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In Situ Vitrification Treatability Study Work Plan

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IN SITU VITRIFICATION WORK PLAN
FOR THE
BURIED WASTE PROGRAM

APPROVED: *[signature]* 3/31/89

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ABSTRACT

The Buried Waste Program was established in October, 1987 to accelerate the studies needed to develop a recommended long-term management plan for the buried mixed waste at the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory. The In Situ Vitrification Project is being conducted in a Comprehensive Environmental Response, Compensation, and Liability Act Feasibility Study format to identify methods for the long-term management of the mixed waste buried.

This In Situ Vitrification Treatability Study Work Plan gives a brief description of the site, work breakdown structure, and project organization; the in situ vitrification technology; the purpose of the tests and demonstrations; and the equipment and materials required for the tests and demonstration.

FOREWORD

Before the establishment of the EG&G Idaho, Inc. (EG&G) current Buried Waste Program (BWP), EG&G remove extra space was chartered to perform studies and provide the U.S. Department of Energy Idaho Operations Office (DOE-ID) with a long-term management recommendation for the buried waste at the Radioactive Waste Management Complex (RWMC). With confirmation in the Summer of 1987 of plutonium migration to sediment beds located below the Surface Disposal Area (SDA) at the RWMC and carbon tetrachloride in the aquifer, the BWP was established in October 1987 to accelerate the studies needed to develop a recommended long-term management plan. The BWP will investigate the viability, effectiveness, cost and safety of remedial actions (including in situ vitrification) using a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Study (FS) format and factor it into the determination of long-range management of the SDA. The present In Situ Vitrification (ISV) Project is being conducted in the CERCLA FS format. ISV will be considered for use in remediation of the mixed-transuranic (TRU) waste and the mixed-low level waste buried at the SDA. As part of this treatability study, a number of bench-scale and engineering-scale ISV tests and intermediate-scale and large-scale ISV demonstrations will be carried out. These tests and demonstrations are described in more detail in this work plan.

During FY-1990, the BWP will recommend a long-term management strategy to DOE-ID for the SDA. Alternatives include, but are not limited to the following: (a) leave waste in place with enhanced monitoring; (b) leave waste in place after treatment via some enhanced confinement or in situ immobilization technique and perform enhanced monitoring; and (c) retrieve, process, and dispose of the wastes in a final repository. The ISV technology by itself will address only the contaminants still located at or near the original burial site. The results of mathematical models indicate that only about 20% of the volatile solvents originally buried remain in their original location, the remainder having evaporated or migrated into surrounding soil or bedrock.[1] It is probable that ISV will be combined with a vapor extraction technique for removing volatile organics from the bedrock underlying the site. It is also possible that the vitrified material will later be retrieved for placement in a waste depository. For further information on the BWP and the SDA remedial action program, see the BWP Program Management Plan (PMP).[1]

CONTENTS

FIGURES

TABLES

ACRONYMS

ADM	Action Description Memo
ARAR	Applicable or Relevant and Appropriate Requirement
BWP	Buried Waste Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOE-ID	U.S. Department of Energy-Idaho Operations Office
DOP	Detailed Operating Procedure
EA	Environmental Assessment
EG&G	EG&G Idaho, Inc.
EPA	Environmental Protection Agency
F&OR	Functional and Operational Requirement
HEPA	High-Efficiency Particulate Air
INEL	Idaho National Engineering Laboratory
ISV	In Situ Vitrification
Mo	Molybdenum
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
OSR	Operational Safety Requirement
PNL	Pacific Northwest Laboratory (Battelle)
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SARA	Superfund Amendments and Reauthorization Act
TRU	Transuranic
WBS	Work Breakdown Structure

1. INTRODUCTION

1.1 CERCLA Investigation

The Buried Waste Program (BWP) at the Idaho National Engineering Laboratory (INEL) anticipates conducting a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) for the U.S. Department of Energy Idaho Operations Office (DOE-ID). A treatability study on the in situ vitrification (ISV) technology will be conducted for this feasibility study. The scope of the treatability study includes the remediation of mixed-low-level waste and mixed-transuranic (TRU) waste[a] buried at the Subsurface Disposal Area (SDA) located at the Radioactive Waste Management Complex (RWMC). The information obtained during this study will also be available to those who are investigating the remediation of other areas. The primary objectives of this treatability study are to:[2]

- Provide sufficient information for the ISV technology to be fully developed and evaluated during the detailed analysis of the remediation alternatives and support remedial design of the ISV technology if it is selected as part of the final remediation,

- Reduce cost and performance uncertainties for the ISV technology alternative to acceptable levels so that a remedy can be selected.

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a. TRU waste as defined in DOE Order 5820.2, is radioactive material that, without regard to source or form, is contaminated with alpha-emitting radionuclides with an atomic number greater than 92, half-lives greater than 20 years, and concentrations greater than 100 nCi/g.

1.2 Buried Waste Program Scope

A BWP has been established within EG&G Idaho, Inc. (EG&G), contractor to DOE-ID, to manage the environmental remediation at the SDA. Currently, the only EPA recognized contaminants of concern at the RWMC are volatile organics. The BWP is conducting a Resource Conservation Recovery Act (RCRA) Facility Investigation (RFI) to evaluate the nature and extent of the release of volatile organics and to gather data to support the corrective measure study.[3] In anticipation of conducting a CERCLA RI/FS, a radionuclide investigation is being conducted including the study of waste transport in the surficial sediments and vadose zone, contouring the surface of the SDA for better surface water drainage, and retrieval and ISV treatability studies[3].

1.3 ISV Work Plan Organization

This work plan is organized as follows. Section 2, Site Background and Project Description, contains a description of the site, work breakdown structure, and project organization. Remedial Technology Description, Section 3, briefly describes the ISV technology. Section 4, Test Objectives, contains the purpose of the demonstrations, the data to be collected from the demonstrations, and how the data will be used to evaluate the technology. Section 5, Installation and Startup, describes the unique equipment required for the intermediate- and large-scale ISV demonstrations.

2. SITE BACKGROUND AND PROJECT DESCRIPTION

2.1 Site Background

The present treatability study considers the feasibility of ISV for the remediation of mixed waste buried at the INEL. Mixed waste was buried at the SDA from 1954 to 1970. For further background information on the history of waste disposal at the INEL, see references 1, 3 and 4.

2.2 Schedule

The BWP uses a tiered approach to scheduling in accordance with the BWP Program Management Plan (PMP). Level 0 consist of DOE-Headquarters (DOE-HQ) milestones. The ISV project is supporting two DOE-HQ milestones, listed in Section 4.3 of this plan.

The Level 1 (Program) schedule and logic diagram, shown in Figure 7-3 of the BWP PMP, is made up of the DOE-ID milestones along with other significant cost account activities directly supporting these milestones. The DOE-ID milestones related specifically to this project are also listed in Section 4.3 of this plan. This schedule will be the primary document DOE-ID will use for statusing program work and giving overall program direction to EG&G.

The Level 2 (Cost Account) schedule (Figure 7-3 in the BWP PMP) adds detail to the Level 1 schedule and is generated by integrating schedule and logic diagrams for each of the program work packages. The Level 2 schedule is the principal vehicle for the EG&G BWP Program Manager to track progress and make program control decisions.

The Level 3 schedules are contained in each work package. The work package is designed to facilitate work control and earned value reporting of cost and schedule status. Work package managers and individual contributors may generate and use schedules of greater detail than described above, but these will not be under control of the formal schedule system.

2.3 Performance Criteria

The ISV Project and BWP performance criteria will be defined in the ARARs document.

2.4 Cost and Manpower Estimates

The ISV Project is funded through the BWP, which is funded through DOE's Congressional appropriations. The BWP anticipated funding levels are shown in Section 7.4 of the BWP Program Management Plan.

Cost and Manpower estimates for the ISV Project are made from Level 3 schedules. Anticipated funding for the ISV Project is shown below in Table 2-1. Current funding levels represent direction from DOE during FY-1989 to accelerate the program.

TABLE 2-1. ANTICIPATED FUNDING FOR THE ISV PROJECT
(in thousands of dollars)

Funding	FY-1989	FY-1990	FY-1991	FY-1992	FY-1993	FY-1994
Target Level	2,000	3,500	4,000	8,400	6,800	13,500

2.5 Organizational Structure

The overall responsibility for the BWP and its management are described in Section 4.1 of the BWP Program Management Plan. The BWP has established task managers or cost account managers for the areas indicated on the BWP organizational diagram shown in Figure 2-1. Task managers and cost account managers are responsible for managing scope, cost, schedule, and technical adequacy for their area. Cost account managers have the additional responsibility of establishing and approving work packages. Functional support is utilized for the areas of safety and quality. A detailed description of responsibilities is given in Section 4.2 of the BWP Program Management Plan.

The ISV project organizational structure is illustrated in Figure 2-2. This organization is the component of the BWP organization responsible for conducting the ISV Project.

March 1989

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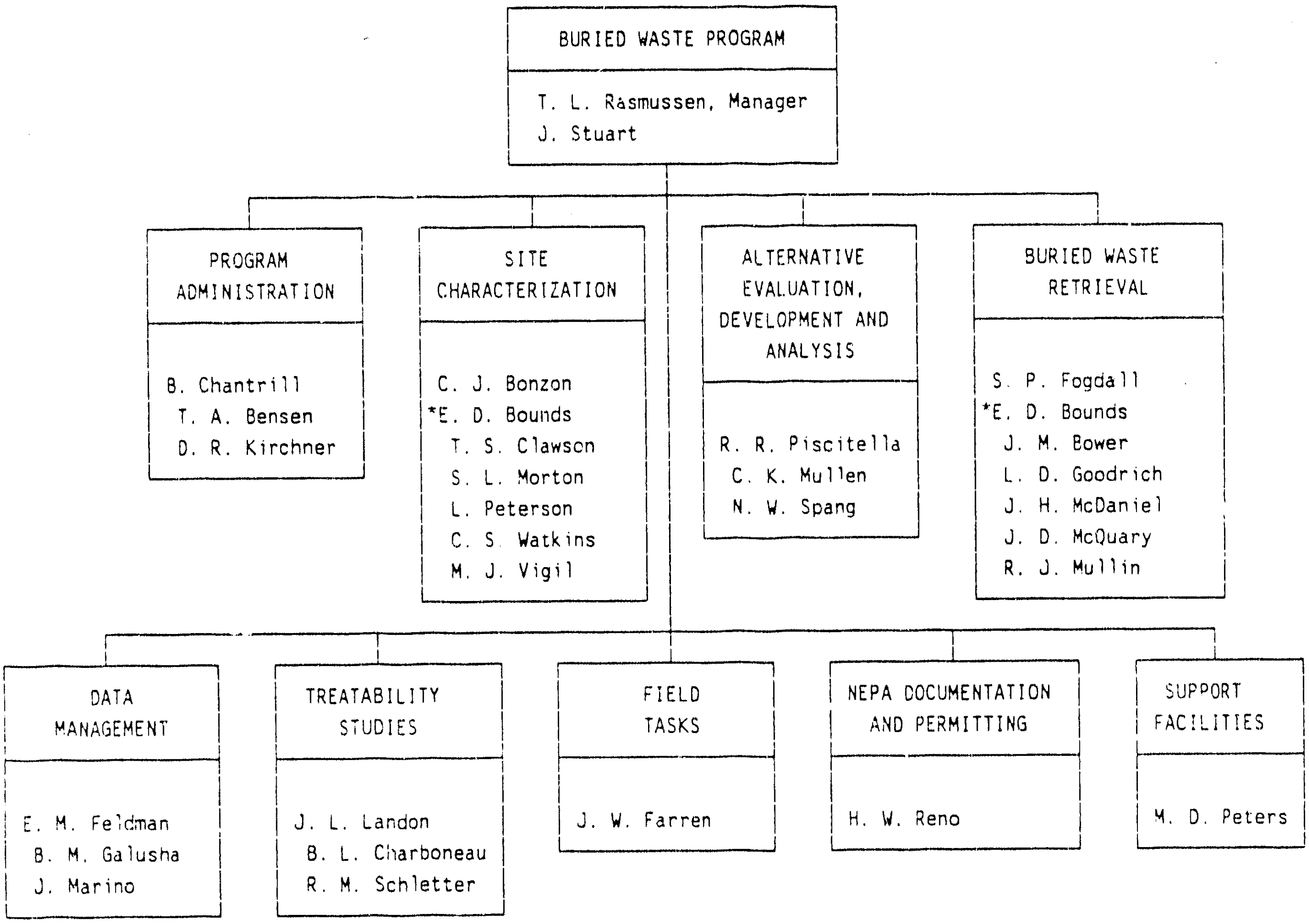

*Dual Capacity

Figure 2-1. BWP organizational responsibilities.

March 1989

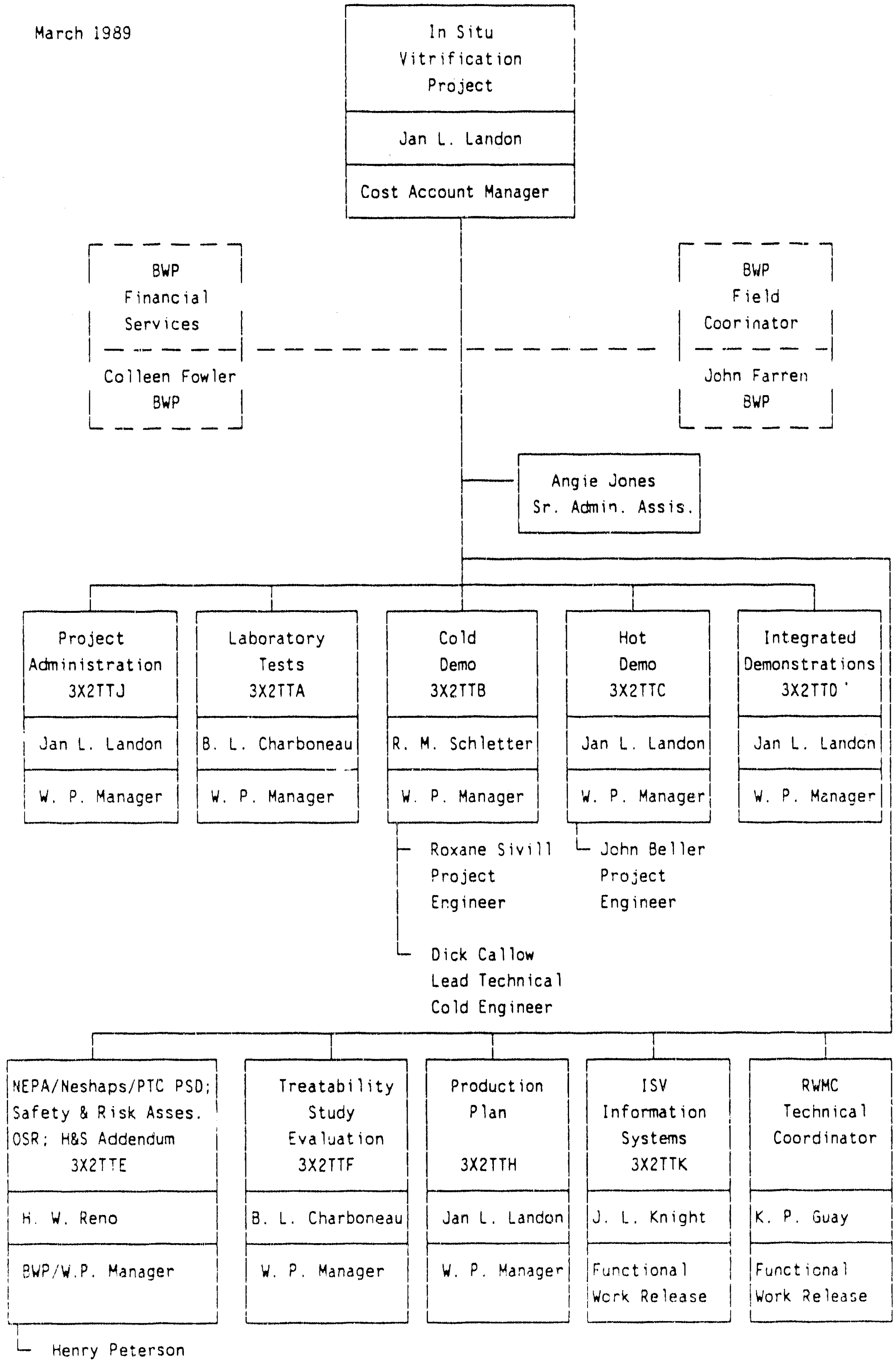

Figure 2-2. ISV Project Organizational Structure

3. REMEDIAL TECHNOLOGY DESCRIPTION

3.1 Technology Overview

In situ vitrification is a thermal treatment process that converts contaminated soil and waste to a chemically inert stable glass and crystalline product. The process has been developed by Battelle at PNL in Richland, Washington, for the DOE, with emphasis on the in-place stabilization of TRU-contaminated soils.[5] A square array of four electrodes [graphite with or without a molybdenum (Mo) core] is inserted into the ground to the desired treatment depth as shown in Figure 3-1. Because dry soil is a poor electrical conductor, a conductive mixture of flaked graphite and glass frit is placed between the electrodes to act as a starter path. An electrical potential is applied to the electrodes to establish an electrical current in the starter path. The resultant power heats the starter path and surrounding soil initially to 3600^{o}F, well above soil-melting temperatures of 2000 to 2550^{o}F. The graphite starter path is eventually consumed by oxidation, and the current is transferred to the molten soil, the operating temperature being between 2650 and 3600^{o}F. As the molten zone grows, it incorporates any radionuclides and nonvolatile hazardous elements, such as heavy metals, that may be present. The high temperature of the process destroys organic components by pyrolysis. The by-products of pyrolysis migrate to the surface of the molten zone, where they burn in the presence of air. A hood placed over the area being vitrified directs the gaseous effluents to an off-gas treatment system.

The development of ISV began in 1980, and since that time numerous experimental tests under a variety of conditions and with a variety of waste types have been conducted.[5] Table 3-1 describes the different scales of tests that have been used during its development. The large-scale ISV demonstrations have culminated in a large-scale ISV demonstration radioactive test on a radioactively contaminated soil site at the PNL site during June 1987. A series of tests that include all scales of testing have been created to evaluate the applicability of the ISV technology to the INEL buried mixed waste. Development of the ISV

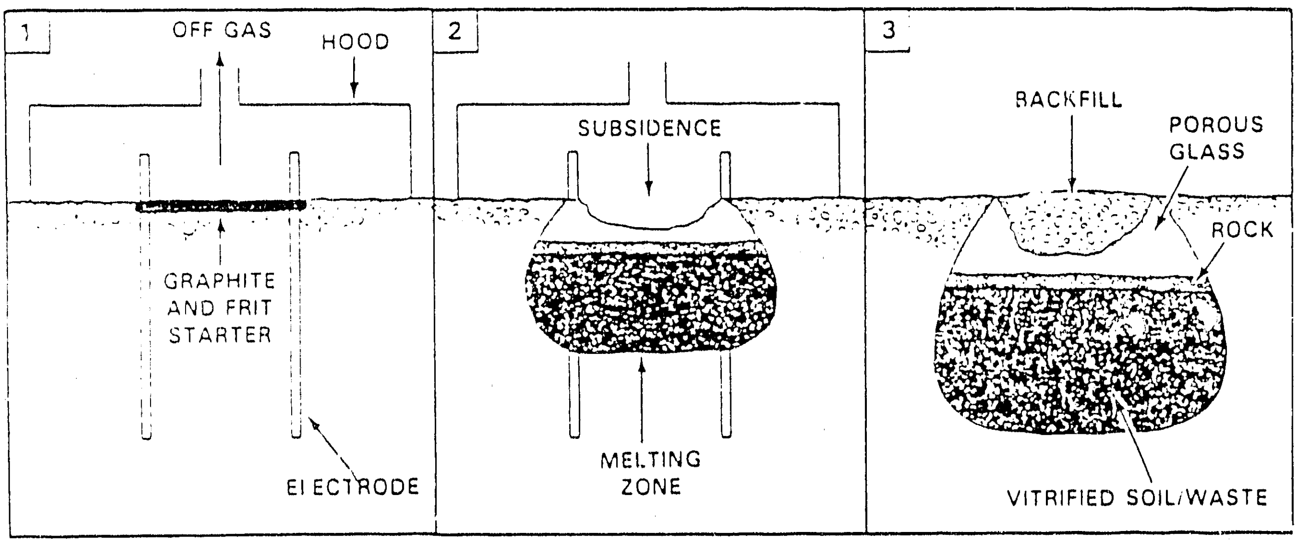

Figure 3-1. Sequence of the ISV process.

technology is being expanded to facilitate its application to the INEL Site. The two major modifications currently identified are (1) a technique to allow the electrodes to be lowered into the ground as the process proceeds downward rather than requiring the electrode to be placed into the waste area prior to the process being initiated, and (2) the identification and application of a new chemical additive for the soil. Chemical additives are being evaluated for enhancing the solubility of metals and reduce the viscosity of the molten mass to facilitate the treatment of the gases generated during the process.

TABLE 3-1. TESTING UNITS FOR DEVELOPING ISV TECHNOLOGY

Equipment Size	Electrode Separation (ft)	Vitrified Mass per Setting	Completed As of 9/30/88
Bench-Scale	0.36	2 to 22 lbs	12
Engineering-Scale	0.7 to 1.2	0.05 to 1 ton	26
Intermediate-Scale	3.0 to 4.9	10 to 50 ton	16
Large-Scale	11.5 to 18.0	400 to 800 ton	5

3.2 Work Description

The specific activities of the ISV project are outlined in the work breakdown structure (WBS) for the project. The WBS contains the following tasks:

1.1 Project Administration
1.2 Treatability Study Evaluation
1.3 Laboratory Tests
1.4 Intermediate-Scale ISV Demonstration
1.5 Large-Scale ISV Demonstration
1.6 Integrated Demonstration
1.7 Production ISV Development
1.8 National Environmental Policy Act (NEPA) Documentation and Permitting
1.9 Information Systems

The WBS presented in Table 3-2 identifies subtasks to be performed.

TABLE 3-2. ISV TREATABILITY STUDY WORK BREAKDOWN STRUCTURE

WBS Number	Title
1.0	In Situ Vitrification Project
1.1	Project Administration
1.1.1	Project Management
1.1.2	ISV Project Plan
1.1.3	BWP Coordination
1.1.4	U.S. Department of Energy (DOE) Interface
1.1.5	Pacific Northwest Laboratory (PNL) Primary Interface
1.1.6	Community Relations
1.1.7	Staffing
1.2	Treatability Study Evaluation
1.2.1	Baseline Sampling and Analysis Plan
1.2.2	Baseline Health and Safety Plan
1.2.3	Applicable or Relevant and Appropriate Requirements (ARARs)
1.2.4	Treatability Study Engineering Analyses of Existing ISV Data
1.2.5	Review and Evaluate Treatability Study Data
1.2.6	Peer Review of Treatability Study Evaluation
1.2.7	Preliminary Recommendation Report (end of FY-1990)
1.2.8	Treatability Study Evaluation Report (end of FY-1992)
1.3	Laboratory Tests
1.3.1	Crucible Test
1.3.1.1	Chemical Flux Evaluation
1.3.1.2	Crucible PNL Plan
1.3.1.3	Performance of Crucible Tests
1.3.1.4	Sample and Analysis
1.3.1.5	Draft Report
1.3.2	Bench-Scale ISV Tests
1.3.2.1	Bench-Scale PNL Plan
1.3.2.2	Performance of Bench-Scale ISV Tests
1.3.2.3	Sample and Analysis
1.3.2.4	Draft Report
1.3.3	Engineering-Scale ISV Tests
1.3.3.1	Engineering-Scale PNL Plan
1.3.3.2	Performance of Engineering-Scale ISV Tests
1.3.3.3	Sample and Analysis
1.3.3.4	Draft Report

TABLE 3-2. (continued)

WBS Number	Title
1.3.4	Final Report
1.4	Intermediate-Scale ISV Demonstration
1.4.1	Site Preparation
1.4.1.1	Site Selection
1.4.1.2	Utilities
1.4.1.3	Clearing/Preparation
1.4.1.4	Facility Procurement
1.4.1.5	Security
1.4.1.6	Fire Protection
1.4.1.7	Craft Support
1.4.1.8	Safety
1.4.2	INEL Test Requirements and Objectives
1.4.2.1	Sampling and Analysis Plan
1.4.2.2	Safety and Risk Assessment
1.4.2.3	Operational Safety Requirements (OSRs)
1.4.2.4	Health and Safety Plan
1.4.2.5	Test Objectives Document
1.4.2.6	Detailed Operating Procedures (DOPs)
1.4.2.7	Environmental Checklist
1.4.2.8	National Emission Standards for Hazardous Air Pollutants (NESHAPS) Letter
1.4.2.9	Readiness Review
1.4.2.10	Training
1.4.2.11	Sample Collection/Shipping
1.4.2.12	Data Validation (QA)
1.4.2.13	Document Reviews
1.4.2.14	Quality
1.4.2.15	Safety
1.4.2.16	Waste Disposal
1.4.3	PNL Support
1.4.3.1	Approvals from DOE
1.4.3.2	Project Management
1.4.3.3	Test Documents/Reviews
1.4.3.4	Electrode Feeding Hood System
1.4.3.5	ISV System
1.4.3.6	Testing
1.4.3.7	PNL Interface
1.4.3.8	Sample Analysis
1.4.3.9	Reports
1.4.3.10	Training
1.4.3.11	Readiness Review

TABLE 3-2. (continued)

WBS Number	Title
1 4.4	Reports
1.4.4.1	Technical Support
1.4.4.2	Data Assessment
1.4.4.3	Review
1.4.4.4	Publication
1.4.5	Demonstration Management
1.4.5.1	Prepare WBS
1.4.5.2	Track Project
1.4.5.3	BWP Interface
1.4.5.4	RWMC Interface
1.4.5.5	Travel
1.4.5.6	Contingency
1.4.5.7	Technical Support
1.5 Large-Scale ISV Demonstration	
1.5.1	Project Requirements
1.5.1.1	Demonstration Requirements
1.5.1.2	ARARs
1.5.1.3	Site Requirements
1.5.1.4	Confinement Requirements
1.5.1.5	Functional and Operational Requirements (F&ORs) and Confinement
1.5.2	ISV System
1.5.2.1	Design
1.5.2.2	Procurement
1.5.2.3	Fabrication
1.5.2.4	Shipping
1.5.2.5	Installation
1.5.3	Site Preparation
1.5.3.1	Site Selection
1.5.3.2	Site Sampling
1.5.3.3	Support Buildings
1.5.3.4	Power Upgrade
1.5.3.5	Fire Protection and Security Coordination
1.5.3.6	Road and Surface Improvements

TABLE 3-2. (continued)

WBS Number	Title
1.5.4	Documentation
1.5.4.1	Addendum to Work Plan
1.5.4.2	Permitting
1.5.4.3	Health and Safety Plan
1.5.4.4	Sampling and Analysis Plan
1.5.4.5	Safety Assessment
1.5.4.6	DOPs
1.5.4.7	Final Report
1.5.4.8	Risk Analysis
1.5.5	Readiness Review
1.5.5.1	Prepare Operational Readiness Review Documentation
1.5.5.2	Operational Readiness Review
1.5.6	Testing
1.5.6.1	Nonradioactive Tests
1.5.6.2	Radioactive Tests
1.5.6.3	Sampling and Analysis
1.6	Integrated Demonstration
1.6.1	Technical Assessment
1.6.2	Project Requirements
1.6.2.1	Demonstration Requirements
1.6.2.2	ARARs
1.6.2.3	Site Requirements
1.6.2.4	Confinement Requirements
1.6.2.5	F&ORs
1.6.3	Integrated System
1.6.3.1	Design
1.6.3.2	Procurement
1.6.3.3	Fabrication
1.6.3.4	Shipping
1.6.3.5	Installation
1.6.4	Site Preparation
1.6.4.1	Site Selection
1.6.4.2	Site Sampling

TABLE 3-2. (continued)

WBS Number	Title
1.6.4.3	Support Buildings
1.6.4.4	Power Upgrade
1.6.4.5	Fire Protection and Security Coordination
1.6.4.6	Road and Surface Improvements
1.6.5	Documentation
1.6.5.1	Addendum to Work Plan
1.6.5.2	Permitting
1.6.5.3	Health and Safety Plan
1.6.5.4	Sampling and Analysis Plan
1.6.5.5	Safety Assessment
1.6.5.6	DOPs
1.6.5.7	Final Report
1.6.5.8	Risk Analysis
1.6.6	Readiness Review
1.6.6.1	Prepare Operational Readiness Review Documentation
1.6.6.2	Operational Readiness Review
1.6.7	Testing
1.6.7.1	Nonradioactive Tests
1.6.7.2	Radioactive Tests
1.6.7.3	Sampling and Analysis
1.7	Production ISV Development
1.7.1	F&ORs
1.7.2	Design
1.7.2.1	Preliminary Cost Estimate
1.7.2.2	Preconceptual Design
1.7.2.3	Conceptual Design
1.7.2.4	Title I Design
1.7.2.5	Title II Design
1.7.3	Procurement
1.7.4	Fabrication
1.7.5	Power Upgrade

TABLE 3-2. (continued)

WBS Number	Title
1.7.6	Documentation
1.7.6.1	Permitting
1.7.6.2	ARARs
1.7.6.3	Health and Safety Plan
1.7.6.4	Monitoring Plan
1.7.6.5	Safety Assessment
1.7.6.6	DOPs
1.7.6.7	Reporting
1.7.7	Production
1.8	NEPA Documentation and Permitting
1.9	Information Systems

The objectives of the principal task in the WBS are described below.

3.2.1 Project Administration (WBS 1.1)

The project administration task will provide management oversight for the project and will interface with other organizations as necessary. Primary interfaces will be with the BWP, other EG&G organizations, DOE, PNL, and the local community. Since the ISV Project is part of the overall BWP investigation, activities will be coordinated with the other BWP Projects to eliminate any unnecessary duplication of tasks. DOE will provide management oversight of the project, and PNL will provide technical support for conducting the ISV demonstrations. Local community concerns will be addressed as outlined in the INEL Community Relations Plan by providing information and obtaining community feedback.[3]

Maintaining control over project documentation and providing for adequate levels of project personnel will be part of the project administration task.

3.2.2 Treatability Study Evaluation (WBS 1.2)

The treatability study evaluation task will integrate and evaluate the information obtained from the ISV Project. This evaluation will be based upon the nine CERCLA criteria identified in Section 4.1 of this plan. This evaluation will allow the ISV technology to be compared with the other possible remedial actions technology. The BWP will be making this comparison when preparing a recommended remedial action plan for the buried mixed waste at the SDA.

3.2.3 Laboratory Tests (WBS 1.3)

Laboratory tests consist of crucible melts, bench-scale ISV tests, and engineering-scale ISV tests. These tests will gather data on the applicability of the ISV process to specific wastes. The tests will gather only limited information on the process equipment required to implement the process in the field.

Laboratory tests will gather data to evaluate the sensitivity of the process to specific waste site characteristics. Knowing the exact waste content of a make-up pit provides the necessary data to evaluate the applicability of the ISV technology within a specific range of conditions. This type of data could only be gained in actual operations with many tests because of the uncertainty of the waste being processed and the inability to identify the characteristics of the waste.

3.2.3.1 Crucible Melts (WBS 1.3.1)

A major objective of crucible melts will be to investigate the feasibility of using chemical additives to prevent electrode shorting and reduce melt viscosity. The potential importance of previtrification oxidation will also be evaluated by conducting tests in which various amounts of simulated metal corrosion products are added to the melt.

3.2.3.2 Bench-Scale ISV Tests (WBS 1.3.2)

A set of three bench-scale ISV tests (9.36 ft electrode separation) will be designed to supplement the existing data base of information on the performance of ISV with different hazardous materials. Preliminary plans call for the first test to evaluate the use of a chemical additive to reduce viscosity effects. The second and third tests will evaluate product quality for melts containing hazardous constituents identified as deficiencies in the current ISV data base. The most likely candidates are volatile organics.

3.2.3.3 Engineering-Scale ISV Tests (WBS 1.3.3)

One of the primary developmental tools for ISV has been the engineering-scale ISV test (0.7 to 1.2 ft electrode separation). The engineering-scale system has many flexible design features for testing new concepts. One of these features is the ability to melt at depth-to-electrode separation ratios that are much greater than during previous intermediate-scale ISV demonstrations. Computer modeling shows that the engineering-scale ISV system is capable of melting to a depth of

5.9 ft with electrode separations of between 0.7 and 1.2 ft. Because of its smaller scale, the engineering-scale system can test new concepts at a reduced cost, while maintaining a high level of confidence in its predictive capabilities for larger-scale operations.

During FY-1988, two engineering-scale ISV tests were conducted to determine the feasibility of vitrifying INEL soil containing large amounts of metal. These tests were carried out on INEL soil that contained a large number of small pieces of steel (bolts, etc.). The amount of metal added to the soil was increased toward the bottom of the container, ranging from a localized wt% of metal of 11% in the top foot of soil to 57% 5 feet below the surface. Test 1 achieved a melt depth of 2.3 ft before being discontinued because of lost electrical conduction. The process effectively vitrified through areas with localized metal contents of 11 wt% and 14 wt%. The block was removed and a second test was continued into the region of the soil with a higher metals content. Before starting Test 2, soil and metals were removed to the 2 ft depth, new electrodes were installed, and 0.5 ft of fresh INEL soil were placed above the metals-bearing soil. The second test effectively vitrified through an area with a localized concentration of 26 wt% metals and 0.5 ft into an area with 42 wt% metals. Test 2 was halted because of loss of power associated with shorting of the electrodes.

In FY-1989, two engineering-scale ISV tests will be performed to evaluate contaminant migration away from the melt, electrode feeding, and waste product quality. In the first test, migration of hazardous volatile organics and EP toxic metals during vitrification will be investigated. Electrode feeding will be evaluated during the second test. Electrode feeding would allow the melt to be started with the electrode buried only in the overburden, the electrodes then being lowered into the melt as the melt front proceeds downward. This would eliminate the need to drill through the waste for electrode placement. This would also distribute electrode oxidation over a large portion of the electrode since electrode oxidation occurs primarily at the upper surface of the melt.

3.2.4 Intermediate-Scale ISV Demonstration (WBS 1.4)

An intermediate-scale ISV demonstration (3.0 to 4.9 ft electrode separation) will provide information concerning the feasibility and performance of a large-scale ISV system at the INEL SDA. Information will be obtained regarding electrode feed system performance, ISV system performance on SDA physically representative waste forms, and performance on wastes with a large metallic content. Of particular interest will be the electrode performance, specifically the ability to vitrify soil with large metal contents. The possibility exists that a large metallic phase of liquid could form during the ISV process and cause electrode shorting or alteration in melt growth rates or shape.

Data from the intermediate-scale ISV demonstration will be used to address some of the safety issues associated with conducting full-scale ISV at the INEL SDA.

3.2.5 Large-Scale ISV Demonstration System (WBS 1.5)

The large-scale ISV demonstration (11.5 to 18.0 ft electrode separation) will provide the actual full-scale performance data needed to fully assess the viability of ISV for treatment of the SDA on a production scale.

3.2.6 Integrated Demonstration (WBS 1.6)

An integrated demonstration will allow the ISV technology to be combined with other remedial action technologies to provide a complete remediation alternative concept.

Complete remediation at the site will probably require multiple technologies. The best solution may require the technologies not only be combined but also modified to facilitate the combination. For example, ISV may be modified to enhance post vitrification retrieval by inducing the blocks to fracture as they cool or by vitrifying smaller sections at a time.

3.2.7 Production ISV Development (WBS 1.7)

The production ISV development task will provide for design of an ISV system suitable for production use at the INEL SDA. The design will proceed from the initial definition of functional and operational requirements through the stages required to develop a description of the complete production system design. By following these stages, the design will represent significant improvement over the current large-scale ISV system. The large-scale ISV demonstration will use the PNL large-scale ISV system, with modifications, to improve usability and performance at the INEL Site. In contrast, the production ISV system will be a newly-designed system. The new design will take advantage of technical developments made subsequent to the original design. Additional changes will also be made based on specific requirements for use at the INEL Site and lessons learned during the large-scale ISV demonstrations.

3.2.8 NEPA Documentation and Permitting (WBS 1.8)

The NEPA documentation and permitting task will provide the necessary documents and permits to meet federal and state requirements. In preparing these documents, an overall strategy will be defined for the demonstration projects with the BWP. This strategy will be described in an Action Description Memorandum (ADM). An Environmental Assessment (EA) for the BWP will address environment concerns for the different demonstration projects, including ISV.

It is currently anticipated that the large-scale ISV demonstrations will not require a National Emissions Standards for Hazardous Air Pollutants (NESHAP), a State Air Quality Bureau Permit to Construct (PTC), and an associated Prevention of Significant Deterioration (PSD) Permit. This is due to the short duration (two melts each having an operation of approximately 8-14 days) and research nature of the demonstration. Letters to the EPA and the State of Idaho requesting these waivers will be prepared. Until these waivers are granted, work will continue with the preparation of the permit applications to insure that the project is not delayed if the waivers are not granted.

3.2.9 Information Systems (WBS 1.9)

The Information Systems task will acquire the hardware and software to implementation of the BWP electronic document management and control system for the ISV Project. Implementation and maintenance of the system is also included in this task.

4. OBJECTIVES

4.1 Project Objectives

The objectives of the BWP (as defined by the BWP Program Management Plan) are as follows:

1. By the end of FY-1990, provide a recommendation for a permanent solution for management of the buried mixed waste at the RWMC. This recommendation will provide the preferred alternative for generation of the Draft Environmental Impact Statement (DEIS) and associated RCRA/CERCLA documentation.

2. During FY-1991 and FY-1992, perform field demonstrations to support development of the DEIS.

3. Issue the DEIS and associated RCRA/CERCLA documentation at the end of FY-1992. This documentation will constitute the official recommendation of the BWP for a permanent solution for management of the buried mixed waste at the RWMC.

The primary objective for the ISV Project is to obtain sufficient data on the ISV process to determine whether current ISV technology (or feasible modifications thereof) will allow vitrification of a substantial portion of the mixed waste at the SDA.

The ISV evaluations have been defined to include performing the initial and detailed assessment of the technology for the comparison with the other alternative technologies. CERCLA has nine criteria against which each alternative should be assessed.[2] These criteria include the following:

- o short-term effectiveness
- o long-term effectiveness and permanence
- o reduction of toxicity, mobility, or volume
- o implementability
- o cost
- o compliance with ARARs
- o overall protection of human health and the environment
- o state acceptance
- o community acceptance.

These assessments will be used as the basis of comparison between the alternatives.

4.2 Technical Objectives

Several technical questions relating directly to the feasibility of applying this process need to be answered in order to fully address the project objectives. Existing information from past ISV investigations and new information from additional engineering analyses and ISV tests and demonstrations will be used to answer the following questions:

I. Can the ISV process be applied to a substantial portion of the INEL mixed waste without irreversible disruption of the process?

A. Will the presence of metallic objects contained within the waste cause the system to short out and stop?

1. Can chemical techniques be used to enhance the processing of wastes containing metallic objects?

2. Can physical techniques be used to enhance the processing of wastes containing metallic objects?

B. Will the high melt viscosity (resulting in high voids) cause a loss of conductance and a stoppage of the ISV process?

C. Will the chemical characteristics of INEL soil (high melting point, etc.) have an adverse effect on electrode performance?

D. Can the electrodes be positioned satisfactorily in the waste areas (without unsolvable problems because of the presence of large metal objects, etc.)

E. Are there methods that can be used to recover from broken or shorted electrodes?

F. Will all waste forms be incorporated into the melt?

1. Will large concrete masses contained in the disposal areas be incorporated into the melt?

2. Will the absence of soil from the waste layers have an adverse effect on the process or the vitrified waste form?

G. Can the ISV melt depth be monitored to ensure that the buried wastes are incorporated into the melt?

1. Can the current depth monitoring equipment be used at the INEL Site with the basalt layer below the Site?

2. If electrode feeding is used, how will the depth of the melt be monitored?

3. What are the alternatives to using the current depth monitoring technique?

II. Can the ISV process be conducted without unacceptable hazards developing during the process?

A. Will the cold cap rise up and interfere with the off-gas system or containment during processing?

B. Will there be any explosions or fires during processing that could breach containment?

C. Will the off-gas system be capable of effectively treating the gases coming off the molten mass?

1. What is the proper sizing for the off-gas system?

2. Will the off-gas system be capable of removing all hazardous and radioactive materials (in both the gaseous and particulate forms) from the gas stream?

3. Will the off-gas system contain gases released from voids and sealed containers?

D. Will volatile organics or other hazardous materials migrate away from the vitrification zone during processing?

E. Will a nuclear criticality occur during processing?

F. Will the process cause a condition that could increase the spread of contamination underground?

1. Could the process cause an uncontrollable underground fire, and if so, what hazards could this cause?

2. Could the process cause an uncontrollable underground chemical reaction, and if so, what hazards could this cause?

III. What would be the chemical and physical characteristics of the ISV waste forms generated? This includes all layers or phases that might be formed in the vitrified block.

A. What is the hazardous organic leachability of the vitrified waste form?

1. Are all hazardous organics contained in the waste destroyed?

2. Are any new hazardous organics created that remain in the vitrified waste form?

3. If there are any hazardous organics remaining in the vitrified waste form? What is the leachability of these components?

B. What is the leachability of the EP toxic metals contained within the vitrified waste form? (EP toxic metals are defined by the metals in 40 CFR Chapter 1, Section 261.24, which exhibit the characteristic of EP toxicity. They include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.)

C. What is the leachability of the hazardous inorganics (not including EP toxic metals) contained in the vitrified waste form?

D. What is the leachability of the radioactive isotopes contained within the vitrified waste form?

1. What is the leachability of the TRU-waste characteristic isotopes contained within the vitrified waste form?

2. What is the leachability of the non TRU-waste characteristic isotopes contained within the vitrified waste form?

E. What are the physical characteristics of the vitrified waste form?

1. Does glass stratification occur during cooling?

2. Do unvitrified waste forms exist within the vitrified matrix?

F. What are the secondary wastes generated from the process?

1. What are the volumes of the secondary wastes generated?

2. What are the chemical properties of the secondary wastes?

3. How will these secondary wastes be disposed of?

4.3 Schedule Objectives

BWP schedule objectives are defined as DOE-HQ and DOE-ID milestones. The current list of these milestones is shown in Table 7-2 of the BWP Program Management Plan.

The ISV project will supply information to meet two of the four current DOE-HQ milestones. These two milestones are

- Submit long-term alternatives recommendation by fourth quarter FY-1990[a]
- Submit Program Draft Environmental Impact Statement by fourth quarter FY-1992.

The ISV project is directly involved with 2 of the 20 current DOE-ID milestones. These two milestone are

- Complete ISV final program plan by 03/89
- Complete engineering-scale ISV testing by 09/89.

a. Note all time periods listed below indicate the last regular working day during the specified time period (i.e., fourth quarter FY-1989 indicates 9/29/89).

Additional DOE-ID milestones to be agreed upon may include the following:

FY-1989

- Transmit Intermediate-Scale Nonradioactive Field ISV Demonstration Safety Assessment to DOE-ID.
- Complete Nonradioactive Intermediate-Scale ISV Demonstration Operational Acceptance Test at the INEL.

FY-1990

- Transmit Nonradioactive Intermediate-Scale ISV Demonstration Report to DOE-ID.
- Complete Radioactive Large-Scale ISV Demonstration Conceptual Design.

FY-1991

- Complete Radioactive Large-Scale ISV Demonstration.

FY-1992

- Transmit Radioactive Large-Scale ISV Demonstration Report to DOE-ID.
- Complete Draft of Title I Design for a Production ISV System.

4.4 Cost Objectives

The BWP, including the ISV project, develops an estimated work scope to equal the target funding established by DOE. After actual funding limits have been identified, the BWP in conjunction with DOE-ID, adds another 7% of work scope. The funding for this additional 7% scope is provided through productivity efforts by BWP personnel.

4.5 Test Objectives

4.5.1 Intermediate-Scale ISV Demonstration

An intermediate-scale ISV demonstration is currently planned for August and September 1989. This demonstration will:

- o Verify encouraging laboratory results using scaled-up system,
- o Conduct electrode feeding system acceptance test,
- o Verify acceptable vitrification in INEL soil with typical waste form,
- o Provide data for potential challenging conditions
  - stacked layer with minimum soil
  - layer with high metal content,
- o Provide data for assessing potential health, safety, and environmental concerns with the full-scale system.

4.5.2 Large-Scale ISV Demonstration

A large-scale ISV radioactive demonstration will be carried out at the SDA in 1991. As presently envisioned, the ISV demonstration at the SDA will be conducted on a portion of pit 9, the same pit targeted for a retrieval demonstration. Two volumes of waste and soil approximately 460 yd^3, measuring approximately 27 ft on a side and 17 ft deep, will be vitrified. Before the radioactive melts, the large-scale ISV equipment will be checked out on the nonradioactive demonstration pit.

5. INSTALLATION AND STARTUP

This section contains a description of the equipment to be used for the field demonstrations. Due to the continuing development of the technology, the equipment design is likely to be modified prior to the conducting the INEL field demonstrations. The site specific installation and startup has not yet been finalized. Reference 5 is the primary source for the equipment descriptions contained in this section.

5.1 Intermediate-Scale ISV Demonstration

The intermediate-scale ISV system uses four electrodes with a 4 ft separation and consists of a power control unit, an off-gas containment hood over the waste site, and an off-gas treatment system that is in a portable semitrailer (see Figure 5-1). This system has been used for six nonradioactive tests and one radioactive test at the PNL. The intermediate-scale ISV demonstration will most likely be carried out at a simulated waste pit constructed at the INEL. Intermediate-scale ISV demonstration equipment can conveniently be discussed in terms of the power system and the off-gas treatment system as follows.

5.1.1 Power System

The intermediate-scale ISV demonstration power system uses a Scott-Tee connection to transform a three-phase 500 kW input power supply to a two-phase secondary load. Each two-phase load is connected on diagonally opposed electrodes in a square pattern. Like the large-scale unit, the hood is equipped with a heat shield installed under the center top panel to protect the hood from heat that radiates from the partially molten surface during processing. The hood makes use of a flexible skirt to provide a seal to the surface of the soil surrounding the zone to be vitrified. The skirt extends away from the hood, allowing for a hood-to-ground seal when covered with a layer of soil. Electrical bus bars, which are extensions of the Mo electrodes, protrude through the hood and are surrounded by electrically insulated sleeves that allow for the adjustment of the electrode positions.

If laboratory tests indicate the feasibility of electrode feeding, the intermediate-scale ISV equipment will be modified to facilitate it.

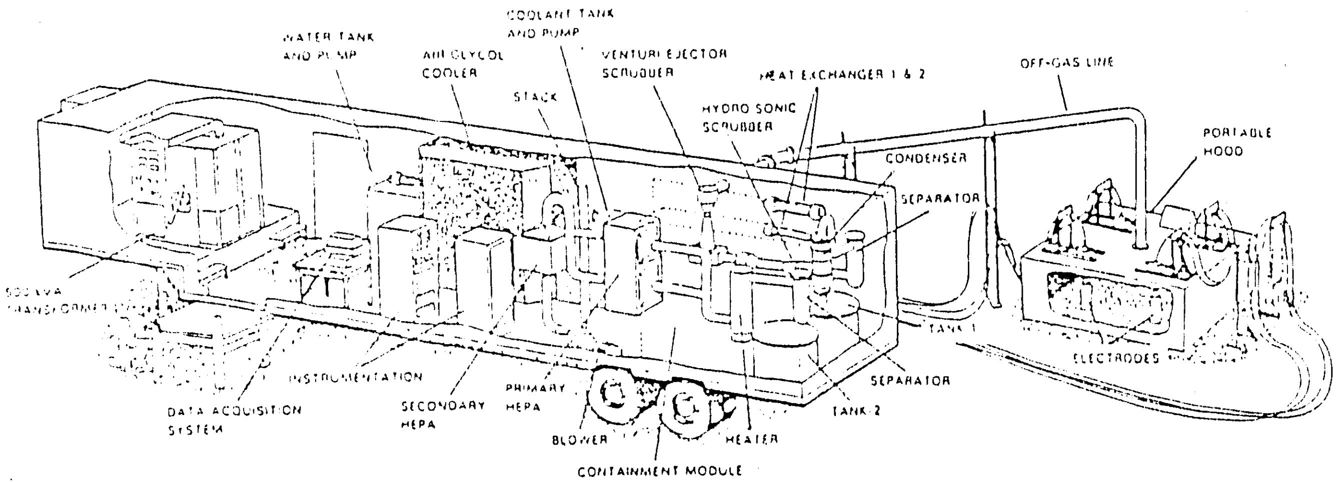

Figure 5-1. Cutaway view of the intermediate-scale ISV demonstration process trailer and hood.

5.1.2 Off-Gas Treatment System

The off-gas passes through a venturi-ejector scrubber and separator, Hydro-Sonic scrubber, separator, condenser, another separator, heater, two stages of high-efficiency particulate air (HEPA) filtration, and a blower. Liquid to the two wet scrubbers is supplied by two independent scrub recirculation tanks, each equipped with a pump and heat exchanger. The entire off-gas system has been installed in a 45-ft-long semitrailer for transportation to a waste site. Except for the second-stage HEPA filter and blower, all off-gas components are housed in a removable containment module that has gloved access for remote operations and is maintained under a slight vacuum.

Heat is removed from the off gas by a closed loop cooling system that consists of an air/liquid heat exchanger, a coolant storage tank, and a pump. A 50% water/ethylene glycol mix is pumped from the storage tank through the shell side of the condenser and the two scrub solution heat exchangers, then through the air/liquid exchanger, where heat is removed from the coolant.

The venturi-ejector scrubber serves both as a quencher and a high energy scrubber; the second scrubber is a two-stage Hydro-Sonic scrubber (tandem nozzle fan drive). The first section condenses vapors, removes larger particles, and initiates growth of the finer particles so that they are more easily captured in the second stage. Particulates are captured when the gas is mixed with fine water droplets produced by spraying water into the exhaust of the subsonic nozzle. Mixing and droplet growth continue down the length of the mixing tube. Large droplets containing the particulate are then removed by a vane separator and drained back into the scrub tank. The unit is designed to remove over 90% of all particulates less than 0.5 microns in diameter when operated at a differential pressure of 4.17 ft of water. Removal efficiency increases with an increase in pressure differential.

Additional water is removed from the off-gas system by a condenser that has a heat exchange area of 95.8 ft^2 and a final separator. The gases are then reheated to approximately 77°F in a 30-kW heater to prevent condensate carry-over to the filters.

The first stage of filtration consists of two 2.0 x 2.0 x 0.96 ft HEPA filters in parallel. During operation, one filter is used and the other remains as a backup in case the generating filter becomes loaded. The primary filter can be changed out during operation. The second-stage HEPA filter acts as a backup if a first-stage filter fails.

5.2 Large-Scale ISV Demonstration

The large-scale ISV demonstration system is designed to vitrify contaminated soils with an electrode separation of up to 18.0 ft on a side. The large-scale ISV demonstration process equipment is shown in Figure 5-2. Controlled electrical power is distributed to the electrodes, and special equipment contains and treats the gaseous effluents. The process equipment required to perform these functions can be described most easily by dividing it into the following five major components: (1) electrical power supply system, (2) off-gas hood, (3) off-gas treatment system, (4) glycol cooling system, and (5) process control station.

Except for the off-gas hood, all of the components are contained in three transportable trailers. They consist of an off-gas trailer, a process control trailer, and a support trailer. All three trailers are mounted on wheels to accommodate a move to any site over a compacted ground surface. The off-gas hood and off-gas line, which are installed on the site to collect gaseous effluents, are dismantled and placed on a flat-bed trailer for transport. The effluents exhausted from the hood are cooled and treated in the off-gas treatment system. The entire process is monitored and controlled from the process control station. A containment evaluation will be made after the safety assessments for the ISV process are completed. The need for an additional enclosure over the off-gas hood will be evaluated. If an additional enclosure is required, a moveable fabric structure will be evaluated for this requirement. This structure

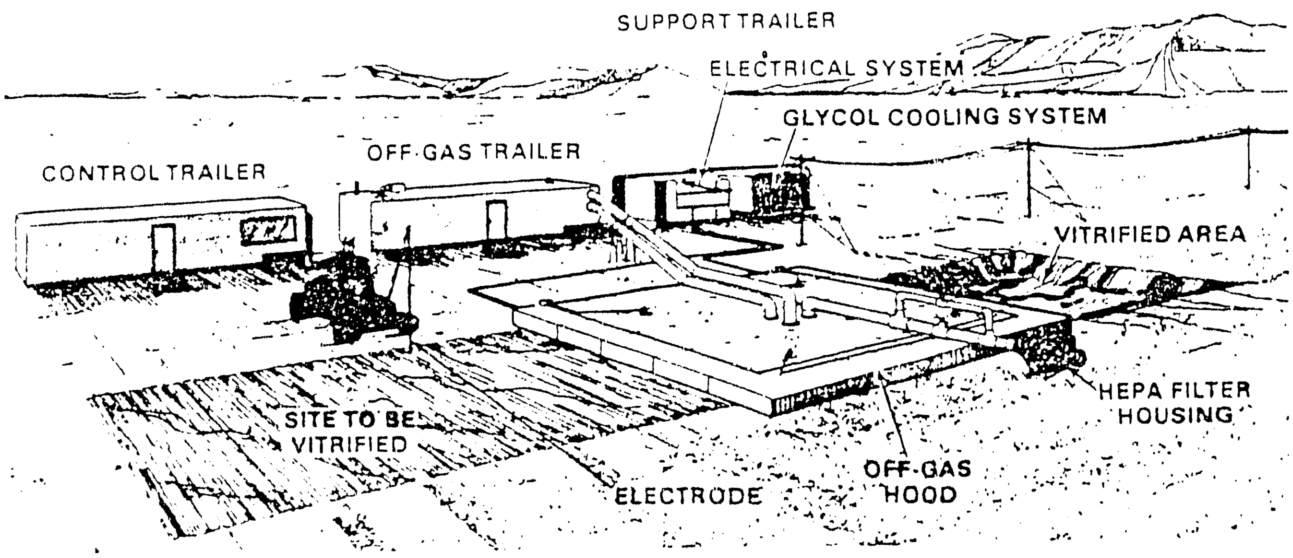

Figure 5-2. Large-scale ISV demonstration process equipment.

would probably be equipped with a gas cooler and a HEPA-filter discharge system. It is anticipated that the off-gas scrubbing system and the other two support trailers will not be contained within any additional structure. A description of the large-scale ISV demonstration production equipment follows.

5.2.1 Power System

The power system for the ISV process uses a Scott-Tee transformer connection to convert three-phase 3750 kW power to two single-phase loads. Each single-phase load is connected to two electrodes, arranged in a square pattern. The Scott-Tee transformer was selected on the basis of even distribution of current within the molten soil, which produces a vitrified product almost square in shape to minimize the overlap between adjacent settings. The connection is commonly used in the glass industry. The vitrification zone continually grows as the ISV process is supplied with power. This creates a constantly changing voltage/current relationship, which requires multiple voltage taps on the Scott-Tee transformer. The multiple taps allow for more efficient use of the power system by maintaining the average power near maximum, which is 3750 kW for the large-scale system. To control the current and/or voltage being introduced into the electrodes, saturable reactors are used for the system.

5.2.2 Off-Gas Containment and Electrode Support Hood

An off-gas hood is placed over the vitrification zone to contain any gaseous/particulate effluents from the process and to direct them to the portable off-gas treatment system. The overall dimensions of the hood are 40 x 40 x 6 ft deep, and it is constructed of 4 x 8 ft panels that can be dismantled for easy storage and shipment. The existing hood is designed for a skin temperature of 1022^{o}F. Higher combustible loadings in the soil, for which the off-gas treatment system is designed (and would be expected for waste sites to be vitrified at the SDA), would require a high-temperature hood design. If a new hood is required, it would probably use a fabric design rather than steel plates. The hood is sealed to the surface of the soil surrounding the zone to be vitrified by a flexible skirt of tightly woven, high-temperature resistant fiber, covered with a few centimeters of dirt. The four electrodes (Mo, graphite, or a combination thereof) protrude through insulated sleeves in the hood at variable separations of 11.5 to 18.0 ft on a side and are supported by insulators above the sleeves, designed to resist breakage of the electrodes caused by movement of the molten mass against the electrodes during processing.

5.2.3 Off-Gas Treatment System

The off-gas treatment system cools, scrubs, and filters the gaseous effluents exhausted from the hood. Its primary components include a gas cooler, two wet scrubber systems (tandem quenchers and nozzle scrubbers), two heat exchangers, a condenser, three mist eliminators (vane separators), a heater, a HEPA filter assembly, and a blower system (see Figure 5-3). The gas cooler reduces the temperatures of the entering off-gases from an expected maximum of 1375 to 575^{o}F. From the gas cooler, the off gas is split and directed into two wet scrubber systems that operate in parallel. The quencher reduces the gas temperature from 575 to 150^{o}F and provides some scrubbing action to remove a portion of the particles and semivolatile radionuclides. The primary functions of the tandem nozzle scrubber are to remove any remaining particles that are less than 0.5 microns in diameter, condense the remaining semivolatile radionuclides, and provide additional cooling of the off gas. The vane separator that follows each tandem nozzle scrubber is designed to remove all droplets less than 12 microns in diameter. After traveling through the scrubber system, the off gas is recombined and cooled. A condenser and mist eliminator provide additional decontamination of the off gas by condensing it and removing water droplets. Final decontamination of the off-gas particulates is achieved in the two-stage HEPA filter assemblies. The gaseous effluents are drawn through the off-gas system components by a 200-hp blower that is capable of achieving 1120 std ft^3/min at 195^{o}F and -7.5 ft of water. After passing through the blower system, the off gases are exhausted to the stack, which is monitored continuously for radionuclides, NO_x, and SO_2.

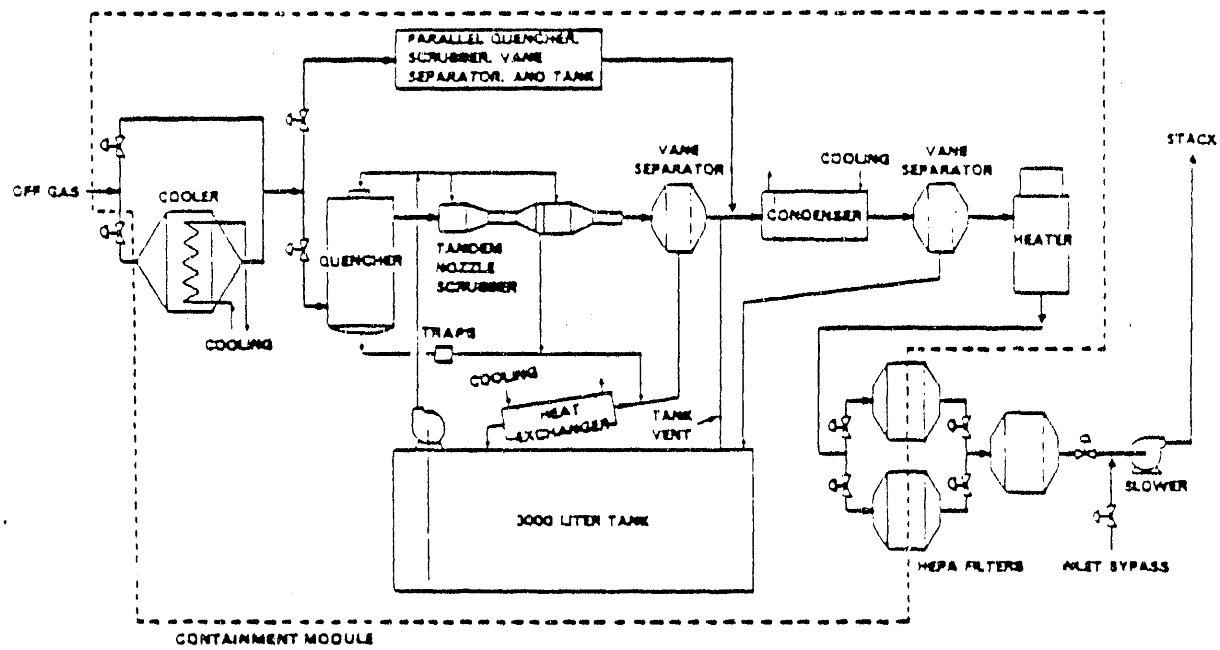

Figure 5-3. Off-gas system for large-scale ISV demonstration.

5.2.4 Glycol Cooling System

Glycol cooling solution is pumped between the support trailer and off-gas trailer to remove the heat from the gaseous effluents. The glycol cooling assembly consists of two fan-cooled radiator systems, each dedicated to its respective glycol loop.

5.2.5 Process Control Station

The process control station consists of a distributed microprocessor monitoring and control system and a control console for the power supply. The process control station monitors and controls important process parameters and automatically activates backup equipment or reroutes off-gas flow if certain equipment fails. The distributed microprocessor control system consists of two process control units and two operator interface units. The process control units are connected to critical and informational sensors located throughout the process. These include sensor readings from pressure elements, thermocouples, gas monitors, and flowmeters. In addition to monitoring these key parameters, the control system performs the following functions: (a) control of scrubber system pressure drop, (b) control of blower inlet vacuum, (c) control of off-gas differential temperature across the heater, (d) control of negative pressure in the hood, and (e) automatic batch logic sequencing of specific operations in the event of equipment failure. As an example of the latter function, if the primary blower fails, the system automatically shuts down power to the electrodes and starts the backup blower. Although the control system is connected to sensors and to an automatic shutdown circuit on the electrode power supply system, it does not directly control the power supply. A separate control console performs that function. The power supply controller provides the necessary saturation current to the saturable reactors that govern the power to the electrodes. This control module maximizes the efficiency of the electrode power system and provides a quick reduction in power in the event of off-standard conditions.

6. REFERENCES

1. Buried Waste Program, RCRA Facility Investigation Work Plan, EGG-WM-8219, December 1988.

2. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Draft, EPA OSWER Directive 9355.3-d, March 1988.

3. RCRA Facility Investigation Work Plan, EGG-WM-8219, Revision 1, December 1988.

4. RWMC Operations Branch, A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory, WM-FL-81-003, Revision 3, July 1985.

5. J. L. Buelt, C. L. Timmerman, K. H. Oma, V .F. Fitzpatrick, J. G. Carter, In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment, PNL-4800, Supplement 1, March 1987.

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