LIMITED

A MEMBER OF THE RENISON GOLDFIELDS CONSOLIDATED GROUP OF COMPANIES
A.C.N. 008 763 666

GENERAL SPECIFICATION

FLORIDA RUTILE

CHEMICAL ANALYSES

Guaranteed Chemical Analyses (% dry basis)

TiO_2	93.5 min
Fe_2O_3 (total iron as Fe_2O_3)	4.0 max
ZrO_2	1.0 max

Special contracts covering other guarantees may be negotiated.

TYPICAL PHYSICAL PROPERTIES

Specific gravity	4.2 to 4.3
Bulk density	2400 to 2600 kg/m³
Angle of repose	30°

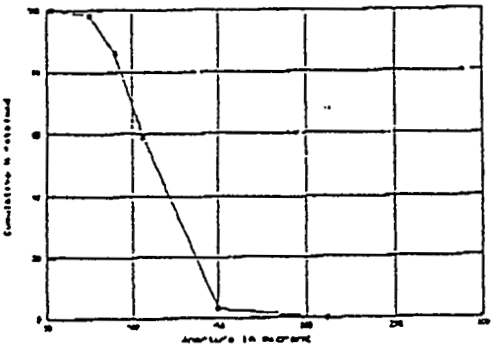
SIZE DISTRIBUTION

Rutile sand concentrate being a natural product is subject to some size variation. The typical size distribution, although not guaranteed, can be expected to be as shown.

Typical Chemical Analyses (% dry basis)

TiO_2	94.2
Fe_2O_3 (total iron as Fe_2O_3)	3.50
ZrO_2	0.12
MnO	0.10
Al_2O_3	0.50
SiO_2	0.40
V_2O_5	0.26
Cr_2O_3	0.18
Nb_2O_5	0.50
MgO	0.05
CaO	0.05
P_2O_5	0.08
S	0.01
U	15ppm
Th	20ppm
Moisture	0.3

Slight variations in chemical composition of this natural product should be expected.



Typical AFS No: 110 - 130

American Standard ANSI/ASTM E-11-81			
American Mesh No	Sieve Aperture (microns)	Cumulative % Retained	
		Typical	Range
70	212	<1	<1
100	150	3	2-4
140	106	59	53-65
170	90	86	77-94
200	75	95	87-99
270	53	99	88-100
-270	pan	100	100

For further information contact

RGC Mineral Sands Limited
Gold Fields House, 1 Alfred Street, Sydney, Australia 2000
Ph: 61 (0)2 934 8888 Tlx: AA120373
Fax: 61 (0)2 934 8666
or in the USA
RGC (USA) Mineral Sands Inc
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ISSUED: 1 January 1994

ISSUE NO: 3

APPENDIX II
SAMPLE HANDLING PROCEDURES

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Vitreous State Laboratory Sampling Instructions

1.0 Purpose

The following sampling instructions are provided to standardize the sampling, labeling, and handling for the Melter System Technology Evaluation testing for all vendors involved in this project. This document provides a concise set of instructions relating to sample integrity issues involved with this effort. Though the use of the following instructions, positive chain of custody, sample identification, and sample tracking will be achieved.

2.0 Scope

The sampling instructions included in this document deal with sample integrity issues (e.g., control of samples, chain of custody, etc.) involved with obtaining samples to submit for analysis or archive. This document is not intended to provide methods for obtaining actual samples. These instructions are specifically written for vendor samplers for use in Phase I tests associated with the Melter System Technology Evaluation project.

3.0 Supplies

Supplies necessary to ensure good sample integrity and positive chain of custody for sampling are as follows:

- Labels
- Evidence Tape
- Chain of Custody Forms
- Locked Sample Storage Area (e.g., locked room or cabinet)
- Sample Log

4.0 Procedure

4.1 Sample Numbering

To facilitate data evaluation and sample identification by Westinghouse Hanford Company (WHC), a sample identification system has been developed. WHC requests that the vendors utilize this system for sample identification during Phase I testing. The system consists of seven separate identifiers and below, each of the fields and expected information are described (Figure A):

- First Character: Vendor Identification, consisting of the first letter in the vendor's name
- Second Character: Phase identifier (e.g., "1" for Phase I testing)
- Third Character: Sample type. The vendor is free to supplement this with additional sample types specific to each individual process. WHC has identified seven different types of samples:
  - S = LLW Simulant
  - A = Additives
  - F = Feed, Mixed
  - I = Intermediate (e.g., samples between feed and glass product)
  - G = Glass
  - O = Offgas
  - W = Waste
- Fourth Character: Sample point number. Used to designate multiple sample points for a specific sample type, and should relate to a sampling diagram in the test plan

- Fifth through Seventh Characters: Serial sample number. Corresponds to the time samples are taken (e.g., assuming a four hour sampling schedule, 10:00 on the first day of testing, all samples taken have an -001 extension, 14:00 on the first day of testing, all samples taken have an -002 extension, 10:00 on the second day of testing, all samples have an -007 extension, etc.)
- Eighth Character: Laboratory identifier. Used to designate sample destination (Figure A)
- Ninth Character: Snapshot set identifier. This is used to designate samplings where samples are taken from all applicable sample and data points (this is to facilitate easy data identification for mass balance, this will usually correlate with offgas measurements)

4.2 Sample Labeling

Sample labels can be supplied by WHC or generated by the vendor. There are five fields of information required for sample labeling:

- Sample Number: Described in section 4.1
- Sample Date: Date sample taken
- Time Sampled: Time sample taken (24 hour clock)
- Sampler Initials: Initials of sample collector. This will also be the individual who initiates the Chain of Custody form
- Laboratory: Destination for the sample:
    - Quanterra
    - Pacific Northwest Laboratory
    - Westinghouse Hanford Company - 222-S Laboratory
    - Geotechnical Engineering Laboratory - Westinghouse Hanford Company
    - Corning
    - USGS

4.3 Chain of Custody

Chain of Custody (COC) for samples is initiated by the sample collector at the time of sampling. At the end of the shift, the COC should be placed in the same locked storage area as the samples. Boxes on the Chain of Custody form not mentioned in this section will be completed by WHC representatives. There are ten areas of concern for vendor samplers (example forms attached):

- Collector: Name of person collecting sample. This person initiates the Chain of Custody form
- Sample Type: The type of sample collected (e.g., simulant, additive, feed, etc.)
- Possible Hazards: Any potential hazards associated with the samples
- Sample Number: The number generated for the sample (section 4.1)
- Sample Point: Point in the process where the sample was taken
- Date Sampled: Date sample was taken
- Time: Time sample was taken
- Relinquished By: Sample is signed over by the collector to another custodian as needed. (e.g., this will also apply to the custodian, shipper, and transporter).
- Received By: Person receiving custody of the sample (e.g., custodian, shipper, transporter, laboratory)
    - Note: Custody must be relinquished and received each time the sample changes hands (e.g. from the collector to the shipper, sample must be relinquished just prior to shipment even though the transporter may not actually sign the form, and finally from the transporter to the lab custodian)

- Special Instructions/Remarks: Complete this section if there are any special instructions for the laboratory

4.4 Sample Log

A sample log is required for summary sampling information and sample tracking. There are eight fields of information required for the sample log (Figure B):

- Sample Number
- Sample Date
- Sample Time
- Sampler Initials
- Sample Type: Type of sample (sample types listed above in section 4.1)
- Sample Point: Location in the process where the sample was taken
- Sample Destination: Location the sample will be shipped to for analysis / archive (section 4.2)
- Shipment Date: Date samples sent for analysis / archive

4.5 Sequential Steps

The following steps should be followed by the vendor to ensure positive chain of custody and sample tracking:

1. Obtain sample
2. Generate sample number (section 4.1)
3. Label sample (section 4.2)
4. Apply tamper resistant evidence tape supplied by WHC and complete initials and date section on tape
5. Complete Chain of Custody form (section 4.3)
6. Complete sample log information (section 4.4)
7. Store sample in a locked area with the Chain of Custody form until shipment

Melter Project: Sample Numbering Scheme

Duratek

D	1	F	1	-	0	0	1	Q	1
Vendor Identification	Phase Identifier	Sample Type	Sample Point Number	Hyphen	Serial	Sample	Number	Lab ID	Snapshot Set ID
Duratek	*Phase 1*	*Feed Sample*	*Sample Point 1*		*Sample*	*Number*	*1*	*Quanterra*	*1 = 1st Mass Balance Set*

Vendor
D = Duratek

Sample Type
S = Simulant
A = Additives
F = Feed, Mixed
I = Intermediate
G = Glass
O = Off-gas
W = Waste
? = Open
? = Open

Lab ID	Sample Set ID
C = Corning	1 = 1st Mass Balance Set
G = Archive (GEL)	2 = 2nd Mass Balance Set
P = PNL	
Q = Quanterra	Blank = Individual Pts.
U = USGS	
W = 222-S	

Figure A

Sample and Shipping Log
Duratek

Sample Number	Sample Date	Time Sampled	Sampler Initials	Sample Matrix	Sample Point	Sample Destination	Shipment Date
D1S1-001Q1	10/5/94	10:00	ABC	Simulant	XYZ	Quanterra	10/7/94
D1S1-001P1	10/5/94	10:00	ABC	Simulant	XYZ	PNL	10/7/94
D1S1-001W1	10/5/94	10:00	ABC	Simulant	XYZ	222-S	10/7/94
D1S1-001G1	10/5/94	10:00	ABC	Simulant	XYZ	Archive	10/7/94
D1A1-001Q1	10/5/94	10:00	ABC	Additive	DEF	Quanterra	10/7/94
D1A1-001P1	10/5/94	10:00	ABC	Additive	DEF	PNL	10/7/94
D1A1-001W1	10/5/94	10:00	ABC	Additive	DEF	222-S	10/7/94
D1A1-001G1	10/5/94	10:00	ABC	Additive	DEF	Archive	10/7/94
D1F1-001Q1	10/5/94	10:00	ABC	Feed	JKL	Quanterra	10/7/94
D1F1-001P1	10/5/94	10:00	ABC	Feed	JKL	PNL	10/7/94
D1F1-001W1	10/5/94	10:00	ABC	Feed	JKL	222-S	10/7/94
D1F1-001G1	10/5/94	10:00	ABC	Feed	JKL	Archive	10/7/94
D1G1-001C1	10/5/94	10:00	ABC	Glass	MNO	Corning	10/7/94
D1G1-001U1	10/5/94	10:00	ABC	Glass	MNO	USGS	10/7/94
D1G1-001G1	10/5/94	10:00	ABC	Glass	MNO	Archive	10/7/94
D1F1-002Q	10/5/94	14:00	ABC	Feed	XYZ	Quanterra	10/7/94
D1F1-002P	10/5/94	14:00	ABC	Feed	XYZ	PNL	10/7/94
D1F1-002W	10/5/94	14:00	ABC	Feed	XYZ	222-S	10/7/94
D1F1-002G	10/5/94	14:00	ABC	Feed	XYZ	Archive	10/7/94
D1F1-002C	10/5/94	14:00	ABC	Glass	DEF	Corning	10/7/94
D1G1-002U	10/5/94	14:00	ABC	Glass	DEF	USGS	10/7/94
D1G1-002G	10/5/94	14:00	ABC	Glass	DEF	Archive	10/7/94
D1G1-003C	10/5/94	14:00	ABC	Glass	GHI	Corning	10/7/94
D1G1-003U	10/5/94	14:00	ABC	Glass	GHI	USGS	10/7/94
D1G1-003G	10/5/94	14:00	ABC	Glass	GHI	Archive	10/7/94

Shipping destinations may include Quanterra, Battelle Pacific Northwest Laboratory, Westinghouse 222-S Laboratory, Corning, and USGS, as well as Westinghouse for archive samples.
Sample numbers ending in "1" indicate a full set of samples obtained from all sample points.
Sample number without a "1" indicate samples obtained from selected sample points.

Figure B

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

COC NUMBER: 94-408

Page ____ of ____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Data Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-9541	Protocol:	Priority / Normal
Sample Point:	Sample Type:	Shipped To: Quanterra	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION				Container Type	Volume	# of Containers	Sample Analysis										
Sample Number	Sample Point	Date Sampled	Time				Unfiltered Metals: Al, Ca, Cr, Fe, K, Mg, Mn, Mo, Na, Si, Cd, Ni 6010	Anions: F, Cl, SO_4, I, NO_2, NO_3, PO_4 EPA 300.0	NO_2, NO_3 EPA 353.2	TOC 9060	TIC 9060M	pH 9040	Visual Color EPA 110.3	Total Phosphorus EPA 365.4	Activity Screen (if) Lab Specific		
				Plastic	300 grams	1											

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant, G = Glass, A = Additives, O = Offgas, F = Feed, Mixed, W = Waste, I = Intermediate

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

SAF NUMBER: 94-108

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Data Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-9541	Protocol:	Priority Normal
Sample Point:	Sample Type:	Shipped To: PNL	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION																	
			Container Type	P			P										
			Weight	100 grams			100 grams										
			# of Containers	1			1										
			Sample Analysis	Specific Gravity	Evaporable Water	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	SEM-EDX	XRD	Optical Microscopy	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	Fe (II) Total Fe	Product Consistency Test (PCT) Method A					
Sample Number	Sample Point	Date Sampled	Time														

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant G = Glass
A = Additives O = Offgas
F = Feed, Mixed W = Waste
I = Intermediate

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

SAF NUMBER: 94-408

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Date Turnaround
Project: Melter Systems Technology Evaluation: Phase I	Telephone No. (509) 376-0541	Protocol:	Priority: Normal
Sample Point: .	Sample Type:	Shipped To: 222-S Laboratory	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION			Container Type	Plastic										
			Volume	250 grams										
			# of Containers	1										
			Sample Analysis	Specific Gravity / Lab Specific	Volume Percent Settled Solids / Lab Specific	Volume Percent Centrifuged Solids / Lab Specific								
Sample Number	Sample Point	Date Sampled	Time											

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant
A = Additives
F = Feed, Mixed
I = Intermediate
G = Glasses
O = Offgas
W = Waste

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

SAF NUMBER: 94-400

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Date Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-9541	Protocol:	Priority Normal
Sampe Point:	Sample Type:	Shipped To: USGS Laboratory	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION																		
			Container Type	P			P											
			Weight	100 grams			100 grams											
			# of Containers	1			1											
			Sample Analysis	Specific Gravity	Evaporable Water	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	SEM-EDX	XRD	Optical Microscopy	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	Fe (II) Total Fe	Product Consistency Test (PCT) Method A						
Sample Number	Sample Point	Date Sampled	Time															

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant G = Glass
A = Additives O = Offgas
F = Feed, Mixed W = Waste
I = Intermediate

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

SAF NUMBER: 94-108

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Date Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-9641	Protocol:	Priority Normal
Sample Point:	Sample Type:	Shipped To: Corning Laboratory	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION																			
			Container Type	P			P												
			Weight	100 grams			100 grams												
			# of Containers	1			1												
			Sample Analysis	Specific Gravity	Evaporable Water	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	SEM-EDX	XRD	Optical Microscopy	Chemical Analysis Al,Ba,Ca,Cr,F,Fe, K,Mg,Mn,Mo,Na,Ni, P,Si,Sr,Ti,Zr,B	Fe (II) Total Fe	Product Consistency Test (PCT) Method A							
Sample Number	Sample Point	Date Sampled	Time																

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant G = Glass
A = Additives O = Offgas
F = Feed, Mixed W = Waste
I = Intermediate

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

CAF NUMBER: 94-408

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DUNATEK	Date Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-9541	Protocol:	Priority Normal
Sample Point:	Sample Type:	Shipped To: Geotechnical Engineering Laboratory	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION	Container Type	P									
	Volume	250 ml / 100g									
	# of Containers	1									
	Sample Analysis	ARCHIVE SAMPLES	Cabinet	Shelf	Date Received by WHC						

Sample Number	Sample Point	Date Sampled	Time	Sample Type							

*Sample Type

S = Simulant
A = Additive
F = Feed, Mixed
I = Intermediate
G = Glass
O = Off-gas
W = Waste

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

III-13

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

SAF NUMBER: 94-408

Page _____ of _____

Collector:	Company Contact: Will Eaton	VENDOR: DURATEK	Date Turnaround
Project: Melter System Technology Evaluation: Phase I	Telephone No. (509) 376-0541	Protocol:	Priority Normal
Sampe Point:	Sample Type:	Shipped To: VSL	Date Required:
Possible Hazards:			

SAMPLE IDENTIFICATION																
			Container Type	P			P									
			Weight	200 ml			100 grams									
			# of Containers													
			Sample Analysis													
Sample Number	Sample Point	Date Sampled	Time													

SPECIAL INSTRUCTIONS / REMARKS:

*SAMPLE TYPE

S = Simulant G = Glass
A = Additives O = Offgas
F = Feed, Mixed W = Waste
I = Intermediate

Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time

APPENDIX III

This Appendix presents a supplemental summary of system configuration and test details for the DuraMelter™ 1000 run that have been determined subsequent to the issuance of the Test Plan. These decisions were made with the benefit of the results and experience obtained from the DuraMelter™ 100 test run.

Feed System

Three feed system alternatives were presented in the Test Plan. Results from the DuraMelter™ 100 system demonstrated that a stable pumpable slurry could be formed from the DSSF simulant and the selected chemical additives with no additional water. The potential benefits of the dry-feed alternative were therefore judged to be insignificant and, consequently, a slurry feed system was selected for the DuraMelter™ 1000 run also.

The feed system includes a dry-chemical feed hopper which operates under negative pressure with dust filtration. Bags of chemicals are opened inside the hopper and the powders transferred to the mix tank by a screw feed. The mix tank and feed tanks are 500-gallon cylindrical tanks fitted with agitators and recycle lines. The DSSF simulant is first homogenized by recirculating to the 55-gallon shipping drum, then pumped to the mix tank; typically four drums of DSSF are used per batch. The dry chemicals are then added slowly while mixing and recirculating to the mix tank. When the batch is completed it is transferred to the feed tank. The feed tank includes a recycle loop which pumps feed to a line above the melter. Two taps from this line supply the two feed pumps which meter the feed into the melter. The water-cooled feed tubes include augers to prevent feed blockages.

Off-Gas System

Modifications to the off-gas system and procedures include the provision of diatomaceous earth (DE) filters for the off-gas sump liquids. As a result of this, additional samples are generated in order to ensure mass-balance closure. These samples are the filter back-wash liquids and any residual filter cake. Samples are also collected from the combined blow-down liquids which are generated as a result of water accumulation in the scrubber sump. The additional sampling points are indicated on Figure AIII-1.

Data Acquisition

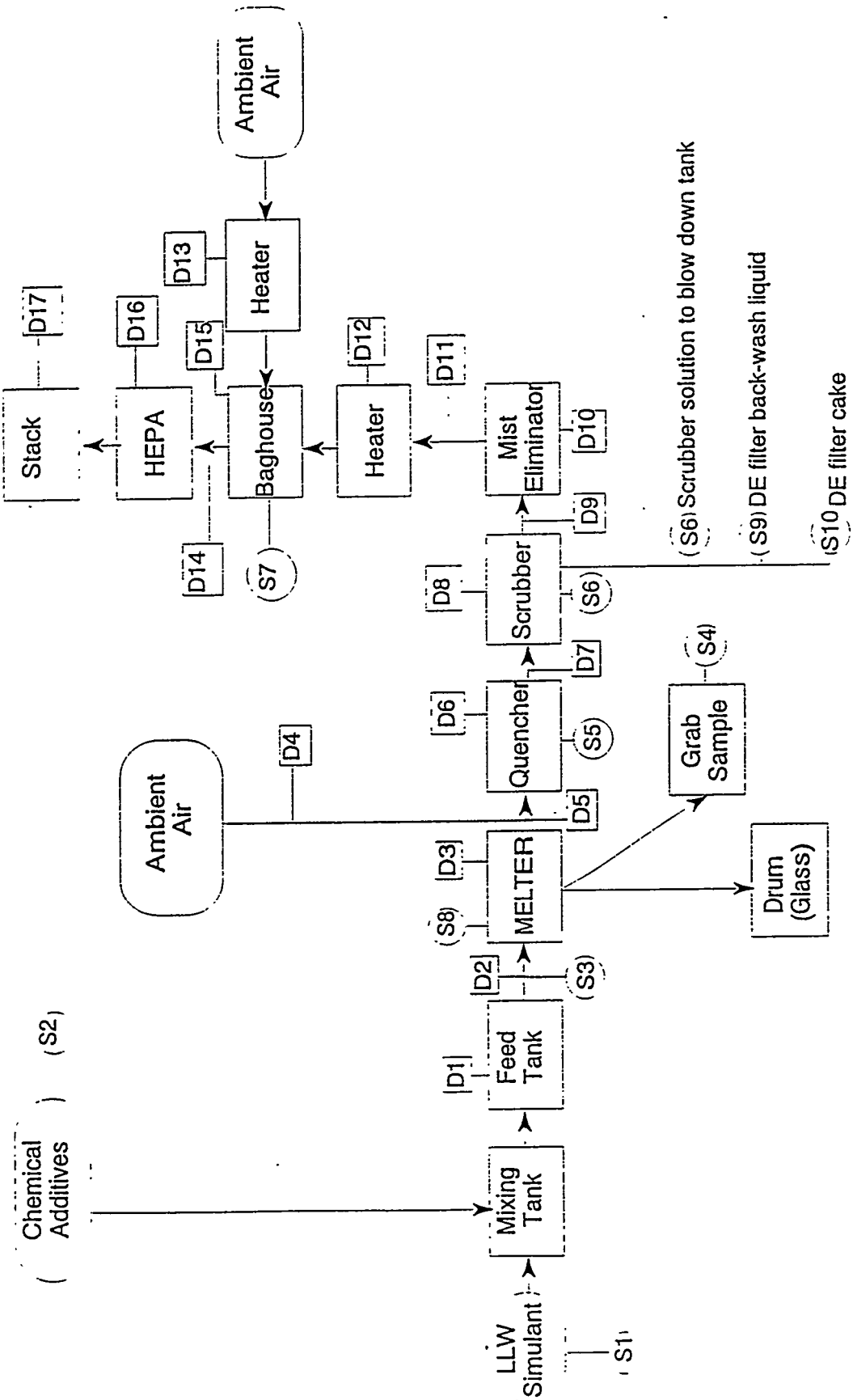
Additional information on the data collection methods and frequencies for the DuraMelter™ 1000 run are presented in Table AIII-1.

Table AIII-1. Data Acquisition Schedule for DuraMelter™ 1000 System

Data Point ID	Description	Parameter	Monitoring Method	Frequency
D1	Feed Tank	Level	Manual (Dipstick)	½ hrs
D2	Feed line to melter	Flow Rate	Manual (Bypass Volumetric)	½ hrs
D3	Melter	Temperature (Zone 1 Plenum Zone 2, Disch) Pressure (absolute) Current/Voltage (Zone 1 Zone 2) Level	TC2, TC5, TC6, TC15 Pressure transducer IV transducer Manual (Visual)	Continuous Continuous Continuous 1/hr
D4	Dilution air	Temperature Flow Rate	--(Ambient) Manual (Rotameter)	N/A 1/hr
D5	Melter - quencher line	Temperature*** Pressure (absolute) Integrated Mass (Isokinetic) Concentration	Manual -- Manual (Isokinetic train) Manual (EC sensors, Nox, COx Comb.)	¼ hrs** N/A ¼ hrs** 1/hr**
D6	Quencher	Temperature (Input) Pressure (differential) Level	TC24 -- --	Continuous N/A N/A
D7	Quencher - scrubber line	Temperature (Evit) Concentration	TC27 Manual (EC sensors, Nox, COx Comb.)	Continuous 1/hr**
D8	Scrubber	Temperature (Sump) Pressure (differential) Level	TC25 DP transducer Manual (sightglass)	Continuous Continuous 1/hr
D9	Scrubber - M.E. line	Concentration	--	N/A
D10	Mist Eliminator (M.E.)	Pressure (differential)	Manual (Photohelic gauge)	½ hrs
D11	M.E. - Heater Line	Temperature Pressure (absolute) Flow Rate Integrated Mass (Isokinetic) Concentration	Manual (readout) -- -- -- --	1/hr N/A N/A N/A N/A
D12	Heater	Temperature	Auto-set-point	N/A
D13	Heater	Temperature	Auto-set-point	N/A
D14	Heater - Baghouse	Temperarure Pressure (absolute) Flow Rate Humidity Concentration	TC26 -- Velocity probe -- Manual (EC sensors, Nox, COx Comb.)	Continuous N/A Continuous N/A 1/hr**
D15	Baghouse	Temperature Pressure (differential)	Manual (Readout) DP transducer	1/hr Continuous
D16	HEPA	Temperature Pressure (differential)	-- Manual (Photohelic gauge)	N/A ¼ hrs
D17	Stack	Temperature*** Pressure (absolute) Flow Rate Humidity Integrated Mass (Isokinetic) Concentration	Manual Manual (Photohelic gauge) Velocity probe Humidity probe Manual (isokinetic train) Manual (EC sensors, Nox, COx Comb.)	¼ hrs** Not recorded Continuous Continuous ¼ hrs** 1/hr**

**To be revised according to process variability

***As a part of isokinetic train only


LLW Simulant
(S1)
Chemical Additives
(S2)
Mixing Tank
D1
Feed Tank
D2
(S3)
MELTER
(S8)
D3
Ambient Air
D4
D5
Quencher
D6
(S5)
Grab Sample
(S4)
Drum (Glass)
D7
Scrubber
D8
(S6)
D9
Mist Eliminator
D10
D11
Heater
D12
(S7)
Baghouse
D13
D14
D15
HEPA
D16
Heater
Ambient Air
Stack
D17
(S6) Scrubber solution to blow down tank
(S9) DE filter back-wash liquid
(S10) DE filter cake