ORNL/ER-307

MARTIN MARIETTA

ENVIRONMENTAL
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PROGRAM

Quality Assurance Project Plan for the Treatability Study of In Situ Vitrification of Seepage Pit 1 in Waste Area Grouping 7 at Oak Ridge National Laboratory

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Quality Assurance Project Plan for the Treatability Study of In Situ Vitrification of Seepage Pit 1 in Waste Area Grouping 7 at Oak Ridge National Laboratory

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Treatability Study of In Situ Vitrification of Seepage
Pit 1 ORNL Waste Area Grouping 7

Phase III
ISV Melting Operations and Posttest Characterization of Pit 1

Submitted by: 5/9/95

S.R. CLINE, ISV PROJECT TEAM MEMBER

Signatories to this document are signifying that they have reviewed and are in agreement with its content, and intend to apply the contents to the conduct of the activities within their respective areas of responsibility.

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ABBREVIATIONS

ASO	Analytical Services Organization
CRF	Change Request Form
DAS	Data Acquisition System
DOE	U. S. Department of Energy
EFS	Electrode Feed System
ER	Environmental Restoration (Program)
ERWM	Environmental Restoration Waste Management
HASP	health and safety plan
HEPA	High Efficiency Particulate Air
HP	Health Physics
ICP	Inductively-coupled plasma emission spectroscopic
INA	inductively-coupled neutron activation
I&C	Instrumentation & Controls Division, ORNL
IROD	Interim Record of Decision
ISV	in situ vitrification
LS	ISV Large Scale Mobile Process System
Energy Systems	Lockheed Martin Energy Systems, Inc.
MM5	Modified Method Five
M&TE	Measuring and Test Equipment
NGVD	National Geodetic Vertical Datam
OAT	Operational Acceptance Test
ORNL	Oak Ridge National Laboratory
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCT	Product Consistency Testing
Phase 1	Determination of Pit 1 Boundaries Using Driven Rods and Pipes
Phase 2	Sampling and Analyses of Pit 1 Soils and Sludge
Phase 3	ISV Melting Operations and Posttest Characterization of Pit 1
PNL	Pacific Northwest Laboratory
PPM	parts per million
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
REE	rare earth element
RFP	Request for Proposal
SOP	Safe Operating Procedure
TS	treatability study

PREFACE

This Quality Assurance Project Plan is specific to Phase 3 of the treatability study of in situ vitrification of Seepage Pit 1, Waste Area Grouping 7. It was prepared to support the Lockheed Martin Energy Systems, Inc., Environmental Restoration Program's Quality Assurance Plan (ORNL/ER-225). This document was prepared under Work Breakdown Structure 1.4.12.6.1.07.20 (Activity Data Sheet 3307, "In Situ Vitrification Demo Pit").

EXECUTIVE SUMMARY

This Quality Assurance Project Plan (QAPjP) establishes the quality assurance procedures and requirements to be implemented for the control of quality-related activities for Phase 3 of the Treatability Study (TS) of In Situ Vitrification (ISV) of Seepage Pit 1, ORNL Waste Area Grouping 7. This QAPjP supplements the *Quality Assurance Plan for Oak Ridge National Laboratory Environmental Restoration Program* (ORNL/ER-225, ERWM 1994a) by providing information specific to the ISV-TS. Phase 3 of the TS involves the actual ISV melt operations and posttest monitoring of Pit 1 and vicinity. Previously, Phase 1 activities were completed, which involved determining the boundaries of Pit 1, using driven rods and pipes and mapping the distribution of radioactivity using logging tools within the pipes. Phase 2 involved sampling the contents, both liquid and solids, in and around seepage Pit 1 to determine their chemical and radionuclide composition and the spatial distribution of these attributes. A separate QAPjP was developed for each phase of the project. (This approach has allowed information from one phase to be used to plan activities in the next phase.)

A readiness review of the Phase 3 activities presented in this QAPjP will be conducted prior to initiating field activities, and an Operational Acceptance Test (OAT) will also be conducted with no contamination involved. After the OAT is complete, the ISV process will be restarted, and the melt will be allowed to increase with depth and incorporate the radionuclide contamination at the bottom of Pit 1. Upon completion of melt 1, the equipment will be shut down and mobilized to an adjacent location at which melt 2 will commence.

A Conduct of Operations matrix has been prepared for this project but is not included as part of this QAPjP. This QAPjP follows the 16 element format established in *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* [EPA-600/4-83-004 (QAMS-005/80)]. The activities described herein may be performed by either Lockheed Martin Energy Systems, Inc. (Energy Systems) staff, subcontractors to Energy Systems, or subcontractors to the U.S. Department of Energy.

1. PROJECT DESCRIPTION

The project "ISV Operations and Posttest Characterization of Pit 1" is Phase 3 of the ISV-TS. The ISV-TS will apply ISV to a portion of Pit 1 to provide information to support a possible Interim Record of Decision (IROD) during as early as FY 1996 for the closure of one or more of the seepage pits and trenches in WAG 7. The ISV-TS will establish the technical performance of ISV for 1) attaining the required depth, nominally 15 ft, to incorporate radioactive source contamination within and beneath the pits, 2) demonstrating field procedures for creating at least two overlapping settings of ISV resulting in fused melt segments, 3) demonstrating off-gas handling technology for accommodating and minimizing the volatilization of Cesium (Cs)-137, 4) demonstrating adequate site characterization techniques to predict ISV melting kinetics, processing temperatures, and product durability, and 5) promoting public education of ISV technology by demonstrating its safety, implementation, site impacts, and air emissions and by coordinating the TS within the regulatory closure process. Background information on the history of Pit 1 and details of the ISV-TS are contained in Spalding (1994).

The ISV-TS has three phases. The goal of Phase 1 was to obtain a three-dimensional map of the boundaries of Pit 1 and the radioactivity within it. Phase 1 involved no removal of materials from Pit 1. Rather, the boundaries and levels of radioactivity have been determined using rods and pipes that were driven into the ground using hand tools (electric jackhammer and airless jackhammer). A general description of the procedures is contained within the ISV-TS Work Plan (Spalding 1994). Phase 2 of the ISV-TS involved obtaining samples of perched water, contaminated soil, and radioactive sludge from within Pit 1. Samples were obtained from locations based on the results of Phase 1. A general description of the approach is contained in Spalding (1994). Detailed sampling procedures were developed and can be found in the Phase 1 and II Site Characterization Activities Summary (Spalding et al. 1994) as well as the Phase 2 QAPjP (ERWM 1994b). Phase 3 is the actual field application of ISV to a portion of Pit 1, including mobilization and demobilization of ISV equipment, and the subsequent posttest assessment of ISV effectiveness.

ISV has been developed and patented for the U.S. Department of Energy (DOE) by Battelle Pacific Northwest Laboratory (PNL). To initiate ISV operations an array of graphite electrodes is inserted into the ground. Because soil is not electrically conductive when its moisture has been driven off, a conductive mixture of graphite and glass frit is placed between each electrode to serve as a starter path. An electrical potential is applied to the electrodes to establish an electrical current in the starter path. The flow of current heats the starter path and surrounding soil to well above the initial soil-melting temperatures of 1100°C to 1400°C. Once the soil becomes molten, it becomes electrically conductive, and the molten region grows outward and downward. Nonvolatile radionuclides and inorganics become incorporated into the molten soil, which is processed at temperatures between 1450°C and 2000°C. Organic components in the soil are destroyed by pyrolysis. The pyrolyzed byproducts migrate to the surface, where they combust in the presence of air. A hood placed over the area being vitrified directs the gaseous effluents to an off-gas treatment system, where they are scrubbed and filtered before being released to the atmosphere. Upon cooling, the solidified glass and crystalline monolith is highly resistant to leaching and is estimated to be stable for geologic periods. For expansive contaminated areas, overlapping settings of the process will result in the formation of a single, contiguous monolith. Three (3) trailers containing the ISV Large Scale Mobile Process System

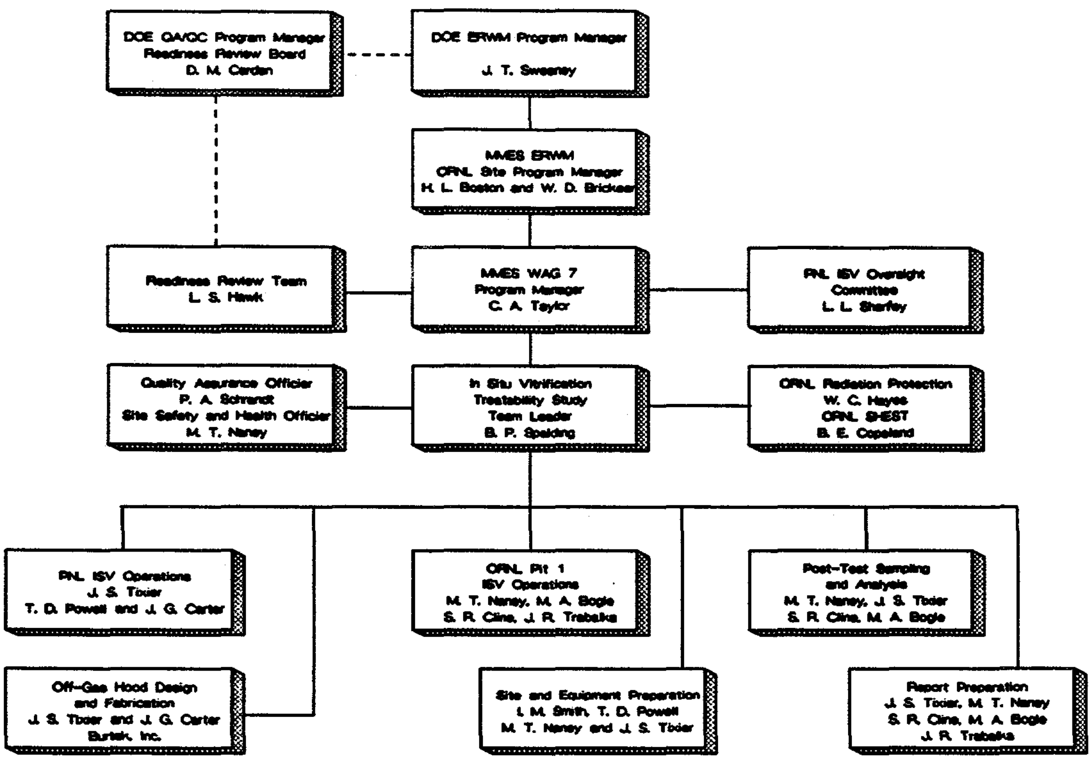
(LS equipment) from PNL will be used in this treatability study, along with a new off-gas hood procured to support this TS and the IROD for the seven (7) pits and trenches at ORNL, WAG 7. Additional information and operating procedures for the equipment can be found in the LS ISV equipment safe operating procedure (Battelle SOP 58, Rev. 9).

The following key activities [and described in Spalding (1994)] will be performed in Phase 3 of the ISV-TS and are discussed, where appropriate, in this QAPjP:

- Off-Gas Hood Design and Fabrication
- Melt Tracer Selection
- Melt Additive Selection
- Pre-ISV Site Preparation
- ISV Operations
  - Temperature Monitoring
  - Depth and Lateral Monitoring
  - Off-Gas Monitoring and Sampling
- Off-Gas Hood Demobilization and Storage
- Posttest Off-Gas Sampling
- Performance of Large Scale ISV Equipment
- Product Sampling
- Posttest Groundwater Monitoring and Characterization

2. PROJECT ORGANIZATION AND RESPONSIBILITY

The project organization consists of an ORNL Project Technical Manager (Brian Spalding), project investigators (Mike Naney, Gary Jacobs, Steve Cline, and Mary Anna Bogle), subcontractors (Pacific Northwest Laboratory), ORNL Analytical Chemistry Division Services, and other support staff. The project manager reports directly to the Environmental Restoration (ER) Project manager, Chris Taylor. QA oversight will be provided by P. A. Schrandt, ORNL ER Program QA officer. All personnel involved with the project shall be familiar with all project documentation, trained, and certified in accordance with the Site Health and Safety Plan (HASP) for Phase 3 of the TS (Spalding and Naney 1995). A summary organization chart for the Phase 3 tasks is depicted in Fig. 1.



Note: Names of individuals performing tasks may change, but the organizational structure will not.

Fig. 1. In Situ Vitrification Treatability Study, Phase 3, project organization.

3. QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT OF DATA IN TERMS OF PARCC

The purpose of this chapter is to define the goals for the level of QA effort and data requirements for Phase 3 of the ISV-TS. Three (3) main types of data will be obtained from the Phase 3 ISV-TS:

- process measurements,
- off-gas treatment system performance data, and
- physical/chemical analyses of the ISV product and other media.

The following sections describe how the parameters of precision, accuracy, representativeness, completeness, and comparability (PARCC) apply to these three types of data to be obtained from Phase 3. (Definitions and explanations of the PARCC parameters can be found in ORNL/ER-225, Sect. 3.7.)

3.1 PROCESS MEASUREMENTS

During ISV operations, thousands of process measurements will need to be taken. Much of this process type data will be collected electronically via a personal computer equipped with a data acquisition system (DAS) (see Sect. 6.2). Process data to be measured include flow rates, electrical current, temperature, etc. (Battelle SOP No. 58, Rev. 9) rather than analyses for contaminants, the on-site, real-time screening will be conducted with an EPA "Screening" QC level. For worker health and safety, field screening for radioactivity will be conducted during ISV operations using hand-held instruments and air sampling devices. Such monitoring will be designated as an EPA Screening QC level.

3.1.1 Accuracy

For this project, accuracy of process measurement data will be determined through user verification that instrumentation is within manufacturer's specifications. Such verification of instrumentation will be recorded on data sheets and/or in the laboratory record book. Refer to Sects. 6.1 and 6.2 for additional information on calibration procedures and frequency. Since the process measurement data will be collected by either the LS ISV DAS or the ORNL DAS, the connections to the DAS will be checked using a calibrated source to simulate the signal from a measurement instrument. The full-scale signal recorded by the ORNL DAS must be within 20% of the input signal to be obtained from the full-scale sensors. This verification will be recorded on data sheets and/or the laboratory record book.

3.1.2 Precision

Precision is the level of agreement among repeated measurement of the same characteristic. Precision, as applied to normal sampling processes is not applicable to the type of data collected from the ORNL DAS and cannot be explicitly determined since the parameters being measured (e.g., temperature) are a function of time and process conditions. Therefore, it is not possible to compare multiple measurements for precision in the field. Precision will be evaluated in the laboratory during the set-up and validation of the ORNL DAS (see Sect. 6.2).

3.1.3 Completeness

Completeness is defined in terms of the total number of valid measurements in relation to the total number of measurements performed. Due to the nature of the ISV process, much of the instrumentation placed into the soil will not survive the entire test. Such an occurrence is expected and desired in order to monitor the width of the melt during operations. Type K thermocouples and pressure sensors are expected to fail at a temperature of 1200°C. For type C thermocouples, the instruments are expected to fail at 1800°C. For the thermocouple sensors, the total number of data points that is expected will be based on the life of the sensor itself, rather than the total number of thermocouple measurements taken over the duration of the demonstration. For the remainder of the process measurement instrumentation, the total number of expected data points is determined by the sampling frequency and duration of the demonstration. For a typical full-scale test, this will be over 10,000 data points. For this TS, completeness of the DAS measurements will be achieved if 80% of total number of measurements gained from each sensor is valid, viable data.

3.1.4 Representativeness

For measurement of temperature and pressure in the soil and vitrification zone, an abundance of instrumentation will be used. Because the purpose of this data is to track the advancing melt front as a function of time, instrumentation is to be placed at multiple locations throughout the vitrification zone. Exact placement of the instruments into the soil at the predefined locations is not required; however, knowing the location of the instrumentation once they are placed is important. Sensors will be installed via Sect. 4.5.1. Location of sensors will be defined with the following parameters: (1) compass direction from drive point start, (2) angle of drive, and (3) length of drive. Knowing the location of all other instrument placement is likewise of greater importance than accurate placement at predefined locations. This will not compromise the representativeness of the data since the data collected will still yield the desired process information (i.e., melt rate, melt shape, melt depth, etc.).

3.1.5 Comparability

Comparability expresses the confidence with which one data set can be compared to another. Comparability for this project will not be quantified, but will be addressed through the use of accepted data analysis methods. The use of standard reporting units also will facilitate comparability with other data sets (e.g., previous large-scale ISV equipment uses). Comparability of other data will be discussed, when appropriate, in the final report.

3.2 OFF-GAS TREATMENT SYSTEM PERFORMANCE

During ISV operations, the off-gas generated will be maintained within the off-gas hood by negative pressure and will then be directed to an off-gas treatment system. Several types of samples will be collected and analyzed (see Sects. 4.5, 4.6, and 4.7) to determine the performance of the off-gas hood and the off-gas treatment system, which is a component of the LS ISV equipment. These samples will be collected during all stages of Phase 3.

3.2.1 Accuracy

For this project, accuracy of off-gas treatment system data will be determined through user verification that instrumentation is within manufacturer's specifications. Such verification of instrumentation will be recorded on data sheets and/or in the laboratory record book. Refer to Chap. 6 for calibration procedures and frequency. Since the process measurement data will be collected by a DAS, the connections to the DAS will be checked using a calibrated source to simulate the signal from a measurement instrument. The full-scale signal recorded by the LS ISV equipment DAS (PNL) must be within 20% of the input signal to be received from a full-scale sensor. This verification will be recorded on data sheets and/or the laboratory record book.

3.2.2 Precision

Precision (the level of agreement among repeated measurement of the same characteristic) of the data collected from the ORNL DAS cannot explicitly be determined since the parameters being measured (e.g., temperature) are a function of time and process conditions. Therefore, it is not possible to compare multiple measurements for precision in the field. Precision will be evaluated in the laboratory during the set-up and validation of the LS ISV system DAS and the ORNL DAS (see Sects. 6.1 and 6.2).

3.2.3 Completeness

The total number of expected data points from the off-gas treatment system is determined by the sampling frequency and the duration of the demonstration. For a typical full-scale test, this will be about 10,000 points. Completeness for the off-gas treatment system data must be greater than 80% to ensure sufficient data for evaluating the off-gas treatment system (i.e., greater than 80% of total number of DAS measurement taken for the off-gas flow meters, sensors, etc. must provide valid, viable data.

3.2.4 Representativeness

Representativeness of the data collected from the off-gas treatment system will be verified by a check of the placement of the instrumentation relative to the piece of equipment being monitored.

3.2.5 Comparability

Comparability for this project will not be quantified, but will be addressed through the use of accepted data analysis methods. The use of standard reporting units also will facilitate comparability with other data sets. Comparability of other data will be discussed, when appropriate, in the final report.

3.3 PHYSICAL/CHEMICAL ANALYSES OF THE ISV PRODUCT AND OTHER MEDIA

Only a few samples of the ISV product will be collected during actual melt operations. However, additional ISV product samples and other media such as off-gas scrub solutions, off-gas filter media, surrounding soil, and groundwater samples will be collected for analysis after the ISV operation is complete to ascertain the effectiveness of the ISV process. Sampling and analysis of Post-ISV media will be conducted with a "Definitive" EPA QC level.

3.3.1 Accuracy

For this project, accuracy will be determined through user verification that analytical equipment is within manufacturer's operating specifications. This verification procedure will be used in place of standards because standards for the ISV product are not available. Documentation that the analytical equipment is within specifications will be a requirement in the statement of work for the laboratory performing the work.

3.3.2 Precision

Precision applies to the physical/chemical laboratory analyses that will be performed on the ISV product, groundwater samples, soil samples, off-gas filter material, etc. Samples for the analyses for the various parameters will be obtained by subdividing the core samples collected from the field into discrete depth intervals prior to laboratory analysis (see Sect. 4.9). Replicate analyses will be performed on some of the lab subsamples. Precision of the instrument measurements for a given parameter can be expressed in terms of the relative percent difference (RPD) of the values obtained from the replicate subsamples.

For chemical durability testing, the RPD must be less than 50% for replicate samples. For chemical composition, the RPD must be less than 50% for the major constituents of duplicate samples. (Major constituents shall be defined as any chemical component that is greater than 1% by weight.)

For physical laboratory analyses, precision is not applicable because the intact core sample submitted for analysis cannot be subsampled and will be compromised during the analysis such that replicate samples will not exist (i.e., the analysis is a destructive analysis).

3.3.3 Completeness

Samples collected for structural analyses, chemical durability, and chemical composition, will be obtained via coring of the final ISV monoliths. This coring will result in numerous samples of the ISV product, not all of which will be analyzed. For this project, completeness for product characteristics will be defined based on the number of samples in which valid analytical results are obtained relative to the total number of samples analyzed for each parameter. A minimum of 90% completeness must be obtained for each of the three product leach analyses listed at the end of Table 6 in Sect. 7.2) with a minimum of six samples being submitted for each analyses. If 90% completeness is not achieved for any given analyses, then a second set of samples will be sent to achieve the completeness target.

3.3.4 Representativeness

The final ISV product is a monolith with a sintered zone surrounding a glass and/or crystalline material. Coring of this final product will result in multiple samples from a cross section of this monolith. Samples selected for analyses will be from multiple locations from within the ISV product to ensure that data from these samples is representative of the entire final product. Previous sampling of ISV melts has concluded that the product is well mixed by convective motions during melting and thus the product is chemically homogeneous (Spalding et al. 1992).

3.3.5 Comparability

Comparability for this project will not be quantified, but will be addressed through the use of accepted data analysis methods. The use of standard reporting units also will facilitate comparability with other data sets. Comparability of other data will be discussed, when appropriate, in the final report.

4. SAMPLING PROCEDURES

A broad overview of the experimental design and sampling scheme was introduced in the Treatability Study Work Plan (Spalding 1994). While only a relatively small number of environmental media samples (air, soil, groundwater, etc.) will actually be collected during the ISV melt operation, the numerous process monitoring measurements to be obtained will be regarded as sampling events and will be discussed here. Procedures regarding sampling of the post ISV product and off-gas samples are also presented in this chapter. The following discussion also describes the design/selection of sampling locations, etc. where applicable. For easy reference, an activity vs. procedure/controlling documentation matrix is presented in Table 1 to summarize the main activities which will be conducted during Phase 3 of this treatability study. Several references are made in Table 1 to the PNL Test Specific Procedural Checklist. This checklist is a part of the test plan or "run plan" being developed by PNL for the ORNL Pit 1 Vitrification TS. The checklist includes specific operational steps that must be completed and other guidelines for the TS. In order to verify the performance of each activity, each operational step on the checklist will be signed off by appropriate person(s) in charge of a particular task. The test plan also includes such items as conventions that will be used in identifying the different types of samples to be collected during Phase 3. The hazards and safety measures which must be taken to accomplish these activities can be found in the HASP for Phase 3 (Spalding and Naney 1995).

4.1 OFF-GAS HOOD DESIGN AND FABRICATION

The vitrification of the ORNL Pit 1 will require an off-gas hood system larger than that presently used by PNL. Hence, the acquisition of a new off-gas hood for possible use in the ISV of all ORNL pits and trenches represented a major project procurement. A contract for the manufacture of a new 50 ft square off-gas containment hood was awarded to Burtek, Inc. of Warren, Michigan. Procurement specifications for the off-gas hood can be found in the Battelle Request for Proposal (RFP) No. 293422 of 7/8/94. While design changes, etc. will likely occur during the design and construction of the off-gas hood, guidelines for handling such issues are outlined in the Battelle RFP mentioned above. Along with technical hood specifications, the RFP also includes requirements for approval authority, change control, calculations, design reviews, document control, QA, etc. The off-gas hood is expected to arrive at ORNL and assembled after the LS equipment has been setup. A separate SOP for the new off-gas hood will be prepared and approved before the start of ISV operations. The off-gas hood will be configured with an 11.5 ft electrode spacing for the Pit 1 project to produce a melt that will encompass the entire width of Pit 1 from the east to west sides. Although the starter trench will only be excavated with a ~20 ft diameter at the bottom, the bottom of the melt will widen to approximately 27 ft in diameter. A 50 ft off-gas hood width as been selected to minimize the effects of differential ground settlement that may occur due to possible subsidence of the 27 ft melt width and to minimize the requirement for extensive site preparation on the west side of Pit 1. Additional information regarding the selection of a 20 ft bottom diameter for the startup trench can be found in Sect. 4.4 below and the Phase 1 Characterization report (Spalding et al. 1994). The addition of graphite electrodes to the target melt region is accomplished via the

Table 1. Activity vs. controlling procedure/document matrix for Phase 3, ISV *Operations*

Time frame	Activity	Supporting Documentation
Pre-ISV Operations	Off-Gas Hood Fabrication	Battelle RFP No. 293422
Pre-ISV Operations	Site Preparation	Energy Systems W.O. #40029, ESO# PX141H-10 Drawing No.'s C3E20000 A958-A961
Pre-ISV Operations	LS Equipment Assembly & Calibration	Battelle SOP No. 58, Rev. 9 PNL Test Specific Procedural Checklist
Pre-ISV Operations	Off-gas Hood Assembly & Testing	Battelle SOP No. * (TBD) PNL Test Specific Procedural Checklist
Pre-ISV Operations	Thermocouple Installation and Calibration	QAPjP Sects. 4.5.1 and 6.2 PNL Test Specific Procedural Checklist
Pre-ISV Operations	Tracer Installation	QAPjP Sect. 4.2 PNL Test Specific Procedural Checklist
ISV Operations	Excavate Starter Trenches	QAPjP Sect. 4.4 Energy Systems W.O. #40029, ESO# PX141H-10 Drawing No.'s C3E20000 A958-A961 PNL Test Specific Procedural Checklist
ISV Operations	Temperature Monitoring	QAPjP Sects. 3.1, 4.5.1
ISV Operations	Depth and Lateral Monitoring	QAPjP Sect. 4.5.2
ISV Operations	Off-Gas Monitoring and Sampling	QAPjP Sects. 3.2 and 4.5.3 Procedure ISV-TS-05
	Waste Management/Disposal	Phase 3 Waste Management Plan (Document No. ORNL/ER-305)
Posttest Phase	Off-Gas Hood Demobilization	QAPjP Sect. 4.6 Battelle SOP No. *TBD PNL Test Specific Procedural Checklist
Posttest Phase	ISV Product Sampling & Soil Sampling	QAPjP Sects. 3.3, 4.9 Procedure ISV-TS-P06
Posttest Phase	Groundwater Sampling	QAPjP Sects. 3.3, 4.10 Procedure ISV-TS-P03
Posttest Phase	Off-Gas Sampling and Analysis	QAPjP Sects. 3.3, 4.7, 7.3, and 9.3 Procedure ISV-TS-P05
Posttest Phase	Analysis of Groundwater/Soil/ISV Product	QAPjP Sects. 7.1, 7.2, 9.1, 9.2 Procedure ISV-TS-P03 Procedure ISV-TS-P04 Procedure ISV-TS-P05
Posttest Phase	Final Site Grading Work	Energy Systems W.O. #40029, ESO# PX141H-10 Drawing No.'s C3E20000 A958-A961
Posttest Phase	Waste Management/Disposal	Phase 3 Waste Mangement Plan (Document No. ORNL/ER-305)

electrode feed system (EFS) that is mounted on top of the off-gas hood. The hood is designed to operate under a negative pressure to prevent untreated off-gas from by-passing the off-gas treatment system. The hood will also be equipped with a backup blower and a high efficiency particulate Air (HEPA) filter through which the off-gas will be routed in the event that power to the LS off-gas treatment system is interrupted.

4.2 MELT TRACERS

The ISV-TS has been designed to include the addition of elemental tracers to the melt in order to enhance data reduction after post-ISV sampling and analyses are complete. The use of melt tracers will aid in evaluating the overall effectiveness of ISV operations by facilitating a calculation of the melt mass produced. A precisely known quantity of chemical tracers will be added to the volume of soil material targeted for the first melt of the ISV-TS of Pit 1 before Phase 3 operations begin. Tracers will be added to the planned center of melt 2 in the same manner; however, two tracers different than those added to the OAT/melt 1 will be utilized. (Knowing the final concentrations of the OAT/melt 1 tracers, their concentration in melt 2 will be used to calculate the amount of Melt 1 incorporated into the overlap.)

In addition to the tracers discussed below, a cesium chloride tracer will also be added to the melt in the OAT. This semi-volatile tracer will function for testing the removal efficiencies of the off-gas roughing filter and HEPA prefilter when these are sampled and analyzed at the end of the OAT.

4.2.1 Tracer Selection

The purpose of the chemical tracers is to provide quantitative indicators for the following:

- product (glass + crystals) chemical homogeneity,
- product mass (determined using the dilution factor for known mass additions of element(s), and
- product remelting and mixing during the reapplication of ISV to an overlapping target soil volume.

The following are desirable properties for the tracer chemicals:

- conservation in the melt (i.e., minimum volatility, minimum fractionation to immiscible metal or metal phosphide liquids);
- low abundance in the starting material (soil, waste);
- available as a chemically stable compound at 1 atm, room temperature (i.e., not hydroscopic at room conditions), but soluble in high temperature silicate melt;
- low cost; and
- nonradioactive (i.e., avoid additions to the radioisotope inventory).

Strong candidates for use as tracers are rare earth element (REE) oxides. They are typically non volatile and conserved in the melt as "incompatible" elements (Boynton, 1989; McKay, 1989). A previous test of ISV conducted in 1991 used La, Ce, and Nd tracers (Spalding, et al., 1992) added to the soil in the form of oxides. Chemical analysis indicated that the percent melt retention for these elements was >99.999%. The retention factors for each of these elements (retained/volatilized) follow: La:210600, Ce:196500, Nd:222300.

Potential problems exist for using La, Ce, and Nd for Pit 1 because of their natural abundance in the soil to be melted. That was a problem in the 1991 test. Soil concentrations were 49, 106, and 48 parts per million (ppm), respectively. Because an estimated 12,000 kg of melt was produced, the melt mass contained approximately 0.5, 1.2, and 0.5 kg of the elements respectively, excluding the contribution of the tracer additions.

Additions of 1.5, 1.5, and 1.0 kg respectively of these oxides were made prior to the start of the ISV test. The background concentration of these elements determined after the test was found to be significant, such that the additions of La, Ce, and Nd yielded 282,124, and 193 % respectively of the soil + limestone contribution to the ISV product. With the errors involved in analyzing the product and the starting material, these additive amounts were too low to provide a precise estimate of melt mass. The upcoming test will exacerbate this situation for La, Ce, and Nd, because a melt mass of 250,000 kg is anticipated. The La, Ce, and Nd contents from the soil, without tracer additions, would be 15, 36, and 14 kg respectively.

Other REE projected melt contents are: Sc=9.9 kg, Y=4.7 kg, Pr=3.7 kg, Sm=2.2 kg, Eu=0.5 kg, Gd=2.1 kg ,Tb=0.3 kg, Dy=1.7 kg, Ho=0.3, Er=1.1 kg, Tm=0.1 kg, Yb=1.1 kg, Lu=0.1 kg, and Hf=2.8 kg (based on the ICP analysis of a Pit One soil sample). Of these potential tracer candidates, Eu and potentially Yb may exhibit some volatility (Boynton, 1989; personal communication) as indicated in Fig. 2, a plot of solid/gas distribution coefficients. Therefore Eu should be avoided as a primary tracer candidate. The relative volatility of Yb is comparable to that of La, Ce, and Nd indicating Yb is a tracer candidate based on the high retention of La, Ce, and Nd during the 1991 ISV test.

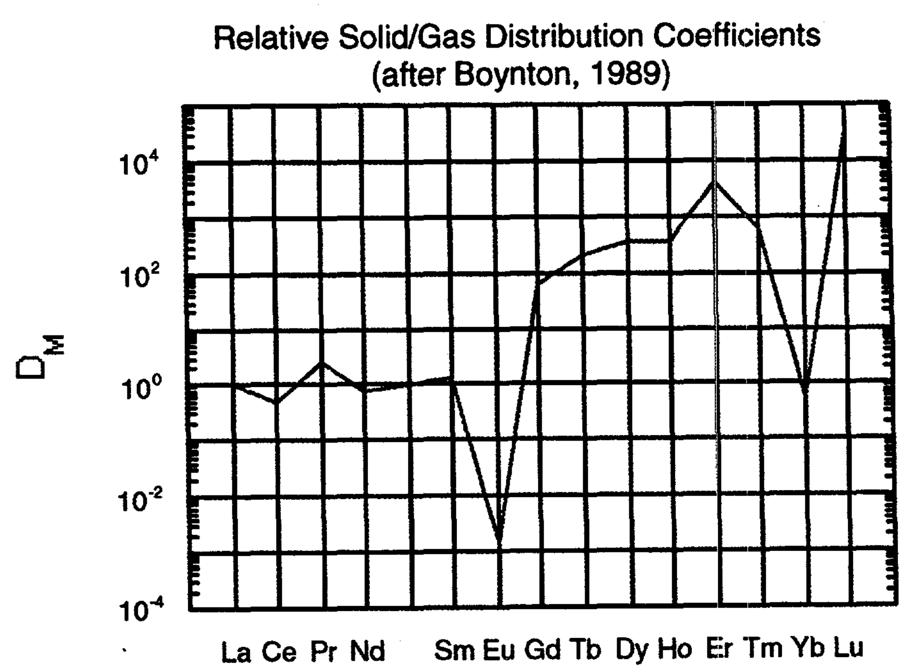


Fig. 2. Solid/gas distribution coefficients of several rare Earth elements.

Although it is anticipated that a Fe, Ni metallic liquid phase (Spalding, et al., 1992) and/or Fe, Ni_3P liquid (Jacobs, et al., 1991) will exsolve and coexist with the silicate, the fractionation of REE to the phosphide phase (Boynton, 1989) is unlikely to occur under the redox conditions of ISV processing (i.e., significant Fe^{2+} will remain in the silicate melt— Boynton, personal communication).

Several criteria were used to evaluate and select specific REE tracers for use during the ISV-TS of Pit 1. The following elements have been chosen as the top five (5) tracer candidates and are presented in ranked order: Lutetium (Lu), Terbium (Tb), Holmium (Ho), Samarium (Sm), and Ytterbium (Yb). Principal criteria used in the selection process are listed in the order of their assigned significance: (1) minimum soil abundance; (2) cost; and (3) analytical precision (with higher ranking given to elements for which both inductively-coupled plasma emission spectroscopic (ICP) and inductively-coupled neutron activation (INA) methods provide good precision).

The tracer materials are delivered with certified analysis reports that provide minimum purities, lot numbers, etc. The entire quantity of each tracer selected was obtained from same manufacturer and from the same lot number to further control product variation. A QC inspection plan will not be adopted for the REE tracers. However, analyses of the tracers will be conducted here prior to use in ISV operations to confirm the certification report and for comparison purposes when post-treatment tracer analyses are conducted. Holumium Oxide and Ytterbium Oxide were obtained from Phone-Poulenc, Inc. with 99% minimum purities (Lot numbers HO-O-2-022 and Yb-O-2-95023, respectively). Samarium Oxide (96% minimum purity) was obtained from Molycorp, Inc.

4.2.2 Tracer Installation

The melt tracers will be added to the targeted melt regions prior to ISV operations. The elemental tracers, contained in polyethylene bottles will be added in an approximately 16 ft^2 area near the center of the target melt region. Holes will be constructed with AWJ drill rod hydraulically pushed or pneumatically driven with the Holegator drill rig. The tracers will be added as deep into the target area as possible without contaminating the installation pipe and associated equipment (*i.e.*, approximately 5 ft below the projected ISV starting depth. The tracers will be added prior to starter trench excavation (Sect. 4.4).

4.3 MELT ADDITIVE SELECTION AND LOADING

The new off-gas hood will be equipped with a solids feeding system for adding soil materials, and/or melt amendments to the melt surface during or subsequent to the melting process. The materials addition system is supported by the superstructure of the off-gas hood and is equipped with valves/airlocks to maintain negative pressure inside the hood shell if used during melting operations. A in-situ thermal barrier will be placed onto the surface of the melt. This barrier, which at this time is likely to be alumina beads, will serve two functions: (1) it will serve as an in-situ filter for volatile ^{137}Cs (before hood prefilter) and (2) it will serve as a insulating blanket to reduce heat loss from the melt surface. To reduce melt operating temperatures, electrode oxidative corrosion, and to lower the viscosity of the upper portion of the melt, limestone will be added to keep the ISV melt at approximately 10 wt% $CaCO_3$. Such action may alleviate formation of oversized gas bubbles by creating a larger viscosity gradient with depth of the melt. Having a greater viscosity at the bottom of the melt may decrease the size of any gas bubbles formed. Moreover, the use of limestone may also decrease the overall operating temperature of the melt, thereby further reducing the volatilization of ^{137}Cs from the melt. Soil backfill (from pre-ISV site preparation work discussed in the next section) will also be accomplished via the materials addition system after the melt has cooled and subsidence events are complete. Addition of any of these materials using the solids additions system will be performed in accordance to the procedure outlined in the ISV off-gas hood SOP (Battelle SOP No. *TBD).

4.4 PRE-ISV PREPARATIONS

Site preparation activities at Pit 1 are currently underway and will continue until the ISV-TS begins. Polypropylene tarps have been placed on Pit 1 and much of the cleared area to the east and west of the pit in order to reduce the amount of water entering into the pit. Changes in groundwater elevations continue to be monitored at least monthly in the same manner described in the site characterization report (Spalding et al. 1994). Grading work will be performed to provide level areas for positioning of the LS ISV equipment. The LS equipment includes three (3) trailers (each up to 60 ft long) which will be located in a row north of Pit 1 parallel to the tree line. The access lane into the site will also be widened to accommodate the large equipment which must be used during the study. Soil sampling in this "support" area was conducted during site characterization, no contamination was found in the 0-3 ft depth cores that were collected and analyzed. The entire support zone will be graded level at 828 ft. This area will also be filled with gravel underlain by a geotextile fabric due to the weight of the equipment/machinery to be used and to allow all weather vehicle and equipment access to Pit 1. Tree-clearing and additional fill will be required in the area just north of the present cleared site to accommodate four 3,000-gallon tanks for holding of ISV off-gas condensate prior to shipping to the ORNL Process Waste Treatment Plant.

The nominal 2 in.-thick asphaltic cap presently covering Pit 1 will be removed, along with the top 3 ft of fill material directly beneath this asphaltic surface. The material to be removed consists of gravel and clay brought to site during capping in 1981. Extensive core sampling and analyses conducted in Phase 1, Site Characterization has shown that no radionuclide contamination exists in this 0-3 ft depth within Pit 1. The material cleared from the pit will be used as fill along the western slope of Pit 1 to increase the level surface area (increase width of pit by 10 ft along its entire length) onto which the 50 ft square off-gas hood can be safely placed. In this fill process, the casings of ORNL groundwater wells 718 and 676 will have to be heightened to maintain their accessibility. Most of the 0.5 in. threaded rod and AQ rod inserted into Pit 1 during Phase 1 (Spalding et al. 1994) has already been withdrawn from the 0-3 ft depth to reduce the intricacy of the site grading work. Some sections of the penetration test rods were left in place below the 0-3 ft depth to prevent exhumation of radioactively contaminated soil. The presence of such additional steel will not affect ISV operations; such materials have already been determined not to affect the volatility of ^{137}Cs. Some AQ rods and 1 in. diameter screened Geoprobe™ groundwater monitoring wells are still present in the 0-3 ft depth to be graded off and are expected to remain in place for Phase 3 testing if at all possible (see Sect. 4.10, Posttest Monitoring).

Site characterization work has also proven that the depth of maximum contamination is at approximately 23-26 ft below the asphalt surface. Since ISV technology has not been proven at such depths, 10 ft deep trenches (approx. 20 ft bottom diameter and 32 ft surface diameter) will be created prior to each melt to ensure that the maximum contaminated zone is incorporated into the melt at a depth less than 15 ft. Phase 1 work has also indicated that the fill material to be removed from the trenches is uncontaminated. Based upon field conditions at the time of excavation, the trench depth may be limited to the depth of groundwater below the asphaltic surface. Any perched water collected during the trench excavation will be collected, analyzed, and then disposed of according to the waste management plan that has been prepared for Phase 3 of the ISV-TS (LMES 1995). The second trench will not be dug until after the first melt has been completed. The two trenches will be adjacent to one another to allow for the creation of an overlapping melt (an ISV-TS objective). The graded surface of Pit 1 will not be covered with gravel like the support zone, but will be immediately recovered by the polypropylene tarp after site preparation work has been completed. All clearing and grading work will be performed by MK-Ferguson personnel under work order No. 40029. Additional information concerning the pre-ISV site preparation work and related field activities can be found in the Draft *Best Management Practices Plan for the In Situ Vitrification Technology Demonstration in WAG 7*, 1994.

All clearing and grading work described above (with exception of the trenches) will be performed prior to the arrival of the LS ISV equipment from PNL (Richland, Washington). Upon arrival, the LS ISV equipment will be assembled and tested for approximately 8 weeks. The new 50 ft Oak Ridge off-gas hood will then be assembled and configured for the melt. All of the procedures and/or calibrations which will need to be performed on the treatment trailers and the off-gas hood can be found in their respective SOPS (Battelle SOP 58, Rev. 9 and Battelle SOP No. TBD). Other pre-ISV activities to be performed include such activities as site specific training of personnel from PNL.

After site clearing and graded worked is complete, slotted well screen will be installed into the target melt zones to allow venting of steam from under the ISV melt into the off-gas hood. This venting should prevent pressure build up under the melt which has been the suspected cause of several molten material expulsion events in previous LS ISV operations conducted elsewhere. Vent holes will be inserted with slotted well screen over the entire length of the hole. Holes will be made using the Holegator angle drill with AWJ drill casing (1.900" inside diam.) with expendable drive points. All well screen stems will vent to the surface inside of the planned off-gas hood containment area. The vents will be installed at three different depth layers to angle under the projected melt zone at various stages of melt progress.

4.5 ISV OPERATIONS

The following sections describe some of the process measurements that will be taken during the actual melting operations. In most instances, the discussions include information on how the particular pieces of equipment were selected for use, a brief description of the sampling procedures, and information regarding the design of the installation/sampling schemes to be used during the ISV-TS. The second melt is expected to occur approximately one month after the first, allowing for cooling , starter trench excavation, and equipment remobilization.

4.5.1 Temperature Measurements

Temperature monitoring will be conducted via thermocouples to ascertain ISV melt depth, actual operating temperatures, kinetics, and cooling temperatures. All thermal monitoring data obtained from thermocouples added into the melt region will be collected by the DAS described later in Sect. 6.2.

4.5.1.1 Thermocouple selection

Thermal sensors will be installed in and around the volume of soil material targeted for the ISV-TS of Waste Seepage Pit One. The purpose of thermal sensor installation and use is to provide:

- a real-time indicator of melt depth, size, and shape;
- measurements of melt temperature;
- measurement of melt cooling kinetics after terminating ISV; and
- measurement of temperature of process off-gas and components (PNL task).

The following are desirable properties for the thermal sensors:

- accurate temperature measurements, ±1% over the range 0-1800°C (Type-C);
- passive operation—sensor does not require external input (i.e., electrical, chemical or operator manipulation) to enable measurement of temperature;
- simple design and robust construction capable of withstanding harsh physical environment of ISV processing (high-temperature to 1800 °C, chemical corrosion—steam oxidation, chemical reduction and dissolution by silicate melt); and
- economical procurement and installation.

A combination of two thermocouple types satisfy these requirements and will be used to make temperature measurements during the ISV-TS. The two types of thermocouple sensors selected and are: (1) type-K, chromel-alumel sheathed thermocouples and (2) type-C, tungsten-rhenium sheathed thermocouples. (The sensors have already been procured.) The type-K sensors provide an economical method for monitoring the growth and advance of the melt. These thermocouples have a working range of 0-1250 °C. Long sensor assemblies needed to accommodate the geometry of the planned ISV study can be fabricated by vendors from commercially available stock materials. Assemblies will have 3.2 mm diameter Inconel 600 sheathes up to 15 m long, MgO insulation and ungrounded thermocouple junctions. The type-K thermocouples will provide several indicators regarding the advance of the melt. (1) Isothermal readings at 100 °C will signal the presence of a boiling water front, advancing approximately one meter ahead of the melt; (2) sensor burn-out following a sharp temperature rise will provide a position indicator and time mark for the arrival of the melt front. A maximum of 48 type-K thermocouples with lengths up to 15 meters will be installed in a 3-D array to monitor melt generation. Long sensor assembly lengths and installation at positions outside the circumference of the vacuum hood will enable optimal positioning of the sensors during the test. A maximum array of six type-C thermocouples will be used to measure melt temperature during the latter part of the treatability study. The use of type-C thermocouples is limited by cost and the availability of materials of construction for sensor lengths greater than approximately 2.3 meters. Type-C thermocouple assemblies will have 4.7 mm molybdenum sheathes, Hf_2O_3 insulation, and ungrounded thermocouple junctions. A previous ISV test conducted in 1991 (Spalding, et al., 1992) successfully used thermocouple assemblies of similar design and deployed in a similar manner to monitor melt generation and cooling.

4.5.1.2 Thermocouple installation

All thermocouple assemblies will be installed within the unconsolidated soil used to backfill the Pit One site. Penetration tests conducted at the site, using 12.7 mm diameter rod, to locate the pit boundaries indicate that simple percussion driving techniques will not permit installation of sensors in the consolidated soils and host rock units forming the sides and base of the old seepage pit. Because more invasive techniques for forming small diameter holes (i.e., drilling) have a significant potential for exhuming contaminated material in the form of drill cuttings, sensor installation will be restricted to the unconsolidated fill using percussion driving methods. Sensors will be installed by percussion driving a string of flush-coupled drill rod to the desired installation depth. Geoprobe, 25.4 mm O.D. x 12.7 mm I.D. diameter rod with expendable drive points will be used to install type-K thermocouples having a nominal diameter of 3.2 mm, and AQ drill rod, 44.4 mm O.D. x 34.9 mm I. D., with expendable drive points will be used to install type-C thermocouple assemblies having an overall diameter of 17.5 mm. Both vertical and angle installation will be possible using a combination of percussion hammering (450 lb air operated hammer) and the 7,200 Kg thrust or pull feed control of a Acker Holegator, crawler mounted drill unit. After driving the selected flush-coupled drill rod to the desired depth (using expendable drive points), the thermocouple assembly will be inserted to the bottom of the drill rod string. The drill rod string will be extracted leaving the thermocouple assembly in the ground. Field experience indicates that slant holes produced in this manner do not remain open for a period long enough to install the thermocouple sensors if the drill rod string is extracted before installation of a thermocouple. Figure 3 illustrates the planned configuration for installation of the thermocouple sensor array in relation to the original seepage pit boundaries and the anticipated melt geometry. The final positioning of the sensors (depth and x-y location) will be determined using data collected during the installation process (rod length below surface, angle of entry, position of entry point, and compass direction of angle drive.)

4.5.2 Melt Depth and Width Monitoring

To verify when and if melt depth and width goals have been attained during field operations, monitoring of melt progress will be performed. The following methods will be employed: (1) visual observations, (2) electrode depth penetration, (3) thermocouple data at selected discrete depth intervals, and (4) product sampling using a non-electrode graphite or ceramic shaft employed as a dipstick.

4.5.2.1 Visual observations

Continuous video monitoring and recording of the melt surface and of the inside off-gas hood conditions will be performed. In addition, a second continuous video recording of a comprehensive site view will be produced to document any unusual occurrences outside the off-gas hood during ISV operations.

4.5.2.2 Electrode depth penetration

In the 1991 radioactive test (Spalding et al. 1992), the depth of penetration of each of the four graphite electrodes during the test interval provided accurate estimates of melt depth. Thus, electrode penetration depths will continue to be the primary depth monitoring technique for this ISV-TS. The electrodes are, however, subject to breakage and oxidative corrosion during ISV, and, although electrode segment replacement is relatively facile, allowing continued ISV operation without significant interruption, such replacement can introduce uncertainty in the estimate of remaining electrode length and subsequent depth measurements.

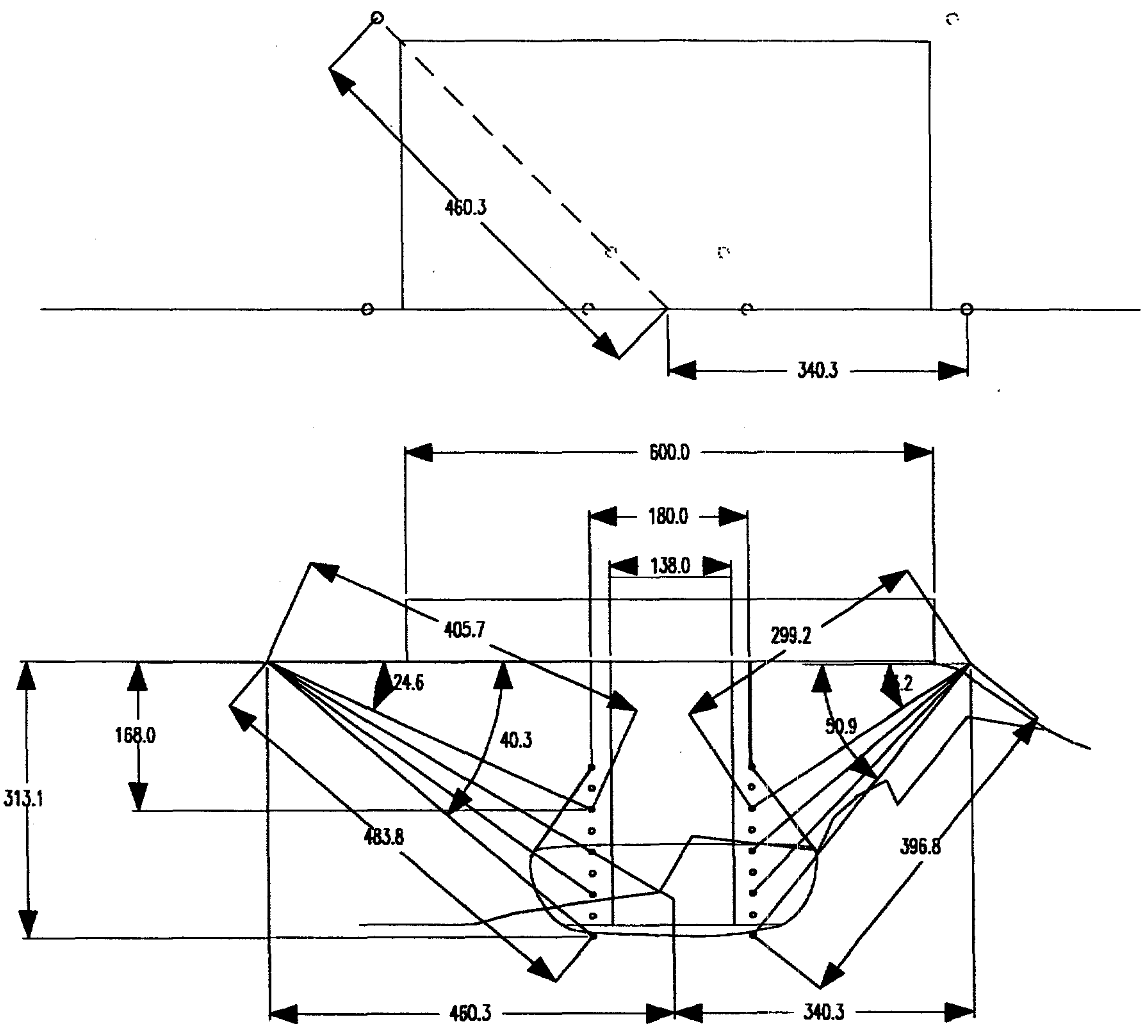


Fig. 3. Typical thermocouple sensor array configuration for Pit 1.

4.5.2.3 Thermocouple data collection

The use of type K thermocouples to monitor melt depth and width was discussed previously in Sect. 4.5.1.1, Thermocouple selection. These thermocouples will provide several indicators regarding the advance of the melt. (1) Isothermal readings at 100 °C will signal the presence of a boiling water front, advancing approximately one meter ahead of the melt and (2) sensor burn-out following a sharp temperature rise will provide a position indicator and time mark for the arrival of the melt front.

4.5.2.4 Product sampling

The final method of depth monitoring will use a specifically designed retractable graphite or ceramic dipstick attached to the off-gas hood. At selected run durations, the dip stick will be lowered, using a specially designed feed mechanism, to the bottom of the melt. Just before turning off power, this device will also be used to sample the final ISV product through a hollow stem capillary within it. Post-cooling core sampling of the ISV product will also verify depth of vitrification. Analyses to be conducted on the molten product will be the same as those to performed on the posttest product sampled after the melt has sufficiently cooled (see Sect. 7.2).

4.5.3 Off Gas Monitoring and Sampling

The off-gas generated during ISV operations will be monitored for temperature, pressure, flow rate, and radioactive content. One goal of the ISV-TS is to prevent any release of untreated off-gas to the environment. It is further desired that the roughing filter (99% Efficiency) in the off-gas hood contains as much of the released contaminants as possible. The roughing filter is based on an off-the-shelf ceramic fabric baghouse system modified for specific application to the ISV hood system. The roughing filter is designed for continuous use during ISV operations without requiring any changeout. This capability is accomplished via pulsed air blowback across the filter bags which will return filter solids to the ISV melt surface. Many of the sampling and analysis procedures described in this plan will be used to determine the radionuclide mass balance of and distribution within the entire off-gas treatment system. A project procedure (ISV-TS-P05) describes the sampling and analysis of the off-gas system components (See Appendix A).

Continuous data logger monitors similar to the Westinghouse Series 1300 Air Particle Detector—Moving Filter will be used. In this device, off-gas is pulled through a rolling sheet of filter paper at discrete intervals, which are then assayed and logged by means of a beta-gamma detector. At least two of these monitors will be used to monitor the off-gas and will provide both a data and sample record of radioactive emissions from the melt. One monitor will sample off-gas directly from the off-gas hood, with the second monitor positioned to sample from the off-gas line downflow from the prefiltration system. If time resolution of particular volatile elements in the off-gas should prove desirable or necessary, the continuous filter strips of the real-time radioactivity monitor will be employed for additional destructive analyses. In addition, the off-gas scrub solutions in the processing trailer will be sampled on a regular basis (e.g., after each incremental foot of melting or six hours of operations); these samples will also be necessary to determine a mass balance, thereby verifying that radionuclides have not permeated the prefiltration device.

4.5.3.1 Temperature, pressure, and flow rate monitoring

Temperature monitoring of the off-gas treatment system will be accomplished via Type K thermocouples placed in several locations throughout the hood and off-gas treatment train. The exact configuration (quantity and location) and installation procedures for these thermocouples can be found in the PNL SOP (Battelle, SOP No. 58, Rev. 9). These thermocouples are a part of the PNL Process Control and Monitoring System that is integrated into the LS ISV equipment. Off-gas pressure/vacuum and flow rate are also monitored at various locations within the off-gas hood, pipes, and processing system as described in the SOP No. 58, Rev. 9

4.5.3.2 Cesium 137 and other radionuclide monitoring

In addition to the routine pressure and temperature monitoring of the ISV off-gas, isokinetic sampling will be employed periodically (e.g., 1 hour every shift) in the off-gas line and at the processing trailer stack (both down gradient of the roughing filter) for air emissions of radionuclides in compliance with 40 CFR 61, subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities. Evacuated canisters, described in previous tests (Spalding et al. 1992, page 74), will be used to sample fixed gases at selected intervals during the melt runs.

4.5.3.3 Other emission monitoring

Due to concentrations of nitrate and sulfate found within the target regions of pit 1 during site characterization, emission monitoring for these volatile species (i.e., NO_x, SO_x,) will be conducted inside in the off-gas processing trailer stack along with CO_2, O_2 and CO.

Perimeter air samplers will also be setup at the site. A continuous radiation air monitor (Eberline Beta Particulate Air Monitor Model AMS-4) will be set up downwind from the ISV operations. Continuous particulate air samplers (Graseby-Anderson Model 205031) will be set up in the dominant upwind and downwind positions on Melton Valley Access Road and the edge of the wooded area to the southeast. Winds in the Oak Ridge Area are generally from either the northeast or the southwest The Eberline monitors will feed their signals directly into the DAS while the tape samplers will be used to provide a continuous sample of air particulate in the area and will be adjusted to change sample position every 2 hours of operation. Sampling will be started several days before actual ISV operations to establish performance and check for background radiation (e.g., due to pollen from contaminated trees to the west of the site).

4.5.4 ISV Product Sampling

Sampling of the ISV project immediately after termination of power to the electrodes will be conducted during the OAT, melt 1, and melt 2. Sampling will be attempted via insertion of a steel "dipstick" from the off-gas hood work platform after removing the extra electrode port cover. Drill rod with a permanent penetration point will be inserted by hand or driven through any cold cap on the melt surface using the electric jackhammer. Once the rod penetrates into the molten body it can be pushed in by hand to the approximate bottom of the melt. This sampling technique worked well in the 1987 ISV demonstration. The rod is immediately withdrawn and the adhering glass allowed to cool for a few minutes while resting the rod on the melt surface or nearby unmelted perimeter. The dipstick is then removed and uncoated section of rod removed. Product glass can be removed by fracturing the glass with a hammer to yield the few grams necessary for analyses; excess product fractured from the dipstick will be returned to the melt surface through the sampling port. Based on radiation field readings external to the off-gas hood and off-gas sampling, the anticipated radiation dose rate of the adhering ISV product can be estimated; a radiation work permit will govern these operations.

4.6 OFF-GAS HOOD DEMOBILIZATION AND STORAGE

Internal surfaces of the off-gas hood and piping system will be surveyed and sampled by smearing for semivolatile radionuclides and elements and decontaminated, as needed, to acceptable levels. By design, the off-gas hood has the capability to be dissembled into major system components. After demobilization, the hood will be moved into storage until it is needed for future stabilization and closure of ORNL seepage pits and trenches in WAG 7. The results of the posttest smear sampling will be used in conjunction with off-gas sampling data to obtain a mass balance on the Pit 1 radionuclide inventory (see Sect. 8.2).

4.7 POSTTEST OFF-GAS SAMPLING

In addition to the real-time monitoring of ISV off-gas, described in Sect. 4.5.3, posttest activities will include obtaining samples from several off-gas system components. First, the prefiltration material (e.g., roughing filter bags and prefilter HEPA) will be sampled to determine the inventory of radionuclides on this primary sink for any volatilized activity, using ISV-TS-05 that is found in Appendix A. As in the 1991 radioactive test, multiple samples will be collected of these materials to measure radionuclides, elements, and total solids evolved from the melt. The absence of the tracer REEs must also be determined to establish their conservation in the melt and, thus, validate their use in calculating melt mass. This data will be supplemented by the analyses of samples collected from the internal surfaces of the off-gas hood and piping during demobilization of the off-gas hood discussed above. Samples will follow the same level of QA effort as the other posttest samples to be collected. (The location and number of posttest off-gas samples are presented later in Table 7.)

4.8 PERFORMANCE OF LARGE SCALE ISV EQUIPMENT

Several of the temperature and pressure sensors are used for the operation and control of the LS ISV equipment and off-gas hood. The data generated from these sensors in conjunction with detailed operator log books will be used to assess the performance of the LS system. Factors which will be considered include power delivery problems, downtime, electrode breakage and EFS performance, pressure logs for the off-gas hood, alarm or malfunction warning, etc.

4.9 POSTTEST PRODUCT SAMPLING AND SOIL SAMPLING

Prior to melting, the elevation of the starting surface will be determined via survey measurements of at least eight locations. After cessation of power to the melt settings and after thermal monitoring indicates that the field product has returned to near ambient temperatures (an interval of two to six months may be required, depending on the mass of product), the depth of the resulting subsidence crater will be determined similarly before any ISV product sampling is initiated.

After subsidence data is collected, the ISV product will be sampled for chemical and radionuclide characterization and leach testing described in Sect. 7.2. In 1991 posttest sampling, diamond-tipped rock coring was found to provide good core recovery and sample quality (Spalding et al. 1992). A project sampling and analysis plan for ISV materials contains detailed procedures for coring the ISV product (ISV-TS-06). Core samples will be taken along two perpendicular transects across the melt. At least five (5) core samples will be collected from the melt region. At least one of these cores will be obtained from a region of melt setting overlap. The breakthrough depth (i.e., the depth at which the core barrel drops into unmelted soil) provides critical data for verifying melt depth (see Sect. 8.1). (It is anticipated that the breakthrough depth will be discernable; *i.e.*, a change in density and/or driving rate will be observed.) Each core sample will be subsampled to obtain around five (5) discrete depth intervals for characterization and analysis. The top and bottom depth intervals will consist of the fill material to fill the subsidence crater and the native soil found below the ISV product, respectively. Field descriptions of the cores are also essential in establishing needs for additional coring. Field monitoring of product core radioactivity will also determine whether the samples need to be processed in shielded hot cells, glove boxes, or can be processed in laboratory hoods. Because field product will be sampled with the graphite rod dipstick at the end of each melt, a good estimation of expected product activity and, thus, its handling procedures will be known prior to coring. Selected sections of core material will be pulverized with a ball mill, as described in the previous study (Spalding et al. 1992). Residual core will be archived for use in future studies. The resulting boreholes through the ISV product will provide access to drive well points beneath the vitrified zone for groundwater elevation and quality monitoring (see Sect. 4.10). Prior to driving well point screens into the ISV product sampling coreholes, each corehole will be logged with a borehole caliper probe to determine the presence, absence, size, and orientation of any fractures or voids. In addition, a borehole video camera will be used to log the depth, orientation, and morphology of any fractures or cavities in the ISV melt zone. Field surveys will also be performed to determine the geographical location (ORNL reference grid) of the coreholes/wells.

An additional four soil core samples will be taken outside of the melt region, in order to verify the boundaries of the melt and to confirm that these regions were not impacted by the ISV operation. Many additional probings, using 0.5 in. diameter threaded rod, will be performed to provide maximal melt width measurement using project procedure ISV-TS-P01. Soil samples will also be collected from below the vitrified mass (below the breakthrough depth observed during ISV product coring. Samples (both soil and ISV product) will be analyzed for physical and elemental properties per Sect. 7.2 of this QAPjP.

4.10 POSTTEST GROUNDWATER MONITORING AND CHARACTERIZATION

In addition to leach test analyses of the ISV product, posttest groundwater monitoring will also be conducted as an in situ performance indicator for the ISV process.

After completion of melting operations, groundwater will be monitored and sampled from several sources at the test site: (1) the current groundwater piezometer wells at the site --ORNL Well No.'s 676, 718, and 719, (2) existing screened Geoprobe™ wells remaining (if any) within Pit 1 after site preparation and ISV operations, (3) screened Geoprobe™ installed into areas of the pit surrounding the posttest melt region, and (4) the five cased wells that will be installed into the coreholes created during product sampling of the ISV melt. (Depending on the final size of the second melt, there may not be enough area to install Geoprobe wells into the central region of the pit to monitor recharge of the perched groundwater after melt operations.) Sample collection and analysis to be conducted during this posttest period will be conducted according to the procedure ISV-TS-P03, with the exception that the groundwater samples will not be analyzed for volatile or semivolatile organic compounds. (The soil and groundwater sampling conducted earlier in Phase 2 did not provide any evidence of their presence in Pit 1.) Sampling of selected groundwater wells will be conducted quarterly to characterize any changes in radionuclide inventory, etc. Ground water levels will continue to be determined on a monthly schedule for at least 1 year after cessation of power to the second melt.

The cased wells and surrounding piezometer wells will also be monitored at discrete depth intervals, by means of the in situ radiation detectors described and used during site characterization to determine any changes during the posttest monitoring interval. Procedure ISV-TS-P01, Procedure for Subsurface Sampling of Radioactively Contaminated Materials in and around ORNL Liquid Seepage Pits, has been written by ISV team members for this task.

5. SAMPLE CUSTODY

Sample identification and labeling will follow the requirements of ORNL/ER-225, Sect. 3.8.1 for all discrete soil, groundwater, or ISV product samples collected at Pit 1 during ISV operations and during Post-ISV monitoring. Per Sect. 3.8.1 ORNL/ER-225, each sample will be labeled with the following components: site name, sample ID, sample collection date/time, type of sample (matrix), name of sampler, sample preservation technique (if any), and type of analyses to be performed.

Many of the samples collected from Pit 1 will be analyzed, or at least prepped for additional analyses in Building 1505 by members of the sampling team. In accordance with ESP-501, Manual Chain of Custody Procedures, a formal chain of custody form will not be required for such samples since the samples will remain in the custody of the sampling person(s). (For this project, those persons to perform sample analyses in Building 1505 will be the chief members of the sampling team.) Chain of Custody Forms and Request for Analysis sheets will, however, be prepared for those samples not to be analyzed "In house", *i.e.*, samples taken to Analytical Services Organization (ASO), etc. In such cases, the chain of custody forms will be prepared and used once the sampling team, moves the samples from Building 1505 to the organization(s) that will be performing the required analyses.

6. CALIBRATION AND FREQUENCY

6.1 LARGE SCALE ISV EQUIPMENT

A majority of the calibration efforts to be performed during Phase 3 will be devoted to the instruments and components of the ISV equipment (electrical system, off-gas treatment system, etc.). A SOP for the LS ISV equipment (Battelle, SOP No. 58, Rev. 9) is currently being revised by PNL personnel and will be in place prior to the start of Phase 3. This SOP incorporates all steps required to safely place the LS equipment into service. A separate operating procedure will be prepared for operation of the new Oak Ridge off-gas hood with its automotive, electrode feed, roughing filter, back-up blower, and solids addition systems (complete by June 1995). All ISV process equipment and associated data sensors will be calibrated prior to use on-site at Pit 1 using independently calibrated electrical measurement equipment. Alarm conditions for all sensors utilized by the LS equipment will be tested by placing sensors into high or low alarm states as specified in Battelle SOP No 58, Rev. 9. All process shutdown logic conditions will also be tested per SOP. Display of all sensor monitoring data will be certified by the PNL ISV equipment manager and project engineer. Calibration testing of the LS equipment is expected to last at least 3-4 weeks. Due to the short time period under which ISV melt operations will be conducted (≈2 months), recalibration of the LS ISV equipment will not be performed during ISV operations unless conditions/events arise which would require recalibration. To qualify the data collected during the TS, calibration of the LS equipment will also be checked during any suspect conditions and at the end of ISV operations. A complete M&TE list will be available for the LS ISV equipment prior to ISV operations.

6.2 ORNL DATA ACQUISITION SYSTEM

A DAS to perform low voltage DC measurement of thermocouple (other sensor) sensors, signal amplification, engineering unit conversion and archival storage of time-temperature data records for up to 80 sensors (maximum 56 thermocouples, max of 4 channels of radiation monitoring data) will be configured, installed and tested prior to the start of the in situ treatability study. The DAS for the in-ground sensors and radiation monitoring will be assembled by ORNL project personnel and will be located in one of the portable storage buildings to the east of Pit 1. In ground thermocouples will be wired through high-voltage isolators in case of contact with the high voltage in the melt. The DAS consists of National Instruments high-resolution multifunction I/O board for the MacIntosh Nubus installed in a MacIntosh IIfx computer operating LabView 3.1 software and linked to ten 8-channel isolation amplifiers installed in a 12-slot multiplexing SCXI instrument chassis. More detailed information concerning the DAS system is discussed below.

6.2.1 System Description, Goals and Performance Measures

1. 80 data channels (maximum low voltage DC input 0-55 mv for type K thermocouple; 0-20mA/0-5 vDC Radiation Detectors)

2. Minimum voltage measurement resolution (0.000015 vDC)

3. Voltage-temperature conversion conformable with NIST reference functions and tables for letter designated thermocouple types based on ITS-90 (NIST Monograph 175)

4. Data storage to dual magnetic media at an average rate of 1 measurement/minute/channel for up to 3 months

5. Additional data storage at a user selectable rate (maximum 1 measurement/10 seconds/channel)

6. Display of data from groups of sensors (6/group) to provide 2-D visualization of temperature in vertical (up to 3) and horizontal (up to 3) planes

7. Display of time vs temperature data for individual sensors in a planar group for a 24 hour period (including periods spanning 2 days)

8. Acquisition, data storage, and display of beta/gamma air monitoring data via RS-485 digital links to instruments (including lightening protection for RS-485 computer ports) or 0-20 mA analog signal

A data storage rate averaging one measurement/minute/channel for up to three months using redundant data writing to two magnetic storage media (dual 44 Mbyte I Omega Bernoulli cartridges) will be used as the default. The data acquisition software will also have the capability to store additional data at a (user selectable) variable rate. Voltage resolution of the measuring system will be equal to or better than 0.000015 volts. The system will convert voltage data to provide storage of engineering units value (temperature °C) in conformance with NIST thermocouple standard voltage vs temperature reference functions and tables maintaining errors of less than 1% of the sensor range (type K: 0-1372 °C; type-C: 0-2315 °C). Data display will provide simultaneous display of up to (6) sensors in a common plane for visualizing melt shape and size. The visualizations will enable three separate vertical-plane views and three separate horizontal-plane views. Data for selected sensors (individual sensors of a single plane) will be displayed on a time vs temperature graph that enables display of up to 24 hours of data (spanning days, 24 hour data files).

Building on experience gained during the 1991 Tracer-Level Radioactive Pilot-Scale Test of In Situ Vitrification at Oak Ridge National Laboratory and that of the engineering staff of Pacific Northwest Laboratory, Apple Macintosh computers and National Instruments LabVIEW software were selected for this data acquisition system. The use of identical computer and data acquisition hardware will ensure compatibility of DAS systems operated by ORNL and PNL during the Treatability Study and provides backup computer hardware and data acquisition hardware in the event of component failures. Table 2 lists the computer equipment will be used to develop the data acquisition system. Table 2 includes serial numbers, ORNL property, and an ORNL Instrumentation and Controls (I&C) Division service number for most system components.

Table 2. DAS System components-computer equipment

Description	Serial number	ORNL property number	I&C number
Apple Macintosh IIfx computer (32 Mb RAM, 250 Mb Hard Drive)	F920AG9M5795	XA11665	M143451
Apple extended keyboard	648930	XA11667	NA
IOmega dual 44Mb removable disk drive	4229370027	XA11668	NA
NEC CD-ROM drive, Model CDR-400-G	46015334D	NA	NA
Apple 12-in. color monitor	5207321	XA11666	NA
Best Microferrups UPS, Model MD1KVA	C1K02967	NA	M142855
Apple ImageWriter LQ printer, Model A9M0340	181700755	XA11633	M071527
An identical system (below) is available as a back-up computer system during the test.			
Apple Macintosh IIfx computer (32 Mb RAM, 500 Mb Hard Drive)	F10150YWM5835	XA11645	M071263
Apple extended keyboard, model M0312	AP016638	XA11642	NA
IOmega dual 44Mb removable disk drive	7750410133	XA11644	NA
Apple 12-in. color monitor. Model M0401	5548098	XA11643	NA

The following National Instruments, Inc., data acquisition components and software in Table 3 will be used to configure the system and develop a software application for the ISV treatability study.

Table 3. DAS System components—acquisition hardware/software

Hardware description	National instruments model number	Serial number
LabVIEW version 3.1 Application Software for Macintosh License # 24650B90	NA	NA
High-Resolution Multifunction I/O Board for the Macintosh NuBus	NB-MIO-16XL-18	NA
SCXI 12-Slot Chassis	SCXI-1001	001485
Ten (10) SCXI 8-Channel Isolation Amplifiers	SCXI-1120	002778 (Assigned to Type K Sensors) 002779 (Assigned to Type K Sensors) 002780 (Assigned to Type K Sensors) 002518 (Assigned to Type K Sensors) 002769 (Assigned to Type K Sensors) 002767 (Assigned to Type C Sensors) 002761 (Type J Sensors and Misc. 002766 (Spare Module) 002762 (Spare Module) 002765 (Spare Module)
Ten (10) 8-Channel Connectors	1328	000688 000693 000670 000672 000684 000673 000690 000692 000683 000676

6.2.2 DAS Setup and Calibration

The ORNL DAS was created as an engineering data acquisition tool for the measurement, storage, and display of supplemental ISV parameters including temperature, pressure, radiation monitoring signals, and other signals which may be desired. Measurement system requirements have been determined to be a system comprised of a maximum of 80 channels, with 56 channels reserved for low voltage DC measurement of thermocouples. The remainder of channels are reserved for high level current loop or voltage inputs for radiation monitoring equipment, pressure sensors, and other high level sensors.

Quality assurance of the data acquisition system shall be conducted in four phases; laboratory validation, on-site burn in, pre-test final check out, and post test verification.

The first phase of system check out will be laboratory validation. Laboratory validation shall determine the validity of all system inputs, computer algorithms, storage rates, and overall system accuracy. Laboratory validation tests will be performed in the Instrumentation and Controls Metrology Research and Development Laboratory, Building 3500, Room 8. At this time, computer thermocouple algorithms based on the International Temperature Scale of 1990 will be tested for accuracy. Voltage levels will be applied to a channel and the indicated temperature will be cross checked against the National Institute of Standards and Technology Monograph 125 thermocouple tables. A high precision voltage calibrator shall be used to apply appropriate signal levels. To ensure correct algorithm implementation, a 10 point check on one channel from each type of thermocouple input (Type K and Type C) shall be conducted. To ensure correct multiplexer operation and channel input type allocation, the full scale voltage signal corresponding to that channel's thermocouple type will be applied to each channel and the operator will validate that the indicated full scale temperature for that thermocouple type results. Similar tests will be conducted for each high level input channel to ensure the multiplexer and allocation of each high level input. These tests will validate the system inputs and computer algorithms. Storage rates and validation of storage accuracy will be performed by applying voltage inputs to several channels and allowing the system to operate for several days within the laboratory environment. Resulting data files shall be checked for timing and storage accuracy against the known inputs. Finally, laboratory validation shall be completed by conducting an overall system accuracy test. This accuracy test is intended to ensure no unforeseen inaccuracies result from assembling the various system components, each of which has its own known accuracy. Several thermocouple assemblies shall be connected to the data acquisition system to simulate final system assembly in the field. These thermocouples will be placed into a fluidized bath and the entire system accuracy will be checked at a minimum of 5 cardinal points from ambient to 600 deg C. Similar system checks will be conducted on select high level input components, such as pressure transducers, etc. as appropriate.

Upon the completion of laboratory validation, the system will be moved to the ISV site and subjected to the second phase of validation testing. This second phase of the system check out will be on-site burn in. The system will be completely assembled to its operational state and allowed to run. Assembly shall consist of computer system setup within the trailer with power provided from an uninterruptable power supply, sensor positioning, and sensor installation into the DAS. For thermocouples, sensor installation will include thermocouple reference junction wiring, lightening protection wiring, and system grounding. During this wiring, several parameters will be recorded to assist problem solving in the event of future system failure. These parameters include overall loop resistance from the lightening protectors to the sensor, and (when possible) insulation resistance between the thermocouple lead and outer sheath. Additionally, as each thermocouple is installed into the DAS, it shall be tested against an ice bath and/or boiling water bath to ensure proper allocation/indication at the DAS display. Upon complete system assembly, the DAS will be initiated and allowed to run continuously. Accessible instrumentation, such as ambient temperature/pressure probes and radiation monitoring equipment, should be subjected to changing conditions and evaluated for correct signal display and logging at the DAS. The overall system shall be evaluated for continued functionality, correctness, and proper data logging. File backup techniques will be employed as if the ISV test was initiated in order to ensure proper operational procedures. During this burn-in period, the system should be intentionally subjected to a "power failure" to ensure the performance of the uninterruptable power supply and to quantify the duration of emergency powered operation.

The final system pre-test check-out shall be conducted approximately one week before the scheduled initiation of the ISV melt. Accessible instrumentation should be subjected to a final "working" test, i.e. ambient thermocouples subjected to ice-water/boiling water, radiation monitors tested with samples. System wiring shall be visually inspected for damage. If any wiring is questionable, problem solving techniques including loop resistance and insulation resistance checks will be employed.

Following the completion of the ISV test, the data acquisition system shall be checked to ensure that no significant drift or decalibration has occurred over the duration of the test. In-situ sensors will be unretrievable from the confines of the melt, therefore, validation will depend only upon an electrical calibration of the system. Simulated thermocouple inputs will be monitored on each channel and logged to data storage media to ensure proper indication and storage of each input. When possible, retrievable instrumentation components, such as pressure sensors or radiation monitoring equipment will be post-test calibrated. The DAS channels of these instruments will be electrically calibrated with simulated inputs.

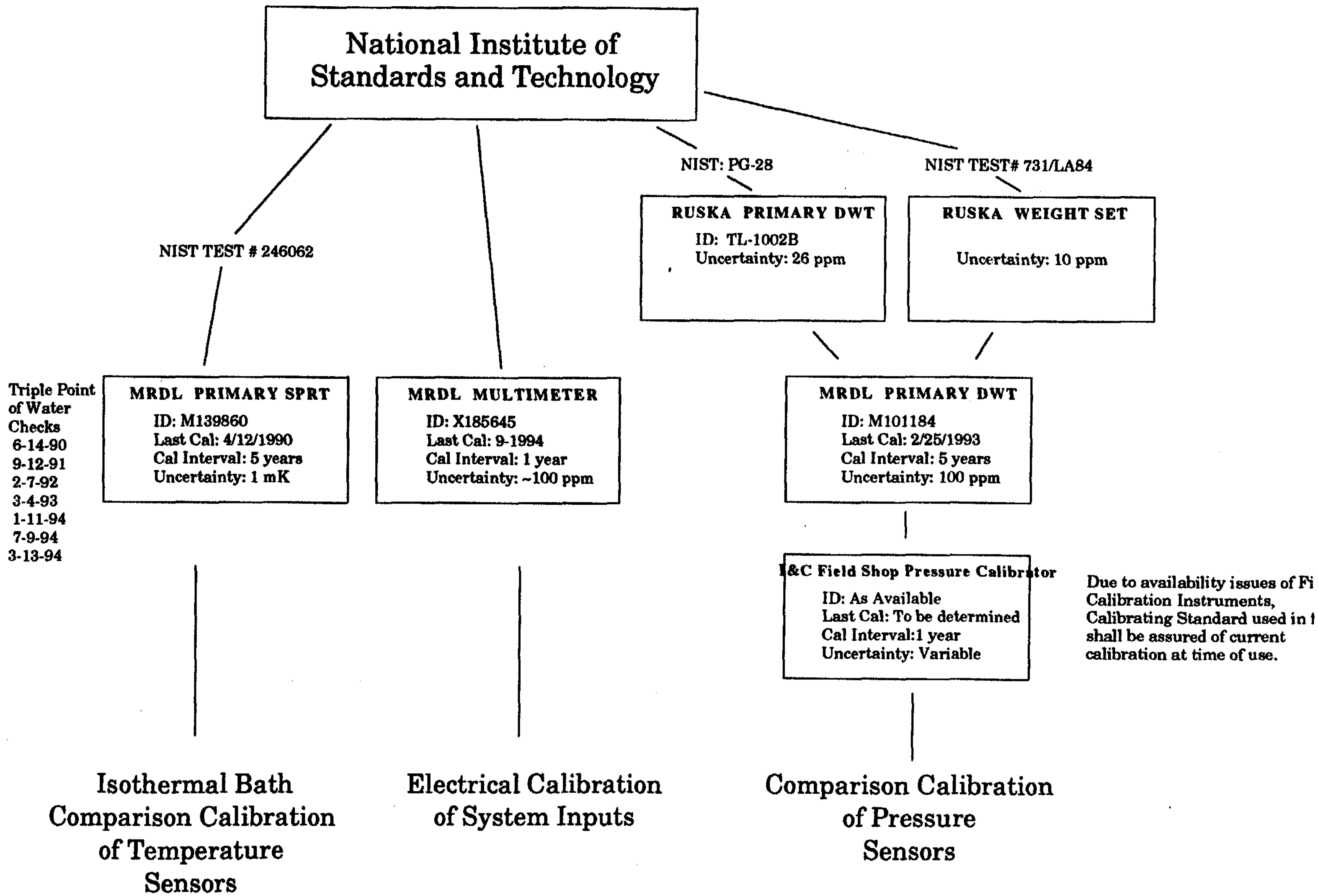
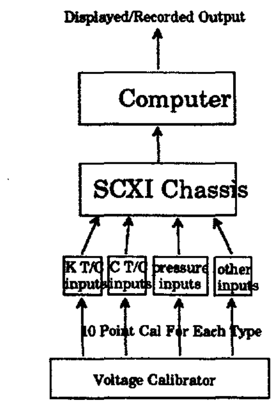


Fig. 4. Equipment to be used for DAS calibration.

ISV Data Acquisition Quality Assurance
Phase 1 - Laboratory Validation

Verification of Algorithm Implementation

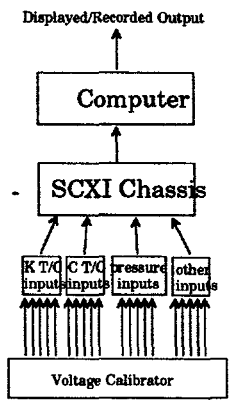


One channel from each input type will receive a 10 point check against a precision voltage calibrator to insure proper algorithm implementation... i.e. correct output for given input.

Thermocouple outputs will be verified against NIST Monograph 125. Other outputs will be verified against known voltage input/engineering unit output relations.

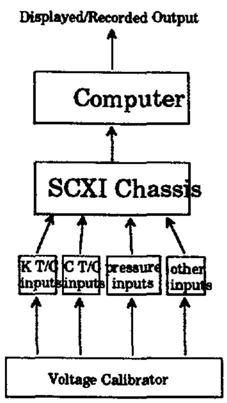
Input signal levels will be cross checked against a precision voltmeter, with current NIST traceable calibration. Due to scheduled availability of this instrument, actual instrument I.D.s will be determined at time of calibration.

Verification of Channel Allocation



Each channel from each input type will receive a Full Scale voltage input as determined by channel type. Operator will determine indicated output is correct for that channel thus insuring appropriate allocation of that input channel.

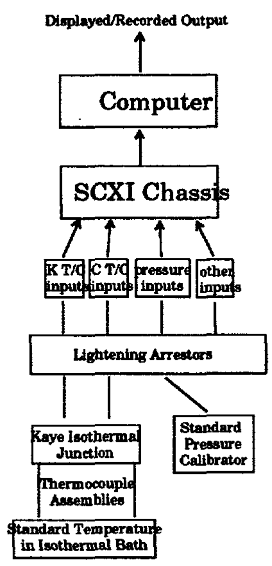
Verification of File I/O and Timing



One channel from each input type will receive a Full Scale voltage input as determined by channel type. Data acquistion will be logged for several days. The output files will then be checked to verify appropriate data storage, timing, and format.

ISV Data Acquisition Quality Assurance
Phase 1 - Laboratory Validation

Verification of Overall System Accuracy



5 Point Cal For Each Type

One channel from each input type will receive a 5 point check agains a known standard. Thermocouples will be connected to duplicate final system assembly and comparison calibrated against a standard platinum resistance thermometer in a fluidized bath.

Pressure sensors will be connected to a NIST traceable standard pressure generator, and given a 5 point calibration.

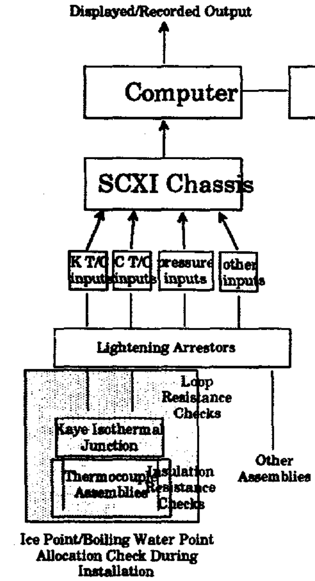
Other sensors will be comparison calibrated as appropriate for their gven type.

Connections shall duplicate final system assembly, including reference junction for thermocouples and lightening arrestors for all inputs.

Fig. 5. Flowsheet of the DAS calibration task.

ISV Data Acquisition Quality Assurance
Phase 2 - On-Site Burn-In

Verification of Overall System Accuracy



All sensors will be assembled for final installation.

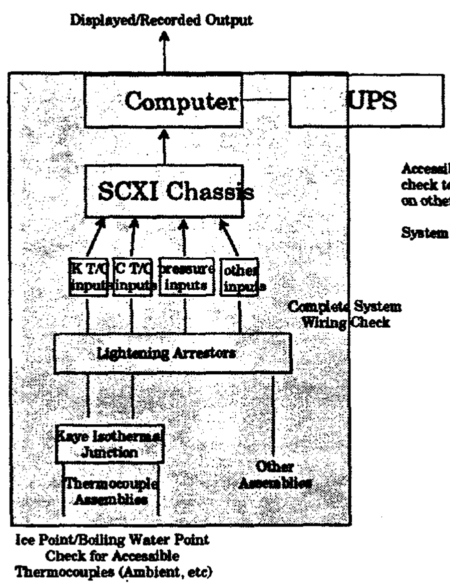
During installation, parameters for sensors including loop resistance and insulation resistance shall be recorded for later diagnostic/problem solving analysis, (when possible).

Thermocouples shall be given a ice bath/boiling water bath check to insure final channel allocation in the field (i.e. proper response on the expected channel). Similar tests will be performed when possible on other types of instrumentation.

System shall be allowed to run continuously and will be evaluated for functionality and performance. File backup techniques will be fully implemented to insure proper operational procedures.

Power failures shall be purposefully initiated to verify performance of emergency power equipment.

ISV Data Acquisition Quality Assurance
Phase 3 - Final System Checkout



Accessible thermocouples shall be given a ice bath/boiling water bath check to insure operation. Similar tests will be performed when possible on other types of accessible instrumentation.

System wiring will be fully inspected for damage and replaced if necessary.

Fig. 5. (continued).

6.3 OTHER LABORATORY TEST EQUIPMENT

The calibration techniques used in the laboratory to conduct sample analyses are included or referenced in the analytical procedures to be performed (see next section). The Project Manager (or designate) shall ensure that each piece of Measuring and Test Equipment (M&TE) is identified, properly labeled, and that calibrations occur as planned. The M&TE pieces listed in Table 4 are owned by ORNL/ESD and will be operated by ISV team members in Laboratory 295, Building 1505. In addition to the listing of M&TE equipment, the associated activity, calibration acceptance criteria, and the frequency of calibrations and checks are also presented in Table 4.

All analyses performed by ORNL ASO will be done in accordance to the specific procedures requested, and all equipment used by ASO will be also be calibrated in accordance to procedures or protocols adopted by ASO. The radiation survey meters and electronic balances are calibrated by I&C Division and are documented by calibration stickers, with expiration date, attached to the instruments; project personnel will document in their project notebooks that, when a given instrument is used, that the calibration date has not been exceeded. All other monitoring and test equipment is calibrated by the user according to the manufacturers' instructions and documented in the project notebook; all manufacturers' instruction/operating manuals are referenced in the project procedures and are maintained in project records. Certification of standards used by project personnel will be maintained in the project files; traceability to these certifications will be noted in the project notebooks.

Table 4. Frequency of project instrument calibration and check requirements

Instrument	Activity	Acceptance criteria	Calibration frequency	Calibration check
Beta/Gamma Survey Meters & Alpha Survey Meters	Field/Personnel Screening	Source Check ≥10 Background Reading	Quarterly (Performed by I&C)	Daily before use
Multichannel Analyzer (Canberra Series 35) & Auto-Gamma Spectrometer (Packard Model 5320)	Groundwater/Soil Sample Analyses	^{137}Cs Counting Efficiency ≥10%	Every use	Every five samples
Liquid Scintillation Analyzer (Packard 2000CA)	Groundwater/Soil Sample Analyses	90Sr Counting Efficiency ≥35%	Every use	Every five samples
Electronic Balance (Mettler PK300)	Laboratory Analyses	Calibration Check 5g±0.0001g	Semiannual (Performed by I&C)	Daily before use
Electronic Balance (Scientech)	Laboratory Analyses	Calibration Check 5g±0.0001g	Semiannual (Performed by I&C)	Daily before use
Digital Titrator (Hach)	Groundwater Alkalinity	Standard 100±5 mg $CaCO_3$/L	Every use	Every ten samples
pH Meter (Corning 610A)	Media Characterization	Standard pH 7.0 ± 0.05	Every use	Every five samples
Conductance Meter (YSI Model 35)	Groundwater/Solution Conductivity Determinations	Standard Solution 1000 ±50 ds/m KCl	Every use	Every five samples

7. ANALYTICAL PROCEDURES

This chapter describes or references the analytical procedures which need to be performed for the successful completion of the ISV-TS. Several different media will be analyzed, e.g., the ISV product, groundwater samples, soil samples, and off-gas filter media, off-gas scrub solutions, etc.

7.1 GROUNDWATER ANALYSES FOR PIT 1 AND VICINITY

The following list of analyses presented in Table 5 will be conducted for aqueous samples collected from Pit 1 and vicinity during Phase 3 of the ISV-TS. The selected analysis methods are presented in this table, along with additional requirements set forth for the samples. The current sampling plan for the groundwater wells and associated QC checks are contained in project procedure ISV-TS-P06, and some QC checks which will be performed are included in Sect. 9.1. The analytical procedures to be performed on these samples are included in project procedure ISV-TS-P03.

7.2 ISV PRODUCT AND SOIL ANALYSES FOR PIT 1 AND VICINITY

Table 6 presents a list of analyses that may be performed on samples of the ISV product or soil samples collected from the area during Phase 3 activities. The ISV product will be evaluated in terms of elemental and tracer composition, radionuclide inventory, leach potential, and physical characteristics. Selected analysis methods are presented in this table, along with additional requirements set forth for the samples. The current sampling procedure for the ISV product and sampling scheme are included in the project procedure ISV-TS-06. Some expected QC checks are presented in Sect. 9.2.

7.3 OFF-GAS ANALYSES AND PRE-FILTER SAMPLES

Table 7 presents the expected anticipated sampling locations and sample quantities to be collected in the off-gas treatment system. More in-depth information on the sampling procedures and analyses to be used for surface smear samples and filter media samples can be found in ISV-TS-P05. Some of the QC checks to be performed during off-gas sampling are presented in Sect. 9.3.

Table 5. Groundwater analyses for Pit 1 and vicinity

Analyses	Method	Container	Preservation	Maximum hold time	Detection limit
Tritium	EPA906.0	Glass	Filter, HNO_3 to pH<2	6 months	15 Bq/L
Gross α	EPA900.0	Glass	Filter, HNO_3 to pH<2	6 months	0.05 Bq/L
Gross β	EPA900.0	Glass	Filter, HNO_3 to pH<2	6 months	0.05 Bq/L
Gamma emitters	EPA901.1	Glass	Filter, HNO_3 to pH<2	6 months	0.05 Bq/L
Total radioactive ^{90}Sr	ISV-TS-PO3	Glass	Filter, HNO_3 to pH<2	6 months	0.15 Bq/L
^{90}Sr	ISV-TS-PO3	Glass	Filter, $HNO_3$to pH<2	6 months	2.0 Bq/L
Gamma emitters	ISV-TS-PO3	Glass	Filter, HNO_3 to pH<2	6 months	1.0 Bq/L
pH	ISV-TS-PO3	Polypropylene	Cool 4°C	4 hr	±0.02 units
Electrical conductance	ISV-TS-PO3	Polypropylene	Cool 4°C	4 hr	10 mS/m
Hardness	ISV-TS-PO3	Polypropylene	Cool 4°C	24 hr	10 mg $CACO_3$/L
Alkalinity	ISV-TS-PO3	Polypropylene	Cool 4°C	24 hr	10 mg $CACO_3$/L
Solids (suspended)	ISV-TS-PO3	Polypropylene	Cool 4°C	24 hr	20 mg/L
Dissolved solids	ISV-TS-PO3	Polypropylene	Cool 4°C	24 hr	20 mg/L
Dissolved metals	EPA200.7	Polypropylene	Filter, HNO_3 to pH<2	6 months	See footnote
Dissolved mercury	EPA245.1	Polypropylene	Filter, HNO_3 to pH<2	28 days	See footnote
Inorganic anions	EPA300.0	Polypropylene	Filter cool 4°C	7 days	See footnote

[1]Element or species have the following analytical detection limits (mg/L):
Ag (5E-03), Al (5E-02), As (5E-02), B (8E-02), Ba (1E-03), Be (1E-03), Ca (1E-02), Cd (5E-03), Co (4E-03), Cr (4E-03), Cu (7E-03), Fe (5E-02), Hg (1E-04), K (5E-01), Li (5E-03), Mg (1E-02), Mn (1E-03), Mo (4E-02), Na (5E-01), Ni (1E-02), P (3E-01), Pb (5E-02), Sb (5E-02), Se (5E-02), Si (2E-01), Sn (5E-02), Sr (5E-03), Ti (2E-02), V (2E-03), Zn (1E-03), Zr (2E-02), Br (0.1), Cl (0.1), F (0.1), NO_3 (0.1), PO_4 (0.5), SO_4 (0.2)

Table 6. ISV product and soil analyses for Pit 1 and vicinity

Analyses	Method	Container	Preservation	Maximum holding time	Detection limit
Frest weight	ISV-TS-PO4	Liner	None	30 days	0.1 mg
Oven dry weight	ISV-TS-PO4	Liner	None	30 days	0.1 mg
Moisture content	ISV-TS-PO4	Liner	None	30 days	0.05%
Bulk density	ISV-TS-PO4	Liner	None	30 days	0.01 g/cm^3
Organic content	ISV-TS-PO4	Liner	None	30 days	0.05%
Gamma emitters ^{90}Sr bremsstrahlung	ISV-TS-PO4	Liner	None	180 days	1.0 Bq/g
Batch extraction	ASTM-D5233	Liner	None	90 days	See footnote 2
$LiBO_2$ fusion	ASTM-D4503	Liner	None	180 days	See footnote 2
TCLP	EPA1311	Liner	None	180 days[1] (metals only)	See footnote 2
Cation and acid leach	Spalding et al. (1992)	Liner	None	180 days	See footnote 2
Product consistency test	Proposed ASTM C26.13	Liner	None	180 days	See footnote 2

[2]Elements (mg/g) and radionuclides (Bq/g) have the following detection limits for all indicated analyses in the table above:
Ag (4E-03), Al (4E-02), As (4E-02), B (6E-02), Ba (8E-04), Ca (8E-03), Cd (4E-03), Co (3E-03), Cr (3E-03), Cu (5E-03), Fe (4e-02), Hg (1E-04), K (4E-01), Li (4E-03), Mg (8E-03), Mn (8E-04), Mo (3E-02), Na (4E-01), Ni (8E-02), P (4E-02), Pb (4E-02), Sb (4E-02), Se (4E-02), Si (2E-01), Sn (4E-02), Sr (4E-03), Ti (2E-02), V (2E-02), Zn (1E-03), Zr (2E-02).

Table 7. Off gas sampling plan for ISV hood and large scale equipment

Off-gas system component	Minimum number of samples	Container type	Maximum holding time	Reagent blanks per suite
Thermal Layer	5/run	polypropylene	180 days	1
Ceramic Roughing Filter Bags	5/run	polypropylene	180 days	1
HEPA Prefilter	4/filters used/run	polypropylene	180 days	1
Hood Walls	5/run	polypropylene	180 days	1
Duct before HEPA	5/run	polypropylene	180 days	1
Duct after HEPA	5/run	polypropylene	180 days	1
Final HEPA in off-gas stack	3/filters/run[3]	polypropylene	180 days	1

[1]Sampling procedures and analyses to be performed are located in procedure ISV-TS-P05.
[2]Detection limits for ^{137}Cs and ^{90}Sr are 0.8 and 1.6 Bq/gram particulate matter, respectively. Detection limits for elements are identical to those listed in Table 6:
Ag (4E-03), Al (4E-02), As (4E-02), B (6E-02), Ba (8E-04), Ca (8E-03), Cd (4E-03), Co (3E-03), Cr (3E-03), Cu (5E-03), Fe (4e-02), Hg (1E-04), K (4E-01), Li (4E-03), Mg (8E-03), Mn (8E-04), Mo (3E-02), Na (4E-01), Ni (8E-02), P (4E-02), Pb (4E-02), Sb (4E-02), Se (4E-02), Si (2E-01), Sn (4E-02), Sr (4E-03), Ti (2E-02), V (2E-02), Zn (1E-03), Zr (2E-02)
[3]Samples only collected and analyzed if contaminants are detected in the scrub solutions.

8. DATA REDUCTION, VALIDATION, AND REPORTING

The data collected in the field and from laboratory analyses will ultimately be synthesized and reduced to aid in determining whether the main objectives set forth for this ISV-TS were accomplished. All data collected from the DAS and analytical results will be handled and reduced by the ISV project team members presented in Figure 1. To prevent loss of the field data, backup copies of the original DAS files will be used when working with the data. The data will first be examined for reasonability, using the PARCC parameters discussed in Chap. 3. This section is organized such that each subheading describes what data will be used (and how it will be reduced) to evaluate each objective of the Pit 1 ISV-TS that was presented in Chap. 1, Project Description. Each type of calculation made via computer spreadsheets, etc. will be hand-checked for correctness. Any assumptions made in the evaluations and calculations will be clearly noted, and all work will be reviewed by at least one other person to reduce the probability of calculation errors and the use of invalid assumptions.

8.1 MELT DEPTH OBJECTIVE

The first objective of this ISV-TS was to determine if the process attained the required depth to incorporate radioactive source contamination within and beneath the pits. The depth of maximum contamination has been found to be around elevation 798-802 ft above National Geodetic Vertical Datam (NGVD). After pre-ISV site preparation activities are complete (see Sect. 4.4), surveying equipment will be used to determine ground elevations and northing/easting grid location of the cut and filled areas. This data will be necessary when selecting and/or computing the actual position of the sensor equipment (thermocouples, etc.). Thermocouple "burn out" data collected by the DAS, visual observations, information gained from the electrode penetration, and results from analysis of post-ISV core samples will all be used to verify the maximum depth of the ISV product. The following equations will be used to reduce the data obtained from the field work.

Electrode Penetration Depth Measurement for each Electrode:

$$\text{Starting Elevation} = TOP_0 - L_0$$

$$\text{Melt Finish Depth} = TOP_f - L_0 - L_1$$

Where:

TOP_0 = Starting Elevation of Electrode Top (ft)
TOP_f = Final Elevation of Electrode Top (ft)
L_0 = Starting Electrode Length (ft)
L_1 = Length of Electrode added to L_0

Note: Electrode lengths determined with tape measure.

Core Hole Depth:
Melt Top = $E_0 - L_{total} + L_{protruding}$
Melt Bottom = $E_0 - DS_{total} + DS_{protruding}$

Where:
E_0 = Starting ground surface elevation (ft) from civil survey
L_{total} = Length of 0.5 inch threaded rod driven (tape measure)
$L_{protruding}$ = Length of 0.5 inch threaded rod protruding (tape measure) above E_0
DS_{total} = Length of drill stem added (tape measure)
$DS_{protruding}$ = Length of drill stem protruding at breakthrough (tape measure)

Melt Depth Based upon Thermocouple Burnout :

$$\text{Melt Depth}_{TC} = TC_{burnout} + \left(h \times \frac{T_{max}}{1800} \right)$$

Where:
$TC_{burnout}$ = Calculated elevation of deepest thermocouple to burnout
h = Vertical distance to next deepest thermocouple
T_{max} = Maximum recorded temperature for the next deepest thermocouple (°C)

Note: values are calculated using information from the surveys and thermocouple installation logsheets .

8.2 OVERLAPPING MELT OBJECTIVE

A second objective was to demonstrate the ability to create at least two overlapping settings of ISV resulting in fused melt segments. To evaluate this objective, reduction of the elemental tracer analyses from the post-ISV product will be an important parameter. The concentration or mass of the elemental tracer found in the overlap region will be compared to that found in both the first and second melt. Before a comparison can be made, the mass and volume of both melts and of the overlap must first be determined. These mass and volume computations will involve use of the tracer concentrations, visual observations, post-ISV survey subsidence data, melt depth values as discussed in the previous section, and density measurements made on the post-ISV product.

The following discussion presents sample calculations which will be necessary to determine melt mass using data obtained from the elemental tracer data: Calculation of product masses, and re-melted mass, during multiple application of ISV to adjacent soil volumes is obtained from equations 1 and 2. Example calculations for estimates of the melt mass generated during a 1991 test of ISV at ORNL are given for a REE tracer addition.

$$M_{melt} = \frac{M_i}{netC_i^{rock}} \quad (1)$$

$$netC_i^{rock} = \overline{C}_i^{rock} - (\overline{C}_i^{soil} a_{soil} b_{soil} + \overline{C}_i^{ls} a_{ls} b_{ls}) \quad (2)$$

definitions and parameter error estimates:

M_{melt} melt mass (gm)
M_i tracer i mass ($\pm$ 0.1 gm)
$netC_i^{rock}$ net concentration tracer i in ISV product (mg / g)
$\overline{C}_i^{rock}$ mean concentration tracer i in ISV product ($\pm$5% mean, mg / g)
$\overline{C}_i^{soil}$ mean concentration tracer i in soil ($\pm$5% mean, mg / g)
a_{soil} soil melt fraction ($a_{soil}^{mean} = 0.775; a_{soil}^{max} = 0.88; a_{soil}^{min} = 0.67$)
b_{soil} soil weight retention on ignition (0.9043)
$\overline{C}_i^{ls}$ mean concentration tracer i in limestone ($\pm$5% mean, mg / g)
a_{ls} limestone melt fraction ($a_{ls}^{mean} = 0.225; a_{ls}^{max} = 0.33; a_{ls}^{min} = 0.18$)
b_{ls} soil weight retention on ignition (0.5822)

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net ISV product concentration = mean measured ISV product concentration
-[(mean soil concentration x soil melt fraction x soil weight retention on ignition)
+(mean carbonate concentration x carbonate melt fraction x carbonate weight retention on ignition)]

Sample calculations for determining the melt mass from dilution of a tracer are given below for an anticipated 250 Mg melt at Pit 1 using soil analysis for Tb with some reasonable assumptions for soil melt fraction and soil weight retention on ignition.

Example case (ISV of Pit 1) - Tb:

mean measured ISV product concentration = 0 00290 mg/g
mean soil concentration = 0.00102 mg/g
soil melt fraction = 0.900
soil weight retention on ignition (vitrification) = 0.9832
mean carbonate concentration = 0.00002 mg/g
carbonate melt fraction = 0.100
carbonate weight retention on ignition = 0.5734

net ISV product concentration = 0.00290mg/g-[(0.00102mg/g x 0.900 x 0.9832) + (0.00002mg/g x 0.100 x 0.5734)]
= 0.0020 mg/g
Tb_2O_3 tracer addition = 575.5 g
as Tb (317.86/365.8582 x Tb_2O_3) = 500.0g

Therefore: 500.0 g / 0.002 x 10^{-3} g/g **= 2.50 x 10^8 g**

8.3 RADIONUCLIDE INVENTORIES VITRIFIED

The radionuclide inventory incorporated into each melt can be determined once the melt mass has been computed using the tracer concentration data (See Sect. 8.2 above). The following calculation will be utilized:

$$\text{Radionuclide Inventory} = \left(\sum \text{Average } {}^{137}\text{Cs} + {}^{90}\text{Sr} + \text{U} + \text{Pu Activity in the melt}\right) \text{X Melt Mass}$$

The average activity of each radionuclide listed in the equation is obtained from all posttest analyses performed on the ISV product of that particular melt.

8.4 OFF-GAS TREATMENT OBJECTIVE

The third objective of this ISV-TS is to demonstrate the capability to safely and effectively handle the volatilization of ^{137}Cs during melt operations. Several types of off-gas samples, which have been discussed in Sect.s 4.5, 4.6, and 4.7, are required to determine the effectiveness of the off-gas hood and the LS off-gas treatment system.
The following approach will be used to obtain a mass balance of the ^{137}Cs in the off-gas treatment system. All of the radionuclide activities to be used in the mass balance have been determined from the analyses listed in Table 7, conducted using project procedure ISV-TS-P05.

Fraction of ^{137}Cs volatilized= Activity of ^{137}Cs in Off-Gas System/Activity in Melt + Activity in Off-Gas System

^{137}Cs Activity in Off-Gas System= Activity in thermal barrier
+ Activity on inside hood surfaces
+ Activity on roughing filter bags
+ Activity on duct between roughing bags and HEPA prefilter
+ Activity on HEPA prefilter
+ Activity on pipe after HEPA but preceding the off-gas trailer connection
+ Activity in scrub solutions
+ Activity on final HEPA filters

Where:

Activity on thermal barrier = (activity / unit weight) X weight added to melt
Activity on hood = (mean activity from smears / unit area) X hood inside surface area
Activity of pipe = (mean activity / unit area) X pipe inside surface area
Activity of prefilter bags = (mean activity / unit area) X (surface area / bag) X # of bags
Activity of HEPA = (mean activity / unit area) X total surface area of HEPA filter
Activity of scrub solution = $\sum$ transfer volume X sample activity / volume

8.5 EFFECTIVENESS OF SITE CHARACTERIZATION

Since the ISV process may be deemed applicable to the other pits and trenches in ORNL WAG 7, this TS is designed to provide information and experiences that will further advance the knowledge base for future melts. In particular, it is expected that the results of this TS will determine what site characterization data are the most important to predict such parameters as ISV melting kinetics, processing temperatures, and product durability.

As discussed throughout this QAPjP, site characterization data will be used to predict melt depth and width, operating temperature, volatilization of ^{137}Cs, water evaporation, subsidence, and product leach characteristics. The spatial distribution of radioactivity will be used to set depth and lateral targets for ISV melting; these will be directly compared with the depth and lateral extents of the two melts. Water table elevation and soil water contents found during site characterization will be used to calculate the amount of water which must be evaporated to attain the desired depth and width of the melts; this calculated volume of water will be compared directly with the volume collected and processed by the ISV off-gas system. The ISV operating temperature, as measured by the type-C thermocouples in the melt, will be compared with the operating temperature measured during the engineered-scale test and with that predicted for the elemental composition (Shade and Piepel 1990). The final field-scale degree of ^{137}Cs volatilization will be compared with the degree measured in laboratory crucible melts. Degree of field subsidence will be compared with that predicted from field characterization of soil bulk density. The final ISV product leach characteristics, as measured by the leach tests presented in the end of Table 6, will be compared to those measured on laboratory crucible melts using sampled soil from Pit 1. The degree of correlation between these various field values and those measured and/or calculated during site characterization will be used to establish the efficiency and/or necessity of these site characterization measurements for future ISV planning of the other WAG 7 seepage pits and trenches.

9. INTERNAL QUALITY CONTROL CHECKS AND FREQUENCY

9.1 GROUND WATER QC CHECKS

Per ORNL/ER-225, replicates samples will be collected in the field at a frequency of 10% per matrix per day (*i.e.*, 1 replicate sample for every 10 analyses). Most of the radionuclide analyses performed on the groundwater samples (i.e., tritium, gross α-β, gamma emitters, and total radioactive Sr) will be performed by ORNL ASO, using their required QC protocols. Rinsate blanks will also be collected at a 10% frequency. One trip blank sample will be made in the laboratory and carried out to the site for each cooler full of samples to be collected. Samples collected for dissolved metals will be analyzed along with samples as was done in the Phase 1 and 2 characterization work. Certified calibration standards when required in the analytical procedures. The samples used for many of the common groundwater property tests to be conducted by ISV team members (i.e., pH, electrical conductance, alkalinity, suspended solids, etc.) will be obtained via laboratory split sampling of a field collected sample. Replicates will also be generated at a 10% frequency from the split samples. Much more detail to items such as sample IDs and the number of planned sampling events per groundwater well is to be presented in the ISV-TS-P06 procedure.

9.2 ISV PRODUCT AND SOIL SAMPLING QC CHECKS

9.2.1 ISV Product

After visual observations and photographs of the ISV core samples are completed, each of the proposed five core samples will be separated into 5 discrete depth intervals (fill soil, three ISV product intervals, and the native soil beneath the melt). This sampling effort will be performed for three main reasons: (1) to show that the radionuclide inventory is contained solely by the ISV product, (2) to evaluate the differences in the properties of the soil and ISV product, and (3) to determine whether a homogeneous melt mass was obtained. Once these subsampled cores are taken to the laboratory, additional subsampling will be conducted to perform the suite of physical and chemical analyses listed in Table 6. Replicate samples will be analyzed at a 10% frequency (*i.e.*, 1 replicate for every 10 analyses) for each of the characterization analyses to be performed on the *vitrified* product. Split sampling will be performed in the laboratory on ISV product core intervals to obtain these replicate samples. Laboratory QC blanks will be run with the samples undergoing extraction/leach test analyses. Appropriate calibration standards will be used when determining the radionuclide and/or tracer concentration in the ISV product samples. Due to the expected homogeneity of the ISV product, elemental composition analyses will only be performed on 8 of the total 15 product subsample intervals obtained from all five of the cores that are collected.

9.2.2 Soil Sampling

The approach discussed above will also be used analyzing posttest soil samples collected above and below the ISV product samples and from the 4 soil coreholes to be created around the melt region (See Sect. 4.9). The results of these analyses can be compared to the pre-ISV soil analyses data from Phases 1 and 2 to determine if the ISV process has in some way impacted the local region. The field subsampling, laboratory split sampling, and other QC checks to be associated with the analyses will be performed in the same manner as discussed above for the ISV product.

9.3 OFF-GAS ANALYSES QC CHECKS

As mentioned throughout this QAPjP, the off-gas samples to be analyzed will be collected from several types of media (e.g., scrub solutions, Modified Method 5 (MM5) air samplers, filter material, surface smears, etc.). In most instances, true replicate samples cannot be collected, since sampling results will be highly dependent upon sample collection location. Several smear samples will be collected for each off-gas component to compensate for not having replicate sampling. Once analyses of these samples are complete, the results can be correlated with numerous beta/gamma survey readings to be taken over the entire surface area in order to determine an average activity per unit area. Subsampling will be performed on the off-gas scrub solutions in order to obtain replicate samples at a 10% frequency. To further ensure quality, all filter material to be used as "blanks" carried through the analyses will be from the same manufacturer lot numbers as the filter media used in the LS ISV off-gas treatment system.

10. PERFORMANCE AND SYSTEM AUDITS AND FREQUENCY

A minimum of two surveillances will be performed during the life of this project. Once to aid in determination of operational readiness and again during test performance. The surveillance will be conducted by ORNL-ER. Additional audits may be conducted by the QA specialist per ORNL/ER-225 to verify that both field and laboratory work is being performed properly, when corrective actions or major changes to the QAPjP are necessary, or upon request of the ISV-TS project manager. The results of surveillances and audits will be made available to project and line management as well as to individuals contacted. Other audits besides those related to QA may also be conducted during the course of Phase 3 (e.g., Site safety and health audit), but such surveillances are governed by independent guidelines and requirements.

11. PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES

Routine equipment and facility maintenance and instrument services ensure the timely and effective completion of a measurement effort. The research and development nature of the ISV equipment is not conducive to a regular preventative maintenance schedule due to its infrequent use. Because of this infrequent use, the equipment is thoroughly checked prior to use and then monitored during testing (see Battelle, SOP No. 58, Rev. 9). Back-ups for every piece of critical equipment are not available. However, all critical process parameters have alternate or manual methods for data acquisition or measurement. For example, current measurements can be taken with a clamp-on ampmeter if automatic measurement systems fail. In addition, sufficient spare parts are on hand to allow repairs on the critical equipment. A complete listing of critical spare parts to be on-hand at ORNL during ISV operations for both the new off-gas hood and the LS ISV equipment is currently being prepared by PNL personnel. This infrequent usage of equipment also extends to the M&TE used in the field. This equipment is also calibrated and checked prior to use. The relatively short duration of use (less than 6 months) does not necessitate the need for calibration of the M&TE during actual ISV operations (PNL 1993). Finally, maintenance of analytical laboratory equipment is the responsibility of the manager of the analytical laboratory.

12. SPECIFIC PROJECT PROCEDURES

Several procedures written specifically for this project have already be been mentioned in this QAPjP. The following procedures have been specifically written to accommodate the collection and analysis of many of these Pit 1 samples.

ISV-TS-P01, Procedure for Driving Rods and Pipes for Determination of Pit 1 Boundaries and Remote Logging of Radioactivity, Rev. 1.

ISV-TS-P02, Procedure for Subsurface Sampling of Radioactively Contaminated Materials in and around ORNL Liquid Seepage Pits, Rev. 1.

ISV-TS-P03, Procedure for Laboratory Characterization of Trench Leachate and Groundwater Samples, Rev. 1.

ISV-TS-P04, Procedure for Laboratory Processing and Characterization of Radioactively Contaminated Soil and Seepage Pit/Trench Sludge, Rev. 1.

ISV-TS-P05, Procedure for Sampling and Analyses of ISV Off-gas System Components.

ISV-TS-P06, Procedure for Sampling and Analyses of ISV Product and Residuals (Soil and Groundwater).

The ISV-TS procedures 1-4 have can be found as appendices to the final characterization report (Spalding et al. 1994b), and ISV-TS-P05 and ISV-TS-P06 are presented in Appendix A of this QAPjP. Many specific, widely accepted analytical procedures are included and referenced in these project specific procedures. Such a practice is important from a QA perspective since all relevant information that may be needed by others in the future can be readily found. Any significant deviations from widely accepted procedures are noted in the ISV specific procedures. Finally, all operating procedures for the LS ISV equipment can be found in independent documents (Battelle SOP No. 58, Rev. 9 and Battelle SOP No. *TBD, Rev. *).

13. NONCONFORMANCES AND CORRECTIVE ACTION

Corrective action are initiated when *unplanned* deviations from procedural, contractual or regulatory requirements occur. The need for corrective action may be revealed by observations of measurement system responses, during data reasonableness checks (brief comparison of newly collected data against observed historical trends), when discrepancies are noted during instrument calibration, or during data analysis.

The SOP for the LS ISV equipment (Battelle, SOP No. 58, Rev. 9) provides extensive information/procedures to take when problems are detected with the LS ISV equipment via alarms or other measurement system responses. All other instruments or equipment found to be operating outside acceptable operating ranges (as specified in the applicable technical procedure or manufacturer's instructions) must be investigated and corrected by those parties responsible for their maintenance and calibration.

Since this project is strongly controlled by field conditions, it is expected and that procedures/techniques performed in the field will vary somewhat, e.g., actual sensor placement or sampling locations. However, it is not expected that minor deviations as those mentioned above will adversely affect quality and will not require corrective action. Explicit deviations from this QAPjP, however, will be documented on the test plan, test procedure, SOP, and/or in the Laboratory Record Book (including justification). In addition, such deviations must be documented on a Change Request Form (CRF) which is approved by the Project Manager or Task Leader and QA specialist (See Appendix B). In addition, any minor deviations from approved laboratory procedures that do not affect quality will also be noted in applicable logbooks, etc.

14. QUALITY ASSURANCE REPORTS TO MANAGEMENT

Deviations from this QA project plan, as well as the results of surveillances and audits, must be documented, described and reported to the Project Manager within twenty working days of the surveillance or audit. Problems identified by project personnel must be reported to the project manager immediately for resolution. Problems involving data quality or sample integrity, must be documented. Per ORNL/ER-225 major variances/deviations which adversely impact the success of the project must be documented on a CRF and transmitted to the ISV-TS project management and the QA specialist.

Final reports generated as a result of this ISV-TS must include a section on QA if measurement data is presented in the report. Items to be included are: results of QA objectives, audit/surveillance results, and deviations from this QAPjP or other SOPs that may have occurred. Finally, reports on the findings of this treatability study will undergo technical review, QA review, and final review by the ISV-TS project manager.

15. REFERENCES

Battelle Pacific Northwest Laboratory, *Safe Operation Procedure: ISV Large-Scale Mobile Process System*, SOP No. 58, Rev. 9, 86 pp. (In Review).

Battelle Pacific Northwest Laboratory, *Safe Operation Procedure: Large Scale ISV Off-Gas Hood,* SOP No. *TBD.

Battelle Pacific Northwest Laboratory, *Request for Proposal No. 293422, ISV Off-Gas Hood System*, July 1994.

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Standard Practice for Dissolution of Solid Waste by Lithium Metaborate Fusion, 1986. D4503-86. ASTM (American Society for Testing and Materials), Philadelphia, Pennsylvania, 19103.

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Appendix A

PROJECT SPECIFIC PROCEDURES

SUBJECT: SAMPLING OF IN SITU VITRIFICATION OFF-GAS HANDLING AND PROCESSING EQUIPMENT

I. Scope and Application

This procedure describes the techniques to sample various handling, containment, and processing equipment for the off-gas from large-scale in situ vitrification application. This equipment will be used for vitrification of ORNL seepage pits and trenches and other radioactively-contaminated soils sites. The off-gas equipment to be sampled includes interior hood panel surfaces, a roughing filter unit, stainless steel pipe, a HEPA prefilter assembly.

II. References

A. ORNL Health Physics Manual. 1990. ORNL/M-804. Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

B. Environmental Surveillance Procedures Quality Control Program. 1988. Martin Marietta Energy Systems, Inc, Oak Ridge, Tennessee.

C. ISV Large-Scale Safe Operating Procedure. 1995. Procedure 58, Revision 9, Battelle Pacific Northwest Laboratory, Richland, Washington.

D. Tracer-Level Radioactive Pilot-Scale Test of In Situ Vitrification For the Stabilization of Contaminated Soil Sites at ORNL. 1992. B. P. Spalding, G. K. Jacobs, N. W. Dunbar, M. T. Naney, J. S. Tixier, and T. D. Powell. ORNL/TM-12201. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

III. Summary of Method

Inside stainless steel surfaces of the ISV off-gas hood panels are sampled for deposited radioactivity after completion of ISV melting operations. Panel sections are removed by unclamping their J-lock retaining clamps after initial radiological survey to determine the level of contamination to be encountered during sampling. A 10 x 10 cm area is marked with indelible marker using a flexible cardboard template. Moistened ashless filter paper is then used to swab the circumscribed sampling area to remove particulates and radioactive contamination. Repeated swabbing is performed with additional paper until a bright metal surface is exposed indicative of complete particulate removal. All filter papers used are stored in seal-lock plastic bags which can be used for direct gamma ray spectroscopy of ^{137}Cs. After assay of ^{137}Cs activity on the filter paper, activity per unit area of hood panel is then calculated. An identical sampling method is used for the 16-in. diameter off-gas line at various points relative to the roughing filter and HEPA prefilter assembly. Flange joints in the off-gas pipe are unbolted to gain access to inside surfaces of the pipe. Inside surfaces of the HEPA and roughing filter housings can be sampled for particulate radioactive deposition in the same manner after removal of outer panels or filter housing door. The HEPA filters themselves are sampled by opening the metal frame of the HEPA, after removal from housing, and unfolding the pleated stack of filter material; sections of 10 x 10 cm size are cut out with a scissors and placed in seal-lock plastic bags. The cylindrical roughing filter bags are sampled after complete removal of a single bag from which samples are subsequently cut of a 10 x 10 cm square area.

IV. Comments

A. These sampling procedures were developed based on sampling experience with similar materials for the pilot-scale radioactive test of in situ vitrification carried out at ORNL in Solid

Waste Storage Area 6 in 1991 (Saplding et al. 1992). In that demonstration, off-gas hood panel surfaces, off-gas pipe, and HEPA filters were sampled.

B. The planned ISV field operations at ORNL seepage pit 1 will be carried out between June and September 1995 in four phases: an Operational Acceptance Test (OAT) which will test equipment and operations on the uncontaminated portion of the first melt setting; a first melt setting (Melt 1); a second overlapping melt setting (Melt 2); and a possible third overlapping melt setting (Melt 3). The OAT will not process any contaminated soil and will be followed by sampling of the noncontaminated off-gas system components by these procedures; these samplings will serve the dual function of training personnel in the procedures and testing the procedures themselves. Modification of this procedure may be required based on the post-OAT sampling. All subsequent post-melt sampling will likely encompass radioactive contamination.

V. Required Equipment and Apparatus

A. Filter paper, Whatman No. 41, coarse, ashless, 15.0 cm diameter (Cat. No. 28478-080 VWR Scientific, Inc., Atlanta, GA.).

B. Portable multichannel analyzer with 3-in. diameter sodium iodide (Thallium-activated) detector, D.C. battery operated (Odyssey 4, Aptec Nuclear Inc., North Tonawanda, NY, 716-754-7401), with PCMCA/WIN software for data acquisition and gamma ray spectroscopy.

C. Survey meter—ORNL-calibrated beta/gamma exposure meter for range 0.25 to 25 mR/hr.

D. Scaler, 6-decade readout, battery-powered (Model 1000, Ludlum Measurements, Inc., Sweetwater, TX 79556, 915-235-5494).

E. Glove bag, disposable, with double equipment openings, 3-mil thick polyethylene with integral gloves, 30 x 20 x 14 in. work space (Model SS-30-20H, Instruments for Research and Industry, Inc. Cheltenham. PA 19012, 215-379-3333).

VI. Safety

It is the policy of Martin Marietta Energy Systems to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with the requirements of Martin Marietta Corporation, DOE, and OSHA established standards and requirements. All field personnel will be provided with appropriate protective clothing and safety equipment.

Personal protective equipment, required while performing this procedure, will be specified on the approved Radiation Work permit. As a minimum, field personnel are required to wear safety shoes, company-issued clothing, and safety glasses while performing any part of this procedure. Refer to the site safety and health plan for detailed health and safety procedures. The site safety and health plan should be reviewed prior to beginning work employing this procedure. A Radiation Work Permit is required for use of this procedure in the seepage pits and trenches waste area grouping. All sampling locations should be surveyed for radiological contamination prior to entry for sampling operations; thus, the nature and level of contamination to be encountered can be determined and appropriate measures taken for both personnel protection and prevention of spread of contamination.

VII. Procedures

A. Sampling of Off-Gas Hood Panels and Surfaces

1. All personnel within the exclusion zone around the sampling point will wear yellow contamination area clothing, gloves, full face respirator with combination (HEPA and activated charcoal vapor adsorbing) cartridges, shoe covers, and hard hats. Respirators will not be removed until it has been determined that either 1) the hood panel section is not contaminated and, thus, respiratory protection is no longer required or 2) the hood panel section sample has been contained, stored, the hood panel section replaced on the hood shell, all tools decontaminated, and all personnel have been surveyed and found free of contamination. Details of required personal protective equipment, clothing, and radiation protection monitoring will be described in a required radiation work permit for application of this procedure. Sampling is a field activity and must only be carried out in the absence of precipitation. If precipitation begins during sampling operations, secure all contaminated surfaces and discontinue further sampling operations until precipitation ceases.

2. The hood panel section to be sampled is surveyed with the G-M meter probe prior to removal to determine which of the following three conditions is met:

   a. The maximum exposure rate at outside contact with the panel is less than 0.5 mR/hr.
   b. The maximum exposure rate at outside contact with the panel is greater than 0.5 mR/hr but less than 10 mR/hr.
   c. The maximum exposure rate at outside contact with the panel is greater than 10 mR/hr. (The maximum expected exposure rate for Pit 1 contaminated soil or sludge was 7 mR/hr; thus, this level of exposure is not expected for deposited particles on the off-gas hood surface.)

3. For hood panels with exposure rates less than 0.5 mR/hr, unclamp the J-lock panel connections securing the desired panel and remove the panel, holding the external J-lock frame, and place the panel on a plastic sheet on the ground surface. Immediately, survey the inside surface for beta/gamma contamination using the GM survey instrument to determine if the exposure rate is significantly higher on the inside surface of the panel. If inside surface exposure rate exceeds 0.5 mR/hr, immediately place hood panel in plastic bags and proceed with sampling as described under section 2.b (above). If inside surface exposure rate is also <0.5 mR/hr, proceed with sampling without additional containment. Mark a 10 x 10 cm square area on the inside surface using an indelible marker (e.g., Sharpie marking pen) using a flexible cardboard template. Many templates can be cut out prior to field operations from file folder material using a desk ruler to check dimensions. Record the GM meter gross count reading at the center of the circumscribed area prior to smear sampling. Swab the circumscribed area with Whatman No. 41 ashless filter paper previously moistened with distilled water. Fold over filter paper to present clean face to steel surface. Repeat as necessary to remove all particulate down to a bright shiny stainless steel surface. Place all filter paper smears into a seal-lock polyethylene bag. Mark bag with date, time, hood panel location, radiation reading, if any, and sampler's name. Record the GM meter gross count reading at the surface of the sampled area. Replace the hood panel section into the hood shell array and clamp into position.

4. For hood panels with exposure rate greater than 0.5 mR/hr but less than 10 mR/hr, unclamp the J-lock panel connections securing the desired panel and remove the panel, holding the external J-lock frame, and place the panel on a plastic sheet on the ground surface. Immediately, place the hood panel section into large plastic bag(s) to prevent spread of contamination. Survey the inside surface of the panel through the plastic bag for beta/gamma contamination using the GM survey instrument to determine if the exposure rate is significantly higher on the inside surface of the panel. If inside surface

exposure rate exceeds 10 mR/hr, immediately do not attempt to sample panel surface; proceed as described under section 2.c (above). If inside surface exposure rate is also <10 mR/hr, proceed with sampling. Place a marking pen, template, three moistened filter papers, and a polyethylene seal-lock bag in the panel containment bag. All subsequent operations must be carried out through the panel containment bag using excess sheeting to provide the required room for required manipulations. All sampling operations are carried out as described in section 3 (above) except that the operations are contained within a de facto "glove bag". Record the GM meter gross count reading through the plastic sheet at the surface of the sampled area. Remove the sealed filter paper polyethylene bag from the hood containment bag by sliding through one of the taped edges. Smear sample the outside surface of this removed polyethylene bag to confirm the absence of contamination. Replace the hood panel into the hood shell array and reclamp into position. Dispose of all containment sheeting as compactible low-level solid waste.

5. For hood panels with exposure rate greater than 10 mR/hr, sampling should not be attempted. Estimates of deposited ^{137}Cs can be obtained from direct probe readings using measured efficiencies for standards counted through panel sections. Perform several GM probe readings, using a scaler rather than the normal ratemeter function for counting intervals of 1 or 2 min. Perform background counting rates by placing the probe on uncontaminated panel sections such as spare parts section not previously used in hood panel array. Determine counting efficiency of probe-panel geometry by placing ^{137}Cs standard (i.e., dried filter paper standard in seal-lock plastic bag) immediately behind panel at the probing point. Using the net counting rate (sample minus background) and counting efficiency, calculate the activity of ^{137}Cs in the 100 cm^2 sample area.

B. Sampling of ISV Off-Gas Pipes and Housing Surfaces -

1. All personnel within the exclusion zone around the sampling point will wear yellow contamination area clothing, gloves, full face respirator with combination (HEPA and activated charcoal vapor adsorbing) cartridges, shoe covers, and hard hats. Respirators will not be removed until it has been determined that either 1) the pipe or housing section is not contaminated and, thus, respiratory protection is no longer required or 2) the pipe or housing section sample has been contained, stored, the hood panel section replaced on the hood shell, all tools decontaminated, and all personnel have been surveyed and found free of contamination. Details of required personal protective equipment, clothing, and radiation protection monitoring will be described in a required radiation work permit for application of this procedure. Sampling is a field activity and must only be carried out in the absence of precipitation. If precipitation begins during sampling operations, secure all contaminated surfaces and discontinue further sampling operations until precipitation ceases.

2. Pipe section inside surfaces will only be sampled during disassembly required for off-gas line reconfiguration between melt settings. Thus, the procedure for unbolting flange pipe connections is not covered specifically in this procedure; pipe end flanges will be covered with plastic or wooden plates immediately prior to sampling. Place plastic sheet and absorbent paper beneath the covered pipe flange. If external pipe exposure rates at greater than 10 mR/hr, sampling should not be attempted. Record external pipe surface exposure rate immediately before opening pipe end cover. Remove pipe end cover and probe internal pipe surfaces for exposure rate. If surface is less than 10 mR/hr, then sampling can precede; if greater than 10 mR/hr, sampling should not be attempted and only surface dose readings obtained. Scribe 10 x 10 cm square area and sample as described in section A.3 (above). Record exposure rate of the smeared surface area immediately after completion of the smearing. Label polyethylene seal-lock bag with date, time, pipe

position description including distance of smear area from flange, and the sampler's name. Record a sketch of pipe location in the off-gas train showing all pipe connections, flanges, bends, and off-gas components.

3. Inside surfaces of the roughing filter and HEPA filter housings can be sampled during changeout or anytime the off-gas system is off. Survey the outside surface of the housing to determine the exposure rate of the target surface. If surfaces are greater than 10 mR/hr, sampling should not be attempted; monitor inside surfaces with a GM probe contained in polyethylene bag to avoid its contamination. Remove housing door or panel onto an underlying plastic sheet with absorbent paper to catch any contaminated condensate or loose particulate. Determine the exposure rate of the target inside surface; if greater than 10 mR/hr, sampling should not be attempted. If less than 10 mR/hr, scribe and sample surface identical to the procedure for off-gas hood panels (section A.3 above). Replace housing door or panel. Prepare a sketch to show the actual location of the sampled area relative to the entire housing. Measure sample location distance for at least two edges of panel or housing fixtures or ports.

C. Sampling ISV Roughing Filter

1. All personnel within the exclusion zone around the sampling point will wear yellow contamination area clothing, gloves, full face respirator with combination (HEPA and activated charcoal vapor adsorbing) cartridges, shoe covers, and hard hats. Respirators will not be removed until it has been determined that either 1) the filter material is not contaminated and, thus, respiratory protection is no longer required or 2) the filter material sample has been contained, stored, the hood panel section replaced on the hood shell, all tools decontaminated, and all personnel have been surveyed and found free of contamination. Details of required personal protective equipment, clothing, and radiation protection monitoring will be described in a required radiation work permit for application of this procedure. Sampling is a field activity and must only be carried out in the absence of precipitation. If precipitation begins during sampling operations, secure all contaminated surfaces and discontinue further sampling operations until precipitation ceases.

2. Access to roughing filter elements is gained through removal of a panel from the off-gas hood work platform. The roughing filter is likely to contain the most radioactive contamination of any ISV off-gas system component. The roughing filter consists of 128 cylindrical ceramic bags (6 in. diameter x 24 in. long) clamped at both ends to a wire-mesh finger. Sampling will entail removal of at least two ceramic bags selected at random from the total. Rather than prolong exposure time to sampling personnel near the open housing, sampling will consist of complete removal and replacement of 2 to 3 bags following by reclosure of the housing. Bags will be placed directly into polyethylene bags which are sealed immediately, and labeled with date, time, filter position, and sampler's name.

3. If the exposure rate of the ceramic bag is greater than 10 mR/hr, sampling of a 10 x 10 cm section must be preformed in a glove bag. If less than 10 mR/hr, subsampling of the 100 cm^2 area can be performed in the field. In either case, cut a 10 x 10 cm square area from the center of the ceramic bag using a scissors after scribing the area using marking pen and template. Place the filter material sample into a seal-lock plastic bag for assay of ^{137}Cs activity. Prepare a duplicate 10 x 10 cm sample. Dispose of residual ceramic filter material as solid low-level radioactive waste.

D. Sampling of High Efficiency Particulate Air (HEPA) Filters -

1. All personnel within the exclusion zone around the sampling point will wear yellow contamination area clothing, gloves, full face respirator with combination (HEPA and activated charcoal vapor adsorbing) cartridges, shoe covers, and hard hats. Respirators will not be removed until it has been determined that either 1) the filter material is not contaminated and, thus, respiratory protection is no longer required or 2) the filter material sample has been contained, stored, the hood panel section replaced on the hood shell, all tools decontaminated, and all personnel have been surveyed and found free of contamination. Details of required personal protective equipment, clothing, and radiation protection monitoring will be described in a required radiation work permit for application of this procedure. Sampling is a field activity and must only be carried out in the absence of precipitation. If precipitation begins during sampling operations, secure all contaminated surfaces and discontinue further sampling operations until precipitation ceases.

2. After isolating the desired HEPA housing from the off-gas flow by closing both knife valves on each side of the housing, allow sufficient time for the housing wall to cool to ambient temperature to avoid sampling thermally hot materials. Each housing contains two HEPA filters and each is accessible from separate doors. Remove the door of the first HEPA filter housing after loosening and turning the latch-swing bolts. Place the door, outside downward, on a piece of plastic sheeting affixed with tape to the prefilter housing platform. Affix the HEPA filter changeout bag to the inside frame of the housing door per manufacturer's directions. Release HEPA filter internal clamps, working through the changeout bag and slide the HEPA filter out of the housing and into the bag. Seal off changeout bag with twist in the end and seal with tape. Remove bag end from housing frame.

3. Survey inside surface of prefilter housing with G-M meter to establish the activity of radioactive contamination on the inside walls of the housing. Inside surfaces of the housing can be sampled at this point for deposited particulate radioactivity by the procedure B above. Slide a new HEPA prefilter into position in the housing and secure in place with the internal clamp. Reattach door to housing frame and tighten down door bolts.

4. The borosilicate glass filter material can now be sampled by cutting sections of the fanfolded material. Sampling must take place inside the changeout bag using a secondary glove bag to manipulate the sampling tools. Place required sampling tools (screwdriver, scissors, plastic seal-lock sample bag) inside the glove bag prior to using it as a secondary enclosure for HEPA filter and changeout bag. The metal screen retaining the filter material must first be removed by snapping the several spot welds holding the screen face to the solid metal rectangular frame. There are approximately 72 fanfolds of filter material which are separated from each other by wire mesh spacers. Using scissors, cut at least three 10 x 10 cm square samples of filter material from fanfolds separated equally from the walls and each other within the fanfold stack (i.e., sample from approximate fanfolds number 18, 36, and 54 of the filter). Place all three samples in the prelabeled (date, time, filter number, and name) seal-lock plastic bag and remove from glove bag into secondary plastic bag.

5. Repeat the filter removal and sampling procedure for the second filter in the selected housing. Dispose of the bagged residual filters in the solid low-level radioactive waste B25 box after noting external radiation dose rate in the sampling log book.

E. Assay of Cesium-137 on ISV Off-Gas Smears and Filter Materials -

1. Cut sections of HEPA filter, ceramic rouging filter material, or smear-sample filter paper into a previously tared 20-mL capacity polypropylene scintillation vial. Weigh the capped vial after resealing lid to determine the net weight of material used. All manipulations must be performed wearing Level C personal protective equipment or manipulations must be performed in a laboratory hood while wearing rubber gloves. Sections of filter material totaling approximately 10 cm^2 should be used; for smear samples, the entire piece of filter paper should be used. Filter material can be folded as necessary to place the material inside the vial. A new pair of clean gloves should be worn for handling each sample of filter material to avoid any cross contamination of samples.

2. Using a Packard Auto-Gamma sample changer controlled by a Canberra Multichannel Analyzer, set up three regions-of-interest per manufacturer's directions. Two regions-of-interest should span the photopeaks for ^{137}Cs and ^{60}Co gamma rays at 0.66 MeV and 1.17/1.33 MeV. Set up a third region-of-interest below the lower limit of ^{137}Cs photopeak down to the lower limit of the gamma/x-ray spectrum. Use radioisotopic standards prepared on filter paper from certified solutions as documented in data set c:\123\radstan.wk1 or D:\excel\radstan.xls. Copies of the certificates of analyses of these standards are kept in reference file "Radioactive Standards" in room 292, Building 1505, Oak Ridge National Laboratory. Records of dilutions and handling of these certified standards are kept in the project notebooks of B. P. Spalding. Additional standards of ^{90}Sr in soil should also be measured along with background samples of uncontaminated soil.

3. Test the functioning of the sample changer and brief region-of-interest output to the serial printer. A brief region-of-interest prints out the sample number, date, time, counting interval (clock and live time), the upper and lower channel numbers of each region-of-interest, and the integral and area counts in each region-of-interest. Select 30 second counting intervals for a programmed number of samples (cycles) to include at least one standard of each isotope and one blank. Observe the accumulation of counts in each region-of-interest for each radioisotopic standard to ascertain that the limits of the regions-of-interest have been set up correctly to bracket each photopeak. Check the printout of each standard or blank to establish the correct printout format and printer functions.

4. Select the counting interval for each sample in the group of samples and standards to be assayed; usually 30 minute counting intervals yield adequate detection limits and, thus, are adequate for routine measurements. Select the number of samples (cycles) to be counted and activate the sample changer and multichannel analyzer controller per manufacturer's operation manuals. Position blanks and standards at regular intervals (e.g., every fifth position in the sample changer belt) so that the sequence of sample printouts can be checked against the order of samples; occasionally, the sampler changer can skip samples or fail to drop a sample into the counting well during unattended operations. With blanks and/or standards at regular intervals, only a small subset of samples, rather than an entire suite of up to 300 samples, may require recounting to determine which one in a group of five had been skipped. Setting the number of cycles for two or three times the number of samples should give multiple counts per sample by repeating counting operations on the sequence of vials two or three times, respectively.

5. Before unloading samples from the sample changer, manually record on the instrument printout the identity of each sample corresponding to each printout. Sample identity information includes whatever is written on the scintillation vial. After it has been verified that a printout has been obtained for each sample/standard/blank, samples can be removed from the changer. If printouts for some samples are missing, repeat the counting operations for those subsets which cannot be identified.

6. Record each sample's integral and area counts for each of the three regions-of-interest from the printout to a spreadsheet data set file (either Excel or Lotus 1-2-3) along with the printout data for each standard and blank. Using the area counts in the ^{137}Cs and ^{60}Co photopeak regions-of-interest for standards of these two isotopes and the computed activities of these standards, calculate the counting efficiency for each radioisotope; typical counting efficiencies should range between 8 and 14% [i.e., (counts per minute x 100)/disintegrations per minute]. Also compute "crosstalk" factors for both the ^{137}Cs and ^{60}Co standards to the lowest-energy region-of-interest integral; these factors are the ratio of counts per minute in the integral to the disintegrations per minute in the standard. Compute the counting efficiency of ^{90}Sr in the lowest region-of-interest from the net integral counting rate divided by the activity in the standard; net integral counting rate is the counts per minute in the ^{90}Sr region-of-interest minus the counting rate in this region-of-interest for a soil blank. The counts from ^{90}Sr (with the ^{90}Y daughter in equilibrium) standard in this lowest-energy region-of-interest are due to bremsstrahlung and non-specific x- or gamma-ray emissions; there is no photopeak for ^{90}Sr bremsstrahlung but rather an exponentially decreasing spectrum of x-rays with increasing energy or channel number.

7. Compute the activities of both ^{137}Cs and ^{60}Co in the samples from the samples area counting rate (area count divided by the counting interval) divided by the counting efficiency of the standards. The activity concentration of each isotope can then be computed by dividing the total activity by the net weight of sample in the scintillation vial. Alternately, activity per unit area of sample can be calculated by the dividing the total area counts by the area of filter material placed into the vial or, in the case of smear samples, the area of surface sampled by the filter paper. Area counts are computed automatically by the multichannel analyzer by computing an average baseline counts per channel, for the four channels on both sides of the photopeak region-of-interest, multiplied by the number of channels in the region-of-interest and subtracting this product from the integral counts. Thus, the area counts are background corrected. Therefore, in theory, a sample with no ^{137}Cs or ^{60}Co, would exhibit an area count of zero although the integral count could be substantially above a blank count due to other radioactivities in the sample.

8. Computing or estimating the activity of ^{90}Sr in a sample involves calculating the amount of bremsstrahlung in the sample which cannot be ascribed to other beta emissions, like those of both ^{137}Cs and ^{60}Co which emit beta particles in addition to gamma-rays, or x-rays due to Compton or photoelectric effects, or ambient x-ray backgrounds. This estimation of ^{90}Sr is performed by subtracting these other sources of x-rays in the ^{90}Sr bremsstrahlung region-of-interest. The contributions of both ^{137}Cs and ^{60}Co are computed from a sample's measured activities of these radioisotopes (see previous step) multiplied by the "crosstalk" factors computed using the radioisotopic standards; the sum of these two computations yield the integral counts in the ^{90}Sr region-of-interest due to these isotopes and are subtracted from a sample's integral for this region-of-interest. In addition, background integral counts are subtracted using the integral counts for uncontaminated soil (blanks). The net integral counting rate for a sample is computed and, thus, the activity of ^{90}Sr by dividing it by the counting efficiency for the ^{90}Sr standard. Due to the inherently low counting efficiency for ^{90}Sr for bremsstrahlung from soil (e.g. 4%) and the correction for other x-ray sources often resulting in calculating a small difference between large numbers, calculated activities can often be negative and this technique can, thus, only be used for estimation. In addition, any other hard beta-emitters in the sample, other than ^{137}Cs or ^{60}Co, may be included in "^{90}Sr" by this bremsstrahlung method.

VIII. Contamination Control

Sampling equipment will be protected from sources of contamination prior to sampling and there are no plans to decontaminate or clean sampling equipment prior to initial use. Equipment will be surveyed to determine that contamination, as measured by exposure rate, does not exceed 0.25 mR/hr. Post-use decontamination will be attempted by wiping tools with moistened towels, paper or cotton, until survey meter readings indicate exposure rates below 0.25 mR/hr. If exposure rates cannot be reduced below 0.25 mR/hr, sampling equipment will be disposed as solid radioactive waste.

IX. Quality Assurance/Quality Control (QA/QC)

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific health and safety measures, the minimum QA/QC requirements for this sampling activity are the following.

A. Control of deviations

When feasible, any departure from specified requirements will be justified and authorized prior to deviation from the requirements and sufficiently documented to allow repetition of the activity as actually performed.

B. QC Samples

There are no QC samples for these surface sampling procedures. Standards for ^{137}Cs on filter paper and filter materials will be prepared from commercial certified standard source solutions which certification certificates traceable to NIST standard reference material. Daily calibration and counting efficiency determination will be preformed and entered into the field record logbook.

C. Verification

Verification activities are required for the above practices including surveillance and periodic record audits.
PROCEDURE: ISV-TS-06

SUBJECT: SUBSURFACE SAMPLING OF RADIOACTIVELY CONTAMINATED PRODUCT AND SOILS AFTER IN SITU VITRIFICATION

I. Scope and Application

This procedure describes the use of a manually-operated steel tube sampler and hydraulically-operated split-spoon or Shelby tube samplers with internal plastic liner to obtain potential radioactively contaminated soil above and the use of core drill to sample underlying radioactive in situ vitrified (ISV) product in treated liquid waste seepage pits and trenches. The procedure is applicable to unconsolidated materials overlying consolidated materials like competent rock in contaminated environments.

II. References

A. JMC Environmentalists' Subsoil Probe Manual. 1993. Clements Associates Inc., R.R.#1 Box 186, Newton, Iowa 50208. (515)-792-8285.

B. ORNL Health Physics Manual. 1990. ORNL/M-804. Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

C. Environmental Surveillance Procedures Quality Control Program. 1988. Martin Marietta Energy Systems, Inc, Oak Ridge, Tennessee.

D. Basic Procedures for Soil Sampling and Core Drilling. 1974. W. L. Acker III, Acker Drill Company, Scranton, Pennsylvania.

E. Environmental Surveillance Procedures Quality Control Program. 1994. Revision #08. ES/ESH/INT-14. Martin Marietta Energy Systems, Oak Ridge, Tennessee. Procedures ESP-303-4, 303-5, and 303-6.

III. Summary of Method

A 1-in. diameter steel tube, internally lined with a clear polyester plastic tube, is used to collect undisturbed 36-in. long core sample segments from soil backfill overlying and around radioactive vitrified soil in treated liquid waste disposal trenches. The sampling tube is driven into the subsurface with an electric vibratory hammer and withdrawn using a hand-operated jack positioned on a 45-in. high elevated work platform. The sampling tube is withdrawn from the ground directly into a polyethylene bag where it can be surveyed for exposure rate at contact with the bag. Based on the measured exposure rate, the sampled segment, prior to shipment to an indoor processing laboratory, can be (1) removed from the bag and sampling tube, which can be reused in the next segment without decontamination, (2) removed from the sampling tube, which can be reused after decontamination, and retained in the plastic bag, or (3) maintained in the sampling tube and its bag. The insertion and withdrawal of the sampling tube is repeated to collect additional 36-in. segments until the total desired depth of sampling is attained or insertion refusal (i.e., no additional penetration within a 30 sec interval with the vibratory hammer) occurs on the top surface of vitrified product; additional attempts to drive the sampler may result in damage to the cutting shoe and/or sampler housing. The residual hole is widened using a Shelby tube sampler to the refusal depth. An AW-sized diamond-tipped core drill is then used to sample the vitrified product. Following breakthrough of the core drill through the vitrified product, underlying soil is sampled using driven soil sampling tube. Both core and underlying soil withdrawal is accomplished into polyethylene bag as described above.

IV. Comments

A. The initial soil sampling procedure is identical to project procedure ISV-TS-P02, "Subsurface Sampling of Radioactively Contaminated Materials In and Around ORNL Liquid Seepage Pits." The subsequent core drill sampling of ISV product is similar to ESP-303-6, "Rock Coring and Sample Collection." However, significant modifications in tools, materials, and methods have been established to control contamination and personnel exposure during sampling of known radioactively-contaminated materials in the ORNL seepage pits and trenches.

B. Expected Radionuclide Activities and Dose Rates from Pit 1 ISV Product Samples - The maximum exposure rates measured during sampling of the maximally-contaminated soil in Pit 1 was 7 mrem/hr at contact with a 1-in. diameter core; no dose rate was measurable at a 2-ft distance from the core samples. Because the ISV process will dilute this maximally-contaminated soil material a minimum of about 100-fold, the maximum exposure rates for all ISV product materials would be expected to be less than 0.1 mrem/hr at contact. Thus, given the anticipated time to retrieve a radioactive soil or ISV product core from the sampling tool and to place it into a storage box, i.e., <1 hr), such operations should result in a dose of less that 0.1 mrem to the most proximate worker and an undetectable dose to workers more than 5 ft away.

V. Required Equipment and Apparatus

A. JMC Environmentalists' Subsoil Probe (ESP) - 36-in. long by 1-in. OD plated-steel tube for use with internal liners to produce 36-in. long by 0.8-in. O.D. soil core (Clements Associates Inc. R.R.#1 Box 186, Newton, Iowa 50208, Part No. PN150).

B. Liners, 36-in. long by 0.9-in. O.D. clear Kodar polyethylene terephthalate (PETG) copolyester 6763 tubes with vinyl end caps (Clements Associates Inc, R.R.#1 Box 186, Newton, Iowa, Part No. PN153).

C. Polyethylene tubing, 2-5/8-in. wide by 1500-ft roll, 4-Mil thickness (McMaster-Carr Supply Co., P.O. Box 740100, Atlanta, GA, Part No. 2062T16).

D. Fixed-Mount Work Platform - 45-in. height with four steps and handrails, 500-pound capacity, with a 2-in. diameter hole in the center of work surface (McMaster-Carr Supply Co, P.O. Box 740100, Atlanta, GA, Part No. 8031T43).

E. Probe Rod Jack - for 1-in. OD probe rods and with variable chuck for 1/2-in., 5/8-in., and 7/8" rod or pipe (Geoprobe Systems, 607 Barney Street, Salina, KS 67401, (913)-825-1842. Part No. AT-99).

F. Bosch Rotary Hammer - 33.75 pounds, with adaptor for Environmentalists' Subsoil Probe (Clements Associates Inc, R.R.#1 Box 186, Newton, Iowa, Part No. PN215).

G. Enviropac-H Vault - a 45 by 34 x 28-in. enamel-coated steel box with weather-proof cover (Environmental Container Corporation, P.O. Box 161, Delafield, WI 53018-0161, (414)-646-2480).

H. Survey meter - ORNL-calibrated beta/gamma exposure meter for range 0.25 to 25 mR/hr.

I. AW-size diamond-tip core barrel assembly with AW drill rod and water swivel - Acker Drill Company, Scranton, Pennsylvania (Part No. 20322-68).

J. Mobile Drill Rig, trailer-mounted, hydraulically-operated, rotary drill machine, Mobile Drill Company, Indianapolis, Indiana.

K. Centrifugal Water Pump, Air-cooled, gasoline-powered, Gorman-Rupp Company, Mansfield, Ohio (Model 811/2A2-8).

L. Portable Water Tank, 100 gallons, with 1.5-in. diameter hose fitting, shut-off valve, and 1.5-in. hose

M. Core boxes, cardboard, wax covered, disposable for up to 2-in. diameter core.

N. Well Screen - 1-1/4 in. inside diameter, 1-5/8-in. outside diameter, male NPT top and flush point bottom, 24 to 60 in. length, 304 stainless steel, with 0.006 in. slot size, V-shaped (Cook Screen Technologies, Inc., Cincinnati, Ohio 45215).

VI. Safety

It is the policy of Martin Marietta Energy Systems to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with the requirements of Martin Marietta Corporation, DOE, and OSHA established standards and requirements. All field personnel will be provided with appropriate protective clothing and safety equipment.

Personal protective equipment, required while performing this procedure, will be specified on the approved Radiation Work permit. As a minimum, field personnel are required to wear safety shoes, company-issued clothing, and safety glasses while performing any part of this procedure. Refer to the site safety and health plan for detailed health and safety procedures. The site safety and health plan should be reviewed prior to beginning work employing this procedure. A Radiation Work Permit is required for use of this procedure in the seepage pits and trenches waste area grouping.

VII. Procedures

A. Sampling of Soil Overlying or Around ISV Product Zone

1. All personnel within the exclusion zone around the sampling point will wear yellow contamination area clothing, gloves, full face respirator with combination (HEPA and activated charcoal vapor adsorbing) cartridges, shoe covers, and hard hats. Respirators will not be removed until it has been determined that either 1) the sample is not contaminated and, thus, respiratory protection is no longer required or 2) the sample has been contained, stored, all tools decontaminated, and all personnel have been surveyed and found free of contamination. Details of required personal protective equipment, clothing, and radiation protection monitoring will be described in a required radiation work permit for application of this procedure.

2. Before sampling tube insertion starts at a particular location, an approximately 3-ft-square piece of polyethylene plastic sheet will be laid out over the ground to serve as protection against the spread of radioactive contamination should any be encountered during the process. An approximately 6-in. diameter hole will be cut with scissors in the center of the plastic sheet and positioned over the desired sampling point for access by the soil sampling tube. The work platform will then be positioned over the plastic sheet and sampling point hole and serve the secondary function of holding down the sheet on the ground surface. The ground surface will be surveyed with the G-M survey meter to establish the level or lack of contamination on the ground surface prior to start of sampling.

3. One end of a 7-ft-long section of polyethylene tubing will be attached to the plastic ground sheet around the central access hole using 2-in.-wide vinyl tape to seal all openings. The assembled sampling tube and liner will then be placed inside the polyethylene tubing, which can be compressed/folded to about 1-ft in length, and positioned at the desired central sampling location. Sufficient sampling tube extension sections will be added to the 3-ft section to be driven into the ground, so that a minimum of 3-ft of extension extends above the central hole of the work platform. A position on the protruding extension, exactly 36 in.es above the starting depth of the sampling tube, will be marked to establish the point at which to stop tube insertion.

4. The operator of the Bosch vibratory hammer will drive the sampling tube into the ground until the tube has attained 36 in.es of penetration or refusal. A second site worker, the data recorder, will measure the time required to complete the driving of the 36-in. tube and record that information in the field log book. Refusal is defined as no further insertion progress in 30 seconds; the data recorder will determine when this refusal criterion is fulfilled and signal the operator to stop the hammer. The operator will then lift the hammer off the sampling tube and disconnect electric power to the hammer.

5. The operator or data recorder will then use the G-M survey meter to determine the exposure rate on the plastic sheet and tool-containing tubing. All exposures, including background readings, will be recorded in the field notebook. If the sampling tube has been inserted more or less than the desired 36 in.es, the actual amount of insertion will be noted in the field log book. This will be determined with a measuring tape and recorded to the nearest 1/8-in..

6. Withdrawal of the 36-in. long sampler section can then be initiated. The probe rod jack will be positioned over the sampling tube extension extending above the work platform. The top of the polyethylene tubing will be attached to the top of the inserted section using either tape or nylon snap hose clamps. During withdrawal by jacking, the probe of the G-M survey meter should be positioned on the ground next to the sampling tube as it is being withdrawn; the probe may be attached via a clamp to a meter stick so that the data recorder is not positioned under the work platform and is removed from the sampling tube. Upon completing withdrawal, the sampling tube, still inside the polyethylene bag, is positioned next to the insertion hole and supported in an upright position by the central hole of the work platform. The sampling tube is surveyed with the G-M meter probe to determine which of the following three conditions is met:

   a. The maximum exposure rate at contact with the polyethylene bag sheath is less than 0.5 mR/hr.
   b. The maximum exposure rate at contact with the polyethylene bag sheath is greater than 0.5 mR/hr but less than 10 mR/hr.
   c. The maximum exposure rate at contact with the polyethylene bag sheath is greater than 10 mR/hr. (The maximum expected exposure rate for Pit 1 contaminated soil or sludge was 7 mR/hr; thus, this level of exposure is not expected.)

7. For bagged sampling tube with exposure rates less than 0.5 mR/hr, disconnect the sampling tube from overlying extension rods (See reference A for procedures for operating the Environmentalists' Subsoil Probe). Lay bagged sampling tube on the plastic sheet and remove clamp attaching bag to top of sampling tube. Perform an alpha activity survey on the sampling tube wall, starting from the top, while pulling the sampling tube from the polyethylene bag. If any alpha contamination >10,000 dpm/100 cm^2 is observed, cease sampling tube removal and reinsert it into the polyethylene bag; seal bag closed and label with date, time, alpha and G-M survey readings, sampling point, and depth information. Place bagged sampling tube in Enviropac-H vault for storage on site. If

alpha contamination on the sampling tube is <10,000 dpm/100cm^2 but >600 dpm/100cm^2, decontaminate the surface of the sampling tube by wiping with a damp cotton towel; repeat wiping until a reading the <600 dpm/100cm^2 is obtained on a dry sampling tube surface. If the sampling tube is found to be <600 dpm/100cm^2 throughout, complete removal from the bag and lay on plastic-covered ground surface. Express the liner and its contained soil core from the sampling tube using the dowel tool provided by the manufacturer. Place vinyl caps on each end of the clear plastic tube using black for bottom and red for top (or roof). Label tube with an indelible marker with the word "TOP" on the top of the core, and label with date, time, sampling location code, and depth interval. Measure length of soil core in the tube to the nearest 1/8 in. and record on tube and in field log book. Repeat G-M survey and record results on tube and in the field log book. Store the minimally-to-uncontaminated core section in labeled core box for transport to laboratory or storage in site utility trailer.

8. For bagged sampling tube with exposure rate greater than 0.5 mR/hr but less than 10 mR/hr, disconnect the sampling tube from overlying extension rods (See reference A for procedures for operating the Environmentalists' Subsoil Probe). Lay bagged sampling tube on the plastic sheet and clamp polyethylene bag near its point of attachment to the plastic ground sheet. Cut the bag beneath the clamp point so that the sampling tube is contained in the bag. Slide the top clamp off the sampling tube and push sampling tube into bag and clamp bag closed to completely seal off the contaminated sampling tube. The 3-ft sampling tube is now contained inside approximately 7-ft of bag if fully extended. Express the clear tube and contained soil core from the sampling tube and segregate sampling tube from core and liner in opposite ends of the bag. Clamp bag in two positions so that the bag can be cut in half with empty, used sampling tube in one half and core and liner in the other. Label bag containing core segment with date, time, sampling location information, and depth interval, and the label "TOP" on the bag at the top of the core section. Tape the ends of the bagged core liner securely to avoid the possibility of core material falling from the liner during storage and hauling. Store the core section in the Enviropac-H vault until radiation survey tags can be completed and arrangements made for transport to the laboratory. Repeat G-M survey of the expressed core and liner and record on the bag. Also record reading in the field log book. Survey the emptied sampling tube for exposure rate. If the exposure rate is now less than 0.5 mR/hr, perform alpha survey and decontaminate, if necessary, as in section G (above). If sampling tube is returned to an exposure rate less than 0.5 mR/hr, with or without decontamination, it can be reused to obtain the next core section within the same sampling hole.

9. For bagged sampling tube with exposure rate greater than 10 mR/hr, disconnect the sampling tube from overlying extension rods (See reference A for procedures for operating the Environmentalists' Subsoil probe). Lay bagged sampling tube on the plastic sheet and clamp polyethylene bag near its point of attachment to the plastic ground sheet. Cut the bag beneath the clamp point so that the sampling tube is contained in the bag. Slide the top clamp off the sampling tube and push sampling tube into bag and clamp bag closed to completely seal off the contaminated sampling tube. Label the bag with date, time, sampling location information, depth interval, the label "TOP" on the end with the top of the core, and exposure rate information. Fold over extra length of bag, tape ends of bag securely to avoid core material falling out either end of sampling tube, and place bagged sampler section in Enviropac-H vault. Repeat labeling information in the field log book.

10. Determine the depth of the sampling hole using a well water level electronic sensor and record in the field log book; if using the 1/2-in. diameter Solinst water level meter, an additional 3.5 in.es must be added to the apparent depth of hole reading because the tape

distance is measured from the water sensor point which is 3.5 in.es above the end of the probe weight. Compare with the measured depth of sampler insertion and recovered core length as recorded in the field log book. Survey the water level probe as it is removed from the sampling hole and decontaminate, if necessary, by wiping or pulling it through a damp cotton towel. Plan the required number of sampling tube extensions to position the sampling tube on top of the next depth interval to be sampled. Inspect the cutting shoe of the sampling probe and replace it per manufacturer's instructions if there is significant damage to its cutting edge. If polyethylene bag was consumed for containing either sampler or expressed liner and core, prepare a new 7-ft section of plastic tubing and ground sheet for use in containing the next segment of core. If only minimally-to-uncontaminated material was handled in the previous sample section, then reuse the bag for the next hole section.

11. When sampler is positioned to the desired depth for continued sampling, attach vibratory hammer and proceed to drive the sampler in another 36 in.es as in section D. Continue with sampler tube withdrawal as in subsequent steps. Any extension section which is driven/inserted into a previously contaminated depth interval (as determined from surveying the antecedent samples from the hole), must be withdrawn into polyethylene bag and surveyed prior to its removal from the sampling stem. Conditions for containment, decontamination, and reuse of extension sections, will be determined by the same criteria as for the sampler section (above). Any extension, with an exposure rate greater than 10 mR/hr, will be discarded as radioactive solid waste. Extensions with exposure rates less than 10 but greater than 0.5 mR/hr, will be decontaminated for reuse within the contaminated depth intervals of the same sampling point but will not be reused at another sampling point.

12. Following the completion of sampling to refusal on the top surface of the ISV product or the desired depth, the residual hole can be temporarily marked and plugged with a plastic survey stake. This hole protection is necessary during subsequent positioning of the drill rig trailer over the residual hole for subsequent core drilling. The core drilling may be performed at a later date and/or by a different personnel. If subsequent ISV product sampling is not to be preformed the same day, remove all plastic sheeting and protective equipment necessary for the soil sampling.

B. Core Sampling of ISV Product

1. Before core drilling starts at a particular location, an approximately 3-ft-square piece of polyethylene plastic sheet will be laid out over the ground to serve as protection against the spread of radioactive contamination should any be encountered during the process. An approximately 6-in. diameter hole will be cut with scissors in the center of the plastic sheet and positioned over the desired sampling point for access by the drill stem. The ground surface will be surveyed with the G-M survey meter to establish the level or lack of contamination on the ground surface prior to start of sampling. The drill rig trailer should be positioned with the drill drive head over the desired sampling point.

2. The first step in sampling is to widen the residual soil sampling hole (nominal 1-in.) to that required for the AW-sized core drill (i.e., 1 and 7/8 in.). The hole for coring is opened through the overlying soil by driving a "boulder-buster" bit (about 2 and 1/2 in. diameter) into the residual soil sampling hole, attached to the AW-sized drill rod to the depth of refusal. When the rod was withdrawn, a borehole resulted to the desired depth and of sufficient stability to allow completion of core drilling. The drill rod stem is driven with a 130-pound safety-hammer using the cathead hoist on the drill rig. Mark the side of the drill rod at ground level using chalk. On removal of the drill rod train, measure the total length of rod which penetrated into the ground. Measure the depth of

open hole by inserting a tape measure to the bottom; record measurements in the filed log book. If the previously sampled soil from a particular hole exhibited radioactive contamination above the 0.5 mR/hr action level, the rod sections should be withdrawn into plastic sleeving as described above for soil sampling. Regardless of previous contamination. the drill stem should be surveyed for contamination and treated as contaminated until survey with monitoring detectors indicates otherwise. If the rod train is contaminated but below 10 mR/hr, decontamination can should be attempted using moistened towels.

3. Core sampling is conducted using an AWG-sized (Diamond Core Drill Manufacturer's Association) rock core drill with diamond-tipped drill bit. The core drill train is inserted into the opened hole to the depth of refusal of the drive point drill rod train; note the depth of insertion by marking the drill stem about two ft above the measured depth of open hole and subtracting the remaining length of rod stem protruding from the hole. The drill flushing is accomplished by using a water swivel at the top of the drill stem, which was supplied with a portable centrifugal pump and a portable tank to hold water. The flow of water should be maintained low enough that no return of water is observed at the ground surface. Based on previous ISV core drilling experience, about an hour will usually be required to drill through the 3 to 5 ft of solidified ISV product. Breakthrough at the bottom of the ISV product is accompanied by a rapid drop in drill stem pressure and a rapid increase in rod train penetration rate. Quickly shut off the drill and the water supply via a valve on the water swivel so there will be minimum penetration into the underlying soil. If breakthrough is not attained after 5 ft of core barrel penetration, cease drilling because the core sampler will be filled if core recovery is complete. Best core recovery and integrity were obtained when using an AWG-sized double-tube core barrel (Acker Drill Co.) rather than a single-tube core barrel. Diamond-tipped drill bits have been necessary because carbide-tipped drill bits proved to be very slow at penetrating the ISV product, particularly crystallized product.

4. Withdraw the core barrel tube from the drill hole into plastic sleeve. Monitor the radiation field on the outside of the core sampling tube. Allow any water within the core barrel to drain back into the hole before lifting core barrel sampler completely from the hole. Place core barrel onto adsorbent paper overlying plastic sheeting. Unscrew drill bit using pipe wrenches to loosen if necessary. Remove core liner and lay out on absorbent paper. Slide core material from liner directly into second plastic tubing and then into waxed-cardboard core box for storage. Write the date, time, corehole number, section, and recorder's name on the plastic tubing with indelible marker. Label top and bottom of core to preserve correct orientation. Measure and record recovered core length in field notebook. Place any loose or small core fragments into seal-lock plastic bags noting where they appeared in the core profile. Note also the depth of penetration of the core sampler from start to finish of coring. Measure also the depth of open core hole using the retractable measuring tape.

5. If additional ISV product depth sampling is required, reassemble core barrel sampler and insert into the residual core hole. Record depth of tool penetration relative to depth of open hole before tool insertion. Repeat steps 3 and 4 above until the entire depth of ISV product is sampled until breakthrough into underlying unmelted material is observed. If core recovery is less than 75% over the entire depth of core sampler penetration, cease continued core sampling until the causes of poor core recovery have been identified by the project manager. Possible causes are to be recorded in the filed notebook and approved by the project manager.

C. Soil Sampling Beneath ISV Product

1. After removal of the core barrel sampler, the soil beneath the ISV product is sampled with an electric vibratory hammer-driven sampler (Method A above) by attaching sufficient extension rods to reach the hole bottom. Measure the residual open hole, before and after each 3-ft of penetration. Collect only a maximum of two 3-ft soil sections beneath each ISV product core or until tool refusal. The purpose of sampling beneath the ISV product zone is to check for any residual radioactive contamination beneath the melt zone; thus, only a few ft of soil sample are required.

2. Label all sample tube liners with date, time, orientation, radiation readings as previously. Record penetration times and depths in the field notebook. Measure depth of open hole after last sampling. Note the elevation of any perched water in the open hole using the electric ground water level meter.

D. Post-Melt Groundwater Monitoring Well Installation -

1. If a groundwater elevation monitoring and sampling well is desired, the residual core and soil sampling hole can be fitted with stainless-steel casing. Attach a 5-ft section of continuous well screen to stainless-steel pipe using 1.25-in. diameter stock. This size pipe and its associated coupling will fit easily into the residual borehole made by AW-sized core barrel.

2. Continue to add pipe sections until a length of 5-ft protrudes from the core hole. At this point, the well screen should be resting on top of the 1-in. diameter soil core hole beneath the ISV product. Drive the well screen an additional 3-ft into this depth interval using the electric jack hammer. Record the total length of well screen and riser pipe placed into the borehole. Record the residual height above ground surface of the protruding pipe.

3. Measure the depth to bottom of the well using the electric water level meter probe. Note also the depth at which any standing water is observed recording also the time and date of the measurement. Record any radiation readings on the water level probe.

4. Survey in the grid coordinates and elevation of top of casing to be used as reference elevation point for all future water elevation measurements.

VIII. Contamination Control

Sampling tools and equipment will be protected from sources of contamination prior to sampling and there are no plans to decontaminate or clean sampling equipment prior to initial use. Equipment will be surveyed to determine that contamination, as measured by exposure rate, does not exceed 0.25 mR/hr. Post-use decontamination will be attempted by wiping tools with moistened towels, paper or cotton, until survey meter readings indicate exposure rates below 0.25 mR/hr. If exposure rates cannot be reduced below 0.25 mR/hr, sampling equipment will be disposed as solid radioactive waste.

IX. Quality Assurance/Quality Control (QA/QC)

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific health and safety measures, the minimum QA/QC requirements for this sampling activity are the following.

A. Control of deviations

When feasible, any departure from specified requirements will be justified and authorized prior to deviation from the requirements and sufficiently documented to allow repetition of the activity as actually performed.

B. QC Samples

There are no QC samples for this ISV product and soil sampling procedure.

C. Verification

Verification activities are required for the above practices including surveillance and periodic record audits. These activities will be documented and become part of the complete project records. Core recovery is always compared to depth of sampling tool penetration. Less than 75% core recovery will require project manager written approval for acceptance of sample and explanation of the cause of poor recovery.

Appendix B

CHANGE REQUEST FORM

CHANGE REQUEST FORM

Project No.__________ Change No.__________ Page ____ of ___

Project: ____

Applicable Document: ____

Description: ____

____

____

____

Reason for Change: ____

____

____

Recommended disposition: ____

____

____

Impact on present and completed work: ____

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Requested by: ______________________________ (Field/Project Manger)

Approval:
Energy Systems Project Manager: ______________________________

Environmental Restoration QAS: ______________________________

Other: ______________________________

Other: ______________________________

NOTE: The Energy Systems Project Manager is notified of the need for changes in project cost, schedule, or scope.

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