DOE/ID/12584-239

GJPO-MWTP-05

Copy No. 07

RECEIVED

FEB 16 1996

OSTI

Mixed-Waste Treatment Program

**Thermal Desorption Treatability Test
Conducted With VAC*TRAX Unit**

January 1996

**U.S. Department of Energy
Grand Junction Projects Office**

Approved for public release; distribution is unlimited.

Work Performed Under DOE Contract No. DE-AC04-94AL96907 for the U.S. Department of Energy

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed in this report, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**Grand Junction Projects Office
Mixed-Waste Treatment Program**

**Thermal Desorption
Treatability Test Conducted With
VAC*TRAX Unit**

January 1996

Prepared for
U.S. Department of Energy
Albuquerque Operations Office
Grand Junction Projects Office

Prepared by
Rust Geotech
Grand Junction, Colorado

Engineering Project Number ENG-430-0005-05-000
Engineering Document Number E0322401

Work Performed Under DOE Contract No. DE-AC04-94AL96907

This page intentionally blank

Signature Page

Prepared by 1/16/96
R. J. Mancik
Project Engineer Date

Reviewed by 1/16/96
R. B. Richardson
Process Engineer Date

Submitted by 1-16-96
R. D. Rowlands
Environmental Restoration Projects Lead Date

Approved by 1-16-96
R. R. Bloom
Project Manager Date

Approved by 1/16/96
L. Bounini
Program Technical Manager Date

This page intentionally blank

Contents

	Page
Acronyms, Abbreviations, and Initialisms	ix
1.0 Introduction	1-1
1.1 Test Objective	1-2
1.2 Summary of Results	1-2
1.3 Summary of Report	1-3
2.0 Description of the DOE-GJPO VAC*TRAX Unit	2-1
2.1 Dryer (TD100)	2-1
2.2 Primary Filters (F100 A&B)	2-2
2.3 Primary Condenser (E100)	2-7
2.4 Vacuum Pump (B100)	2-7
2.5 Secondary Condenser (E110)	2-7
2.6 Secondary Filter (F200)	2-8
2.7 Carbon Canister	2-8
2.8 Hot-Oil System	2-8
2.9 Nitrogen System	2-9
2.10 Chilled Water	2-9
2.11 Instrumentation	2-9
2.12 Other	2-10
3.0 Waste Stream Samples Tested	3-1
3.1 GJPO-TG 1	3-1
3.2 KCP-1.1	3-2
3.3 LANL-S 10.1	3-2
3.4 LANL-S 10.2	3-2
3.5 LANL-L 13	3-2
3.6 SNL/NM-TG 8	3-3
3.7 GJPO-SSD	3-3
3.8 PTX-1574	3-3
4.0 Test Procedure and Results	4-1
4.1 Introduction	4-1
4.1.1 Definitions	4-1
4.1.2 General Procedures	4-2
4.2 Waste Stream Sample Preparation	4-3
4.2.1 Grand Junction Projects Office	4-4
4.2.2 Kansas City Plant	4-5
4.2.3 Los Alamos National Laboratory	4-6
4.2.4 Sandia National Laboratory/New Mexico	4-8
4.2.5 Pantex	4-8
4.3 Pilot VAC*TRAX Treatability Test Runs	4-9
4.3.1 Surrogate Sample Runs	4-9
4.3.2 Sludge Waste Stream Sample Runs	4-10
4.3.3 Soil Waste Stream Sample Runs	4-12
4.3.4 Vermiculite Waste Stream Sample Run	4-12

Contents (continued)

	Page
4.3.5 Pliable Debris Waste Stream Sample Runs	4-13
4.3.6 Nonpliable Debris Waste Stream Sample Runs	4-14
4.3.7 Mixed Soil and Nonpliable Debris Waste Stream Sample Runs	4-14
4.3.8 Pliable PPE Runs	4-14
4.3.9 Feed Sample Runs	4-15
4.4 Results	4-15
5.0 Technical Evaluation	5-1
5.1 RCRA Contaminant Removal from Solids	5-1
5.1.1 Effect of Operating Parameters on Treatment Times	5-2
5.2 Radionuclide Contamination in Condensate	5-4
5.3 Heat-Transfer Coefficient	5-11
5.4 Liquid Content and Fog Formation	5-15
6.0 Design Considerations for Mobile Treatment Unit	6-1
6.1 The "Debris Rule"	6-1
6.2 Feed Preparation	6-1
6.3 Dryer Design	6-2
6.3.1 Dryer Type	6-2
6.3.2 Comparison of the CTC and GJPO Dryers	6-2
6.3.3 Design Considerations	6-3
6.4 Filter Design	6-5
6.5 Operational Considerations	6-7
6.5.1 Treatment Times	6-7
6.5.2 Other Operational Considerations	6-7
7.0 References	7-1

Appendices

Appendix A. Plans and Procedures for VAC*TRAX Tests	A-1
Appendix B. Analytical Results	B-1
Appendix C. Clemson Technical Center PCB-Contaminated Waste Test Results	C-1
Appendix D. Additional VAC*TRAX Treatability Tests on Pantex Vermiculite	D-1

Figures

Figure 2-1. DOE-GJPO VAC*TRAX As-Built Piping and Instrumentation Diagram	2-3
2-2. Komeline-Sanderson Dryer	2-1
2-3. DOE-GJPO VAC*TRAX Filter Installation	2-2
2-4. DOE-GJPO VAC*TRAX Hot-Oil System	2-9
6-1. Blow Back Effect on Filter Pressure Drop	6-6

Tables

	Page
Table 1-1. RCRA Compound Removal Results	1-4
3-1. Waste Stream Samples Tested With Thermal Desorption Technology at DOE-GJPO	3-4
4-1. Division of Waste Stream Sample GJPO-TG 1	4-4
4-2. Division of Waste Stream Sample GJPO-SSD	4-5
4-3. Division of Waste Stream Sample KCP-1.1	4-6
4-4. Division of Waste Stream Sample LANL-S 10.1	4-7
4-5. Division of Waste Stream Sample LANL-S 10.2	4-7
4-6. Division of Waste Stream Sample LANL-L 13	4-7
4-7. Division of Waste Stream Sample SNL/NM-TG 8	4-8
4-8. Division of Waste Stream Sample PTX-1574	4-8
4-9. DOE-GJPO VAC*TRAX Treatability Test Runs and Results	4-16
5-1. Removal of Contaminants from Treated Solids	5-3
5-2. Condensate Radionuclide Levels	5-4
5-3. Alpha Radioactivity in G-TG 1 and LANL S 10.1 Feeds and Condensates	5-6
5-4. Condensate Radiation Levels and Filter Performance	5-8
5-5. Maximum Heat-Transfer Coefficients from DOE-GJPO Tests	5-12
5-6. Maximum Heat-Transfer Coefficients vs. Percent Liquid	5-13
5-7. Liquid Content of Waste Samples	5-15
6-1. Comparison of Air Leak Rates for CTC and KS Dryers	6-4

This page intentionally blank

Acronyms, Abbreviations, and Initialisms

acfm	actual cubic feet per minute
aq	aqueous phase
atm	atmosphere
b.p.	normal boiling point
Btu/hr	British thermal unit(s) per hour
Btu/hr-ft ² -°F	British thermal unit(s) per hour per square foot per degree Fahrenheit
°C	degrees Celsius
CLF	chloroform
cp	centipoise
CTC	Clemson Technical Center
DCM	dichloromethane
DF	decontamination factor
DMP	dimethyl phtalate
DOE	U.S. Department of Energy
DOE-AL	DOE Albuquerque Operations Office
DOE-GJPO	DOE Grand Junction Projects Office
FDA	U.S. Food and Drug Administration
ft ²	square foot (feet)
g	grams
GJPO	Grand Junction Projects Office
gpm	gallons per minute
HEPA	high efficiency particulate air
hp	horsepower
Hg	mercury
hr	hour
ipa	isopropyl alcohol
KCP	Kansas City Plant
kg	kilogram(s)
KS	Komeline-Sanderson
LANL	Los Alamos National Laboratory
lb	pound(s)
LDR	land disposal restriction
LNAPL	light nonaqueous phase liquid
LOD	loss on drying
μm	micrometer(s)
μg/L	micrograms per liter (equivalent to parts per billion for aqueous substances)
μg	micrograms
MEK	methyl ethyl keotone
mg/L	milligrams per liter (equivalent to parts per million for aqueous substances)
mg/kg	milligrams per kilogram
mL	milliliter(s)
MTU	mobile treatment unit
MWTP	Mixed-Waste Treatment Program
NRC	Nuclear Regulatory Commission
O&M	operation and maintenance
org	organic phase
PC	pseudocumene
PCB	polychlorinated biphenyl

Acronyms, Abbreviations, and Initialisms (continued)

pCi/g	picocuries per gram
pCi/L	picocuries per liter
PIP	Project Implementation Plan
PPE	personal protective equipment
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PTX	Pantex
RCRA	Resource Conservation and Recovery Act
rpm	revolutions per minute
RWP	Radiological Work Permit
scfh	standard cubic feet per hour
scfm	standard cubic feet per minute
SNL/NM	Sandia National Laboratory, New Mexico
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TD	thermal desorption
TSCA	Toxic Substance Control Act
U	uranium
UTS	Universal Treatment Standard

1.0 Introduction

In 1992, Congress passed the Federal Facilities Compliance Act, requiring the U.S. Department of Energy (DOE) to treat and dispose of its mixed waste in accordance with Resource Conservation and Recovery Act (RCRA) treatment standards. In response to the need for mixed-waste treatment capacity, where off-site commercial treatment facilities do not exist or cannot be used, the DOE Albuquerque Operations Office (DOE-AL) organized a Treatment Selection Team to match mixed waste with treatment options and develop a strategy for treatment of mixed waste. DOE-AL manages nine sites with mixed-waste inventories.

The Treatment Selection Team determined a need to develop mobile treatment units (MTUs) to treat waste at the sites where the wastes are generated. Treatment processes used for mixed wastes must remove the hazardous component (i.e., meet RCRA treatment standards) and contain the radioactive component in a form that will protect the worker, public, and environment.

On the basis of the recommendations of the Treatment Selection Team, DOE-AL assigned projects to the sites to bring mixed-waste treatment capacity on-line. The three technologies assigned to the DOE Grand Junction Projects Office (DOE-GJPO) include thermal desorption (TD), evaporative oxidation, and waste water evaporation. Rust Geotech, the prime contractor for DOE-GJPO, was tasked with designing and fabricating MTUs for the three technologies assigned to the DOE-GJPO and to deliver them to selected DOE-AL sites.

Development of TD treatment capacity requires the following sequenced activities:

1. Conduct treatability tests to confirm applicability of the technology for the identified DOE-AL waste streams and to provide information for the design of the MTU.
2. Develop a preliminary and detailed design for the MTU.
3. Fabricate the MTU, develop operating and maintenance procedures, and complete a project hazards analysis.
4. Conduct acceptance testing and support users with permitting assistance.

The *Project Implementation Plan (PIP) for Thermal Desorption* (DOE 1994) called for treatability tests to be performed at the DOE-GJPO using a Rust-patented VAC*TRAX pilot plant to be leased from Rust Federal Services' Clemson Technical Center (CTC) located Anderson, South Carolina. Due to a conflict in schedules, this pilot plant was not available at the time it was needed for the DOE-GJPO treatability studies. To conduct TD treatability tests at the DOE-GJPO within the required schedule, therefore, it was necessary for Rust Geotech to design, procure, and fabricate a second pilot plant using the patented VAC*TRAX technology.

Because the main component of the VAC*TRAX system is the vacuum dryer, it was first necessary to identify a dryer that would be used for the DOE-GJPO pilot plant. A suitable dryer with a maximum capacity of 2 cubic feet or 15 gallons was leased from Komeline-Sanderson (KS), a manufacturer of TD dryers. With the capacity of the dryer established, Rust Geotech Engineering staff completed the process design and detailed design for the remaining components of the pilot plant using the KS dryer data and the patented VAC*TRAX conceptual design.

Equipment and materials for the pilot plant were procured from outside sources. A contract was established to rent space in a local fabricator's facility where Rust Geotech personnel fabricated the modules. The modules were delivered to DOE-GJPO and Rust Geotech personnel erected the pilot plant in the high-bay area of Building 7. The design of the pilot plant started in early January 1995, and the completed pilot plant was commissioned in mid-March 1995.

In parallel with the design and fabrication of the pilot plant, the procedures and plans listed in Appendix A were developed by Rust Geotech Engineering personnel, with assistance from Waste Management and Health, Safety, and Security Subsection staff. Operators for both feed preparation and treatability testing were formally trained using these procedures and plans. A formal Conduct of Operations review of procedures, training, and facilities and a Work Readiness Review for both feed preparation and treatability testing were conducted by DOE-GJPO personnel, with support from Rust Geotech Quality Assurance Subsection personnel, prior to commissioning the pilot plant.

1.1 Test Objective

Two documents were developed to define requirements and objectives for the VAC*TRAX testing: the *Thermal Desorption Treatability Test Feed Preparation Plan* (TD Feed Prep Plan) (DOE 1995e) and the *Thermal Desorption Treatability Test Plan* (TD Test Plan) (DOE 1995g).

The primary objective of the treatability testing was to demonstrate the ability of the TD unit to effectively remove volatile and semivolatile organics from nonvolatile, radiologically contaminated solids. The key performance parameter was the concentration of the volatile or semivolatile contaminant in the residual soils or sludges, and a test was considered successful if the concentration of contaminants in the residual soils was low enough to meet the treatment standards.

In general, a successful test is one that results in treatment residuals that can be disposed of. At a minimum, this means the solid portion of the treated will meet the RCRA treatment standards for the volatile and semivolatile hazardous constituents originally present in the untreated waste. Ideally, the liquid condensate residual also would be free of radiological components, other than tritium, resulting in lower disposal costs, even though treatment capacity exists for radiologically and hazardous-contaminated liquids.

The secondary objective of the treatability testing was to obtain operational information useful in the design of the full-scale VAC*TRAX MTU. The operational experience obtained by treating waste samples representative of DOE-AL waste streams will increase the chance of successful implementation of the technology for the treatment of the DOE-AL mixed-waste inventory.

1.2 Summary of Results

- VAC*TRAX technology demonstrated the ability to treat solid mixed-waste samples so that concentrations of RCRA volatile and semivolatile organic hazardous compounds in the treated solid residues were below RCRA Universal Treatment Standards (UTSs) without further treatment.
- Removal of volatile and semivolatile compounds was related to treatment duration, operating temperature, and vacuum level to provide a basis for determining the required treatment duration for individual RCRA constituents.

- Concentrations of radionuclides in the condensates produced during the treatability tests were below detection limits in 41 of the 45 runs; therefore, the condensate could be managed as hazardous rather than as mixed waste.
- The maximum overall heat-transfer coefficient of the dryer, the single most important design parameter for the MTU, is a function of waste matrix and liquid content. Typical maximum heat-transfer coefficients were 5 to 7 British thermal units per hour per square foot per degree Fahrenheit ($\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$) for soils, 1 to 3 $\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$ for debris samples, and as high as 20 $\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$ for sludge samples that contained high levels of both water and organics.
- Treatment of wastes containing high-boiling-point organics resulted in plugging of the primary filters due to condensation on the filter surfaces and interstices. The filters were cleaned by baking in a 580 $^\circ\text{F}$ -oven. Plugging was greatly reduced by heat tracing and can be prevented by effective heat-jacketing of the filter housings (as demonstrated at CTC).
- Accurate, representative sampling of debris wastes is very difficult because of poor homogenization. Untreated debris waste samples were biased towards visibly contaminated material to confirm the presence of contaminants by chemical analysis. A good-faith effort was made to obtain representative debris samples after treatment for confirmation of the extent of treatment by chemical analysis.

Table 1-1 summarizes RCRA compound removal results from the treatability tests for each waste stream sample tested. Concentrations of the RCRA compounds varied from charge to charge for the same waste stream samples. The waste feed concentration data presented in Table 1-1 are the maximum concentrations found in each waste stream sample for each component. The corresponding treated product concentrations are the final concentrations for the same runs from which the feed concentrations were taken. Therefore, the concentration values given in Table 1-1 represent the maximum removal achieved for each component in each waste stream sample tested.

1.3 Summary of Report

Section 2.0 of this report describes the components of the DOE-GJPO VAC*TRAX unit and Section 3.0 discusses the wastes streams tested in the unit. Section 4.0 describes the results of each individual test run in detail and Section 5.0 presents a detailed technical evaluation of these results. Section 6.0 offers design considerations for the VAC*TRAX MTU based on the DOE-GJPO treatability test results and CTC's experience with the VAC*TRAX. Appendix A lists the plans and procedures under which the treatability test program was performed. Appendix B gives the full analytical profile for every sample taken during the treatability tests. Finally, the scope of the DOE-GJPO treatability tests was somewhat limited because the DOE-GJPO site does not have a Toxic Substances Control Act (TSCA) permit and cannot perform tests on TSCA-regulated waste samples, so results of tests performed at CTC, using that site's VAC*TRAX unit on waste samples containing PCBs, are included in this Report as Appendix C.

Table 1-1. RCRA Compound Removal Results

Waste Stream Sample	Matrix	RCRA Waste Code	RCRA Compound	Waste Feed (mg/kg)	Treated Product (mg/kg)	RCRA Treatment Standard (mg/kg)
GJPO-TG 1	Sludge	D018 D019 D022	chloroform	240,000	< 0.2	30
			carbon tetrachloride	160	< 0.16	6
			benzene	100	< 0.16	10
			dimethyl phthalate	290	22	28
			phenol	< 120	4.5	6.2
LANL-L 13	Soil	D030 D032 D033 D034 D036 D043	2,4-dinitrotoluene	< 0.34	Not Quantitated	140
			hexachlorobenzene	< 0.34	Not Quantitated	10
			hexachlorobutadiene	< 0.34	Not Quantitated	5.6
			hexachloroethane	< 0.34	Not Quantitated	30
			nitrobenzene	< 0.34	Not Quantitated	14
			vinyl chloride	< 0.010	Not Quantitated	6
PTX-1574	Vermiculite	D001 D003	xylene	115	24	30
KCP-1.1-1366	Debris	F002	dichloromethane	< 0.25	< 0.2	30
KCP-1.1-1367	Debris	F002	dichloromethane	< 0.16	< 0.2	30
SNL/NM-TG 8	Debris	D001 F001 F003	trichloroethylene	< 3.1	< 0.62	6
			1,1,1-trichloroethane	< 3.1	< 0.62	6
			1,1,2-trichloroethane	< 3.1	< 0.62	6
			dichloromethane	0.25	< 1	30
			methanol	< 33.5	Not Quantitated	0.75 mg/L TCLP
LANL-S 10.1	Debris	F005	dichloromethane	22,000	2	30
			acetone	240	< 12	160
			methyl ethyl ketone	240	< 12	36
			methyl isobutyl ketone	500	0.99	33
			benzene	< 62	< 6.2	10
			ethylbenzene	33	< 0.31	10
			toluene	37	1.2	10
			xylene	201	0.88	30

Table 1-1 (continued). RCRA Compound Removal Results

Waste Stream Sample	Matrix	RCRA Waste Code	RCRA Compound	Waste Feed (mg/kg)	Treated Product (mg/kg)	RCRA Treatment Standard (mg/kg)
LANL-S 10.2	Debris	F002 F003	dichloromethane	29,000	5.1	30
			methanol	41,200	Not Quantitated	0.75 mg/L TCLP
			methyl ethyl ketone	290	0.9	36
			methyl isobutyl ketone	3,800	3.7	33
			xylenes	24	< 0.32	30
			acetone	150	< 0.69	160

This page intentionally blank

2.0 Description of the DOE-GJPO VAC*TRAX Unit

The VAC*TRAX system treats radiologically contaminated solids that have volatile and semivolatile organic and inorganic constituents. These mixed wastes are primarily trash, soils, and sludges. Operating in batch mode, the VAC*TRAX unit vaporizes the volatile and semivolatile organics and volatilizable inorganics (e.g., mercury) at 500 to 650 °F and near-total vacuum. These contaminants are condensed and removed in a series of downstream condensers. Radionuclides remain with the treated solids in the dryer. When the solids are removed at the end of the run they can be managed as radioactive waste. Figure 2-1 shows the as-built piping and instrumentation diagram for the DOE-GJPO VAC*TRAX unit. Specific components of the DOE-GJPO VAC*TRAX system and performance issues of concern are discussed below.

2.1 Dryer (TD100)

The main process unit in the DOE-GJPO VAC*TRAX pilot unit is the vacuum paddle dryer manufactured by KS (see Figure 2-2). The KS dryer is a Model 3SO3B with a heat transfer area of 12.1 square feet in the jacket and 5.9 square feet in the paddle area. The dryer capacity is approximately 15 gallons. The heating jacket covers the sides and bottom of the dryer, but the top plate and both end plates are not jacketed. Design pressure and temperature of the jacket and paddle are 140 pounds per square inch gauge (psig) and 500 °F. The vessel is coded by the American Society of Mechanical Engineers (Section VIII, Division 1) and stamped UM for process operation of 50 psig to full vacuum. The process contact parts are 316L and 304 stainless steel.

Figure 2-2. Komeline-Sanderson Dryer

The dryer is equipped with a 3 horsepower (hp) motor, reversible hydrostatic speed variator (0 to 10 revolutions per minute [rpm]), and a rotary Johnson Joint. The Johnson Joint allows hot oil to flow from the stationary supply and discharge piping into the rotating paddle. Three ¾-inch couplings are provided for the thermocouple, pressure gauge, and for introduction of nitrogen. The top of the dryer is hinged for addition of feed. Off gases leave the dryer through two 3-inch nozzles mounted on the top of the dryer, and treated solids are discharged through a single 3-inch discharge valve on the bottom of the dryer. The dryer is elevated on supports, allowing installation of a 15-gallon drum under the discharge valve.

When treating moist soils, the dryer is equipped with a cleaning bar, which removes material accumulated on the paddle. For debris (the majority of the material treated) the cleaning bar is not necessary. For large objects, both the cleaning bar and the paddle are removed, and the dryer is operated as an "oven."

2.1 Primary Filters (F100 A&B)

Two primary filter housings are installed on the 3-inch gas outlet flanges on top of the dryer. The filter housings were made from two stainless-steel 6-inch pipe stubs each welded to a 6- by 3-inch eccentric reducer. Blind flanges were drilled and weldolets attached to accept screw-in filters. Each filter housing contains three sintered stainless-steel filter elements capable of operating at full vacuum and up to 600 °F. The filters are rated for 100 percent removal of particles greater than 0.4 micrometer (μm), and can be blown back using pressurized nitrogen. Figure 2-3 shows the filter installation.

Figure 2-3. DOE-GJPO VAC*TRAX Filter Installation

Figure 2-1. DOE-GJPO VAC*TRAX As

SYMBOL	MEANING
#	PROCESS STREAM NUMBER (SEE SHEET 2 OF 2)
	NORMALLY CLOSED BALL VALVE
	NEEDLE VALVE

NO.	DATE	REVISIONS	DWN.	CXD.	SUB.	NO.	DATE	REVISIONS	DWN.	CXD.	SUB.
PROJECT LOCATION			U.S. DEPARTMENT OF ENERGY GRAND JUNCTION PROJECTS OFFICE, COLORADO								
GJPO			MIXED WASTE TREATMENT								
REFERENCE			THERMAL DESORPTION AS-BUILT PIPING AND INSTRUMENTATION DIAGRAM								
APPROVED FOR CONSTRUCTION			PROJECT NO. ENG-430-0005-05-000								
SUPERVISOR			PROJECT NO. E02705-R01-Y01-B								
SURVEY DATE			SHT. 1 OF 2								

Built Piping and Instrumentation Diagram

MATERIAL

		①	②	③	④	⑤
SOLIDS POUNDS/RUN	1 2	110.5 46	110.5 46	— —	— —	1.1
WATER POUNDS/RUN	1 2	59.5 MINOR	0	— —	— —	59.5
NITROGEN POUNDS/HR	1 2	— —	— —	— —	15.6 15.6	15.6
ORGANIC POUNDS/RUN	1 2	0.85 0.50	0 0	— —	— —	0.85 0.50
TEMP. °F	1 2	70 70	200–500 200–400	550 450	550 400	550 400
PRESS. PSI	1 2	ATM ATM	ATM ATM	50 PSIG 50 PSIG	14 14	1–1 1–1
FLOW ACFM	1 2	— —	— —	— —	6.6 6.6	27
GPM	1 2	— —	— —	8.6	— —	— —
DENSITY POUNDS/CF	1 2	100 27	100 27	54.4 54.4		

Figure 2-1 (continued). DOE-GJPO VAC*TR.

BALANCE

6	7	8	9	10	11	11
0 0	0 0	— —	0 0	0 0	0 0	— —
59.5	0.28	59.2	TRACE TRACE	TRACE	NA NA	TRACE TRACE
15.6 15.6	15.6	— —	0—15.6	15.6	— —	— —
0.85 0.50	TR TR	0.85 0.50	0		— —	TRACE
550 400	50 50	50—75 50—75	50—75 50—75	50—75 50—75	40 40	50—75
1—14 1—14	1—14 1—14	ATM	ATM	ATM		
27	14.5	— —	0—14.5	0—14.5		
— —	— —	8 GPH			10	

- 1 SOILS WASTE
2 PPE WASTE

NO.		DATE		REVISIONS		DWN.		CKD.		SUB.		NO.		DATE		REVISIONS		DWN.		CKD.		SUB.							
PROJECT LOCATION						U.S. DEPARTMENT OF ENERGY																							
GJPO						GRAND JUNCTION PROJECTS OFFICE, COLORADO																							
REFERENCE						DESIGNED		DATE		MIXED WASTE TREATMENT																			
						S.G.S.		11-95		THERMAL DESORPTION MATERIAL																			
						P.E.M.		11-95		AS-BUILT																			
						APPROVED FOR CONSTRUCTION				BALANCE TABLE																			
SURVEYOR						SURVEY DATE						PROJECT NO.						EHC-430-0005-05-000						SHT. 2 of 2					
RUST GEOTECH INC.						EHC-430-0005-05-000						EHC-430-0005-05-000																	

As-Built Piping and Instrumentation Diagram

During the test of the GJPO-TG 1 waste sample, which consisted of heavy sludge from environmental remediation, the filters plugged near the end of each run when the higher boiling compounds (primarily petroleum products) were desorbed. By the end of the first GJPO-TG 1 test series, the filters were so badly plugged they could no longer be used. Temporary replacement elements were acquired from CTC, but the rating on the replacement filters was absolute at 0.8 μm . Several tests were completed with the more porous CTC filters. Table 4-1 indicates which filters were used in each treatability test.

Chemical and ultrasonic cleaning of the original filter elements was unsuccessful. The filters were heated in a separate oven at 580 °F for 6 hours, which removed the material that had plugged the pores of the sintered metal. To try to reduce condensation of heavy organics on the filter elements in the future, electric heat tape was added to the exterior of the filters under the insulation. The temperature of the heat tape is adjustable up to 900 °F, but is usually operated at approximately 600 °F.

2.3 Primary Condenser (E100)

The primary condenser is a vertically orientated, single-pass, stainless-steel shell-and-tube heat exchanger. The condenser is 40 inches long, 4 inches in diameter, and has a heat-transfer surface area of 15 square feet. The tube diameter is $\frac{3}{8}$ inch. Off gas passes downward through the tubes and is cooled by chilled water/glycol from the packaged chiller (see Section 2.10) at 35 to 45 °F. The chilled liquid flows upwards (countercurrent) ensuring a flooded shell.

The condensed liquid is collected in a 2-inch sight glass and pipe assembly. Both the inlet and outlet pipes to the condenser are valved. During normal operation, the inlet valve is open and the discharge valve is closed. The receiver is drained by reversing the line-up. Because the receiver operates under vacuum, during early operation a significant amount of oxygen from the air was drawn into the system during the draining operation. A small slip stream of the discharge of the vacuum pump is used to purge the receiver when it is being drained, preventing oxygen excursions.

2.4 Vacuum Pump (B100)

The vacuum pump is a Travaini Model PVL70 rotary vane pump equipped with a 3 hp, totally enclosed, fan-cooled motor. The capacity of the pump is 38 actual cubic feet per minute (acfm) at full vacuum.

A vapor recycle line runs from the discharge of the secondary condenser to the suction of the blower to regulate the system pressure. The recycle stream is taken off after the secondary condenser so that the heat of compression can be removed by the condenser to avoid excessive heat build up in the gas stream during periods of high recycle.

The vacuum pump is oil filled and the oil is in contact with the vanes, providing a seal between the housing and the rotating vanes. When testing wastes containing high levels of organics, the oil became an absorbent for some of the organics. On the GJPO-TG 1 sludge run the oil volume increased to such an extent that the seals were damaged by pressure buildup. Analysis of the oil indicated that the material absorbed was a petroleum distillate and is not a hazardous or mixed waste, and no radioactivity was detected in the oil. To minimize the extent of seal damage, maintenance procedures were changed to require changing the oil between waste stream runs.

2.5 Secondary Condenser (E110)

The secondary condenser, like the primary, is a stainless-steel, vertically orientated shell-and-tube heat exchanger, with the gases flowing downward through the tubes and water from the chiller flowing upward

on the shell side. The condenser is 20 inches long and 4 inches in diameter, containing 84 $\frac{3}{8}$ -inch-outside-diameter tubes, and the heat transfer area is 9.1 square feet.

The secondary condenser is on the discharge side of the vacuum pump and so operates at slightly positive pressure. Adjusting the vacuum and the split of chilled water between the primary and secondary condensers makes it possible to shift the condensing load between them. When the dryer is operating at low vacuum (i.e., near-atmospheric pressure), condensation conditions in the two condensers will be similar. The primary condenser is larger and located first in the condensing train, so it will condense the bulk of the material. When the dryer is operating at high vacuum to vaporize less-volatile compounds, condensation conditions will be more favorable in the secondary condenser, which will then have the higher heat duty.

2.6 Secondary Filter (F200)

The secondary filter is a HEPA-rated filter manufactured by Farr Filtration Company. The secondary filter was installed to contain any radionuclides that break through the primary filters. Gases leaving the secondary condenser are heated with a 750-watt electric heater to 120 °F to avoid condensation in the secondary filter.

2.7 Carbon Canister

A standard 55-gallon carbon canister was installed as a final adsorber for any trace organics that escape the condensers. It is anticipated that some organics were adsorbed on the carbon. The canister will be sampled and returned to the manufacturer.

2.8 Hot-Oil System

The hot-oil system, leased from CTC, is a modular unit manufactured by Budzar Industries (Model HCU-10T-4850-GOM-SP). The unit has two 24-kilowatt electric heaters and a spare, empty heater case. The oil pump (P200) is a belt-driven, Viking L4125 gear pump, with a 3 hp, 1,725 rpm, totally enclosed, fan-cooled Baldor motor (Model M3611 T), capable of pumping 50 gallons per minute (gpm) at 30 psig. Normally, 15 gpm at 15 psig was supplied to the dryer, with the balance of the flow being recycled.

Paratherm NF was the heat transfer fluid used during the DOE-GJPO tests. Paratherm is nontoxic and U.S. Food and Drug Administration (FDA) approved. The physical properties of Paratherm are:

Appearance	clear odorless liquid
Flash Point	335 °F
Autoignition Temperature	690 °F
Boiling Point	650 °F
Specific Gravity	0.868 at 25 °C, 0.762 at 550 °F
Molecular Weight	350
Viscosity	32 centipoise (cp) at 25 °C, 0.46 cp at 550 °F

The hot-oil system has a 60-gallon nitrogen-blanketed expansion tank. A Ketema (Model 6-Y-36-MVHTR) 33-square-foot cooling exchanger (E120) was included with the system for cooling the hot oil at the end of each run. Domestic water was used as the cooling medium for this exchanger. Figure 2-4 shows the hot-oil system.

Figure 2-4. DOE-GJPO VAC*TRAX Hot-Oil System

2.1 Nitrogen System

Nitrogen is used as a sweep gas to provide an inert atmosphere in the dryer to ensure that an explosive mixture could not be generated. Nitrogen is also used as an inert gas for blowing back the filters when they became clogged. The oxygen content is monitored by an oxygen analyzer in the off-gas stream, and the nitrogen flow rate is adjusted as needed to maintain an oxygen concentration of less than 5 volume percent. The nitrogen is stored in multiple dewars of liquefied nitrogen gas. Two 750-watt electric immersion heaters with a temperature controller provided heat to maintain the nitrogen supply temperature above the dryer off-gas temperature so that the nitrogen would not function as a coolant. A 2-gallon nitrogen accumulator tank and piping is provided to blow back the filters.

2.2 Chilled Water

Water chilled to between 35 and 45 °F is supplied by an electric closed-loop packaged glycol/water chiller. The chilled water provides cooling for the two condensers. The design flow is 5 gpm to each condenser.

2.3 Instrumentation

The only automatic controls on the VAC*TRAX pilot unit are the temperature controllers on the hot-oil supply, nitrogen, and the heat tape for the HEPA filters. Local indicators and manual adjustments are used for all other control functions. A Rosemount oxygen analyzer provides monitoring for the oxygen in the off gas. Temperature indication is local with one digital readout. The individual thermocouple and/or digital read out could be selected by dialing the number on a rotary switch.

2.12 Other

The DOE-GJPO VAC*TRAX pilot-unit design and installation included the following additional features:

1. A portable pumping system with a small tank was fabricated to pump a detergent or solvent through the off-gas piping, from the primary to the secondary condenser, including the recycle line, but bypassing the vacuum pump, for decontamination.
2. An FM 200 fire-suppression system was installed in the treatability testing room.
3. The dryer assembly had a 1-ton bridge crane used to facilitate paddle removal, hoist the vacuum pump for repairs, and hoist material on to the deck.
4. A ventilation hood was constructed with Visqueen and plastic pipe. An Isonex blower assembly with a portable HEPA filter and supply and discharge 12-inch tubing was used for ventilation (primarily to draw air away from the operator during loading of the dryer).

3.0 Waste Stream Samples Tested

TD technology is applicable to nonvolatile, radiologically contaminated solids that are also contaminated with volatile and semivolatile RCRA-regulated compounds. Waste streams from several DOE sites were identified as potential candidates for TD treatment. Samples of waste streams from the GJPO, Kansas City Plant (KCP), Los Alamos National Laboratory (LANL), Sandia National Laboratory, New Mexico (SNL/NM), and Pantex (PTX) were sent to DOE-GJPO for treatability testing in the pilot VAC*TRAX unit.

RCRA allows waste generators to use knowledge of the origin of a waste to identify hazardous constituents believed present in the waste stream. For these treatability tests it was important to confirm the presence of each RCRA-hazardous constituent, whether or not it was identified by the generator, and to demonstrate that the hazardous constituents could be removed with TD treatment in the pilot VAC*TRAX unit. Thus, samples of both the untreated and treated waste samples were taken and analyzed.

Because debris wastes are difficult to sample representatively and because contaminants are not necessarily evenly distributed throughout the debris waste, the actual contaminant content of the debris waste samples should only be considered approximately equal to the analytical results. In most cases, sampling of untreated debris waste was biased toward the high side by taking samples that were visibly wet. This type of sampling was done so as not to miss confirmation of the presence of the contaminants. (For results of the treated waste sample analysis, see Section 4.0 of this report.)

Table 3-1 at the end of this section is a summary of the waste stream samples tested in the pilot VAC*TRAX unit. The table identifies the waste stream from which the sample was taken by using the designation assigned by the Mixed Waste Treatment Program. The table compares the hazardous and radioactive constituents each generator site believed present in their waste with the constituents found by laboratory testing at DOE-GJPO before treatment. Also included in the table are the RCRA hazardous waste codes assigned to each waste stream sample by the generator. It is important to note that analytical data in Table 3-1 apply to the specific sample of each waste stream sent to DOE-GJPO for treatment and may not be representative of the total waste stream at the generator site.

The text provided below discusses the information presented in Table 3-1. Each section identifies the waste sample tested and gives a short description of it. The hazardous constituents identified by the generator as being present and the RCRA contaminants of concern are identified. For the purpose of this report "contaminants of concern" are those RCRA-regulated compounds present in concentrations greater than the RCRA treatment standard. In some cases, the generator identified contaminants that are either not RCRA regulated or were present in concentrations below the treatment standard. Also, in some cases the generator did not identify hazardous constituents that were found by laboratory analysis at DOE-GJPO to be present in concentrations exceeding the RCRA treatment standard.

3.1 GJPO-TG 1

The GJPO-TG 1 waste stream sample was sludge removed during site remediation of a laboratory sump. The generator identified benzene, carbon tetrachloride, and chloroform as present in the waste. Laboratory analysis indicated that dimethyl phthalate was also present in concentrations above the RCRA treatment standard and that the chloroform was present in concentrations of up to 24 percent by weight. The radionuclides identified and analyzed by the generator were uranium-238, uranium-235, uranium-234, thorium-230, and polonium-210 (see Table 3-1 for concentrations and activities). The sludge was a fine-

textured soil containing some organic material (e.g., leaves, roots) as well as some debris (e.g., small pieces of glass and plastic).

3.2 KCP-1.1

The KCP-1.1 waste stream sample consisted of items contaminated by a promethium-147 source spill and the associated cleaning materials (e.g., gloves, wipes, boots) used to remediate the spill. The source had leaked on a work bench, contaminating bench vises, hand tools, an intercom, the external surface of a packet of beryllium foil, electrical connectors, film, and office supplies as well as floor tiles around the work bench. The generator identified the hazardous constituents in the waste sample to be methylene chloride and "alcohol." DOE-GJPO laboratory analysis indicated that no RCRA-regulated constituents were present at concentrations greater than the RCRA treatment standard. However, isopropyl alcohol was found at 27 mg/kg. Isopropyl alcohol is not a RCRA-regulated compound and has no treatment standard. The generator identified promethium-147 as the principal radionuclide present. Laboratory analysis in this study identified lead-212 as the radionuclide remaining in the waste after promethium radiation sources were removed from the waste sample.

3.3 LANL-S 10.1

The LANL-S 10.1 waste stream sample consisted of oily rags, paint chips, paint cans, and solvent cans generated during routine pump maintenance and oil spill cleanup. The generator identified the hazardous constituents in the waste sample as methyl ethyl ketone, benzene, "alcohol," toluene, and "lacquer thinner." DOE-GJPO laboratory analysis indicated that methyl ethyl ketone, toluene, methylene chloride, acetone, methyl isobutyl ketone, ethylbenzene, and xylenes were present in concentrations greater than the RCRA treatment standards. The laboratory analysis could not confirm that benzene was present because the detection limits for benzene in the waste sample were higher than the treatment standard. The generator identified plutonium-239 as the radiological constituent of this waste sample. However, laboratory analysis identified the radiological contaminants as uranium-234, uranium-238, and tritium.

3.4 LANL-S 10.2

The LANL-S 10.2 waste stream sample consisted of solvent-contaminated paint chips contained in plastic bags with a small amount of free liquid present. The generator identified the hazardous constituents in the waste sample as methylene chloride and methanol. DOE-GJPO laboratory analysis confirmed that these were the hazardous constituents present in concentrations greater than the RCRA treatment standards. Laboratory analysis indicated that methyl ethyl ketone and methyl isobutyl ketone were also present in concentrations higher than RCRA treatment standards. Acetone and xylenes were found by laboratory analysis in concentrations approaching the RCRA treatment standard. The generator identified plutonium-239, plutonium-242, uranium-238, and americium as the radiological constituents in the waste. Laboratory analysis only found uranium present in the waste sample.

3.5 LANL-L 13

The LANL-L 13 waste stream sample consisted of soil in several sample jars. The organic contaminants identified by the generator were 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, nitrobenzene, and vinyl chloride. The generator identified several heavy metals present in the sample but treatment for metals was not within the scope of these treatability tests. DOE-GJPO laboratory analysis of a composite sample of soil from the jars indicated that no RCRA-regulated organic contaminants were present in the composite charge at concentrations greater than RCRA treatment standards. The radiological contaminants identified by the generator were americium-241, cesium-137,

tritium, potassium-40, plutonium-238, plutonium-239, radium-226, strontium-90, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235, and uranium-238. No radiological analyses were performed on the waste sample for the treatability test. Results from earlier radiological analysis had been supplied by LANL.

3.6 SNL/NM-TG 8

The SNL/NM-TG 8 waste stream sample was decontamination debris consisting of wipes, gloves, rags, cans, small tools, and plastic. The organic contaminants identified by the generator were ethanol, methanol, isopropyl alcohol, acetone, and trichloroethane (isomer not specified). DOE-GJPO laboratory analysis indicated that no RCRA regulated compounds were present in concentrations greater than RCRA treatment standards. Traces of methylene chloride were found but were below treatment standards. Tritium was identified and analyzed as the radiological contaminant.

3.7 GJPO-SSD

The GJPO-SSD waste stream sample consisted of wipes, paper, plastic, glass, respirator cartridges, and soil generated during a sampling exercise at a Uranium Mill Tailings Remedial Action site in Grand Junction, Colorado, where both hazardous and radioactive wastes were present. The waste stream was not originally included in the scope of these treatability tests, but was later judged to be eligible for TD. The organic contaminants identified by the generator were benzene, carbon tetrachloride, chloroform, and trichloroethylene. The generator identified several inorganic constituents present in the sample but treatment for inorganics was not within the scope of these treatability tests. The radiological contaminant was uranium mill tailings. No analyses were performed for this treatability test due to sample characteristics, the relatively small quantity of material, and availability of analytical results obtained at the time this waste was generated.

3.8 PTX-1574

The PTX-1574 waste stream sample was vermiculite contaminated by broken and leaking liquid scintillation vials. Those vials contained bioassay samples. The generator identified the hazardous constituents in the waste sample to be xylene and pseudocumene (1,2,4-trimethylbenzene). GJPO laboratory analysis confirmed the presence of xylene and pseudocumene. Toluene was also identified as a possible contaminant but none was detected in the feed sample. The radiological contaminant identified and analyzed was tritium. Prior to shipment to DOE-GJPO, personnel at PTX had sorted the drum containing the sample and removed all glass and plastic from the vermiculite.

Table 3-1. Waste Stream Samples Tested With Thermal Desorption Technology at DOE-GJPO

Generator	Waste Stream	RCRA Hazardous Waste Code Identified by Generator	Hazardous Constituents Identified by Generator	Hazardous Constituents Identified by DOE-GJPO Analysis	Concentration Identified by DOE-GJPO Analysis (mg/kg)	Principal Radionuclides Identified by Generator	Principal Radionuclides Identified by DOE-GJPO Analysis	Activity Identified by DOE-GJPO Analysis (pCi/g)
GJPO	TG 1	D018 D019 D022	Benzene Carbon Tetrachloride Chloroform	Benzene Carbon Tetrachloride Chloroform Dimethyl phthalate	100 160 24% 290	Uranium-238 Uranium-235 Uranium-234 Thorium-230 Polonium-210	Uranium-238 Uranium-235 Uranium-234 Thorium-230 Polonium-210	828 81 839 1,211 299
KCP	1.1	F002	Methylene Chloride Alcohol	Isopropyl Alcohol	27	Promethium-147	Lead-212	62.79 206 (Gross $\alpha\beta$)
LANL	S 10.1	F005	Methyl Ethyl Ketone Benzene Alcohol Toluene Lacquer Thinner	Methyl Isobutyl Ketone Toluene Methylene Chloride Acetone Xylenes Methyl Ethyl Ketone Ethylbenzene	240 37 22,000 240 201 500 33	Plutonium-239	Uranium-234 Uranium-238 Tritium	0.72 0.11 11. 37.5 (Gross $\alpha\beta$)
LANL	S 10.2	F002 F003	Methylene Chloride Methanol	Methylene Chloride Methanol Methyl Ethyl Ketone Methyl Isobutyl Ketone Acetone Xylenes	29,000 41,200 290 5,000 150 24	Plutonium-239 Plutonium-242 Uranium-238 Americium	Uranium	0.43 3,318 (Gross $\alpha\beta$)

Table 3-1 (continued). Waste Stream Samples Tested With Thermal Desorption Technology at DOE-GJPO

Generator	Waste Stream	RCRA Hazardous Waste Code Identified by Generator	Hazardous Constituents Identified by Generator	Hazardous Constituents Identified by DOE-GJPO Analysis	Concentration Identified by DOE-GJPO Analysis (mg/kg)	Principal Radionuclides Identified by Generator	Principal Radionuclides Identified by DOE-GJPO Analysis	Activity Identified by DOE-GJPO Analysis (pCi/g)
LANL	L 13	D004 D006 D007 D008 D009 D010 D011 D030 D032 D033 D034 D036 D043	Arsenic Cadmium Chromium Lead Mercury Selenium Silver 2,4-Dinitrotoluene Hexachlorobenzene Hexachlorobutadiene Hexachloroethane Nitrobenzene Vinyl Chloride	No Analysis For Metals No Volatile or Semivolatile Organic Compounds Detected		Americium-241 Cesium-137 Tritium Potassium-40 Plutonium-238 Plutonium-239 Radium-226 Strontium-90 Thorium-228 Thorium-230 Thorium-232 Uranium-234 Uranium-235 Uranium-238	No Analysis Performed	0.820 ^a 3.28 272 29.3 1.04 93.2 5.18 0.992 0.208 1.69 4.27 19.7 1.27 19.1
SNL/NM	TG 8	D001 F001 F003	Ethanol Methanol Isopropyl Alcohol Trichloroethane	Methylene Chloride	0.25	Tritium	Tritium	56.21 56.2 (Gross α p)
GJPO	SSD	D007 D008 D009 D018 D019 D022 D039 D040 F002	Chromium Lead Mercury Benzene Carbon Tetrachloride Chloroform Tetrachloroethylene Trichloroethylene Spent Solvents	No Analysis Performed	No Analysis Performed	Uranium Mill Tailings	No Analysis Performed	No Analysis Performed
PTX	1574	D001 F003	Xylene Pseudocumene Toluene	Xylenes Pseudocumene	115 5,500	Tritium	Tritium	426.63

Note: Waste Codes, constituents, and analytical data apply to the specific sample of each waste stream sent to DOE-GJPO for treatment and may not be representative of the total waste stream at the generator site.

^aActivities reported by LANL. Total pCi in waste stream.

This page intentionally blank

4.0 Test Procedure and Results

4.1 Introduction

4.1.1 Definitions

The following terminology is used throughout these tables to distinguish and track all the separate waste stream samples, charges, processing runs, reprocessing runs, and associated sampling, analytical, and operational data.

A "waste stream" is a group of similar wastes generated at a specific DOE site. A "waste stream sample" is the portion of the waste stream that was actually processed in the treatability test. The waste stream sample is identified by the designation given to the corresponding waste stream by the Mixed-Waste Treatment Program (MWTP). The waste stream sample designation includes the specific DOE site and an alpha-numeric waste stream designation. Thus, "LANL-S 10.1" refers to a group of similar wastes generated at LANL and given the designation "S-10.1" by the MWTP.

A waste stream sample used for treatability testing is further identified by adding to the site and waste stream designation the specific container number that the waste stream sample was shipped in by the generator. In some cases, the waste stream sample was shipped in more than one container. Thus, "KCP 1.1-1366" and "KCP 1.1-1367" refer to the first and second drums, respectively, in which the KCP 1.1 waste stream sample was shipped to DOE-GJPO for treatability testing.

The waste stream samples are divided into individual charges for the processing runs. The individual charges may be contained in several containers, each with its own identifier. Waste stream sample LANL-S 10.2 was divided into two plastic bags and designated as two charges, "LANL-S 10.2-Bag 1" and "LANL-S 10.2-Bag 2." Similarly, waste stream sample GJPO-TG 1 was divided into containers "GJPO-TG 1-A," "GJPO-TG 1-B," and so forth. Individual processing runs are referred to by the set of containers comprising a charge. Thus, the run "GJPO-TG 1-DEF" is a processing run of a charge composed of waste material from "GJPO-TG 1-D," "GJPO-TG 1-E," and "GJPO-TG 1-F."

The duration of processing runs varied. In some cases, the duration of a run lasted 2 days and the pilot VAC*TRAX unit was shut down before completing the processing run. The processing run was completed on the second day and termed a "restart" to distinguish it from the first day of the run.

As a simple cross reference for this report, the individual process runs are grouped and given simple run numbers. The runs are numbered so that wastes having similar matrices are grouped together. Within these matrices, the runs are numbered chronologically, but the ordering of the runs is not chronological overall. Reprocessing runs ("reruns") are given a modifier to indicate they represent further processing of the original waste stream sample charge and follow the original run of the material. Thus, Run "4A" is the "rerun" of the treated waste product of Run "4" and the original charge for these runs was GJPO-TG 1-GHI. Chronologically, runs of other material were made between "4" and "4A." The run groupings are in the following order of matrix: sludge, soil, vermiculite, pliable debris, nonpliable debris, pliable/PPE, feed samples.

"Pliable debris" is material such as shredded cloth and plastic that meets the RCRA definition for debris and is able to be processed in the pilot VAC*TRAX dryer with the dryer agitator operating.

"Nonpliable debris" is material such as paint cans and other large items that could not be shredded with the equipment available for these treatability tests. These items were processed in the pilot VAC*TRAX unit with the dryer agitator either not operating or physically removed from the pilot unit.

"Pliable/PPE" is discarded protective clothing and cleaning wipes generated in the process of conducting the treatability tests. This material was shredded and is also "pliable debris," but it is grouped separately to distinguish it from the waste stream samples. The discarded protective clothing and cleaning wipes is not a designated "waste stream."

4.1.2 General Procedures

The general procedures followed to complete treatability testing were

1. Obtain samples of each proposed waste stream from the generator, following the time limitations, quantity limitations, and record-keeping requirements of RCRA treatability test exclusions. The specific treatability test exclusion requirements are beyond the scope of this report and will not be detailed.
2. Prepare the waste stream sample for treatment in the pilot VAC*TRAX unit by segregating items that could not be processed in the pilot unit; shredding any large pieces of debris to prevent entanglement in the pilot unit; and when free liquids were present, adding absorbent to the waste to facilitate handling and to minimize scale formation inside the pilot unit (although scale formation proved not to be a problem based on the GJPO-TG 1 runs).
3. Divide the prepared waste stream sample into a number of separate charges. The quantity of each waste stream sample was greater than the capacity of a single charge to the pilot unit. Because all of the waste stream sample was to be treated, several tests were needed for each waste stream sample to be tested.
4. Sample and analyze the prepared charges to characterize the waste material, to confirm the presence of RCRA constituents, and to provide a baseline for demonstrating the effectiveness of the treatment.
5. Process each waste charge in the pilot VAC*TRAX unit at sufficient conditions and duration to remove the target constituents to the extent that RCRA treatment standards are met. Operational data taken during processing would be considered in evaluating the effectiveness of the process and in designing the full-scale VAC*TRAX MTU.
6. Sample and analyze the treated solid product for residual contaminants to demonstrate the effectiveness of removing the RCRA target constituents. Sample and analyze the resulting condensate to demonstrate the separation of the RCRA components from the radiological components.
7. Minimize secondary waste by processing in the pilot VAC*TRAX unit the used PPE; unused, untreated feed samples; and other items generated during the treatability test operations.

Before actual mixed-waste stream samples were prepared and processed in the pilot VAC*TRAX unit, surrogate waste sample charges were prepared and processed in the unit to verify procedures,

methodology, and equipment functionality, and to gain experience in safe loading and operation of the pilot unit. Both soil and pliable debris surrogate waste charges were prepared from clean soil, pliable debris, and water. The surrogate waste charges contained no hazardous or radioactive components.

4.2 Waste Stream Sample Preparation

The objective of waste stream sample preparation was to divide the waste stream samples into suitable charges for processing in the pilot VAC*TRAX unit. The pilot VAC*TRAX unit can normally only accept soils, sludges, granular material, and pliable debris that will not interfere with the mechanical agitator in the unit's dryer. Nonpliable debris can be processed in the unit either with the agitator disabled or physically removed. Waste stream sample charges have to be no larger than about 1.7 cubic feet, which is the working volume of the pilot VAC*TRAX unit. Certain items unsuitable for treatment, such as radioactive sources, were included in some of the waste stream samples received at DOE-GJPO for treatability testing. These unsuitable items were rejected and returned to the generator untreated.

During waste stream sample preparation, large pieces of pliable debris waste were size reduced with scissors or other means to render them suitable for processing with agitation. Size reduction ensures that the waste material can be easily and safely charged to the dryer and that the treatment can be conducted in a manner conducive to exposing all material surfaces for maximum efficiency of the TD process. Harborlite, a dry, powdered absorbent, was added to waste material that contained free liquid to make it easier to handle and to render it suitable for processing. Nonpliable debris was processed in the unit either with the agitator disabled or physically removed.

After the TD Feed Prep Plan was finalized and prior to handling an actual waste stream sample, a surrogate sample feed preparation dry run was performed on February 28, 1995. Safety briefings were held to discuss hazards associated with the waste stream to be prepared. To prepare the surrogate waste stream samples, one 55-gallon drum was filled with native soil augmented with tap water and another 55-gallon drum was filled with various nonchemically, nonradiologically contaminated PPE. The drums were then treated as if they were real waste stream samples. These parent drums were moved into a walk-in hood where the soil was transferred from the parent drum into 5-gallon plastic pails lined with heavy duty plastic bags. The PPE, which consisted of gloves, poly-coated tyvek, and booties, was transferred from the parent drum into a large, heavy duty plastic bag. The bag of PPE was then taken to a stand-up hood and shredded to less than 10-inch pieces. Approximately 13 gallons of shredded PPE were placed into multiple bags and consecutively labeled. Mock analytical samples were taken from the surrogate soil and PPE samples. The TD Feed Prep Plan was revised to reflect what was learned during the dry run. All subsequent waste stream samples were prepared using the revised procedures in the TD Feed Prep Plan.

Preparation of actual waste stream samples began on March 9, 1995. Drums of waste stream sample obtained from the generators were opened in a walk-in hood. Operators wore full personnel protective clothing and were provided with respirators and supplied breathing air. The contents of each drum were inspected and inappropriate items (such as vises and other items too large or heavy to be handled in the dryer) were removed and set aside. Pliable materials were size reduced, to avoid balling up or tangling around the agitator, and transferred into smaller bags containing approximately 13 gallons each, which constituted a single dryer charge. Soils and sludges, much heavier than the pliable materials, were transferred into lined 5-gallon pails for easier handling. Three of these pails were used as a single charge for the dryer.

Physical limitations on feed for the VAC*TRAX unit depended on the dryer configuration: with or without the agitator installed. Debris size with the agitator installed was limited to ¼ inch for rigid material and 10 inches for pliable material. Debris size without the agitator installed was limited to the dryer opening size, approximately 12 by 15 inches.

The TD Feed Prep Plan defines the plan for handling waste stream samples from the time they arrive at DOE-GJPO until they are fed to the pilot VAC*TRAX unit. One significant finding during feed preparation was that the characterization data supplied by the waste generator was often inadequate, incomplete, or incorrect. For future treatment or treatability studies it should be recognized that the characterization data is not reliable.

4.2.1 Grand Junction Projects Office

GJPO-TG 1

The generator described waste stream sample GJPO-TG 1 as soil and sludge. The waste stream sample was in a metal 55-gallon drum, which was contained in an overpack drum. Inside the 55-gallon drum was approximately 2 inches of free liquid over a compacted sludge. The metal 55-gallon drum inside the overpack was highly corroded. Harborlite was added to the liquid phase in the metal drum and stirred to take up the free liquid. There was no free liquid present after adding Harborlite. After transfer to the 5-gallon pails, free liquid surfaced on the containers. The free liquid proved not to be a problem for the dryer.

Soil and sludge, including the added Harborlite, was then transferred into consecutively labeled 5-gallon buckets (GJPO-TG 1-A through -L). Material taken from lower in the drum was wetter than material taken from higher in the drum. As soil was transferred, rocks larger than ¼ inch were separated and placed into a 5-gallon bucket labeled GJPO-TG 1-Rocks. Used respirator cartridges generated from feed preparation activities were added to this charge. A total of about 10 pounds of glass and plastic debris was also encountered during the transfer and were separated from the sludge fraction for treatment as charge GJPO-TG 1-Debris. A composite analytical sample was taken of every 3 buckets (i.e., GJPO-TG 1-ABC, -DEF, -GHI, -JKL). Division of waste stream sample GJPO-TG 1 is shown in Table 4-1.

Table 4-1. Division of Waste Stream Sample GJPO-TG 1

Division/Charge	Matrix	Amount (lb)	Fate
GJPO-TG 1-AB	Sludge	96	Treatability Test, Run 1
GJPO-TG 1-C	Sludge	39	Treatability Test, Runs 2, 3A
GJPO-TG 1-DEF	Sludge	124	Treatability Test, Runs 3, 3A
GJPO-TG 1-GHI	Sludge	147	Treatability Test, Runs 4, 4A
GJPO-TG 1-JKL	Sludge	83	Treatability Test, Runs 5, 5A
GJPO-TG 1-Rocks	Nonpliable Debris	14	Treatability Test, Run 23
GJPO-TG 1-Debris	Nonpliable Debris	10	Treatability Test, Run 24

GJPO-TG 13

Waste stream sample GJPO-TG 13 was contained in a 55-gallon drum and described by the generator as oily sludge. A smaller inner drum was highly corroded and liquid contained in it was almost entirely oil. Approximately one pound of Harborlite was added to the drum and stirred. After observing the large amount of petroleum still present, the drum was disqualified from treatment in the VAC*TRAX unit, resealed, and returned to the generator. The liquid petroleum product was not considered appropriate feed for the VAC*TRAX unit.

GJPO-SSD

Preliminary preparation was performed on the GJPO-SSD waste stream sample prior to transfer to the MWTP. The generator described the waste as residual material from a sampling effort at a Uranium Mill Tailings Remedial Action site. The generator had divided the waste stream sample into two soil and two nonpliable (metal cans and respirator cartridges) portions. Three separate charges were made from the four portions for processing in the pilot VAC*TRAX unit. Division of waste stream sample GJPO-SSD is shown in Table 4-2.

Table 4-2. Division of Waste Stream Sample GJPO-SSD

Division/Charge	Matrix	Amount (lb)	Fate
SSD-W940000254, 265	Nonpliable Debris	8	Treatability Test, Run 28
SSD-W940000255, 256	Soil, Nonpliable Debris	11	Treatability Test, Run 29
SSD-W940000253	Soil	6	Treatability Test, Run 30

4.2.2 Kansas City Plant**KCP-1.1-1366**

The generator described waste stream sample KCP-1.1-1366 as rags and metal debris. There were twelve individual bags in the 55-gallon parent drum. The individual bags contained cloth, paper, gloves, electrical components, tape, and pieces of metal. Rejected materials and metal objects were placed into two separate 5-gallon pails. Pliable materials were placed into three consecutively labeled bags (KCP-1.1-1366-Bag 1, -Bag 2, -Bag 3).

KCP-1.1-1367

Waste stream sample KCP-1.1-1367 was described by the generator as similar to KCP-1.1-1366. In addition to inventoried items, several radioactive source containers, two vises, a block of rouge buffing compound, and tile with asbestos mastic were found. The tile was rejected because asbestos is a TSCA-regulated material and DOE-GJPO does not have a TSCA permit. The radioactive source containers were rejected for treatment because the dose rate from the sources would have exceeded the Radiation Work

Permit unnecessarily complicating the testing. Four charges of pliable material, two charges of nonpliable material, and one bag of rejected debris resulted from feed preparation. Division of waste stream sample KCP-1.1 is shown in Table 4-3.

Table 4-3. Division of Waste Stream Sample KCP-1.1

Division/Charge	Matrix	Amount (lb)	Fate
KCP-1.1-1366-Bag 1	Pliable Debris	12	Treatability Test, Run 8
KCP-1.1-1366-Bag 2	Pliable Debris	7	Treatability Test, Run 9
KCP-1.1-1366-Bag 3	Pliable Debris	12	Treatability Test, Run 10
KCP-1.1-1367-Bag 1A	Pliable Debris	9	Treatability Test, Run 13
KCP-1.1-1367-Bag 1B	Pliable Debris	11	Treatability Test, Run 14
KCP-1.1-1367-Bag 2A	Pliable Debris	12	Treatability Test, Run 11
KCP-1.1-1367-Bag 2B	Pliable Debris	12	Treatability Test, Run 12
KCP-1.1-1367-Bags 4,6,7	Nonpliable Debris	11	Treatability Test, Run 26
KCP-1.1-1367-Bag 8	Nonpliable Debris	23	Treatability Test, Run 27
KCP-1.1-1366, -1367 Metal Debris	Nonpliable Debris	20	Treatability Test, Run 25
KCP-1.1-1366, -1367 Rejected Items	Nonpliable Debris		Returned to Generator

4.2.3 Los Alamos National Laboratory

LANL-S 10.1

The generator described waste stream sample LANL-S 10.1 as rags and other cleanup materials. The sample was mostly paint chips saturated with stripping compound; the remainder of the sample was two paint cans and a small quantity of oily rags. Two items were rejected because their radioactivity levels were beyond the scope of these treatability tests. Three charges of pliable debris, one bag containing two paint cans, and a container of rejected items resulted from feed preparation. Division of waste stream sample LANL-S 10.1 is shown in Table 4-4.

Table 4-4. Division of Waste Stream Sample LANL-S 10.1

Division/Charge	Matrix	Amount (lb)	Fate
LANL-S 10.1-Bag C1	Pliable Debris	16	Treatability Test, Runs 17, 17A
LANL-S 10.1-Bag C2	Pliable Debris	14	Treatability Test, Run 18
LANL-S 10.1-Bag C3	Pliable Debris	18	Treatability Test, Run 19
LANL-S 10.1 Metal	Nonpliable Debris	3	Treatability Test, Run 22
LANL-S 10.1 Rejected Items	Pliable Debris		Returned to Generator

LANL-S 10.2

The generator described waste stream sample LANL-S 10.2 as stripped paint and PPE. The waste was mostly paint chips saturated with stripping compound; the remainder of the waste was rags. Harborlite was added to absorb approximately ¼ inch of free liquid from the bottom of the drum. Two charges of pliable debris resulted from feed preparation. Division of waste stream sample LANL-S 10.2 is shown in Table 4-5.

Table 4-5. Division of Waste Stream Sample LANL-S 10.2

Division/Charge	Matrix	Amount (lb)	Fate
LANL-S 10.2-Bag 1	Pliable Debris	22	Treatability Test, Runs 20, 20A
LANL-S 10.2-Bag 2	Pliable Debris	44	Treatability Test, Run 21

LANL-L 13

The generator described waste stream sample LANL-L 13 as soil samples. The 30-gallon drum contained 190 sample jars ranging from 4 to 16 ounces in size. Preparing the charge amounted to mixing the contents of the sample jars into two 5-gallon buckets. Some of the individual samples were rejected because the mercury or arsenic content would have resulted in industrial hygiene precautions that would have unnecessarily complicated the treatability test operations. Other individual samples were rejected because the soil within them was solidified and could not be removed. A single soil charge resulted from feed preparation. Division of waste stream sample LANL-L 13 is shown in Table 4-6.

Table 4-6. Division of Waste Stream Sample LANL-L 13

Division/Charge	Matrix	Amount (lb)	Fate
LANL-L-13-AB	Soil	41	Treatability Test, Run 6
LANL-L-13-Rejected Items	Soil	3	Return to Generator

4.2.4 Sandia National Laboratory/New Mexico

SNL/NM-TG 8

The generator described waste stream sample SNL/NM-TG8 as paper, plastic, and trash. The matrix description was mostly accurate; however, small, yellow, pill-shaped detectors from Thermoluminescent Dosimeters were present and levels of radiation were higher than anticipated. Two charges of pliable debris and two paint cans resulted from feed preparation. The small yellow pills were disqualified from treatment because their radioactivity levels were beyond the scope of these treatability tests. Division of waste stream sample SNL/NM-TG 8 is shown in Table 4-7.

Table 4-7. Division of Waste Stream Sample SNL/NM-TG 8

Division/Charge	Matrix	Amount (lb)	Fate
SNL/NM-TG 8-Bag 1	Pliable Debris	12	Treatability Test, Run 15
SNL/NM-TG 8-Bag 2	Pliable Debris	8	Treatability Test, Run 16
SNL/NM-TG 8-Metal	Nonpliable Debris	3	Treatability Test, Run 22
SNL/NM-TG 8-Rejected Items	Irradiated Sulfur Tablets	2	Return to generator

4.2.5 Pantex

PTX-1574

Feed preparation was performed on this waste prior to arrival at DOE-GJPO. The generator described the waste as scintillation cocktail-contaminated vermiculite. The 15-gallon plastic drum was opened in the drum fume hood for inspection. The vermiculite had been sorted and most of the glass and plastic items (liquid scintillation vials and lids) had been removed by the generator. The vermiculite was contained in three separate plastic bags inside one large bag. No further feed preparation was necessary prior to loading this single charge into the dryer. Division of waste stream sample PTX-1574 is shown in Table 4-8.

Table 4-8. Division of Waste Stream Sample PTX-1574

Division/Charge	Matrix	Amount (lb)	Fate
PTX-1574-A	Vermiculite	53	Treatability Test, Run 7

4.3 Pilot VAC*TRAX Treatability Test Runs

The objective of each treatability test run was to process the waste stream samples at a sufficient combination of temperature, time, and applied vacuum until the target RCRA constituents were removed to meet RCRA treatment standards. The basic strategy used for these treatability test runs was to process the waste stream samples until the bulk liquid content was removed and then continue to process the waste stream sample in the unit for some additional period of time at the maximum temperature and vacuum achievable. Removal of the bulk liquid was judged complete by observing the expected drop off of the condensation rate as the waste stream sample approached dryness. An additional period of processing time was included to address the uncertainties of the process such as matrix effects and the degree of removal needed.

The general procedure for removing the bulk liquid content of the waste stream samples was to initially limit the temperature and vacuum to the dryer until most of the liquid was removed from the waste stream sample. This procedure was followed because the dryer had the capability of removing volatile compounds faster than the first condenser could condense them. It was necessary to condense most of the volatile compounds in the first condenser to prevent fouling of the pilot VAC*TRAX unit's vacuum pump oil. Thus, to get maximum treatment in the minimal amount of time, it was necessary to balance the vaporization rate with the capacity of the first condenser. Applied temperature effected this balance because the higher the applied temperature, the higher the vaporization rate. The presence of low melting material in some of the waste stream samples limited the maximum temperature used for those samples. Applied vacuum effected the balance in two ways. As the vacuum was increased, the boiling point of the liquids in the waste decreased and the vaporization rate of the liquid increased. Second, the capacity of the first condenser was reduced as the vacuum increased. For each test run the combination of temperature and vacuum was varied to maximize the condensation rate in the first condenser.

After the condensation rate was observed to fall off to a rate of 20 to 40 milliliters (mL) per hour, the temperature and vacuum were increased to maximum and held for a period of time. The duration at these final conditions was essentially a judgement call and was usually an hour or two.

The results of each treatability test run are presented in Section 4.4. The following is a descriptive summary of operations of each of the treatability test runs with the pilot VAC*TRAX unit.

4.3.1 Surrogate Sample Runs

Soils: The first surrogate soils run commissioned the hot-oil unit and was also a part of operator training. Operation and maintenance procedure were improved during surrogate training.

The dryer was first operated with breaker (cleaning) bars installed to keep soil from building up on the agitator shaft. At the end of the soil surrogate runs with breaker bars installed, the agitator shaft had a small amount of soil build up and the shell was coated with a ½-inch layer of soil. Operating conditions varied from 200 to 300 °F and up to 23.4 inches mercury (Hg) vacuum.

The dryer was then operated without the breaker bars to facilitate loading and decontamination. Soil was heavily caked (greater than 90 percent) on the agitator shaft and dryer shell at the end of the run. When the caked-on soil was removed, soil beneath the crust was visibly wet. These surrogate tests proved the breaker bars were necessary for the soils and sludges tests.

PPE: Surrogate runs were performed on various types of PPE to verify procedures.

4.3.2 Sludge Waste Stream Sample Runs

Run 1 (GJPO-TG 1-AB)

The VAC*TRAX unit was started three times during this run. The first start was terminated when the vacuum pump began making an abnormal sound. Oil was drained from the vacuum pump that was less viscous than unused oil and apparently contaminated with chloroform from the process vapor. The vacuum pump was originally filled to capacity with 2 liters of oil; 3 liters of liquid were drained after shutting the unit down when the pump failed.

After the vacuum pump was repaired, the VAC*TRAX unit was restarted twice. To prevent organic compounds from collecting in the vacuum pump, the temperature and dryer vacuum were adjusted to condense all the organics in the first condenser, thereby eliminating them from the process vapor. Instead of allowing an equal amount of chilled water to flow to both condensers, the chilled water was directed to the first condenser to increase the capacity of the first condenser to condense most of the vapor prior to going through the vacuum pump. Final hot-oil temperature was 335 °F, nitrogen flow was 52 standard cubic feet per hour (scfh), and dryer and vacuum pump pressures were 4 and 8 inches Hg, respectively, at the end of the run. This waste stream sample charge met treatment standards after processing.

Run 2 (GJPO-TG 1-C)

This waste stream sample charge was processed in one continuous 12-hour period. Final hot-oil temperature was 225 °F, nitrogen flow was 90 scfh, and dryer and vacuum pump pressures were 18.5 and 23.5 inches Hg, respectively. This charge was reprocessed to meet the treatment standard for chloroform, (although, resampling may have avoided the retest). Therefore, GJPO-TG 1-C was combined with the treated charge from Run 3 (GJPO-TG 1-DEF) and processed as Run 3A.

Run 3 (GJPO-TG 1-DEF)

This waste stream sample charge was processed in one continuous 15-hour period. Initially, the vaporization rate was high (up to 10 pounds per hour, as measured by the condensate collected), causing a slight positive pressure on the dryer. The vacuum pump pressure was 3.5 inches Hg and dryer pressure was 1 psi. Positive pressure on the dryer was alleviated by pulling more vacuum at the vacuum pump. Final hot-oil temperature was 350 °F, nitrogen flow was 60 scfh, and dryer and vacuum pump pressures were 19.2 and 23 inches Hg, respectively.

The processed soils from charges GJPO-TG 1-C and -DEF were combined and rerun as Run 3A because their chloroform concentrations of 11 and 28 mg/kg, respectively, were still above the treatment standard of 6 mg/kg. The two charges of processed soil were combined because the total volume was within the capacity of the pilot VAC*TRAX unit. Before it was reprocessed, the combined charge in the dryer was agitated for 15 minutes to mix the material and was then sampled. Sample analysis indicated a chloroform concentration of 7.6 mg/kg in the combined charge.

The combined charge was reprocessed during one continuous 7.5-hour period. The shutdown procedure for this and subsequent runs was modified to isolate the dryer from the off-gas train at the end of the run so that contaminants present in the piping could not reenter the treated material. Nitrogen was piped to the vacuum pump pressure relief to eliminate this source of air in leakage and thus decrease the amount of nitrogen flow required through the dryer. Final hot-oil temperature was 400 °F, nitrogen flow was 5 scfh, and dryer and vacuum pump pressures were 14.5 and 24.5 inches Hg, respectively. This combined charge met treatment standards after processing.

Run 4 (GJPO-TG 1-GHI)

The pilot VAC*TRAX unit was operated twice for this waste stream sample charge. Condensate collected at a hot-oil temperature of 200 °F was present in two distinct phases. A small volume of a dense, third-phase condensate was collected at a hot-oil temperature of 250 °F. Nitrogen flow was increased and the vacuum was held constant. Final hot-oil temperature was 500 °F, nitrogen flow was 75 scfh, and dryer and vacuum pump pressures were 12 and 23 inches Hg, respectively. The high pressure drop across the dryer filters (10 inches Hg) was attributed to partial clogging of the filters by condensation on the filters of high boiling compounds. The presence of an oily phase in the condensate suggested that the GJPO-TG 1 waste stream sample contained some amount of a petroleum product or some other high boiling organic compound.

Upon analysis, this treated waste stream sample charge was found to be above the 6 mg/kg treatment standard for chloroform. To confirm that the treated waste did contain greater than 6 mg/kg of chloroform, it was sampled again before reprocessing. Analysis of this second sample indicated that the chloroform concentration had been only 1.1 mg/kg after the first processing and, thus, had met the treatment standard. (Several runs were completed before analytical results were obtained from resampling Run 4.) Upon investigation, it was determined that the original sample had likely been taken from the last material to be removed when the dryer was unloaded. The second sample had been taken from the unloaded material that was mixed before sampling and was more representative of the treated charge. Evidently, the last material removed from the dryer was material that had collected in the ends of the dryer vessel. It is conceivable that the small amount of material collected in the ends of the dryer does not mix as well as the bulk of the material in the dryer and would likely contain greater concentrations of volatile contaminants. Because of these observations, extra effort was used to obtain more representative samples of the treated product.

The waste stream sample charge was reprocessed as Run 4A during one 6-hour shift. Final hot-oil temperature was 400 °F, nitrogen flow was 9.5 scfh, and dryer and vacuum pump pressures were 15 and 16.5 inches Hg, respectively. This charge met treatment standards after processing.

Run 5 (GJPO-TG 1-JKL)

This waste stream sample charge was processed in one 17-hour shift. Final hot-oil temperature was 500 °F, nitrogen flow was 29 scfh, and dryer and vacuum pump pressures were 6 and 23.5 inches Hg, respectively. Clumps of treated material were present when soil was unloaded from the dryer. As in Run 4, the high pressure drop across the dryer filters (17.5 inches Hg) was attributed to partial clogging of the filters by condensation on the filters of high boiling compounds. The increase in pressure drop in this run from the pressure drop in Run 4 indicated the filters were becoming more clogged.

As in Run 4, the treated waste stream sample charge in Run 5 was thought to have not met the treatment standard for chloroform. Resampling and analysis confirmed that the standard was met, but not until after the treated waste stream sample charge had been rerun.

GJPO-TG 1-JKL was reprocessed as Run 5A during one 7-hour shift. The dryer discharge valve was difficult to seal during this run, possibly due to a physical obstruction from the previous run. Final hot-oil temperature was 400 °F, nitrogen flow was 9 scfh, and dryer and vacuum pump pressures were 15 and 16.5 inches Hg, respectively. This charge met treatment standards after processing.

Because the pressure drop across the dryer filters had become unacceptably high, the filter elements were removed from the pilot VAC*TRAX unit after Run 5 and inspected. The filters were found to be coated

with a substance similar to motor oil. The filters were washed then treated in an ultra sonic bath with an Alconox cleaning solution. The heavy oil was removed from the surface of the filters by the Alconox cleaning wash. However, water would not pass through the filters, so they were treated with ultra sound in a sodium bicarbonate solution in an attempt to further clean them. Water would still not pass through the filters after the bicarbonate treatment. Replacement filters elements had to be procured.

While replacement filter elements were being procured, the VAC*TRAX unit was modified. Heat tape was installed on the dryer filter housings to prevent liquid from condensing on the filter elements and thus prevent high pressure drops across the filters during operation. Organic vapor readings were taken at the carbon drum indicating 120 ppm of organic vapor at the inlet and at the exhaust of the carbon drum. An oxygen meter on/off switch was installed so that if the meter malfunctioned, the meter could be reset.

Replacement filters from CTC were installed. The original filters had a rating of 100 percent rejection of particles larger than 0.4 μm . The replacement filters had a rating of 100 percent rejection of particles larger than 0.8 μm .

The pressure drop across the replacement filters was less than 1 inch Hg when the unit was restarted; however, the oxygen level was above its operating limit of 7 percent, which suggested an air leak. The air leak was determined to be a deteriorated epoxy seal around the nitrogen heater element wires. The leaking seal was plugged using a high-temperature, nonconductive sealant.

4.3.3 Soil Waste Stream Sample Runs

Run 6 (LANL-L 13-AB)

Final run conditions for this waste stream sample charge were a hot-oil temperature of 500 °F and 23-inches Hg vacuum. The vacuum pump pressure-relief cap was found to be leaking; when a nitrogen source was placed near the cap, the oxygen concentration significantly decreased. The run was completed before analytical results were obtained that showed the untreated waste did not contain any RCRA regulated organic constituent above the treatment standard. Thus, analysis of the treated product was not performed.

4.3.4 Vermiculite Waste Stream Sample Run

Run 7 (PTX-1574)

This run was completed in two separate sessions. At the beginning of the run, the dryer's Johnson Joint began to leak. The leak was repaired in 1½ hours and the run was continued. Shortly after restarting the pilot VAC*TRAX unit, the vacuum pump discharge pressure rose above the normal operating range (up to 3 psi) because the pump's exhaust filter was saturated with liquid. The filter was replaced mid-run and operating parameters were reestablished within 1½ hours. Final operating conditions were a hot-oil temperature of 500 °F, and vacuum pump and dryer vacuums were 24 inches and 4 inches Hg, respectively. The 20 inches Hg pressure drop across the dryer filters suggested they had become clogged during this run. The waste stream sample charge met treatment standards after processing.

After the run was completed, the inside of the dryer lid and the dryer sides were coated with oil. The dryer lid and the top portion of the sides were not provided with hot-oil jacketing. The filters housings were taken apart and were not coated with oil, probably because the filter housings were heated to 550 °F with heat tape. The filters themselves, however, had oil inside them. The oil may have condensed in the piping

beyond the filter housings and then drained down into the filters. The filters were cleaned by heating in an oven to 580 °F, which removed the oil.

4.3.5 Pliable Debris Waste Stream Sample Runs

Runs 8 – 10 (KCP-1.1-1366-Bag 1, Bag 2, and Bag 3)

Three charges of pliable debris were processed at 200 °F and 22 inches Hg vacuum. These waste stream sample charges met treatment standards after processing.

Runs 11 – 14 (KCP-1.1-1367-Bag 1A, Bag 1B, Bag 2A, and Bag 2B)

Four charges of pliable debris were processed at 200 °F and 22 inches Hg vacuum. These waste stream sample charges met treatment standards after processing.

Runs 15 and 16 (SNL/NM-TG 8)

Charges SNL/NM-TG 8-Bag 1 and SNL/NM-TG 8-Bag 2 were processed with the 0.8 µm filters installed. The runs were made with an oil temperature of 200 °F, and 23 inches and 4 inches Hg vacuum on the dryer for SNL/NM-TG 8-Bag 1 and SNL/NM-TG 8-Bag 2, respectively. The nitrogen heaters were found to be leaking while processing SNL/NM-TG 8-Bag 2; the leak was sealed with a silicone sealant. These waste stream sample charges met treatment standards after processing.

Runs 17 – 19 (LANL-S 10.1)

Three charges of LANL-S 10.1 were run as LANL-S 10.1-Bag C1, Bag C2, and Bag C3. These runs were completed with the 0.8 µm filters installed. Hot-oil temperature was 200 °F for LANL-S 10.1-Bag C1, and 225 °F for Bag C2 and Bag C3. The dryer vacuum was 23-inches Hg for all three runs. Immediately after processing the LANL-S 10.1-Bag C2 charge, the dryer was unloaded and reloaded with LANL-S 10.1-Bag C3. The heavy plastic bags, which originally contained paint chips saturated with paint stripper, were brittle after being processed in the dryer. Because they were hot, the bags were pliable and conformed to the agitator, which made unloading difficult. LANL-S 10.1-Bag C1 and Bag C3 met treatment standards after processing.

LANL-S 10.1-Bag C1 was reprocessed as Run 17A because high levels of dichloromethane (88 mg/kg) were in the product from the first processing. This rerun was completed with the 0.4 µm filters installed. Hot-oil temperature was 225 °F and dryer vacuum was 16 inches Hg. This charge met all treatment standards after reprocessing.

Runs 20 – 21 (LANL-S 10.2)

LANL-S 10.2-Bag 1 and LANL-S 10.2-Bag 2 charges were processed with the 0.8 µm filters installed and at an oil temperature of 225 °F; vacuum was 23.5 inches and 4 inches Hg for LANL-S 10.2-Bag 1 and LANL-S 10.2-Bag 2, respectively. Dryer vapor temperature at the end of charge LANL-S 10.2-Bag 1 was stable; at the end of LANL-S 10.2-Bag 2, however, dryer vapor temperature was highly erratic and actually decreased about 10 degrees during the last hour of the run. LANL-S 10.2-Bag 2 met treatment standards after processing.

LANL-S 10.2-Bag 1 was reprocessed as Run 20A because high levels of dichloromethane (43 mg/kg) were in the product after the first processing. The charge was reprocessed with the 0.4 µm filters installed,

with a hot-oil temperature of 225 °F and 15 inches Hg vacuum. The charge met all treatment standards after processing.

4.3.6 Nonpliable Debris Waste Stream Sample Runs

Run 22 – 24 (SNL/NM-TG 8, LANL-S 10.1, and GJPO-TG 1)

Nonpliable debris runs were for items that could not be processed with the dryer agitator running. For these runs, the nonpliable debris was simply placed in the dryer and baked under a vacuum. These charges met treatment standards after processing.

Run 25 (KCP-1.1-1366 and 1367)

Nonpliable debris from KCP-1.1-1366 and -1367 that had a high melting point was processed at 250 °F and 19 inches Hg vacuum. These charges met treatment standards after processing.

Runs 26 and 27 (KCP-1.1-1367)

Nonpliable debris from KCP-1.1-1367 that had a low melting point was processed at 225 °F and 18.5 inches Hg vacuum. The agitator was removed to fit the large debris items into the dryer. When this material was processed, the 0.8µm alternate filters were installed. A total of approximately 400 mL of condensate was collected. These charges met treatment standards after processing.

Run 28 (SSD-W940000254, 265)

Nonpliable debris was processed with a hot oil temperature of 225°F and a dryer vacuum of 18 inches Hg. This charge met treatment standards after processing.

4.3.7 Mixed Soil and Nonpliable Debris Waste Stream Sample Runs

Run 29 (SSD-W940000255, 256)

This charge was processed with a hot oil temperature of 225°F and a dryer vacuum of 18 inches Hg. This charge met treatment standards after processing.

Run 30 (SSD-W940000253)

This charge was processed with a hot oil temperature of 225°F and a dryer vacuum of 24.3 inches Hg. This charge met treatment standards after processing.

4.3.8 Pliable PPE Runs

Runs 31–40 (KCP-1.1-Feed Prep, GJPO-TG 1-PPE, LANL-S 10.1, 10.2-PPE, and PTX-1574-PPE)

These runs consisted of PPE generated as a secondary waste while performing the treatability tests. These charges met treatment standards after processing.

4.3.9 Feed Sample Runs

Runs 41 – 45 (Feed Samples)

These runs consisted of unused analytical samples of the prepared wastes and met treatment standards after processing.

4.4 Results

Table 4-9 summarizes the pilot VAC*TRAX unit treatability test runs. The table includes the concentrations of RCRA constituents in the untreated (Feed) and treated (Product) waste stream sample charges. Gross alpha and beta concentrations in the solid waste feeds are given as well as gross alpha and beta concentrations in the resulting condensate and the amount of condensate collected. The hot-oil temperature and dryer vacuum varied during each run; Table 4-9 gives the maximum values of these parameters during each run along with the total run duration.

Table 4-9. DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration			Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
								Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)					
GJPO-TG 1-AB	1	05/11,15, 16/95	Sludge	43,584	Chloroform: 2,200 Dimethyl Phthalate: 81 Carbon Tetrachloride: < 87 Benzene: < 87 Phenol: < 120	2.4 11 < 0.62 < 0.62 48	Po: 299 Th: 1211 U-238: 828 U-235: 81 U-234: 839	A: 10.4 O: 153 A: < 7.3 O: < 145	335	12.5	14	10,885	
GJPO-TG 1-C	2	05/17/95	Sludge	17,706	Chloroform: 2,200 Dimethyl Phthalate: 81 Carbon Tetrachloride: < 87 Benzene: < 87 Phenol: < 120	11 23 < 1.2 < 1.2 < 10	"	A: 226 O: 212 A: 91.7 O: < 198	225	18.0	10.0	3,480	
GJPO-TG 1-DEF	3	05/22/95	Sludge	56,298	Chloroform: 98,000 Dimethyl Phthalate: 130 Carbon Tetrachloride: 55 Benzene: 33 Phenol: < 120	28 7 < 0.50 < 0.50 12	"	A: 996 O: 262 A: 247 O: < 198	350	19.0 ^a	14.5	12,715	
GJPO-TG 1-CDEF (Rerun)	3A	07/31/95	Sludge	31,326 ^b	Chloroform: 8 Dimethyl Phthalate: cc Carbon Tetrachloride: < 0.31 Benzene: < 0.31 Phenol: c	< 0.2 N/A < 0.16 < 0.16 N/A	"	340 < 200	400	23.0	7.5	385	

^aDryer was under positive pressure for part of the run.

^bUnloaded weight.

^cCharges were combined for rerun, not resampled

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Conden- sate (pCi/L)				
GJPO-TG 1-GHI	4	05/24, 25/95	Sludge	66,738	Chloroform: 180,000	1.1	"	A: 1,014	500	13.0	19.5	17,109
					Dimethyl Phthalate: 210	< 10		O: < 166				
					Carbon Tetrachloride: 160	< 0.16		A: 252				
					Benzene: 86	< 0.16		O: < 198				
GJPO-TG 1-GHI (Rerun)	4A	08/01/95	Sludge	"	Phenol: < 150	3.5	"		400	15.0	6.0	90
					Chloroform: 1.1	< 0.2		3,990				
					Dimethyl Phthalate: < 10	NA						
					Carbon Tetrachloride: < 0.16	< 0.16		2,350				
GJPO-TG 1-JKL	5	05/30/95	Sludge	62,652	Benzene: < 0.16	< 0.16	"		500	6.0 ^a	17.0	16,940
					Phenol: 3.5	NA						
					Chloroform: 240,000	22		L: 2,120				
					Dimethyl Phthalate: 290	< 10		A: 1,464				
GJPO-TG 1-JKL (Rerun)	5A	08/03/95	Sludge	37,682	Carbon Tetrachloride: < 96	< 0.16	"	D: < 166	400	15.0	7.0	135
					Benzene: 100	< 0.16		L: 1,360				
					Phenol: < 150	97		A: 402				
								D: < 198				
LANL-L 13-AB	6	07/27/95	Soil	18,614 ^b	Chloroform: 1.9	< 0.2	"	1,650	500	23.0	10.0	830
					Dimethyl Phthalate: < 10	NA						
					Carbon Tetrachloride: < 0.16	< 0.16		1,030				
					Benzene: < 0.16	< 0.16						
PTX-1574-A	7	08/30,31 /95	Vermiculite	24,062	Phenol: 97	NA	"		500	12.0	25	8,300
					2,4-dinitrotoluene: < 0.34	NA		NA				
					Hexachlorobenzene: < 0.34	NA		< 34				
					Hexachlorobutadiene: < 0.34	NA						
PTX-1574-A	7	08/30,31 /95	Vermiculite	24,062	Hexachlorobutadiene: < 0.34	NA	"		500	12.0	25	8,300
					Hexachloroethane: < 0.34	NA		< 40				
					Nitrobenzene: < 0.34	NA						
					Vinyl Chloride: < 0.01	NA						
PTX-1574-A	7	08/30,31 /95	Vermiculite	24,062	Pseudocumene: 5,500	9	"	2.4	500	12.0	25	8,300
					Xylene: 115	< 32		23				

^a Dryer was under positive pressure for part of the run.^b Unloaded weight.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
							Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)				
KCP-1.1-1366-Bag 1	8	04/18/95	Debris	5,354	Acetone: 0.40	1	4	< 43	200	2.0	4.5	280
					Methylene Chloride: < 0.250	< 0.2	26	< 21				
KCP-1.1-1366-Bag 2	9	04/19/95	Debris	3,194	Acetone: 0.32	0.6	< 3	< 16.3 ^a	200	22.0	4.5	135
					Methylene Chloride: < 0.100	< 0.2	3.3	< 13.5 ^a				
KCP-1.1-1366-Bag 3	10	04/20/95	Debris	5,211	Acetone: 8.00	1	< 5	< 16.3 ^a	200	22.0	3.5	105
					Methylene Chloride: < 0.100	< 0.2	38	< 13.5 ^a				
KCP-1.1-1367-Bag 2A	11	04/25/95	Debris	3,336	Acetone: 0.58	1 ^b	< 3	< 109	200	23.0	4.0	40
					Chloroform: 0.11	< 0.1	20	< 107				
KCP-1.1-1367-Bag 2B	12	04/26/95	Debris	6,914	Acetone: 0.58	0.5	< 3	< 59	200	22.0	4.0	180
					Chloroform: 0.11	< 0.1	20	< 71				
KCP-1.1-1367-Bag 1A	13	04/28/95	Debris	2,889	Acetone: 0.06	1 ^b	74	NA	200	22.0	4.0	0
					Chloroform: 0.06	< 0.1	132	NA				
KCP-1.1-1367-Bag 1B	14	05/01/95	Debris	3,111	Acetone: 0.06	3 ^b	74	NA	200	22.0	3.5	1
					Chloroform: 0.06	< 0.1	132	NA				
					Methylene Chloride: < 0.050	0.6						

^aCondensate composite.
^bAcetone analytical blank.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)	
							Gross Beta						
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)					
SNL/NM-TG 8-Bag 1 ^a	15	06/23/95	Pliable	5,485	Acetone:	< 6.20	< 1	8	< 62	200	23.0	5.5	260
					Methylene Chloride:	< 6.20	< 1						
					Chloroform:	< 3.10	< 0.6						
					Carbon Tetrachloride:	< 3.10	< 0.6	1.3	< 79				
					Benzene:	< 3.10	~0.1						
					Trichloroethylene:	< 3.10	< 0.62						
					1,1,1-Trichloroethane:	< 3.10	< 0.62						
					1,1,2-Trichloroethane:	< 3.10	< 0.62						
					Methanol:	< 33.5	NA						
SNL/NM-TG 8-Bag 2 ^a	16	06/26/95	Pliable	3,503	Acetone:	0.62	< 1	14,100	< 62	200	5.0	5.0	25
					Methylene Chloride:	0.25	< 1						
					Chloroform:	< 0.16	< 0.6						
					Carbon Tetrachloride:	< 0.16	< 0.6	3,200	< 79				
					Benzene:	< 0.16	< 0.6						
					Trichloroethylene:	< 0.16	< 0.62						
					1,1,1-Trichloroethane:	< 0.16	< 0.62						
					1,1,2-Trichloroethane:	< 0.16	< 0.62						
					Methanol:	< 33.5	NA						
LANL-S 10.1-Bag C1 ^a	17	06/28/95	Pliable	6,856	Acetone:	29.00	< 12	33	199 ^b	200	23.0	4.5	405
					Methylene Chloride:	22,000	88						
					Methyl Ethyl Ketone:	97	< 12						
					Methyl Isobutyl Ketone:	770	< 12	4.5	< 80 ^b				
					Benzene:	< 3.1	< 6.2						
					Ethylbenzene:	33	< 6.2						
					Toluene:	37	< 3.8						
					Xylenes:	201	5						

^aCTC filters installed.^bComposite of all LANL-S10.1 condensate.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)	
							Gross Beta						
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)					
LANL-S 10.1-Bag C1 (Rerun)	17A	9/8/95	Pliable	6,856	Acetone:	< 12	0.82	33	NA	225	24.0	5.5	43
					Methylene Chloride:	88	6.4	4.5	NA				
					Methyl Ethyl Ketone:	< 12	1.1						
					Methyl Isobutyl Ketone:	< 12	0.99						
					Benzene:	< 6.2	< 0.31						
					Ethylbenzene:	< 6.2	< 0.31						
					Toluene:	< 3.8	< 0.18						
Xylenes:	5	< 0.62											
LANL-S 10.1-Bag C2 ^a	18	06/29/95	Pliable	5,964	Acetone:	29.00	< 1	33	199 ^b	225	23.0	5.0	50
					Methylene Chloride:	22,000	2	4.5	< 80 ^b				
					Methyl Ethyl Ketone:	97	7.5						
					Methyl Isobutyl Ketone:	770	1.4						
					Benzene:	< 3.1	0.25						
					Ethylbenzene:	33	0.12						
					Toluene:	37	0.38						
Xylenes:	201	0.88											
LANL-S 10.1-Bag C3 ^a	19	06/29/95	Pliable	7,823	Acetone:	29	< 12	33	199 ^b	225	23.0	5.0	190
					Methylene Chloride:	22,000	2	4.5	< 80 ^b				
					Methyl Ethyl Ketone:	97	< 12						
					Methyl Isobutyl Ketone:	770	< 12						
					Benzene:	< 3.1	< 6.2						
					Ethylbenzene:	33	< 6.2						
					Toluene:	37	1.2						
Xylenes:	201	6.3											
LANL-S 10.2-Bag 1 ^a	20	06/30/95	Pliable	9,869	Acetone:	140	6.8	3,300	< 62	225	23.5	6.0	1,090
					Methylene Chloride:	29,000	43	18	< 71				
					Methyl Ethyl Ketone:	220	5.2						
					Methyl Isobutyl Ketone:	3,800	53						
					Xylenes:	21.4	2.5						
					Methanol:	41,200	NA						

^aCTC filters installed.

^bComposite of all LANL-S 10.1 condensate.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
							Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)				
LANL-S 10.2-Bag 1 (Rerun)	20A	08/24/95	Pliable	6,003 ^a	Acetone: 6.8		3,300	NA	225	15.0	7.5	10
					Methylene Chloride: 43	5.1						
LANL-S 10.2-Bag 2 ^b	21	07/03/95	Pliable	20,000	Methyl Ethyl Ketone: 5.2	1.5			225	4.0	5.5	2,480
					Methyl Isobutyl Ketone: 53	3.7						
					Xylenes: 2.5	< 0.32	18	NA				
					Methanol: NA	NA						
					Acetone: 150.00	1.2	370	< 56				
					Methylene Chloride: 25,000	7.4						
SNL/NM-TG 8 and LANL-S 10.1, ^{a, c}	22	07/10/95	Nonpliable	1,228 ^d 1,244 ^c	NA	NA	NA	NA	250	24.0	4.0	50
							NA	NA				
GJPO-TG 1-Debris ^a (High Temperature)	23	07/11/95	Nonpliable	6,218 ^c	NA	NA	NA	NA	250	12.5	6.0	25
							NA	NA				
GJPO-TG 1-Debris ^a (Low Temperature)	24	07/13/95	Nonpliable	4,290 ^c	NA	NA	NA	NA	225	5.0	6.5	40
							NA	NA				
KCP-1.1-1366, -1367 ^a (Metal Debris)	25	07/14/95	Nonpliable	9,080	NA	NA	NA	< 61	250	19.0	7.5	375
							NA	< 71				
KCP-1.1-1367 Bags 4,6,7 ^a	26	07/17/95 07/18/95	Nonpliable	4,900 ^c	NA	NA	NA	< 111	225	18.5	6.0	25
							NA	< 107				

^a Unloaded weight.^b CTC filters installed.^c Agitator not installed.^d Unloaded weight.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
							Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)				
KCP-1.1-1367-Bag 8 ^a	27	07/18/95	Nonpliable	10,285 ^c	NA	NA	NA	< 111	225	18.5	4.0	0
							NA	< 107				
SSD-W940000254, 265 ^a	28	07/19/95	Nonpliable	5,330	NA	NA	NA	< 98	225	18.0	8.0	30
							NA	< 107				
SSD-W940000255, 256 ^a	29	07/20, 21 /95	Soil, Nonpliable	4,750	Acetone: < 0.4 Chloroform: < 0.2 Benzene: < 0.2	0.1 0.003 < 0.005	NA	< 98	225	18.0	10	75
							NA	< 107				
SSD-W940000253 ^a	30	07/24, 25 /95	Soil	2,585 ^b	Acetone: NA Chloroform: NA	0.1 0.002	NA	< 37	235	24.3	20	300
							NA	< 40				
KCP-1.1-Feed Prep Bag 1	31	05/05/95	Pliable/ PPE	7,491 ^b	NA	NA	NA	NA	200	23.3	5.0	0
							NA	NA				
KCP-1.1 Feed Prep Bag 2	32	06/01/95	Pliable/ PPE	5,139 ^b	NA	NA	NA	NA	200	21.0 ^c	3.5	4
							NA	NA				
GJPO-TG 1-PPE Bag 1	33	06/02/95	Pliable/ PPE	10,880 ^b	NA	NA	NA	NA	210	2.0 ^c	7.5	175
							NA	NA				
GJPO-TG 1-PPE Bag 2	34	06/02, 05, 19 /95	Pliable/ PPE	10,880 ^b	NA	NA	NA	NA	225	2.0	22	3570 ^d
							NA	NA				
GJPO-TG 1-PPE Bag 3	35	06/20/95	Pliable/ PPE	11,502 ^b	NA	NA	NA	NA	200	1.5	6.0	25
							NA	NA				

^a CTC filters installed.

^b Unloaded weight.

^c Dryer was under positive pressure for part of the run.

^d Chloroform added (condensate from earlier run) in attempt to clean filters

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
							Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)				
GJPO-TG 1-PPE Bag 1A	36	08/07/95	Pliable/ PPE	5,110 ^b	NA	NA	NA	NA	225	8.5	6.5	20
							NA	NA				
GJPO-TG 1-PPE Bag 2B	37	08/08/95	Pliable/ PPE	3,060 ^b	NA	NA	NA	NA	225	8.8	5.5	0
							NA	NA				
GJPO-TG 1-PPE Bag 3C	38	06/20/95	Pliable/ PPE	11,502 ^a	NA	NA	NA	NA	200	1.5	6.0	25
							NA	NA				
LANL-S 10.1 LANL-S 10.2-PPE	39	08/11/95	Pliable/ PPE	4,881 ^a	NA	NA	NA	NA	225	9.0	6.0	15
							NA	NA				
PTX-1574-PPE	40	09/04/95	Pliable/ PPE	3,000 ^b	NA	NA	NA	NA	225	10.2	6.0	74
							NA	NA				
KCP-1.1-Feed Samples	41	08/17/95	Feed Samples	3,330	Acetone: 8.00 Chloroform: 0.060 Methylene Chloride: 0.25	NA	74	NA	225	15.0	5.5	30
							132	NA				
LANL-S 10.1 and LANL-S 10.2 Feed Samples	42	08/18/95	Feed Samples	6,060 ^a 2,100 ^a	Acetone: 150 Methylene Chloride: 29,000 Methyl Ethyl Ketone: 290 Methyl Isobutyl Ketone: 5,000 Benzene: < 3.1 Ethylbenzene: 33 Toluene: 37 Xylenes: 201 Methanol: 41,200	NA	3,300	NA	225	13.0	6.5	35
							18	NA				

^a Unloaded weight.^b Approximate weight.

Table 4-9 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results

Waste Stream Sample	Run No.	Date	Matrix	Load Weight (g)	Organic Concentration		Gross Alpha		Maximum Hot Oil Temp. (°F)	Maximum Dryer Vacuum (" Hg)	Run Time (hr)	Condensate Collected (mL)
							Gross Beta					
					Feed (mg/kg)	Product (mg/kg)	Feed (pCi/g)	Condensate (pCi/L)				
SNL/NM-TG 8 Feed Samples	43	08/21/95	Feed Samples	2,289 ^a	Acetone: 0.620 Methylene Chloride: 0.250 Trichloroethylene: < 3.10 1,1,1-Trichloroethane: < 3.10 1,1,2-Trichloroethane: < 3.10 Methanol: <33.5	NA	14,100	NA	225	16.0	6.0	90
					3,200	NA						
GJPO-Feed Samples	44	08/22/95	Feed Samples	1,383 ^a	Chloroform: 22.00 Dimethyl Phthalate: 290 Carbon Tetrachloride: 160 Benzene: 100 Phenol: 97	NA	NA	NA	225	15.0	6.0	10
					NA	NA						
LANL-L 13 Feed Samples	45	08/25/95	Feed Samples	1,000 ^a	Methylene Chloride: < 0.010 2,4-dinitrotoluene: < 0.34 Hexachlorobenzene: < 0.34 Hexachlorobutadiene: < .34 Hexachloroethane: < 0.34 Nitrobenzene: < 0.34 Vinyl Chloride: < 0.01	NA	NA	NA	225	13.0	6.5	30
					NA	NA						

Key:

A = Aqueous
D = Dense organic
L = Light organic
NA = No representative sample

^aApproximate weight.

5.0 Technical Evaluation

5.1 RCRA Contaminant Removal from Solids

The primary purpose of the TD process as applied to mixed waste is the removal of RCRA constituents in the waste feed. The TD Test Plan says that “. . . thermal desorption technology will be considered acceptable if the unit is effectively capable of removing volatile and semi-volatile organics and mercury from the nonvolatile, radioactively contaminated solids. Operational parameters will be chosen to assure effective removal of the contaminants to meet applicable RCRA land disposal restrictions (LDRs) and consequent success of the technology.”

The key to the requirement “to meet applicable LDRs” is removal of RCRA constituents from the waste to the extent that the treatment standards of 40 CFR 268 Subpart D are met. In general, chemical analysis of the treated waste residue is required to verify that the treatment standards in 40 CFR 268.7 (b) (3) have been met. RCRA allows an alternative to numerical treatment standards for treated hazardous debris. The alternative treatment standards, according to 40 CFR 268.45 and 268.7 (d), are documented and certified treatment by an appropriate technology with no numerical standards and no required chemical analysis of the treated debris. The appropriate technology must remove the RCRA constituents to “a measure of performance . . . equivalent to that . . . of other technologies . . . and is protective of human health and the environment” (40 CFR 268.42 (b)). One goal of the TD treatability test program is to demonstrate that treatment is appropriate for the waste streams. Because the only guideline as to what degree of removal would achieve a measure of performance that is protective of human health and the environment is the numerical treatment standards of 40 CFR 268 Subpart D, these numerical standards also are used to determine the effectiveness of TD treatment of debris in this report.

The numerical treatment standards were used for demonstrating TD effectiveness in this report because the only means available for demonstrating the extent of treatment for debris was by sampling and analyzing the treated product and comparing the analytical results with the numerical treatment standards. In all cases, samples of the final treated product met the numerical standards for soils, sludges, and debris wastes. Demonstrating “equivalency,” as required by 40 CFR 268.45 to show that alternate treatment standards for hazardous debris are met, was not attempted and was not within the original scope of these treatability tests. However, the results of the treatability tests suggest that “equivalency” for TD treatment of the debris wastes treated may be demonstrated. In all cases, the residual concentrations of contaminants in the final treated debris product samples were at least four times lower than the numerical treatment standard. Because the sample analysis results were so low, it is unlikely that the residual concentration of contaminants in the aggregate treated debris is higher than the numerical treatment standard and, thus, the treated debris waste is unlikely to pose a hazard to human health and the environment.

To reduce the time required to vaporize the contaminants, the temperature and vacuum of each run were chosen to be above the free boiling point of all contaminants of concern (with the exception of dimethylphthalate and phenol, which were only present in one sludge waste stream.) Debris waste would be expected to be easier to treat than soil or sludge waste. The debris wastes in this study were composed largely of paper, cloth, and thin plastic. As material enters the falling rate drying period, diffusion and capillary effects become more dominant and thin material or nonporous sheet material would offer little resistance to these effects compared to a soil or sludge matrix.

Therefore, based on the methodology described in this report, the goal of removing the volatile RCRA constituents to the extent that treatment standards are met for the waste samples was achieved for each of the waste stream samples tested. Table 4-1 shows the concentration of RCRA constituents in the treated

solids. As shown in Table 4-1, four runs, involving two of the waste stream samples, failed to meet treatment standards after initial treatment in the VAC*TRAX unit. Chloroform concentrations in the solids product from GJPO-TG 1 Runs 2 and 3 exceeded the treatment standard of 6 milligrams per kilogram (mg/kg). Solids products from the LANL-S 10.1 waste stream samples, Runs 17 and 20, failed to meet the treatment standard of 30 mg/kg for dichloromethane after the initial runs of those samples. Each of these solids products was fed back into the unit for additional treatment; samples from these reruns are labeled as Run 2A, Run 3A, etc. All product samples from the reruns met the applicable treatment standards.

5.1.1 Effect of Operating Parameters on Treatment Times

During operation of the VAC*TRAX unit, the only guidance available as to whether the treatment time had been sufficient to successfully treat the waste sample was the rate of condensation coupled with the off-gas temperature. When the rate of condensation approached zero, the waste was effectively dry and little volatile constituents were expected to be left. The cessation of condensation was accompanied by a leveling-off of the vapor temperature.

A total of 12 runs were made during the tests of GJPO-TG 1, LANL-S 10.1 and S 10.2, and Pantex 1574-A, the four waste stream samples that DOE-GJPO analytical results indicated were above treatment standards as received. Four of the 12 runs, or one-third of the total, initially failed to meet treatment standards and required additional treatment. Evaluation of waste stream samples GJPO-TG 1 and Pantex 1574-A, the soil and sludge samples for which numerical treatment standards explicitly apply (unlike debris samples) and for which representative samples were available, gives the same result. There were six runs made on these two waste stream samples and two of these runs, again one-third, initially failed to meet treatment standards. Run plans called for treatment to conclude when the rate of condensation became essentially zero. Based on the DOE-GJPO treatability test results, use of this general guideline may be expected to yield products that require rerunning in about one-third of the total runs.

Determining the "point at which the condensation rate goes to zero" will be difficult with the VAC*TRAX mobile treatment unit because the condensate will be collected in large receivers that do not lend themselves to easy determination of low flow rates. Because extending the initial treatment time is more cost-effective than rerunning the waste once it has been treated, improving the method for predicting treatment times over what was done during the DOE-GJPO treatability tests appears highly desirable.

Logically, removal of volatile compounds is enhanced by treating samples at higher temperatures, at lower pressures, and for longer durations. An ideal measure of treatment duration would combine the effect of all three of these variables in a single parameter that could be related to a measure of removal of RCRA compounds. One such quantitative measure of level of treatment is a component-specific physical parameter called "vapor pressure ratio hours," which combines the effect of temperature and pressure by calculating the vapor pressure of the component of interest using the dryer vapor temperature. The vapor pressure is then divided by the actual dryer pressure to yield the vapor pressure ratio, which can then be numerically integrated over the run time to yield vapor pressure ratio hours.

Table 5-1 shows the percent removal achieved during the DOE-GJPO treatability tests for a number of waste samples containing one or more of the RCRA compounds dichloromethane (normal boiling point [b.p.] 103.7 °F), chloroform (b.p. 142.3 °F), methyl isobutyl ketone (b.p. 241.6 °F), and dimethyl phthalate (b.p. 542.7 °F). The percent removal shown in Table 5-1 is calculated from initial feed weight, condensate weight, and feed and product concentrations. The last column of Table 5-1 presents the total vapor pressure ratio hours calculated for each of these components.

The most reliable data in Table 5-1 should be the chloroform and dimethyl phthalate data, which were taken from sludge samples that were reasonably homogeneous. Indeed, for both chloroform and dimethyl phthalate, the percent removal increases with increasing extent of treatment as indicated by increasing vapor pressure ratio hours. The data for dichloromethane and methyl isobutyl ketone, from debris samples, is more random than those for chloroform and dimethyl phthalate from the sludge samples. Representative samples are essentially impossible to obtain from debris wastes, and this sampling effect could account for some or most of the variability. Another possibility is some sort of matrix effect whereby different matrices have different affinities for organic compounds. However, the debris data in Table 5-1 are randomly scattered even within the same waste stream, let alone within the same matrix, in apparent defiance of the laws of physical chemistry. This suggests that the problem is due to a random (e.g., sampling) phenomenon rather than a systemic (e.g., matrix effects) one.

Vapor pressure ratio hours can be easily calculated in real time with the aid of a computer, requiring only the measured vapor temperature and dryer pressure and a simple vapor-pressure equation. The trend shown by the sludge data in Table 5-1 suggest that calculation of vapor pressure ratio hours may provide a more conservative and generally more applicable guideline for predicting treatment times than the condensation rate. However, the sludge data in Table 5-1 are too few to support derivation of a general correlation for prediction of extent of treatment. Additional data from laboratory studies, treatability tests, and/or actual waste treatment, are needed to derive a defensible general correlation.

Table 5-1. Removal of Contaminants from Treated Solids

Matrix	Compound	Percent Removed	Vapor Pressure Ratio Hours
Sludge	DMP	79.2	0.0162
Sludge	DMP	92.2	0.0775
Sludge	DMP	96.5	0.1734
Sludge	CLF	99.633	52.29
Sludge	CLF	99.937	86.04
Sludge	CLF	99.995	170.69
Sludge	CLF	99.9995	291.28
Sludge	CLF	99.9996	358.88
Debris	MIBK	98.831	12.70
Debris	DCM	99.628	81.86
Debris	DCM	99.871	134.52
Debris	MIBK	99.885	2.50
Debris	DCM	99.975	57.86
Debris	DCM	99.986	27.12

Key
 CLF = chloroform
 DCM = dichloromethane
 MIBK = methyl isobutyl ketone
 DMP = dimethyl phthalate

5.2 Radionuclide Contamination in Condensate

The TD Test Plan establishes a second acceptance criterion for the VAC*TRAX process as applied to mixed waste: "On the basis of prior experience with the pilot TD system at the Clemson Technical Center, no radionuclides are expected to be present in the condensate or vent streams excluding tritium. Any concentration of radionuclide in any of these waste streams, in excess of normal background or waste water levels, would be considered unacceptable."

A total of eight waste stream samples were tested during the DOE-GJPO VAC*TRAX treatability test program (see Table 3-1). The only radionuclide in the Pantex vermiculite sample was tritium, which is volatile and would be expected to report to the condensate (hence the specific exclusion of tritium from the acceptance criteria of the TD Test Plan). Radioactivity levels for all condensate samples from five of the other seven waste stream samples were below detection limits. The remaining two waste stream samples, GJPO-TG 1 and LANL-S 10:1, produced one or more condensate samples with radioactivity levels above detection limits, using standard DOE-GJPO analytical techniques. Based on DOE Performance Objectives (DOE 1993), the samples from these two wastes would be considered radiologically contaminated.

Notwithstanding the stringent criterion given in the TD Test Plan, carryover of radionuclides into the condensate is an economic rather than a process concern. Radioactivity in the condensate necessitates managing the condensate as a mixed waste rather than as a hazardous waste. Mixed-waste condensate increases the cost of final residual treatment, but does not otherwise impact treatment of those residuals, nor does it affect the overall goal of the technology, which is the removal of RCRA contaminants from the solid waste matrix.

The results of all radiation analyses on condensate produced during the DOE-GJPO VAC*TRAX treatability tests are shown in Table 5-2. The abbreviations (aq) and (org) refer to the aqueous and organic phases, respectively, for those condensates that showed two distinct phases or, in the case of GJPO-TG 1 buckets J, K, and L, an aqueous phase and two distinct organic phases.

Table 5-2. Condensate Radionuclide Levels

Run No.	Waste Stream Sample	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
1	GJPO-TG 1-AB (aq)	10.4	< 7.3
1	GJPO-TG 1-AB (org)	153	< 145
2	GJPO-TG 1-C (aq)	226	91.7
2	GJPO-TG 1-C (org)	212	< 198
3	GJPO-TG 1-DEF (aq)	996	247
3	GJPO-TG 1-DEF (org)	262	< 198
3A	GJPO-TG 1-CDEF	340	< 200
4	GJPO-TG 1-GHI (aq)	1,014	252
4	GJPO-TG 1-GHI (org)	< 166	< 198

Table 5-2 (continued). Condensate Radionuclide Levels

Run No.	Waste Stream Sample	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
4A	GJPO-TG 1-GHI	3,990	2,350
5	GJPO-TG 1-JKL (aq)	1,464	402
5	GJPO-TG 1-JKL (light org)	2,120	1,360
5	GJPO-TG 1-JKL (heavy org)	< 166	< 198
5A	GJPO-TG 1-JKL	1,650	1,030
6	LANL-L 13-AB	< 34	< 40
8	KCP-1.1-1366-Bag 1	< 43	< 21
9	KCP-1.1-1366-Bag 2	< 16.3	< 13.5
11	KCP-1.1-1367-Bag 2A	< 109	< 107
12	KCP-1.1-1367-Bag 2B	< 59	< 71
15,16	SNL/NM-TG 8	< 62	< 79
17,18,19	LANL-S 10.1-C1, 1,2,3	199	< 80
20	LANL-S 10.2-Bag 1	< 62	< 71
21	LANL-S 10.2-Bag 2	< 56	< 71
25	KCP-1.1-Metal Debris	< 61	< 71
26	KCP-1.1-1367-Bag 4,6,7	< 111	< 107
28	SSD-W940000254, 265	< 98	< 107
29	SSD-W940000255, 256	< 93	< 107
30	SSD-W940000253-PPE	< 37	< 40
38	SSD-PPE	1,040	610
39	LANL-S 10.1/10.2-PPE	1,900	1,040

Key:

aq = aqueous phase

org = organic phase

The waste streams for which condensate samples showed radiation levels above detection limits were the GJPO-TG 1 and LANL-S 10.1 waste stream samples, and the SSD and LANL PPE samples. The SSD and LANL PPE runs immediately followed Run 5A, the last of the series of GJPO-TG 1 reruns that produced very high levels of condensate radioactivity. The SSD and LANL PPE tests generated little condensate. The radiation in the condensate samples from the SSD and LANL PPE tests is almost certainly due to cross-contamination from the GJPO-TG 1 sample, because the off-gas piping was not decontaminated after the second series of GJPO-TG 1 tests. The TD Test Plan calls for such decontamination "prior to treatment of a new waste sample" (see Section 3.2.6 of the TD Test Plan). Decontamination would have required 10 to

15 gallons of decontamination solvent for each waste sample, and the spent solvent would be considered a secondary waste requiring further treatment. To minimize generation of such secondary wastes, the off-gas piping was not routinely decontaminated during the DOE-GJPO treatability tests.

Table 5-3 shows total alpha radiation levels in the feed and condensate for the GJPO-TG 1 and LANL-S 10.1 waste stream samples. The calculation of radiation level in the GJPO-TG 1 feed is based on an isotopic analysis of that waste showing that the combined alpha level in the feed sample was 3,257.76 pCi/g. The alpha radiation level in the LANL-S 10.1 feed was 33 pCi/g. Because these analyses are based on the dry weight of the sample, the charge weights shown in Table 5-3 were adjusted using the total loss on drying (LOD) analysis for each of the GJPO-TG 1 and LANL-S 10.1 samples (see Appendix B), to give the total feed alpha activity as shown in the third column. The only LANL-S 10.1 condensate sample submitted for analysis was a composite of the condensate for all three runs of that waste, so the radiation balance for LANL-S 10.1 is based on the total alpha level in the feed samples from the three runs.

Table 5-3. Alpha Radioactivity in GJPO-TG 1 and LANL S 10.1 Feeds and Condensates

Batch	Feed		Condensate				Radioactivity In Condensate (%)
	Wet weight (g)	Total pCi	Phase	pCi/L	Volume (mL)	Total pCi	
GJPO-TG 1							
AB	43,584	98,822,403	aq	10.4	14,910	155	0.0002
			org	153	470	72	
C	17,706	40,146,601	aq	226	3,630	820	0.0022
			org	212	300	64	
DEF	56,298	127,283,329	aq	996	12,180	12,131	0.0104
			org	262	4,450	1,166	
GHI	66,738	136,537,491	aq	1014	11,780	11,945	< 0.0100
			org	ND (< 166)	10,300	< 1710	
JKL	62,652	126,341,106	aq	1464	14,855	21,748	< 0.0210
			light org	2120	1,905	4,039	
			heavy org	ND (< 166)	4,780	< 793	
CDEF	(rerun)	167,415,749		340	180	61	0.00004
GHI	(rerun)	136,525,546		3990	90	359	0.00026
JKL	(rerun)	126,315,320		1650	135	223	0.00018
TOTAL GJPO-TG 1		529,130,930				52,782	0.0100

Table 5-3 (continued). Alpha Radioactivity in GJPO-TG 1 and LANL S 10.1 Feeds and Condensates

Batch	Feed		Condensate				Radioactivity in Condensate (%)
	Wet weight (g)	Total pCi	Phase	pCi/L	Volume (mL)	Total pCi	
LANL-S 10.1							
C1	6,856	174,844					
C2	5,964	155,787					
C3	7,823	209,186					
TOTAL LANL-S 10.1		539,817	(comp)	199	645	128	0.0238

Key: aq = aqueous
org = organic

Overall, about 99.99 percent of the total radioactivity in the GJPO-TG 1 feed remained in the treated product. For the LANL-S 10.1 sample, retention of radionuclides in the treated product was over 99.976 percent. Total radionuclide losses were very low for both wastes; the higher losses from LANL-S 10.1 may have been because the tests on that waste stream samples were performed using the more porous filters that were borrowed from CTC while the original filters were being cleaned (see Section 4.3.2, Run 5). Also, because LANL-S 10.1 was a debris waste, the feed samples may not have been as representative as those from the GJPO-TG 1 sludge, which may skew the results to some extent.

Radionuclides could conceivably get past the particulate filters and into the condensate in any of the three physical phases:

1. Solid, as fine particulates passing through or around the filters;
2. Liquid, as soluble compounds (e.g., carbonates) or colloidal suspensions condensing on and flowing through the filters; or
3. Gas, as radioactive gases or volatile radionuclide compounds.

Elemental analysis of the condensate produced during the GJPO-TG 1 treatability tests showed that the radionuclides included uranium and thorium; so, even if radioactive gases were present, they were not the primary source of radiological contamination of these condensates. Further, the first step in the gross alpha/beta analysis used at DOE-GJPO was evaporation of the sample, and the test was performed only on the solid residue. Thus, the radioactive gas/volatile radionuclide scenario can be discounted.

After the first series of GJPO-TG 1 runs, electric heat tape was added to the exterior of the filters under the insulation to try to reduce condensation on the filter elements, on the theory that if the radiological contamination of the condensate was due to water-soluble radionuclides, eliminating condensation on the filters would eliminate this contamination mechanism. Examination of the filters and filter housings after Run 7 showed that the heat tracing greatly reduced condensation on the filters. Yet radioactivity levels in the condensate from Runs 3A, 4A, and 5A, the reruns of the GJPO-TG 1 waste stream samples, were higher than those in any of the other runs made at DOE-GJPO, including the first series of tests on the same waste samples. These results suggest that the radioactivity may not have been due to liquid carryover. Additional data discussed below show that high levels of condensate radioactivity were obtained even at low filter pressure drops and tends to confirm that carryover of liquid-phase radionuclides, which would be enhanced at higher pressure drops, is not significant.

Solid radioactive particulates could get past the filters in any of three ways:

1. Particles smaller than 0.4 μm would not be completely rejected by the filters. Clay particles range in size from about 2 μm down to 0.1 μm and smaller. In the case of a waste such as GJPO-TG 1, which had a high clay content, some very small radionuclide-bearing particles could reasonably be expected to pass through the particulate filters. Radionuclide contamination from this mechanism would be waste-specific, occurring in many but not all of the runs on some waste streams and not at all for others, even when operated under comparable conditions.
2. Partial blockage of the filter pores would cause higher particle velocities through the unblocked portion of the filters, which might result in reduced rejection of particles. This action could be correlated with filter pluggage, and would naturally be low when the filters were clean and high when they were partially plugged.
3. Vapor containing entrained particles could bypass the filters through leaks at the threaded connections. In this case, radionuclide carryover would be general and would be found in all runs.

Table 5-4 shows results of the condensate radiation analyses with the data arranged in chronological order rather than by run number. Arranging the data in chronological order shows time trends and effects such as cross-contamination, which are not apparent when the data is arranged by run (i.e., waste matrix) number. The fact that radionuclide contamination was not found in many of the condensates indicates that bypassing of the threaded filter connections did not occur to any significant extent.

Table 5-4. Condensate Radiation Levels and Filter Performance

Run No.	Waste Stream Sample	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Filter Percent Open	Face Velocity (fpm)
8	KCP-1.1-1366 Bag 1	< 43	< 21	100	5.1
9	KCP-1.1-1366 Bag 2	< 16.3	< 13.5	100	4.5
10	KCP-1.1-1366 Bag 3			100	6.7
11	KCP-1.1-1367 Bag 2A	< 109	< 107	100	6.2
12	KCP-1.1-1367 Bag 2B	< 59	< 71	100	5.7
13	KCP-1.1-1367 Bag 1A			100	6.6
14	KCP-1.1-1367 Bag 1B			100	7.2
1	GJPO-TG 1 AB (aq)	10.4	< 7.3	58	5.0
	(org)	153	< 145		
2	GJPO-TG 1 C (aq)	226	91.7	9.2	24.2
	(org)	212	< 198		
3	GJPO-TG 1 DEF (aq)	996	247	14	15.9
	(org)	262	< 198		

Table 5-4 (continued). Condensate Radiation Levels and Filter Performance

Run No.	Waste Stream Sample	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Filter Percent Open	Face Velocity (fpm)
4	GJPO-TG 1 GHI (aq)	1,014	252	10	20.2
	(org)	< 166	< 198		
5	GJPO-TG 1 JKL (aq)	1,464	402	3.2	31.7
	(light org)	2,120	1,360		
	(heavy org)	< 166	< 198		
34	GJPO-TG 1 PPE-3	< 126	< 73	N/A	N/A
15/16	SNL/NM-TG 8 Bag 1 & 2	< 62	< 79	N/A	N/A
17/18/19	LANL-S 10.1 1/2/3 (comp)	199	< 80	N/A	N/A
20	LANL-S 10.2 Bag 1	< 62	< 71	N/A	N/A
21	LANL-S 10.2 Bag 2	< 56	< 71	N/A	N/A
25	KCP-1.1-Metal Debris	< 61	< 71	N/A	N/A
26	KCP-1.1-1367-Bag 4,6,7	< 111	< 107	N/A	N/A
28	SSD-W940000254, 265-T	< 98	< 107	N/A	N/A
29	SSD-W940000255, 256	< 93	< 107	N/A	N/A
30	SSD-W940000253	< 37	< 40	N/A	N/A
6	LANL-L 13 AB	< 34	< 40	16	8.9
3A	GJPO-TG 1 CDEF	340	< 200	N/A	N/A
4A	GJPO-TG 1 GHI	3,990	2,350	51	0.5
5A	GJPO-TG 1 JKL	1,650	1,030	29	1.4
38	SSD-PPE1-3	1,040	610	N/A	N/A
39	LANL-S 10.1/10.2-PPE	1,900	1,040	N/A	N/A

Key:

aq = aqueous phase
 comp = composite charge
 N/A = not applicable
 org = organic phase

Table 5-4 also shows the percent of the total filter area that was open (not plugged) during each run. This value was calculated using the maximum filter pressure drop observed during the run, and the gas flow rate at the time when the maximum filter pressure drop was observed. According to the manufacturer, the filters used during the DOE-GJPO treatability tests (except for the borrowed CTC filters) should have a pressure drop of 0.091 psi per acfm of gas flow rate per square foot of surface area when the filters are clean. The DOE-GJPO VAC*TRAX unit included six filters with a surface area of 0.59 square feet per filter. So, for

example, the maximum pressure drop observed during Run 1, the test of GJPO-TG 1 batches A and B, was 5.4 psi. The calculated flow rate at this time was 9.75 acfm, and the total filter area is 3.54 square feet. So the pressure drop would be $(5.4 \text{ psi}) \div (9.75 \text{ acfm} \times 3.54 \text{ ft}^2) = 0.16 \text{ psi/acfm/ft}^2$. Since pressure drop is inversely proportional to area, ratioing the measured pressure drop of $0.16 \text{ psi/acfm/ft}^2$ to the manufacturer's specification of $0.091 \text{ psi/acfm/ft}^2$, with 3.54 ft^2 of available clean surface area, gives an effective surface area of 2.01 ft^2 , or 58 percent of the total available. Table 5-4 clearly shows that the filters plugged during the GJPO-TG 1 runs. (The borrowed CTC filters were used for Runs 15 through 30. Accurate performance data on these filters are not available.)

The final column in Table 5-4 gives the gas velocity at the filter face, calculated by dividing the acfm of gas by the open surface area (as calculated in the Filter Percent Open column). The manufacturer states that the filters will meet the performance specification of 100 percent removal of particles $0.4 \mu\text{m}$ and larger when the velocity at the filter face is between 5 and 10 feet per minute (fpm).

Examination of the filters when they were removed following the first series of GJPO-TG 1 treatability tests showed that the high pressure drops observed did not result from accumulation of a cake of filtered particles "blinding" the filter, which would actually increase the filtration efficiency, but from condensed organics coating the filter element. Analysis of the coating showed it to be a petroleum product. This coating dramatically reduced the available filter surface area, as shown in Table 5-4, which in turn would act to reduce filtration efficiency.

Data in Table 5-4 show that cleaning the original filters was partially effective. Calculated face velocities during Runs 4A and 5A were well within the range specified by the manufacturer. However, radiation levels in the condensate produced during the second GJPO-TG 1 series, after the filters were cleaned, were even higher than they had been during the first series. This suggests that the radiation in the condensate was *not* greatly related to filter pressure drop.

Filters are rated by decontamination factor (DF), defined as the ratio of the number of particles of a given particle size that are stopped by the filter to the number that pass through the filter. The definition of a HEPA filter is at least 99.97 percent removal of $0.3 \mu\text{m}$ particles, for a DF of 3333 for this size particle. Most typical HEPA filters exhibit DFs of around 10^4 . U. S. Nuclear Regulatory Commission (NRC) guidelines (Burchsted et al. 1978) for plutonium and other transuranics in gaseous effluents from nuclear power plants recommend a DF of at least 10^{11} . Therefore, because DFs are multiplicative rather than additive, at least three HEPA filters in a series (assuming a DF of 10^4) would be necessary to effect this level of decontamination.

The manufacturer of the particulate filters used in the DOE-GJPO VAC*TRAX unit determined that these filters will meet the HEPA specification for removal of $0.3 \mu\text{m}$ particles provided that the face velocity at the filter surface does not exceed 0.7 feet per minute. As shown in Table 5-4, the actual face velocity at the filters was generally much higher than this figure. Therefore, the filters as installed and operated in the DOE-GJPO VAC*TRAX unit would not be expected to perform at the level of a HEPA filter in most cases.

The conspicuous exception to this general rule, again, is found in the GJPO-TG 1 reruns. The face velocity for Run 4A was 0.5 fpm, which is well within the range in which the primary filters should meet HEPA performance standards. Yet, the level of radioactivity in the condensate from Run 4A was the highest of any condensate sample from the entire DOE-GJPO treatability test program. There are at least two possible explanations for this finding.

1. Particulate carryover may relate to a jetting effect in the off-gas line. Although the total filter area of the DOE-GJPO VAC*TRAX unit is 3.54 ft², the total cross-sectional area of the dryer off-gas nozzles is less than 0.1 ft². The filter housings do not provide for significant dissipation of the high velocity that the gas achieves as it passes through the outlet nozzles, and the particles may simply be blown through the filters before they have a chance to slow down.
2. A single HEPA filter may not be adequate to remove radioactive particles from the vapor stream. The HEPA designation, which grew out of bioengineering (0.3 μm is the minimum size of bacteria), has little significance for radioactive particles. As mentioned above, NRC guidelines for nuclear power plants require much higher levels of decontamination than can be achieved by a single HEPA filter.

No attempt was made to determine the size of the radioactive particulates in the GJPO-TG 1 condensates, or even to determine whether the radioactivity was due to particulates at all; as mentioned above, the possibility that the radioactive contamination was due to water-soluble radionuclides seems unlikely in light of subsequent observation, but cannot be ruled out. Based on the evidence from the DOE-GJPO and CTC test work, it appears that radiation in condensate can be minimized by providing a large gas outlet, such as the CTC cupola, to minimize gas velocity; providing at least two, and possibly three, HEPA filters in a series; and heat-tracing the outlet cupola to reduce liquid bleed-through.

5.3 Heat-Transfer Coefficient

According to the TD Test Plan, "The secondary objective of this treatability test is to determine the limitations of the technology and to obtain operational data . . . for the design of a mobile full-scale unit." Perhaps the key operational parameter for designing a full-scale unit is the heat-transfer coefficient of the dryer. This parameter sets the maximum heat input into the dryer, which in turn sets the sizing of the hot-oil and chilled-water systems, the condensers, and the off-gas piping, including the HEPA filters. Accurate estimates of the heat-transfer coefficient are very important for the full-scale design.

The overall heat-transfer coefficient is defined by the following expression:

$$Q = U_o A \Delta T$$

where

- Q = total heat duty in Btu/hr
 U_o = overall heat-transfer coefficient in Btu/hr-ft²-°F
 A = surface area available for heat transfer, in square feet
 ΔT = temperature difference between the hot and cold surfaces, in °F

Heat-transfer coefficients for the dryer were calculated for every data point of every run during the DOE-GJPO treatability tests. The calculated coefficients varied widely over the course of a run, since they are a function of the amount of condensate being produced. The capability of the dryer can be most accurately related to the characteristics of a particular waste using the *maximum* heat-transfer coefficient, obtained when the condensate production is at its highest. In addition, drying times can be estimated if information relating the heat-transfer coefficient to changes in the moisture level of the waste is available.

Table 5-5 presents the maximum heat-transfer coefficient obtained during each run of the DOE-GJPO treatability tests. The heat duty, Q , is calculated from the measured rate of condensate formation and the latent heat of vaporization of the liquid. The temperature difference, ΔT , is calculated by subtracting the dryer vapor temperature (the cold side) from the average hot-oil temperature (the hot side). The total

surface area, as supplied by the dryer vendor, is 18 ft² (12.1 ft² in the jacket, and 5.9 ft² in the agitator). Table 5-5 does not include reruns and restarts, because most of the condensate had already been removed and the total heat transfer was very low.

As expected, the heat-transfer coefficient is matrix-specific. Maximum values for U_o for the GJPO-TG 1 sludge are several times higher than those of the debris samples (pliable), while values for the other soils and the vermiculite fall somewhere in between.

Table 5-5. Maximum Heat-Transfer Coefficients from DOE-GJPO Tests

Run No.	Waste Stream Sample	Matrix	U_o (Btu/ hr-ft ² -°F)
A	Soil/Clean H ₂ O Surrogate	Soil	2.29
B	3rd Soils/Sand	Soil	7.37
C	Soil Surrogate	Soil	5.47
D	PPE Surrogate	Pliable	2.50
E	Soil Surrogate	Soil	6.98
8	KCP-1.1-1366-Bag 1	Pliable	2.16
9	KCP-1.1-1366-Bag 2	Pliable	0.61
10	KCP-1.1-1366-Bag 3	Pliable	0.68
11	KCP-1.1-1367-Bag 2A	Pliable	0.14
12	KCP-1.1-1367-Bag 2B	Pliable	0.49
14	KCP-1.1-1367-Bag 1B	Pliable	0.01
15	SNL/NM-TG 8 Bag 1	Pliable	1.47
16	SNL/NM-TG 8 Bag 2	Pliable	0.37
17	LANL-S 10.1 C1	Pliable	1.31
18	LANL-S 10.1 C2	Pliable	0.17
19	LANL-S 10.1 C3	Pliable	0.59
20	LANL-S 10.2 Bag 1	Pliable	1.75
21	LANL-S 10.2 Bag 2	Pliable	3.78
1	GJPO-TG 1 AB	Sludge	8.49
2	GJPO-TG 1 C	Sludge	5.02
3	GJPO-TG 1 DEF	Sludge	10.71
4	GJPO-TG 1 GHI	Sludge	20.63

Table 5-5 (continued). Maximum Heat-Transfer Coefficients from DOE-GJPO Tests

Run No.	Waste Stream Sample	Matrix	U_o (Btu/ hr-ft ² -°F)
5	GJPO-TG 1 JKL	Sludge	16.29
6	LANL-L 13 AB	Soil	0.78
30	SSD-W940000253	Nonpliable	0.27
29	SSD-W940000255, -256	Nonpliable	0.06
7	PTX-1574-A	Vermiculite	2.83

To determine the extent, if any, to which the heat-transfer coefficient is affected by the amount of liquid in the sample, Table 5-6 compares the maximum heat-transfer coefficient with the liquid content, using the value calculated from the sample and condensate weights. (The exception is the GJPO-TG 1 sludge runs, for which the LOD is used because samples were combined and condensate weights were not available for the first runs and because the GJPO-TG 1 samples were representative enough that there was little difference between LOD and sample/condensate liquid concentrations [see Table 5-7].)

To facilitate comparisons, the data in Table 5-6 are sorted by matrix, and within matrix, by increasing liquid content. The value for U_o in the Measured column is the actual (measured) maximum value obtained during the run. The Calculated value was calculated by correlation of the liquid content.

Table 5-6. Maximum Heat-Transfer Coefficients vs. Percent Liquid

Run No.	Waste Stream Sample	Matrix	Liquid %	U_o (Btu/ hr-ft ² -°F)	
				Measured	Calculated
A	Soil/clean H ₂ O Surrogate	Soil	17.07	2.29	-
B	3rd Soils/sand	Soil	10.10	7.37	7.09
C	Soil Surrogate	Soil	6.42	5.47	5.67
E	Soil Surrogate	Soil	9.57	6.98	6.96
1	GJPO-TG 1-ABC	Sludge	30.4	8.49	9.85
3	GJPO-TG 1-DEF	Sludge	30.6	10.71	9.99
4	GJPO-TG 1-GHI	Sludge	37.2	20.63	17.42
5	GJPO-TG 1-JKL	Sludge	38.1	16.29	18.97
16	SNL/NM-TG 8 Bag 2	Pliable	0.71	0.37	0.52
10	KCP-1.1-1366 Bag 3	Pliable	1.61	0.68	0.63
11	KCP-1.1-1367 Bag 2	Pliable	1.80	0.14	0.65
19	LANL-S 10.1-C3	Pliable	3.31	0.59	0.83

Table 5-6 (continued). Maximum Heat-Transfer Coefficients vs. Percent Liquid

Run No.	Waste Stream Sample	Matrix	Liquid %	U_o (Btu/hr-ft ² -°F)	
				Measured	Calculated
15	SNL/NM-TG 8 Bag 1	Pliable	3.87	1.47	0.89
8	KCP-1.1-1366 Bag 1	Pliable	4.48	2.16	0.96
9	KCP-1.1-1366 Bag 2	Pliable	5.01	0.61	1.03
17	LANL-S 10.1-C	Pliable	15.40	1.31	2.25
20	LANL-S 10.2 Bag 1	Pliable	16.18	1.75	2.34
21	LANL-S 10.2 Bag 2	Pliable	19.80	3.78	2.76

The correlation used to obtain the calculated heat-transfer coefficients for the surrogate soil and GJPO-TG 1 sludge samples in Table 5-6 is

$$U_o = -0.45322 + 1.41325 \times (\% \text{ Liquid}) - 8.12256\text{E-}2 \times (\% \text{ Liquid})^2 + 1.50944\text{E-}3 \times (\% \text{ Liquid})^3$$

The correlation coefficient (R^2) for this expression is 0.893, indicating a satisfactory correlation with the existing data. (The data for surrogate Run A, the first run made with the DOE-GJPO VAC*TRAX unit was not included in this correlation, because the operators were still learning how to operate the equipment during Run A and the data from it would be suspect.) Assuming that there is continuity between the surrogate soil and sludge samples, the correlation between U_o and liquid content is strongly positive when the liquid content is low (≤ 10 percent). At 10 percent liquid, the calculated heat-transfer coefficient is about 7 Btu/hr-ft²-°F. Above 10 percent liquid, the U_o remains essentially unchanged, at between 7 and 8 Btu/hr-ft²-°F, until the liquid content reaches about 25 percent. As the liquid content increases above 25 percent, the heat-transfer coefficient begins to increase rapidly, reaching a predicted value of 23 Btu/hr-ft²-°F at 40 percent liquid.

The relationship between heat transfer to the soil/sludge and liquid content is not surprising at low liquid concentrations, where additional moisture makes the material behave less like dry sand, which transfers heat very poorly, as the moisture content increases. Nor is it surprising at high concentrations where the material is moving towards a free-liquid state where heat transfer is excellent. The intermediate range of moisture contents between 10 and 30 percent is problematic. However, there is no actual data (except for the discarded Run A point) in this range, so the "flattening" behavior indicated by the correlation given above should not be taken as definitive; data is obviously required to define the correlation for this range. However, the correlation as presented may be adequate for "order-of-magnitude" prediction of maximum heat-transfer coefficient for soils and sludges, and for modeling of drying behavior as moisture content drops during the course of the run.

The correlation used to obtain the calculated heat-transfer coefficients for the pliable debris samples in Table 5-6 is

$$U_o = 0.438 + 0.1175 \times (\% \text{ Liquid})$$

Here the correlation coefficient is only 0.578, indicating a relationship which is generically true (in general, debris samples having higher liquid contents should and do show higher heat-transfer coefficients) but of little predictive value, as can be seen by comparison of the Measured and Calculated maximum heat-

transfer coefficients in Table 5-6. For design of a debris drying system, the correlation shown above would be of no value for any except the crudest estimating purposes.

Data such as that presented in Tables 5-5 and 5-6 should only be extrapolated to other wastes and other similar dryers with caution, and should not be extrapolated to other dryer types at all. The peculiarities of the KS dryer design used at DOE-GJPO also need to be taken into account when using this data for other rotary dryers. For instance, the KS dryer is not jacketed on the top of the shell or on the ends. Because there is little agitation at the ends of the dryer, and no continuous contact between the dryer shell and the dryer contents at the top of the dryer, the KS design is jacketed only where such jacketing is most effective. Before attempting to use the DOE-GJPO data to predict the performance of other dryers of different jacket configurations (e.g., the CTC dryer, which is completely jacketed), the surface area of the ends and the top of the dryer should be subtracted from the total heat-transfer area available.

For wastes having a vermiculite matrix, the only run with complete data available as of this writing yielded a U_o of 2.83. However, additional tests are planned using waste streams with a vermiculite matrix. Design of VAC*TRAX systems for vermiculite wastes should await the analysis of the data from these tests.

5.4 Liquid Content and Fog Formation

Most of the waste samples used in the DOE-GJPO treatability tests were analyzed for total liquid content prior to introduction into the dryer, using a simple LOD procedure. This value can be compared with the liquid content of the sample as determined by dividing the weight of condensate collected during the test by the weight of the sample as charged to the dryer. Table 5-7 shows the liquid content for the samples tested at DOE-GJPO, both as measured by the LOD method and as determined from run data (sample and condensate weights).

The difference between the analyzed LOD and the calculated liquid content appears to be due to sampling variations. The GJPO sludge was carefully sampled to ensure that the sample was representative, and the close agreement observed between LOD and liquid content confirms that the sampling was successful. Many of the other samples were intentionally biased towards high moisture content, by deliberately sampling the wettest portion of the waste in order to obtain as much liquid as possible for chemical analysis. The *VAC*TRAX Design Data Report* (VAC*TRAX DDR) (DOE 1995j) suggests that formation of a fog in the condensers was a problem during early treatability tests. However, the close agreement between analyzed LOD and calculated liquid content for the GJPO sludges indicates that fog formation was minimal.

Table 5-7. Liquid Content of Waste Stream Samples

Run No.	Waste Container	Percent Liquid	
		LOD	Run Data
4	GJPO-TG 1-GHI	37.2	37.2
5	GJPO-TG 1-JKL	38.1	38.1
8	KCP-1.1-1366-Bag 1	9.14	4.48
9	KCP-1.1-1366-Bag 2	5.77	5.01
10	KCP-1.1-1366-Bag 3	10.54	1.61

Table 5-7 (continued). Liquid Content of Waste Stream Samples

Run No.	Waste Container	Percent Liquid	
		LOD	Run Data
11	KCP-1.1-1367-Bag 2	12.15	1.80
13	KCP-1.1-1367-Bag 1	6.14	0.00
15	SNL/NM-TG 8-1432-Bag 1	21.82	3.87
16	SNL/NM-TG 8-1432-Bag 2	14.33	0.71
17	LANL-S 10.1-1392-Bag C	22.72	15.40
19	LANL-S 10.1-1392-Bag C3	18.97	3.21
20	LANL-S 10.2-1391-Bag 1	32.48	14.71
21	LANL-S 10.2-1391-Bag 2	25.07	16.37

6.0 Design Considerations for Mobile Treatment Unit

The purpose of this report is to summarize the results of the VAC*TRAX treatability tests performed at DOE-GJPO. However, a summation of the lessons learned from these tests, as they apply to the design and operation of a VAC*TRAX MTU, should not ignore the significant experience gained during tests using the CTC VAC*TRAX unit, which has logged many hours of operation on diverse waste streams. This section concentrates on the lessons of the DOE-GJPO studies. However, in some cases the CTC experience has provided valuable additional information, which is included in this section where appropriate.

6.1 The "Debris Rule"

40 CFR 268.2(g) defines "debris" as a waste predominantly consisting of pieces of material at least 60 millimeters (mm) or about 2½ inches in one or more dimensions. The purpose of the regulation is to recognize that obtaining representative samples of such wastes is difficult, if not impossible and, therefore, analytical verification that such wastes have been treated so that the concentrations of all hazardous compounds are below treatment standards (40 CFR 268 Subpart D) is unrealistic. Treatment of wastes meeting the "debris" classification requires the treatment technology to be accepted as appropriate for the waste and the contaminant(s), the operation of the treatment unit to be documented, and that certification of treatment be submitted (as per 40 CFR 268.7(d)(3)(iii), in accordance with 40 CFR 268.45) confirming that the treated debris no longer poses an environmental hazard. Analysis of the treated debris is not required.

The chief advantage of the "debris rule" from the generator's point of view is the "conditioned exclusion," outlined in 40 CFR 268.45(c). This exclusion says that, once treatment is completed and certified, the material is not considered a hazardous waste and does not have to be disposed of in a hazardous-waste (Subtitle C) facility. In the case of mixed wastes, treated debris is considered to be low-level radioactive waste and can be disposed of as such, greatly reducing residual disposal cost.

Regulators for the State of New Mexico have interpreted the sizing restriction in the "debris rule" to mean that the waste must meet the sizing criterion of at least 60 mm at all stages of the treatment process. This means that the treated residue from waste material such as the paint chips in the LANL-S 10.1 and LANL-S 10.2 waste streams, which were received as long strips but were ground into fine powder in the treatment process, would not be considered debris. As nondebris waste, the residue would have to be analyzed to confirm that it meets treatment standards, and disposed of in a Subtitle C disposal facility. Also, shredding of debris wastes to less than 60 mm, which facilitates handling, treatment, and sampling, would take the treated residue out of the debris classification, making it subject to the same nondebris hazardous-waste restrictions. This regulatory interpretation has a significant impact on the VAC*TRAX MTU design.

6.2 Feed Preparation

Prior to beginning the treatability tests, it had been hoped that the VAC*TRAX MTU design could simply allow drums of waste to be unloaded either directly into the dryer or into a shredder coupled to the dryer, without opening the drums and sorting the contents. However, a number of the waste sample drums that were opened during waste sample preparation for the DOE-GJPO VAC*TRAX treatability tests contained items inappropriate for treatment in VAC*TRAX, such as radiation sources that were clearly not low-level for radioactivity. The drums also contained vises and other large, nonpliable items that would damage or destroy the dryer or shredder if fed directly, but which could be treated in the dryer after the agitator was

removed. The chief lesson learned from the waste sample preparation process is that, prior to shredding or charging to the dryer, it will be necessary to manually open each drum and inspect the contents.

Waste sample preparation for PPE, plastic sheeting, and other pliable material consisted of cutting the material into long strips. During testing, these strips quickly wound around the paddle, making organic removal difficult and prolonging treatment time. It was found that strips not exceeding 10 inches in length or width did not wind around the paddle, and so could be effectively treated. However, even these smaller strips were difficult to unload through the single 3-inch discharge valve.

The feed preparation system for the VAC*TRAX MTU must provide for size reduction of PPE, plastic sheeting, and other pliable material so it can be loaded into the dryer, effectively treated, and discharged from the dryer once treatment is complete. Regulatory interpretation of the "debris rule" (Section 6.1) essentially requires that the feed preparation system for the VAC*TRAX MTU be designed so that debris materials remain predominantly 60 mm or larger in at least one dimension after size reduction. A test of a pilot shredder unit on samples of PPE, duct tape, herculite sheets, tires, sticks, plastic bottles, and cans, produced long strips that comply with the definition of debris.

6.3 Dryer Design

6.3.1 Dryer Type

The VAC*TRAX DDR assumes that the VAC*TRAX MTU will use a double-cone or twin-shell dryer. This choice was based on the expectation, borne out by subsequent pilot testing by DOE-GJPO that this type of dryer would yield better mixing and faster and more thorough drying than the horizontal rotary dryers used in both the CTC and DOE-GJPO VAC*TRAX pilot units. However, review of the results of the DOE-GJPO treatability tests show that radionuclide carryover is a significant potential problem (see Section 5.2), and the off-gas handling system of the double-cone or twin-shell dryer design would aggravate that problem due to its high velocities. Design of radionuclide containment for the double-cone or twin-shell dryer system would constitute a major engineering project in itself, with success by no means assured. Therefore, the VAC*TRAX MTU design should use the rotary dryer, incorporating the best features of both the CTC and DOE-GJPO units as demonstrated by pilot-test experience. The dryer must be capable of handling nonpliable debris up to at least 2½ inches in any dimension.

6.3.2 Comparison of the CTC and GJPO Dryers

The KS rotary dryer used in the DOE-GJPO tests was chosen solely because it was the only rental dryer unit available during the time frame of the DOE-GJPO treatability tests. The original CTC VAC*TRAX unit used a Paul Abbe rotary dryer, which was different from the KS dryer in a number of ways.

1. The KS dryer was pressure-rated for up to 50 psig on the jacket. The jacket of the CTC dryer did not have a pressure rating, so it was necessary to provide a special pressure-relief system to keep the hot-oil pressure below 1 atmosphere (atm).
2. The CTC dryer was cylindrical and the oil jacket covered the full circumference of the dryer, as well as both end plates. The KS dryer was semiellipsoidal with a flat top plate, and the top plate and both end plates were not jacketed.
3. The off-gas line on the CTC dryer was a single 13-inch flange, on which was mounted a cupola 16 inches in diameter that contained 13 primary filters elements. The KS dryer had two 3-inch

off-gas flanges, on which were mounted 6-inch filter housings fabricated from eccentric reducers. These housings contained three primary filters each, for a total of six elements.

4. The solids outlet on the KS dryer was a 3-inch ball valve, while the CTC dryer used a 4-inch hinged door. The CTC dryer door was a major leak source unless the sealing surfaces were carefully cleaned each time product was discharged. On the other hand, its larger surface area was much more effective at removing solids than the KS design.
5. CTC experience indicates that its dryer design was fairly effective in removing solids from the dryer at the end of the run, while as much as 40 percent of the solids were typically left in the KS dryer at the end of DOE-GJPO runs. This suggests that the design of the agitator in the CTC dryer, which was different from the KS dryer, may minimize stagnant zones at the ends of the dryer where heat and mass transfer, and hence drying, would be poor.

In addition to these physical differences, air leakage into the KS dryer at high vacuum was considerably higher than into the CTC dryer. Comparing data for typical runs of comparable durations and similar average leak rate (Run 1017-07 of the CTC Teller Arms study [CTC 1994] and Run 18 of the DOE-GJPO treatability tests) shows the difference in air leak rates (calculated from nitrogen makeup rates and oxygen concentrations) between the CTC and KS dryers, as presented in Table 6-1. While air leakage into the KS dryer increases at higher vacuum levels, the CTC dryer actually seals better at high vacuum.

6.3.3 Design Considerations

The VAC*TRAX rotary dryer operates between atmospheric pressure and full vacuum, and there is no advantage in operating above atmospheric pressure. Therefore, the design pressure of the shell need only be a low positive value, such as 1 atm, in addition to full vacuum. For waste treatment, the higher the temperature, the shorter the treatment time required (see Section 5.1). The DOE-GJPO dryer had a maximum temperature of 500 °F, which was adequate for the wastes stream samples tested at DOE-GJPO but would have greatly limited its ability to treat wastes containing, for example, PCBs. From a practical standpoint, the dryer design temperature, and the jacket design temperature and pressure, will be limited by the characteristics of available heat-transfer fluids. The Paratherm heat-transfer fluid used in the DOE-GJPO treatabilities tests is nontoxic, which eliminates most safety and RCRA concerns, and has a low vapor pressure, which reduces the required jacket and hot-oil design pressure. However, Paratherm has a maximum operating temperature of 600 °F. Alternatives include Therminol 66, with low vapor pressures like Paratherm and a maximum operating temperature of 650 °F. Increasing the operating temperature by 50 °F has the potential to reduce treatment times significantly. However, Therminol and other similar high-temperature fluids are toxic. The final decision about dryer design conditions will have to weigh these considerations.

As described in Section 6.3.2, the heat-transfer jacket of the dryer used in the DOE-GJPO tests covered only the lower portion of the straight shell. During inspection following the DOE-GJPO tests on wastes containing significant concentrations of heavy oils (e.g., GJPO-TG 1 and PTX-1574), a significant buildup of heavy "tarry" material was noted on the top surface of the dryer and in the filter housings. This material was similar to the material that plugged the filters during the first GJPO-TG 1 series (Section 5.2.) The CTC dryer was jacketed around its entire circumference and both ends, and the filter cupola was also jacketed. No such buildup of heavy material was ever noted during any of the CTC runs, nor has CTC had trouble with filter plugging. The dryer used in the VAC*TRAX MTU should be completely jacketed, including the filter cupola, following the CTC design. Full jacketing should also preclude refluxing of condensed material on the top of the dryer, shortening drying times and making higher removal levels possible.

Table 6-1. Comparison of Air Leak Rates for CTC and KS Dryers^a

Elapsed Time (hr)	CTC Data		KS Data	
	Pressure (psia)	Leak Rate (scfm)	Pressure (psia)	Leak Rate (scfm)
0.00	4.9	2.14	11.4	0.05
0.25	4.7	1.81	—	—
0.50	4.7	1.36	11.4	0.05
0.75	4.4	1.40	—	—
1.00	3.5	1.44	11.4	0.06
1.25	3.5	1.07	—	—
1.50	2.5	0.65	11.4	0.05
1.75	1.5	0.21	—	—
2.00	1.0	0.12	5.6	0.17
2.25	1.0	0.11	—	—
2.50	1.0	0.09	5.8	0.16
2.75	1.0	0.09	—	—
3.00	1.0	0.09	5.8	0.16
3.50	1.0	0.10	1.0	0.74
4.00	0.5	0.09	1.0	0.76
4.50	1.0	0.11	0.9	0.75

Note: Air leakage rates into the KS dryer were calculated at half-hour intervals only.

^aComparison is from Run 1017 of the CTC Teller Arms study and Run 18 of the DOE-GJPO treatability tests.

Inspection of material found in the filter housings suggested that at least some of it may have been deposited by mechanical lifting action (i.e., dryer contents actually lifted into the housing, rather than occurring through gas carryover). The large gas outlet flange on the CTC dryer was tapered so that the inside diameter of the outlet opening was larger on the inside of the dryer than on the outside. In this way, the outlet piping does not form a shelf where buildup of material can occur. The VAC*TRAX MTU dryer should incorporate this feature.

The DOE-GJPO product-handling system was not designed to handle hot material. Therefore, after the end of a test, the dryer was allowed to cool overnight and the product was removed the next day. During the CTC tests on solids containing PCBs (for which the TSCA-allowable concentrations are as low as 6 parts per billion) if the product was allowed to cool overnight as was done at DOE-GJPO, it never met TSCA requirements. However, if the product was dumped and sealed while it was still at maximum temperature, PCB concentrations were at or below TSCA limits. It was speculated at the time that the hot material absorbed residual PCBs from the atmosphere as it cooled. Regardless of the source of the

post-treatment contamination, it is apparent from this experience that for treatment of certain wastes, it will be necessary to unload the product while it is at maximum temperature before the hot-oil temperature is reduced, and the VAC*TRAX MTU should be designed accordingly.

6.4 Filter Design

To minimize the chances for radionuclide carryover into the condensate, the VAC*TRAX MTU design will minimize the face velocity at the filter surface by using a single off-gas flange of the largest practical diameter and by mounting the filters in a filter cupola with the same diameter as the dryer shell. As mentioned earlier, the cupola will be completely jacketed with hot oil providing no net loss of heat to the surroundings (hence, no condensation of heavy components) until the gas enters the outlet piping. The vapor outlet line should exit the cupola from the side of the top head, rather than from the top of the head, and be sloped downwards to the primary condenser with no pockets.

To maximize the radiological decontamination factor (Section 5.2), the primary filters should be specified and operated to maintain at least a HEPA rating. The DOE-GJPO treatability tests showed that a single set of HEPA filters may not be adequate to prevent breakthrough of radionuclides in all cases, suggesting that multiple banks of HEPA filters in a series may be required to achieve complete radiological decontamination. However, as noted in Section 5.2, radionuclide carryover into the condensate is an economic rather than a process concern, because radioactive condensate must be treated as mixed waste rather than as hazardous. Therefore, the final decision about how many banks of HEPA filters should be installed on the VAC*TRAX MTU will be economic, based on need and considerations weighing the cost of extra bank(s) of filters against additional costs that will be incurred to treat radiologically contaminated residue. DOE-GJPO experience provides a basis for an order-of-magnitude estimate of the likelihood of radionuclide breakthrough, which occurred in one of the two soil samples, and one of the five debris samples tested at DOE-GJPO. This estimate should be considered when deciding the appropriate number of filter banks to include in the VAC*TRAX MTU design.

Both the CTC and DOE-GJPO primary filters were equipped with blow-back systems that supplied pressurized nitrogen to clean accumulated dust off the filters. Such systems are standard equipment in many filtration installations, baghouses, electrostatic precipitators, and the like. However, data from the DOE-GJPO tests (substantiated by anecdotal evidence from CTC) suggest that filter blow back is not effective in thermal desorption service. During the DOE-GJPO treatability tests, the filters were only blown back once while the unit was operating, although they were blown back routinely at the end of each run. Figure 6-1 shows the pressure drop across the primary filter before and after that blowback, which took place at approximately 12 hours elapsed time. The blow back clearly had no salutary effect on the pressure drop.

Blow back is most effective at removing dry, uniform cakes from filter surfaces. The filters in the VAC*TRAX units have not been observed to form such uniform cakes. Plugging in the primary filters appears to be primarily due to deposition of condensables on the filter surfaces and in the pores. The only filter cleaning technique that proved effective was baking the filters in a separate oven at 580 °F, which vaporized the interstitial nonvolatiles. CTC experience indicates that if the filters are properly heated, they will plug infrequently, if at all; DOE-GJPO experience indicates that when they do plug, blow back is ineffective. Based on this experience, there is no reason to include filter blow back in the VAC*TRAX MTU design.

GJPO-TG-1-JKL
05/30/95

Figure 6-1. Blow Back Effect on Filter Pressure Drop

6.5 Operational Considerations

6.5.1 Treatment Times

VAC*TRAX is a batch treatment process, and the effectiveness of treatment is enhanced by higher temperatures, lower pressures, and longer treatment duration (Section 5.1.1). Continuing treatment after it is no longer needed wastes time and energy, while terminating treatment before it is complete necessitates rerunning the waste to meet treatment standards. A substantial portion of the heat required by the TD process goes to heating the solid substrate (the dryer itself) and is lost to the environment rather than into vaporizing volatiles (see Section 2.1.4 of the VAC*TRAX DDR), so re-treating a waste to remove trace contaminants is nearly as time and energy intensive as the original treatment.

The guideline used during the DOE-GJPO treatability tests for determining process completion was to continue treatment until the condensate rate was negligible. This approach could also be used during waste treatment with the VAC*TRAX MTU. However, as discussed in Section 5.1.1, use of this guideline gave unsatisfactory results in one-third of the DOE-GJPO test runs. This guideline would be of little value when treating a waste containing volatile RCRA-regulated compounds and less-volatile nonregulated constituents (e.g., oils and greases). In such cases, as the dryer temperature is increased, the dryer would continue to make condensate, due to vaporization of innocuous compounds, long after the concentrations of RCRA compounds may have dropped below treatment standards. In addition, a major difficulty with use of condensate flow measurements is the wide range of condensate rates, which typically vary by more than 100 to 1 over the course of the run. Accuracy over such ranges is a challenge to the best of flow instruments. The VAC*TRAX DDR shows level gauges on both condensate receivers, with the flow indicated by totalizers on the level gauges, which may not yield sufficient accuracy for the range of flow rates required. Considering such practical limitations, establishing a value for "negligible" that is realistic yet acceptable to regulators may prove difficult.

By definition, treatment of hazardous wastes (excepting debris; see Section 6.1) is complete when the concentrations of all RCRA-regulated compounds in the original waste have dropped below their respective treatment standards in the treated product. Unfortunately, such determination may be difficult to make on-line. Analysis of RCRA volatile and semivolatile compound concentrations in solids samples does not lend itself to quick turnaround analyses that could be performed while the dryer is maintaining a steady-state condition. Thus, for actual waste treatment, it is desirable to be able to estimate the time actually required to remove all listed constituents.

Section 5.1.1 includes discussion of a method for relating percent removal of volatile and semivolatile compounds to extent of treatment using "vapor pressure ratio hours," which combines the effects of temperature, pressure, and treatment duration into a single parameter. The data collected during the DOE-GJPO tests, while indicating the potential promise of this approach, was not sufficient to support derivation of a general formulation for calculating treatment times. Additional data, from laboratory studies, treatability tests, and/or actual waste treatment, are needed to derive a defensible general correlation.

6.5.2 Other Operational Considerations

The best indicator of dryer operation is the vapor temperature. When significant amounts of condensate are being produced, the vapor temperature remains essentially constant, at the boiling point of the compound being vaporized. The temperature rises once vaporization of that compound is finished. This indicator proved very useful during the treatability tests on the GJPO-TG 1 waste, the only waste sample that contained large amounts (greater than 1 percent) of more than one liquid. The vapor temperature gave

a direct indication of which component (chloroform, water, or heavy organic) was being vaporized at any given time. For tracking the progress of waste treatment, plots of off-gas temperature and condensate production would be very useful.

Oxygen content in the DOE-GJPO VAC*TRAX system off gas was monitored by the off-gas analyzer. In general, this instrument was reliable and did not need frequent recalibration, although it was very sensitive to moisture content. The operating procedures called for nitrogen to be added to keep the oxygen content below 7 percent. This general guideline was taken from the CTC operating procedures, but it needs to be verified by actual data on explosive limits of organics in oxygen-depleted atmospheres before being incorporated in the VAC*TRAX MTU operating procedures.

The nitrogen purge to the dryer should be controlled to maintain a temperature at least 50 °F above the dryer vapor temperature at all times. Since the nitrogen flow is highly variable and depends on the leak rate into the dryer (which was quite low at both DOE-GJPO and CTC), the nitrogen heater must either have a minimum flow rate, or the heater must be interlocked to shut down at low flow rates, to avoid burning out the heater elements.

During cool-down of the dryer, condensed material in the off-gas piping and the primary condenser can revaporize when the dryer temperature is low enough. This revaporization is thought to have contributed to trace contamination of the treated solids. During normal operation of the VAC*TRAX MTU, the product should be discharged from the dryer while still hot (see Section 6.3), so revaporization will not be as much a consideration. Nonetheless, the nitrogen purge should be continued at least until the product is discharged. Also, to avoid recontamination of the dryer, valving should be provided so that the dryer can be isolated from the off-gas piping once cool-down is completed.

Draining of the primary (vacuum side) condensate receiver on the DOE-GJPO VAC*TRAX unit resulted in oxygen excursions until the operators learned to purge the receiver with dryer off gas to pressurize it prior to opening. A similar system should be incorporated into the VAC*TRAX MTU design.

The physical layout of the DOE-GJPO VAC*TRAX pilot unit required operators to reach across the top of the dryer to operate valves in the nitrogen and off-gas piping. The piping layout of the VAC*TRAX MTU should be carefully reviewed by personnel familiar with operation of the unit to ensure that such ergonomic issues are properly addressed in the final design.

7.0 References

Burchsted, C.A., A.B. Fuller, and J.E. Kahn, 1978. *Nuclear Air Cleaning Handbook—Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*, ERDA 76-21, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Clemson Technical Center, 1994. *Draft Topical Report on VAC*TRAX Vacuum Thermal Desorption, Phase I Pilot Testing Results*, Section 6.0, Clemson Technical Center, Anderson, South Carolina, June.

Rust Geotech. *Conduct of Operations Manual* (Manual 119), U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

U.S. Code of Federal Regulations

40 CFR, *Protection of the Environment*, Part 268, "Land Disposal Restrictions."

U.S. Department of Energy, 1993. *Performance Objective for Certification of Nonradioactive Hazardous Waste*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, December.

_____, 1994. *Project Implementation Plan for Thermal Desorption*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, September.

_____, 1995a. *Health and Safety Plan for Thermal Desorption Treatability Test Feed Preparation*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

_____, 1995b. *Health and Safety Plan for Thermal Desorption Treatability Testing*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

_____, 1995c. *Pilot Thermal Desorption Treatability Test Operation and Maintenance Procedure*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, May.

_____, 1995d. *Thermal Desorption Feed Preparation Conduct of Operations Applicability Matrix*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado.

_____, 1995e. *Thermal Desorption Treatability Test Feed Preparation Plan*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

_____, 1995f. *Thermal Desorption Treatability Test Feed Preparation Sampling and Analysis Plan*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

_____, 1995g. *Thermal Desorption Treatability Test Plan*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

U.S. Department of Energy, 1995h. *Thermal Desorption Treatability Test Sampling and Analysis Plan*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, March.

_____, 1995i. *Thermal Desorption Treatability Test Unit Design Basis*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado.

_____, 1995j. *VAC*TRAX Design Data Report* prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, August.

Appendix A

Plans and Procedures for VAC*TRAX Tests

This page intentionally blank

Appendix A

Plans and Procedures for VAC*TRAX Tests

This appendix includes brief descriptions of the plans and procedures developed by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office (DOE-GJPO) and used for the DOE-GJPO VAC*TRAX treatability testing.

A.1 Thermal Desorption Treatability Test Unit Design Basis, February 1995

The Design Basis document was issued to develop and document the basis for the design of the DOE-GJPO VAC*TRAX pilot unit. The pilot unit was designed, equipment was procured, and the unit was constructed based on the guidance of this document. The design basis document includes the following:

- General description and mission
- System description, including each piece of equipment and electrical, structural, instrumentation, piping requirements, etc.
- Waste acceptance criteria for the wastes identified from six DOE-Albuquerque (AL) sites
- Equipment list
- Primary electrical
- Instrument list
- Valve list
- Schedule
- Attachments included the Process Flow Diagram, Piping and Instrument Drawings, and Material Balance

A.2 Thermal Desorption Treatability Test Feed Preparation Plan, March 1995

The Feed Preparation Plan was written to establish and document the requirements for preparing feed for the treatability tests. The samples received from the six DOE-AL sites were in either 55- or 30-gallon drums. The plan addresses handling, inventorying, opening, and recontainerizing the drums. The following are the contents of the Feed Preparation Plan:

- Scope, including list of responsible individuals
- Documentation requirements for handling, opening, and repacking samples

- Safety issues, including operator training requirements, prejob briefings, and PPE requirements
- Prejob responsibilities
- Work area readiness to ensure availability of all PPE, equipment, and tools
- Waste management requirements
- Drum arrival requirements
- Drum inspection
- Drum opening
- Division of drum contents
- Particle size reduction
- Feed characterization
- Oven testing for melting point determination

A.3 Thermal Desorption Treatability Test Feed Preparation Sampling and Analysis Plan (FPSAP), March 1995

The FPSAP delineates sampling and analysis requirements during feed preparation for each proposed sample. The FPSAP also defines the quality control/assurance necessary and procedures for collecting, handling, and tracking samples.

A.4 Health and Safety Plan for Thermal Desorption Treatability Test Feed Preparation, March 1995

This Health and Safety Plan was developed specifically for feed preparation. It contains the following major sections:

- Introduction, including the scope, record keeping, and background
- Key personnel responsibilities
- Hazard assessments
- Training requirements
- PPE requirements
- Temperature extremes
- Exposure monitoring and air sampling

- Site control and work permits
- Decontamination
- Emergency response
- Confined space entry
- Spill containment

A.5 Thermal Desorption Feed Preparation Conduct of Operations Applicability Matrix, March 1995

The applicability matrix addresses the Rust Geotech Conduct of Operations Manual (Manual 119) guidelines. Applicable guidelines were identified and conformance was confirmed by independent oversight. Because feed preparation was a separate part of the overall treatability testing, the Conduct of Operations for the feed preparation was performed separately from the Conduct of Operations for the actual testing. DOE performed the Conduct of Operations for both feed preparation and the testing.

A.6 Thermal Desorption Treatability Test Plan, March 1995

The TD Test Plan was developed to outline the steps required to perform the TD treatability tests. The Plan defines success based on the system's ability to remove volatile and semivolatile organics from the nonvolatile, radiologically contaminated solids to the extent that the residual solids meet applicable treatment standards. In addition, issues such as the fate of the residuals and material handling are addressed. The Plan includes:

- Introduction, with a statement of purpose and responsible personnel
- Overview of the VAC*TRAX system
- General test description
- Waste stream descriptions (as known at the time the plan was written)
- Health and Safety procedures relative to identified hazards
- Procedures, referencing the *Pilot Thermal Desorption Operation and Maintenance Procedure*
- Process sampling and analysis, referencing the *Thermal Desorption Treatability Test Sampling and Analysis Plan*
- Residual Management

A.7 Thermal Desorption Treatability Test Sampling and Analysis Plan (SAP), March 1995

The SAP details how the samples will be collected, what analysis will be run on each sample, and the quality requirements for the analysis. Each waste stream sample is listed with required analysis for the solid, liquid, and rinse streams. It should be noted that the SAP was amended to delete some analyses when it was determined that a representative sample could not be ensured.

A.8 Health and Safety Plan for Thermal Desorption Treatability Testing (HASP), March 1995

The HASP for the treatability tests addresses the following:

- General introduction and scope
- Responsible personnel
- Hazards and controls
- Training, safety meetings, and visitor pre-entry requirements
- PPE requirements
- Heat stress
- Medical surveillance requirements
- Exposure monitoring, including personnel responsible for monitoring
- Site-access control
- Decontamination, including test area plan view
- Emergency response/contingency plan
- Spill containment

The HASP was modified with a Page Change Notice on April 15, 1995, to lessen PPE requirements. Also, a letter dated April 13, 1995, from the DOE-GJPO health physicist allowed for the reuse of PPE, which significantly reduced the usage of new PPE.

A.9 Pilot Thermal Desorption Treatability Test Operation and Maintenance (O&M) Procedure, May 1995

The O&M Procedure provides a detailed procedure for operating, maintaining, and decontaminating the VAC*TRAX unit. The O&M Procedure includes start-up, shutdown, loading, maintenance, and decontamination procedures. Each procedure was prepared with the activities in sequential order and each

activity has a line for the operator to initial when the activity is completed. This was the most used procedure during testing. During surrogate testing, the procedure was revised several times as the operating personnel became more familiar with the operation and developed more effective and efficient routines. Every test involved utilization of the forms. Critical valve lineups were not only initialed by the primary operator, but verified by the second operator.

A.10 Thermal Desorption (TD) Treatability Test Conduct of Operations, April 1995

As with the feed preparation, a full scale Conduct of Operations Work Readiness Review was performed by DOE. The Review culminated in the sign-off of the Thermal Desorption Conduct of Operations Applicability Matrix.

A.11 Other Plans

In addition to the *Thermal Desorption Treatability Test Plan*, supplemental waste-specific run plans were developed for both feed preparation and testing. The run plans address deviations from the original plans, usually due to additional waste sample characterization data accumulated.

This page intentionally blank

Appendix B

Analytical Results

This page intentionally blank

Appendix B

Analytical Results

The tables in this appendix are a compilation of the results from analyses performed on the waste stream samples treated during the VAC*TRAX treatability tests. If no number appears in a column, that analysis was not requested for the waste stream sample submitted. Each table is divided into solids versus liquids to allow for the appropriate units of measure to be noted.

The following terminology is used throughout these tables to distinguish and track all the separate waste stream samples, charges, processing runs, reprocessing runs, and associated sampling, analytical, and operational data.

A "waste stream" is a group of similar wastes generated at a specific DOE site. A "waste stream sample" is the portion of the waste stream that was actually processed in the treatability test. The waste stream sample is identified by the designation given to the corresponding waste stream by the Mixed-Waste Treatment Program (MWTP). The waste stream sample designation includes the specific DOE site and an alpha-numeric waste stream designation. Thus, "LANL-S 10.1" refers to a group of similar wastes generated at LANL and given the designation "S-10.1" by the MWTP.

A waste stream sample used for treatability testing is further identified by adding to the site and waste stream designation the specific container number that the waste stream sample was shipped in by the generator. In some cases, the waste stream sample was shipped in more than one container. Thus, "KCP 1.1-1366" and "KCP 1.1-1367" refer to the first and second drums, respectively, in which the KCP 1.1 waste stream sample was shipped to DOE-GJPO for treatability testing.

The waste stream samples are divided into individual charges for the processing runs. The individual charges may be contained in several containers, each with its own identifier. Waste stream sample LANL-S 10.2 was divided into two plastic bags and designated as two charges, "LANL-S 10.2-Bag 1" and "LANL-S 10.2-Bag 2." Similarly, waste stream sample GJPO-TG 1 was divided into containers "GJPO-TG 1-A," "GJPO-TG 1-B," and so forth. Individual processing runs are referred to by the set of containers comprising a charge. Thus, the run "GJPO-TG 1-DEF" is a processing run of a charge composed of waste material from "GJPO-TG 1-D," "GJPO-TG 1-E," and "GJPO-TG 1-F."

After completion of a processing run, the waste stream sample charge was removed from the pilot VAC*TRAX unit and sampled and analyzed. The treated waste product was put in containers identified with the processing run designation appended with the suffix "T." Thus, "LANL-S 10.1-Bag 1-T" refers to the container (in this case a plastic bag) used to contain the treated waste product from processing the charge "LANL-S 10.1-Bag 1," which is a subset of the waste stream sample "LANL-S 10.1."

In a few cases, the analytical results from the treated waste stream sample indicated that additional processing was needed in order to remove sufficient contaminants for the treated product to meet the RCRA treatment standards. In these cases, the treated waste product was again charged to the pilot unit and processed further. These are referred to as "reruns." Treated waste product from "reruns" are identified by modifiers on the "T." Thus, "LANL-S 10.1-Bag C1T2" is the treated waste product from the reprocessing of the treated waste product "LANL-S 10.1-Bag C1T."

This page intentionally blank

Table B-1. Radiological Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Gross Alpha	Gross Beta	Gamma Spectroscopy	Isotopic RAD
<i>Solids</i>				pCi/g	pCi/g	pCi/g	pCi/g
NBE 438	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1T	dryer, debris	1,981	486		H3 = 5
NBE 439	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2T	dryer, debris	579	140.3		H3 = 17.91
NBE 941	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1	feed prep	8	1.3		H3 = 32.28
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	14,100	3,200		H3 = 35.87 (see Table B-7)
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	45	11.2		H3 = 56.21 (see Table B-7)
NBE 484	PTX-1574	PTX-1574-A	feed sample				H3 = 426.63
NBE 939	LANL-S 10.2	LANL-S 10.2-Bag 1	feed prep	3,300	18	U = 170	canceled
NBE 940	LANL-S 10.2	LANL-S 10.2-Bag 2	feed prep	370	5.0	U = 430	canceled
NBE 936	LANL-S 10.1	LANL-S 10.1-A/B	feed prep	< 30	40	Pb-212 = 30.51 Am-241 = 96.21	final (see Table B-7)
NBE 937	LANL-S 10.1	LANL-S 10.1-Bag C	feed prep	33	4.5	Pb-212 = 7.49 Am-241 = 516.14	final (see Table B-7)
NBE 938	LANL-S 10.1	LANL-S 10.1-Bag C3	feed prep	720	16	Pb-212 = 7.11 Am-214 = 256,480	final (see Table B-7)
NBE 931	KCP-1.1-1367	KCP-1.1-1367-Bag 1	feed prep	74	132	none detected	
NBE 935	KCP-1.1-1367	KCP-1.1-1367-Bag 2	feed prep	< 3	20	Pb-212 = 55.54	
NBE 989	KCP-1.1-1367	KCP-1.1-1367-Bag 2AT	dryer, debris	2.7	31		
NBE 990	KCP-1.1-1367	KCP-1.1-1367-Bag 2BT	dryer, debris	< 1.7	8.8		
NBE 991	KCP-1.1-1367	KCP-1.1-1367-Bag 1AT	dryer, debris	< 6	12		
NBE 992	KCP-1.1-1367	KCP-1.1-1367-Bag 1BT	dryer, debris	11	185		
NBE 932	KCP-1.1-1366	KCP-1.1-1366-Bag 1	feed prep	4	26	Pb-212 = 62.55	
NBE 933	KCP-1.1-1366	KCP-1.1-1366-Bag 2	feed prep	< 3	3.3	Pb-212 = 62.79	
NBE 934	KCP-1.1-1366	KCP-1.1-1366-Bag 3	feed prep	< 5	38	Pb-212 = 36.75	
NBE 984	KCP-1.1-1366	KCP-1.1-1366-Bag 1-T	dryer, debris	2.4	23		
NBE 985	KCP-1.1-1366	KCP-1.1-1366-Bag 2-T	dryer, debris	24	600		
NBE 986	KCP-1.1-1366	KCP-1.1-1366-Bag 3-T	dryer, debris	2.2	26		
<i>Liquid</i>				pCi/L	pCi/L		pCi/mL
NBE 464	GJPO-SSD	SSD-W940000254, 265-T	condensate	< 98	< 107		
NBE 465	GJPO-SSD	SSD-W940000255, 256-T	condensate	< 93	< 107		
NBE 469	GJPO-SSD	SSD-W940000253-PPE-T	condensate	< 37	< 40		

Table B-1 (continued). Radiological Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Gross Alpha	Gross Beta	Gamma Spectroscopy	Isotopic RAD
Liquid (continued)				pCi/L	pCi/L		pCi/mL
NBE 480	GJPO-SSD	SSD PPE1-3	condensate	1,040	610		
NBE 443	SNL/NM-TG 8	SNL/NM-TG 8-1&2	condensate composite	< 62	< 79		H3 = 198.01
NBE 488	PTX-1574	PTX-1574-AT	condensate				H3 = 1331.96
NBE 462	LANL-S 10.2	LANL-S 10.2-Bag 1T	condensate	< 62	< 71		
NBE 463	LANL-S 10.2	LANL-S 10.2-Bag 2T	condensate	< 56	< 71		
NBE 471	LANL-L 13	LANL-L 13-AB	condensate	< 34	< 40		H3 = 14,920
NBE 444	LANL-S 10.1	LANL-S 10.1-1,2,3	condensate composite	199	< 80		H3 = 113.90
NBE 481	LANL-S 10.1/S 10.2	LANL-S 10.1/10.2 PPE	condensate	1,900	1,040		
NBE 447	KCP-1.1-1367	KCP-1.1-1367-Bag 2A	condensate	< 109	< 107		
NBE 459	KCP-1.1-1367	KCP-1.1-1367-Bag 2B	condensate	< 59	< 71		
NBE 461	KCP-1.1-1367	KCP-1.1-1367-Bag 4,6,7	condensate	< 111	< 107		
NBE 460	KCP-1.1-1366/1367	KCP1.1-Metal Debris-T	condensate	< 61	< 71		
NBE 987	KCP-1.1-1366	KCP-1.1-1366-Bag 1T	condensate	< 43	< 21		
NBE 988	KCP-1.1-1366	KCP-1.1-1366-Bag 2T&3T	condensate	< 16.3	< 13.5		
NBE 428	GJPO-TG 1	GJPO-TG 1-GHI-T	organic phase condensate	< 166	< 198		
NBE 429	GJPO-TG 1	GJPO-TG 1-GHI-T	aqueous phase condensate	1014	252		
NBE 432	GJPO-TG 1	GJPO-TG 1-JKL-T	DNAPL phase condensate	< 166	< 198		
NBE 433	GJPO-TG 1	GJPO-TG 1-JKL-T	aqueous phase condensate	1464	402		
NBE 434	GJPO-TG 1	GJPO-TG 1-JKL-T	LNAPL phase condensate	2120	1360		
NBE 435	GJPO-TG 1	GJPO-TG 1-PPE-3T	condensate #2 composite	< 126	< 73		
NBE 474	GJPO-TG 1	GJPO-TG 1-CDEFT2	condensate post 2nd run	340	< 200		
NBE 478	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run	3,990	2,350		
NBE 479	GJPO-TG 1	GJPO-TG 1-JKL-T2	condensate 2nd run	1,650	1,030		
NBE 482	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run				final (see Table B-7)
NBE 993	GJPO-TG 1	GJPO-TG 1-AB-T	aqueous phase condensate	10.4	< 7.3		
NBE 994	GJPO-TG 1	GJPO-TG 1-AB-T	organic phase condensate	153	< 145		
NBE 996	GJPO-TG 1	GJPO-TG 1-C-T	aqueous phase condensate	226	91.7		
NBE 997	GJPO-TG 1	GJPO-TG 1-C-T	organic phase condensate	212	< 198		
NBE 998	GJPO-TG 1	GJPO-TG 1-DEF-T	aqueous phase condensate	996	247		
NBE 999	GJPO-TG 1	GJPO-TG 1-DEF-T	organic phase condensate	262	< 198		

Table B-2. Total Volatile Organic Compounds Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Methanol	VOC Acetone	VOC Dichloro-methane	VOC Chloroform	VOC Carbon Tetrachloride	VOC Benzene
<i>Solids</i>				µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
NBE 456	GJPO-SSD	SSD-W940000255, 256	feed prep		< 420	< 420	< 210	< 210	< 210
NBE 457	GJPO-SSD	SSD-W940000256-Soil-T	dryer, soil		53 TCLP	< 10 TCLP	~3 TCLP	< 5 TCLP	< 5 TCLP
NBE 458	GJPO-SSD	SSD-W940000255, 256-T	dryer, debris		< 160	< 78	< 78	< 78	< 78
NBE 467	GJPO-SSD	SSD-W940000253-Soil-T	dryer, soil		64*	~2*	~2*	< 5*	< 5*
NBE 468	GJPO-SSD	SSD-W940000253-PPE-T	dryer, PPE		~290	< 310	< 160	< 160	< 160
NBE 438	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1T	dryer, debris		< 1,200	< 1,200	< 620	< 620	~120
NBE 439	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2T	dryer, debris		< 1,200	< 1,200	< 620	< 620	< 620
NBE 941	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1	feed prep		< 6200	< 6200	< 3100	< 3100	< 3100
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	< 33.5	620	250	< 160	< 160	< 160
NBE 484	PTX-1574	PTX-1574-A	feed sample		< 62,000	< 31,000	< 31,000	< 31,000	< 31,000
NBE 485	PTX-1574	PTX-1574-AT	treated vermiculite @ 20 hr			< 31,000	< 31,000	< 31,000	< 31,000
NBE 486	PTX-1574	PTX-1574-AT	treated vermiculite @ 26 hr		< 31,000	< 16,000	< 16,000	< 16,000	< 16,000
NBE 483	LANL-S 10.2	LANL-S 10.2-Bag 1T2	debris 2nd		690 B	5,100	< 160	< 160	< 160
NBE 939	LANL-S 10.2	LANL-S 10.2-Bag 1	feed prep	41,200,000	140,000	29,000,000	< 16,000	< 16,000	< 16,000
NBE 940	LANL-S 10.2	LANL-S 10.2-Bag 2	feed prep	34,800,000	150,000	25,000,000	< 16,000	< 16,000	< 16,000
NBE 440	LANL-S 10.1	LANL-S 10.1-Bag C1T	dryer, debris		< 12,000	88,000	< 6,200	< 6,200	< 6,200
NBE 441	LANL-S 10.1	LANL-S 10.1-Bag C2T	dryer, debris		< 1,200	1,500	< 620	< 620	~250
NBE 442	LANL-S 10.1	LANL-S 10.1-Bag C3T	dryer, debris		< 12,000	~2,500	< 6,200	< 6,200	< 6,200
NBE 487	LANL-S 10.1	LANL-S 10.1-Bag C1T2	debris 2nd		820	6400	< 310	< 310	< 310
NBE 936	LANL-S 10.1	LANL-S 10.1-Bag A/B	feed prep		5,100	15,000	< 1,600	< 1,600	< 1,600
NBE 937	LANL-S 10.1	LANL-S 10.1-Bag C	feed prep		29,000	22,000,000	< 3,100	< 3,100	< 3,100
NBE 938	LANL-S 10.1	LANL-S 10.1-Bag C3	feed prep		240,000	17,000,000	< 62,000	< 62,000	< 62,000
NBE 947	LANL-L 13	LANL-L 13-A&B	feed prep		< 5	< 10	< 5	< 5	< 5
NBE 445	LANL-S 10.2	LANL-S 10.2-Bag 1T	dryer, debris		6,800	43,000	< 2,100	< 2,100	< 2,100
NBE 446	LANL-S 10.2	LANL-S 10.2-Bag 2T	dryer, debris		< 1,200	7,400	< 620	< 620	< 620
NBE 931	KCP-1.1-1367	KCP-1.1-1367-Bag 1	feed prep		55	< 50	60	< 25	< 25
NBE 935	KCP-1.1-1367	KCP-1.1-1367-Bag 2	feed prep		580	< 160	110	< 78	< 78
NBE 989	KCP-1.1-1367	KCP-1.1-1367-Bag 2AT	dryer, debris		< 78	1000	< 78	< 78	< 78
NBE 990	KCP-1.1-1367	KCP-1.1-1367-Bag 2BT	dryer, debris		< 78	160	< 78	< 78	< 78
NBE 991	KCP-1.1-1367	KCP-1.1-1367-Bag 1AT	dryer, debris		< 78	450	< 78	< 78	< 78

Table B-2 (continued). Total Volatile Organic Compounds Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Methanol	VOC Acetone	VOC Dichloro-methane	VOC Chloroform	VOC Carbon Tetrachloride	VOC Benzene
				µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Solids (continued)									
NBE 992	KCP-1.1-1367	KCP-1.1-1367-Bag 1BT	dryer, debris		< 78	630	< 78	< 78	< 78
NBE 932	KCP-1.1-1366	KCP-1.1-1366-Bag 1	feed prep		400	< 250	< 120	< 120	< 120
NBE 933	KCP-1.1-1366	KCP-1.1-1366-Bag 2	feed prep		320	< 100	< 50	< 50	< 50
NBE 934	KCP-1.1-1366	KCP-1.1-1366-Bag 3	feed prep		8000	< 100	< 52	< 52	< 52
NBE 984	KCP-1.1-1366	KCP-1.1-1366-Bag 1-T	dryer, debris		1200	< 160	< 78	< 78	< 78
NBE 985	KCP-1.1-1366	KCP-1.1-1366-Bag 2-T	dryer, debris		570	< 160	< 78	< 78	< 78
NBE 986	KCP-1.1-1366	KCP-1.1-1366-Bag 3-T	dryer, debris		1400	< 160	< 78	< 78	< 78
NBE 426	GJPO-TG 1	GJPO-TG 1-C-T	dryer, soil		< 2,500	< 2,500	11,000	< 1,200	< 1,200
NBE 427	GJPO-TG 1	GJPO-TG 1-DEF-T	dryer, soil		< 1,000	< 1,000	28,000	< 500	< 500
NBE 430	GJPO-TG 1	GJPO-TG 1-GHI-T	dryer, soil		< 2,500	< 2,500	11,000	< 1,200	< 1,200
NBE 431	GJPO-TG 1	GJPO-TG 1-JKL-T	dryer, soil		< 2,500	< 2,500	22,000	< 1,200	< 1,200
NBE 470	GJPO-TG 1	GJPO-TG 1-CDEF-T	dryer, soil pre 2nd run		910	~190	7,600	< 310	< 310
NBE 472	GJPO-TG 1	GJPO-TG 1-GHI-T	dryer, soil pre 2nd run		460	< 310	1,100	< 160	< 160
NBE 473	GJPO-TG 1	GJPO-TG 1-CDEFT2	dryer, soil post 2nd run		660	< 310	< 160	< 160	< 160
NBE 475	GJPO-TG 1	GJPO-TG 1-JKL-T	dryer, soil pre 2nd run		620	~62	1,900	< 160	< 160
NBE 476	GJPO-TG 1	GJPO-TG 1-GHI-T2	dryer, soil post 2nd run		570	< 310	< 160	< 160	< 160
NBE 477	GJPO-TG 1	GJPO-TG 1-JKL-T2	dryer, soil post 2nd run		450	< 310	< 160	< 160	< 160
NBE 926	GJPO-TG 1	GJPO-TG 1 ABC	feed prep		< 170,000	< 87,000	2,200,000	< 87,000	< 87,000
NBE 927	GJPO-TG 1	GJPO-TG 1 DEF	feed prep		< 160,000	< 82,000	98,000,000	~55,000	~33,000
NBE 928	GJPO-TG 1	GJPO-TG 1 GHI	feed prep		< 180,000	< 92,000	180,000,000	160,000	86,000
NBE 929	GJPO-TG 1	GJPO-TG 1 JKL	feed prep		< 190,000	42,000	240,000,000	< 96,000	100,000
NBE 995	GJPO-TG 1	GJPO-TG 1-AB-T	dryer, soil		< 1,200	< 1,200	2,400	< 620	< 620
Liquid				µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
NBE 443	SNL/NM-TG 8	SNL/NM-TG 8-1&2	condensate composite		300	~100	< 100	< 100	< 100
NBE 462	LANL-S 10.2	LANL-S 10.2-Bag 1T	condensate		660,000	8,700,000	< 250,000	< 250,000	< 250,000
NBE 463	LANL-S 10.2	LANL-S 10.2-Bag 2T	condensate		540,000	84,000,000	< 250,000	< 250,000	< 250,000
NBE 444	LANL-S 10.1	LANL-S 10.1-Bag 1,2,3	condensate composite		75,000	1,400,000	< 2,500	< 2,500	< 2,500
NBE 987	KCP-1.1-1366	KCP-1.1-1366-Bag 1T	condensate		9000	< 500	< 250	< 250	< 250
NBE 429	GJPO-TG 1	GJPO-TG 1-GHI-T	aqueous phase condensate		< 50,000	< 50,000	710,000	< 25,000	< 25,000
NBE 432	GJPO-TG 1	GJPO-TG 1-JKL-T	DNAPL phase condensate		< 1,200,000	2,800,000	860,000,000	4,700,000	5,000,000

Table B-2 (continued). Total Volatile Organic Compounds Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Methanol µg/L	VOC Acetone µg/L	VOC Dichloro- methane µg/L	VOC Chloroform µg/L	VOC Carbon Tetrachloride µg/L	VOC Benzene µg/L
<i>Liquid (continued)</i>									
NBE 433	GJPO-TG 1	GJPO-TG 1-JKL-T	aqueous phase condensate		< 50,000	< 50,000	300,000	< 25,000	< 25,000
NBE 434	GJPO-TG 1	GJPO-TG 1-JKL-T	LNAPL phase condensate		< 1,200,000	< 1,200,000	6,200,000	< 620,000	< 620,000
NBE 474	GJPO-TG 1	GJPO-TG 1-CDEFT2	condensate 2nd run		84,000	< 10,000	< 5,000	< 5,000	< 5,000
NBE 478	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run		24,000	< 10,000	< 5,000	< 5,000	< 5,000
NBE 479	GJPO-TG 1	GJPO-TG 1-JKL-T2	condensate 2nd run		22,000	< 10,000	< 5,000	< 5,000	< 5,000
NBE 993	GJPO-TG 1	GJPO-TG 1-AB-T	aqueous phase condensate		11,000	< 12,000	120,000	< 6,200	< 6,200
NBE 996	GJPO-TG 1	GJPO-TG 1-C-T	aqueous phase condensate		< 50,000	< 50,000	590,000	< 25,000	< 25,000
NBE 998	GJPO-TG 1	GJPO-TG 1-DEF-T	aqueous phase condensate		< 50,000	< 50,000	830,000	< 25,000	< 25,000

Table B-3. Total Organic Carbon

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Total Organic Carbon (µg/L)
<i>Liquid</i>				
NBE 987	KCP-1.1-1366	KCP-1.1-1366-Bag 1T	condensate	4100
NBE 429	GJPO-TG 1	GJPO-TG 1-GHI-T	aqueous phase condensate	20,600
NBE 433	GJPO-TG 1	GJPO-TG 1-JKL-T	aqueous phase condensate	25,800
NBE 474	GJPO-TG 1	GJPO-TG 1-CDEFT2	condensate 2nd run	26,800,000
NBE 478	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run	14,000,000
NBE 479	GJPO-TG 1	GJPO-TG 1-JKL-T2	condensate 2nd run	17,400,000
NBE 993	GJPO-TG 1	GJPO-TG 1-AB-T	aqueous phase condensate	629,000
NBE 996	GJPO-TG 1	GJPO-TG 1-C-T	aqueous phase condensate	9,300
NBE 998	GJPO-TG 1	GJPO-TG 1-DEF-T	aqueous phase condensate	7,500

Table B-4. TCLP Metals

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	RCRA Ag (µg/kg)	RCRA As (µg/kg)	RCRA Ba (µg/kg)	RCRA Cd (µg/kg)	RCRA Cr (µg/kg)	RCRA Hg (µg/kg)	RCRA Pb (µg/kg)	RCRA Se (µg/kg)
Solids											
NBE 457	GJPO-SSD	SSD-W940000256-Soll-T	treated soil	TCLP ~8.9	TCLP < 127	TCLP ~418	TCLP ~14.4	TCLP ~3.3	TCLP < 2.0	TCLP ~86.7	TCLP < 147

Table B-5. Oil and Grease

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Oil and Grease (µg/L)
Solids				
NBE 938	LANL-S 10.1	LANL-S 10.1-Bag C3	feed prep	51,130,000
NBE 936	LANL-S 10.1	LANL-S 10.1-Bag A/B	feed prep	2,230,000
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	122,100,000
NBE 937	LANL-S 10.1	LANL-S 10.1-Bag C	feed prep	10,600,000
NBE 941	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1	feed prep	100500000

Table B-6. Loss on Drying Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Loss on Drying (%)
Solids				
NBE 926	GJPO-TG 1	GJPO-TG 1 ABC	feed prep, soll	30.4
NBE 927	GJPO-TG 1	GJPO-TG 1 DEF	feed prep, soll	30.6
NBE 928	GJPO-TG 1	GJPO-TG 1 GHI	feed prep, soll	37.2
NBE 929	GJPO-TG 1	GJPO-TG 1 JKL	feed prep, soll	38.1
NBE 936	LANL-S 10.1	LANL-S 10.1-Bag A/B	feed prep, debris	3.68
NBE 937	LANL-S 10.1	LANL-S 10.1-Bag C	feed prep, debris	22.72
NBE 938	LANL-S 10.1	LANL-S 10.1-Bag C3	feed prep, debris	18.97
NBE 939	LANL-S 10.2	LANL-S 10.2-Bag 1	feed prep, debris	32.48
NBE 940	LANL-S 10.2	LANL-S 10.2-Bag 2	feed prep, debris	25.07
NBE 932	KCP-1.1-1366	KCP-1.1-1366-Bag 1	feed prep, debris	9.14

Table B-6 (continued). Loss on Drying Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Loss on Drying (%)
Solids (continued)				
NBE 933	KCP-1.1-1366	KCP-1.1-1366-Bag 2	feed prep, debris	5.77
NBE 934	KCP-1.1-1366	KCP-1.1-1366-Bag 3	feed prep, debris	10.54
NBE 931	KCP-1.1-1367	KCP-1.1-1367-Bag 1	feed prep, debris	6.14
NBE 935	KCP-1.1-1367	KCP-1.1-1367-Bag 2	feed prep, debris	12.15
NBE 947	LANL-L 13	LANL-L 13-A&B	feed prep, soil	3.48
NBE 941	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1	feed prep, debris	21.82
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep, debris	14.33

Table B-7. Additional Laboratory Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Notes
Solids				
NBE 438	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1T	dryer, debris	2-butanone = 10,000 µg/kg
NBE 439	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2T	dryer, debris	2-butanone = 9,600 µg/kg
NBE 941	SNL/NM-TG 8	SNL/NM-TG 8-Bag 1	feed prep	ethanol < 950 µg/kg, isopropanol < 1,300 µg/kg, methanol < 3,400 µg/kg
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	split by lab = oily appearing
NBE 942	SNL/NM-TG 8	SNL/NM-TG 8-Bag 2	feed prep	split by lab = dry appearing
NBE 484	PTX-1574	PTX-1574-A	feed sample	xlenes = 115,000 µg/kg, trimethylbenzene = 5,500,000 µg/kg
NBE 485	PTX-1574	PTX-1574-AT	treated vermiculite @ 20 hr	trimethylbenzene = 24,000 µg/kg
NBE 486	PTX-1574	PTX-1574-AT	treated vermiculite @ 26hr	trimethylbenzene = 9,200 µg/kg
NBE 939	LANL-S 10.2	LANL-S 10.2-Bag 1	feed prep	2-butanone = 220,000 µg/kg, 4-methyl-2-pentanone = 3,800,000 µg/kg, ethylbenzene = 6,200 µg/kg, xlenes = 21,400 µg/kg
NBE 940	LANL-S 10.2	LANL-S 10.2-Bag 2	feed prep	2-butanone = 290,000 µg/kg, 4 methyl 2- pentanone = 5,000,000 µg/kg ethylbenzene = 6,200 µg/kg, xlenes 24,000 µg/kg
NBE 440	LANL-S 10.1	LANL-S 10.1-Bag C1T	dryer, debris	toluene = 3,800 µg/kg
NBE 441	LANL-S 10.1	LANL-S 10.1-Bag C2T	dryer, debris	2-butanone = 7,500 µg/kg
NBE 487	LANL-S 10.1	LANL-S 10.1-Bag C1T2	debris 2nd run	trimethylbenzene = 470 µg/kg
NBE 936	LANL-S 10.1	LANL-S 10.1-Bag A/B	feed prep	H3 = 9.41 pCi/g, U-234 = 0.33 pCi/g, 2-butanone = 4,700 µg/kg 4-methyl-2-pentanone = 9,100 µg/kg

Table B-7 (continued). Additional Laboratory Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Notes
Solids (continued)				
NBE 937	LANL-S 10.1	LANL-S 10.1-Bag C	feed prep	H3 = 11.00, 2-butanone = 97,000 µg/kg, TCE = 3,800 µg/kg, toluene = 37,000 µg/kg, xylenes = 140,000 µg/kg, ethylbenzene = 33,000 µg/kg, pentanone = 770,000 µg/kg
NBE 938	LANL-S 10.1	LANL-S 10.1-Bag C3	feed prep	H3 = 8.49 pCi/g, U-234 = 0.72 pCi/g, U-238 = 0.11 pCi/g, 2-butanone = 240,000 µg/kg, 4-methyl-2-pentanone = 310,000 µg/kg, xylenes = 84,000 µg/kg
NBE 947	LANL-L 13	LANL-L 13-A&B	feed prep	SVOC = none remarkable
NBE 445	LANL-S 10.2	LANL-S 10.2-Bag 1T	dryer, debris	4-methyl-2-pentanone = 53,000 µg/kg
NBE 446	LANL-S 10.2	LANL-S 10.2-Bag 2T	dryer, debris	4-methyl-2-pentanone = 7,200 µg/kg
NBE 931	KCP-1.1-1367	KCP-1.1-1367-Bag 1	feed prep	tetrachloroethane = 49 µg/kg
NBE 935	KCP-1.1-1367	KCP-1.1-1367-Bag 2	feed prep	IPA = 830 µg/kg, tetrachloroethane = 160 µg/kg
NBE 989	KCP-1.1-1367	KCP-1.1-1367-Bag 2AT	dryer, debris	acetone in blank
NBE 990	KCP-1.1-1367	KCP-1.1-1367-Bag 2BT	dryer, debris	acetone in blank
NBE 991	KCP-1.1-1367	KCP-1.1-1367-Bag 1AT	dryer, debris	acetone in blank
NBE 992	KCP-1.1-1367	KCP-1.1-1367-Bag 1BT	dryer, debris	acetone in blank
NBE 932	KCP-1.1-1366	KCP-1.1-1366-Bag 1	feed prep	IPA = 4,000 µg/kg
NBE 934	KCP-1.1-1366	KCP-1.1-1366-Bag 3	feed prep	IPA = 27,000 µg/kg
NBE 984	KCP-1.1-1366	KCP-1.1-1366-Bag 1-T	dryer, debris	2-ethyl-1-hexanol = 3,600 µg/kg
NBE 985	KCP-1.1-1366	KCP-1.1-1366-Bag 2-T	dryer, debris	2-ethyl-1-hexanol = 1,300 µg/kg
NBE 986	KCP-1.1-1366	KCP-1.1-1366-Bag 3-T	dryer, debris	2-ethyl-1-hexanol = 2,500 µg/kg
NBE 426	GJPO-TG 1	GJPO-TG 1-C-T	dryer, soil	SVOC = none remarkable
NBE 427	GJPO-TG 1	GJPO-TG 1-DEF-T	dryer, soil	phenol = 12,000 µg/kg, dimethyl phthalate = 6,900 µg/kg, chloromethane = 3,000 µg/kg
NBE 430	GJPO-TG 1	GJPO-TG 1-GHI-T	dryer, soil	SVOC = none remarkable
NBE 431	GJPO-TG 1	GJPO-TG 1-JKL-T	dryer, soil	SVOC: phenol = 97,000 µg/kg, 2,6-dinitrotoluene = 13,000 µg/kg
NBE 926	GJPO-TG 1	GJPO-TG 1 ABC	feed prep	dimethyl phthalate = 81,000 µg/kg
NBE 927	GJPO-TG 1	GJPO-TG 1 DEF	feed prep	dimethyl phthalate = 130,000 µg/kg
NBE 928	GJPO-TG 1	GJPO-TG 1 GHI	feed prep	dimethyl phthalate = 210,000 µg/kg
NBE 929	GJPO-TG 1	GJPO-TG 1 JKL	feed prep	dimethyl phthalate = 290,000 µg/kg, dichlorobenzene = 2,000,000 µg/kg
NBE 995	GJPO-TG 1	GJPO-TG 1-AB-T	dryer, soil	phenol = 48,000 µg/kg, dimethyl phthalate = 11,000 µg/kg

Table B-7 (continued). Additional Laboratory Analyses

Sample Ticket	Waste Stream Sample	Waste Charge	Sample Point	Notes
Liquids				
NBE 462	LANL-S 10.2	LANL-S 10.2-Bag 1T	condensate	4-methyl- 2-pentanone = 6,800,000 µg/L, toluene = 470,000 µg/L
NBE 463	LANL-S 10.2	LANL-S 10.2-Bag 2T	condensate	2-butanone = 1,400,000 µg/L, toluene = 2,400,000 µg/L 4-methyl-2-pentanone = 12,000,000 µg/L, xylene = 1,800,000 µg/L
NBE 444	LANL-S 10.1	LANL-S 10.1-Bag 1,2,3	condensate composite	2-butanone = 850,000 µg/L, 4-methyl-2-pentanone = 3,200,000 µg/L
NBE 987	KCP-1.1-1366	KCP-1.1-1366-Bag 1T	condensate	phenol = 2,200 µg/L, alpha < 25 pCi/g, beta 28.6 pCi/g (in sediment) IPA = 94,000 µg/L
NBE 988	KCP-1.1-1366	KCP-1.1-1366-Bag 2T&3T	condensate	alpha < 23 pCi/g, beta < 12.2 pCi/g (in sediment)
NBE 429	GJPO-TG 1	GJPO-TG 1-GHI-T	aqueous phase condensate	phenol = 24,000 µg/L, dimethyl phthalate = 64,000 µg/L, undecane = 93,000 µg/L dodecane = 64,000 µg/L, tridecane = 38,000 µg/L, tetradecane = 26,000 µg/L
NBE 432	GJPO-TG 1	GJPO-TG 1-JKL-T	DNAPL phase condensate	dimethyl phthalate = 120,000 µg/L
NBE 433	GJPO-TG 1	GJPO-TG 1-JKL-T	aqueous phase condensate	phenol = 41,000 µg/L, dimethyl phthalate = 95,000 µg/L, undecane = 170,000 µg/L, dodecane = 150,000 µg/L, tridecane = 1000,000 µg/L, tetradecane = 80,000 µg/L
NBE 434	GJPO-TG 1	GJPO-TG 1-JKL-T	LNAPL phase condensate	top layer LNAPL, SVOC = none remarkable
NBE 434	GJPO-TG 1	GJPO-TG 1-JKL-T	LNAPL phase condensate	bottom layer LNAPL, dimethyl phthalate = 78,000 µg/L, phenol = 140,000 µg/L
NBE 474	GJPO-TG 1	GJPO-TG 1-CDEFT2	condensate post 2nd run	phenol = 160,000 µg/L, dimethyl phthalate = 33,000 µg/L, 2-butanone = 22,000 µg/L
NBE 478	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run	phenol = 24,000 µg/L, benzoic acid = 110,000 µg/L dimethyl phthalate = 150,000 µg/L
NBE 479	GJPO-TG 1	GJPO-TG 1-JKL-T2	condensate 2nd run	phenol = 15,000 µg/L, benzoic acid = 110,000 µg/L dimethyl phthalate = 150,000 µg/L
NBE 482	GJPO-TG 1	GJPO-TG 1-GHI-T2	condensate 2nd run	water—U-234 = 1,770 pCi/L, U-235 = 94.6 pCi/L, U-238 = 1980 pCi/L Th-230 = 246 pCi/L oil—U-234 < 0.14 pCi/L, U-235 < 0.20 pCi/L, U-238 < 0.20 pCi/L, Th-230 < .3 pCi/L
NBE 993	GJPO-TG 1	GJPO-TG 1-AB-T	aqueous phase condensate	phenol = 6,700 µg/L, dichlorobenzene = 2,400 µg/L, nitrobenzene = 1,100 µg/L dimethyl phthalate = 19,000 µg/L
NBE 996	GJPO-TG 1	GJPO-TG 1-C-T	aqueous phase condensate	phenol = 18,000 µg/L, dimethyl phthalate = 44,000 µg/L
NBE 998	GJPO-TG 1	GJPO-TG 1-DEF-T	aqueous phase condensate	phenol = 15,000, dimethyl phthalate = 41,000 µg/L

This page intentionally blank

Appendix C

Clemson Technical Center PCB-Contaminated Waste Test Results

This page intentionally blank

VAC*TRAX - Thermal Desorption For Mixed Wastes

Michael J. McElwee (803-646-2413)

Carl R. Palmer (803-646-2413)

Rust- Clemson Technical Center
100 Technology Drive
Anderson, SC 29625

Abstract

The patented VAC*TRAX process was designed in response to the need to remove organic constituents from mixed waste, waste that contains both a hazardous (RCRA or TSCA regulated) component and a radioactive component. Separation of the mixed waste into its hazardous and radioactive components allows for ultimate disposal of the material at existing, permitted facilities.

The VAC*TRAX technology consists of a jacketed vacuum dryer followed by a condensing train. Solids are placed in the dryer and indirectly heated to temperatures as high as 260°C, while a strong vacuum (down to 50 mm Hg absolute pressure) is applied to the system and the dryer is purged with a nitrogen carrier gas. The organic contaminants in the solids are thermally desorbed, swept up in the carrier gas and into the condensing train where they are cooled and recovered. The dryer is fitted with a filtration system that keeps the radioactive constituents from migrating to the condensate. As such, the waste is separated into hazardous liquid and radioactive solid components, allowing for disposal of these streams at a permitted incinerator or a radioactive materials landfill, respectively. The VAC*TRAX

system is designed to be highly mobile, while minimizing the operational costs with a simple, robust process. These factors allow for treatment of small waste streams at a reasonable cost.

The VAC*TRAX pilot system has proven effective at treating soil, sludge, and assorted debris streams, removing volatile and semi-volatile organic compounds, including polychlorinated biphenyls (PCBs), from the solid matrix. Removal efficiencies typically exceed 99%, and the system has repeatedly proven the ability to remove difficult components, such as PCBs, completely; PCBs were not detected in the product for a number of test runs on PCB contaminated soil and debris. Batch testing has indicated that the system may prove equally effective in treating streams contaminated with elemental mercury. In all cases involving mixed waste, the VAC*TRAX system demonstrated superior containment of the radioactive material within the solid matrix, with negligible partitioning of the material into the condensate.

This paper describes the VAC*TRAX thermal desorption process, as well as results from the pilot testing program. Also, the design and application of the full-scale treatment system is presented.

Research Sponsored by the U.S. Department of Energy's Morgantown Energy Technology Center, under contract DE-RA21-92MC28245 with Rust Federal Services, 100 Technology Drive, Anderson, SC 29625; 803-646-2413, 803-646-5311 (fax)

Technology Description - the VAC*TRAX Pilot System

The VAC*TRAX process is shown in Figure 1. As can be seen in the figure, material is loaded into the dryer through a flanged port. In the pilot unit, up to 31 L of material may be charged per batch. After loading, the inlet flange is sealed, the dryer is purged with nitrogen, and a strong vacuum is pulled on the system. The dryer is then heated by a conventional hot oil unit, circulating heated oil through an internal agitator and external jacket on the dryer. The heated dryer, in turn, heats the waste material charged to the system. The waste is heated at a time and temperature appropriate to the matrix and contaminants of concern: removing high concentrations of PCBs from soil would typically require heating the material at 260°C for at least 6-8 hours, while acetone or other volatile contaminants could be removed from the same matrix in less than half this time. After being heated for the required time, the vacuum on the system is reduced, and the product is dropped through a hinged door on the bottom of the dryer into a steel vessel that is fastened to the unit. The unit is then ready to begin another treatment cycle, and the solids from the previous batch may be sampled and/or disposed of, as appropriate.

The nitrogen is heated and introduced directly into the dryer. The desorbed vapors and nitrogen exit the dryer through an upper cupola section attached to the dryer. This cupola section is equipped with filter elements that remove entrained solids (dust) from the exiting gas stream. These solids are retained in the dryer and are returned to the treated product from the filters by sending a short burst of nitrogen

Fig. 1. VAC*TRAXSM Process Flow Diagram

through the filters and into the dryer, essentially "blowing back" the filters. The solids can then be emptied as previously mentioned. The gases are then condensed in a system employing three heat exchangers in series. The first heat exchanger rejects heat to ambient temperature, while the second and third exchangers are operated at near 0°C with a chiller system. These units condense the water and volatile contaminants that were removed from the waste in the dryer. The liquids drain to collection traps, where they are removed using double block valves. The remaining gas stream, essentially nitrogen with trace volatile constituents and oxygen, is then passed through a high efficiency particulate air (HEPA) filter to provide absolute removal of all remaining solid particles. The stream then passes through an activated carbon adsorption system, removing residual organic vapors that could not be condensed prior to venting of the stream to the atmosphere. Total hydrocarbon emissions from the unit are extremely low; in runs performed on debris spiked with volatile organic compounds, none of the spiked compounds were found in the process vent after the carbon adsorption system. Particulate (and radioactive) emissions are non-detectable.

Technology Description - the VAC*TRAX Full-scale System

Based on a market survey, it appears that there is a demand for two sizes of VAC*TRAX systems. These are a small (2-6 drum) unit to handle a large number of low-volume waste streams and a larger (40 drum) unit to handle significant quantities of waste present at a few DOE facilities. At present, the smaller unit is being designed. Rapid mobilization, with minimal cost for installation of utilities and other support facilities are key considerations for the unit. Additionally, the system will be designed to operate within presently existing structures, not requiring that a building be constructed to house this unit. The system is totally self-contained, except for the need for a propane or natural gas fuel source for the hot oil system. The system will be capable of processing waste within a week of arrival on-site, and will be designed for ease of decontamination to decrease demobilization time. These features combine to make the system an economical choice for small waste volumes.

Accomplishments

Over five-hundred hours of testing on spikes, RCRA and TSCA waste, RCRA mixed waste, and TSCA mixed waste have been performed using the VAC*TRAX system. Over 80% of the test runs have been performed on mixed waste. Excellent removal efficiencies have been demonstrated for volatiles, semi-volatiles and PCBs, as shown in Table 1. Even at low temperatures (100°C), the VAC*TRAX system was able to reduce volatiles in a F002 debris waste to below the regulatory level. At 240-260°C, PCBs have been

successfully removed from sludge and debris, with starting levels as high as 10% PCBs (100,000 ppm).

In addition to excellent removal efficiencies, the VAC*TRAX system has proven its other main goal, containment of radioactive material within the dryer. For six distinct radioactive waste streams, the condensate recovered from VAC*TRAX testing was found to be non-radioactive based on gross alpha/beta analysis for waste. These results are summarized in Table 2.

Table 1. Contaminant Removal Efficiencies using the VAC*TRAX Process

Contaminant	Solids Matrix	Final Solid Temp (°C)	Time at Temp (min)	Init. Conc. ⁵ (ppm)	Ending Conc. (ppm)	Removal (%)
<u>Volatiles</u>						
Acetone ¹	Soil/Clay	239	45	1,644	5.98	99.6
Acetone	Debris	101	240	7.51	BQL(0.4)	> 94.5
Carbon Tetrachloride ¹	Soil/Clay	239	45	105	BQL(0.2)	> 99.8
2-hexanone	Debris	101	240	5.93	0.2	96.6
Toluene	Debris	104	360	6.7	0.055	99.2
Tetrachloroethene ¹	Soil/Clay	239	45	118	BQL(0.2)	> 99.8
Tetrachloroethene ²	Soil/Lint	257	360	1,000	J(0.003)	>99.99997
Tetrachloroethene ²	Sludge	243	210	272	BQL(1)	> 99.6
Ethylbenzene ¹	Soil/Clay	239	45	630	BQL(0.2)	> 99.97
Ethylbenzene	Debris	104	360	20	0.075	99.6
MIBK	Debris	104	360	15	0.14	96.8
Xylene ¹	Soil/Clay	239	45	2,672	BQL(0.2)	> 99.993
Xylene	Debris	104	360	110	0.092	99.92
Styrene ¹	Soil/Clay	239	45	461	BQL(0.2)	> 99.96
Styrene	Debris	104	360	230	0.14	99.94
Trichlorofluoromethane	Sludge	243	210	2,701	BQL(1)	> 99.92
<u>Semi-volatiles</u>						
Bis(2-ethylhexyl)phthalate ¹	Soil/Clay	239	45	577	1.05	99.8
Pentachlorophenol	Soil/Clay	247	90	581	126	83.2
<u>PCBs</u>						
Arochlor 1242	Soil/Clay	260	600	990	BQL(1)	> 99.90
Arochlor 1242	Soil/Clay	257	240	760	BQL(1)	> 99.87
Arochlor 1254	Sludge	241	1710 ⁴	107,000	BQL(0.5)	>99.9995
Arochlor 1254	Debris	241	270	500	BQL(0.5)	> 99.90
Arochlor 1260	Debris	241	350	178	BQL(0.5)	>99.7
Elemental Mercury ³	Soil	252	360	70,700	8,800	87.6

Notes:

1. Test Performed on spike sample
2. Test performed on mixed waste
3. Test performed in a vacuum oven test; the VAC*TRAX system is known to perform significantly better for most contaminants.
4. Test run divided over 4 days of operation
5. All results are converted to a dry weight basis

BQL(A) = Below quantitation limit; A = quantitation limit

J(A) = Estimated value of A, below quantitation limit

Table 2. Containment of Radioactivity within the VAC*TRAX Dryer

Radioactive Constituent	Average Level in Feed	Level in Composited Condensate	% Radioactivity carried to condensate
Co-57 pCi/g	16.91	BQL(0.2)	< 1.2
Co-60 pCi/g	44,000	BQL(0.16)	< 0.00037
Cs-134 pCi/g	25.0	BQL(0.16)	< 0.64
Cs-137 pCi/g	1,195	BQL(0.2)	< 0.017
Sb-125 pCi/g	19.5	BQL(0.48)	< 2.5

Future Expectations

Construction of the small (2 to 6 drum) commercial unit is expected to begin in October of this year. Applications for the required permits will be produced and submitted along a parallel track, thus limiting any unnecessary delays. Demonstration of the full-scale system is expected to first be performed during the fall or winter of 1996. After this, the unit will be used for the remediation of various DOE mixed waste streams. Construction of the large (40 drum) unit will depend on the market demand for the system.

Acknowledgements

A significant portion of the VAC*TRAX demonstration program has been funded by a Program for Research and Development Announcement (PRDA) managed by Bill Huber at the Morgantown Energy Technology Center (METC).

References

McElwee, M.J., "Vacuum Oven Thermal Desorption Treatability Study on PCB and Radioactive Contaminated Soil and Sediments from Oak Ridge, Tennessee", Technical Report CTC-TR95-010, June 1995.

McElwee, M.J. and Montez, P.L.

"Demonstration of a Vacuum Assisted Thermal Desorption Process on Mixed Wastes", Southeast Defense Conference, Atlanta, GA, March 1995.

McElwee, M.J. and Palmer,

C.R., "Treatability Study for Low Temperature Thermal Desorption Treatment of Uranium Mill Tailings with a RCRA Listed Waste", Technical Report CTC-TR94-015, 1994.

McElwee, M.J. and Palmer, C.R.,

"Topical Report on VAC*TRAX Vacuum Thermal Desorption Phase I Pilot Testing Results", Contract DE-AC21-92MC29105, Technical Report CTC-TR94-014, 1994.

Palmer, C.R. and McElwee, M.J.,

"Successful Demonstration of the VAC*TRAX Thermal Desorption Process on Hazardous and Mixed Wastes", Spectrum '94 Conference, Atlanta, GA, 1994.

Appendix D

Additional VAC*TRAX Treatability Tests
on
Pantex Vermiculite

This page intentionally blank

Appendix D

Additional VAC*TRAX Treatability Tests on Pantex Vermiculite

D.1 Introduction

The objective of treatability testing with the U.S. Department of Energy Grand Junction Projects Office VAC*TRAX unit was to demonstrate the ability of thermal desorption (TD) to remove volatile and semivolatile organic Resource Conservation and Recovery Act (RCRA) contaminants from a solid matrix mixed waste. As reported in the main text of this report, over 80 individual VAC*TRAX runs were made on eight waste stream samples from five DOE sites. All RCRA-regulated organic constituents were removed to below RCRA treatment standards as a result of processing the samples in the VAC*TRAX unit. The treatability tests described in this Appendix were performed to further satisfy the objectives stated in Section 1.1 of this report.

One of the waste streams processed during the initial VAC*TRAX treatability tests consisted of vermiculite contaminated with mixed waste from the DOE Pantex site. The initial Pantex sample (PTX-1574) was processed on August 30 and 31, 1995. The results of the initial treatability testing performed on PTX-1574 indicate successful removal of RCRA-regulated compounds to below RCRA treatment standards (see Section 4.0).

Vermiculite is an extremely sorbent material used to package laboratory samples and soak up spills. The adsorbent properties of vermiculite make removal of organic constituents difficult. In order to firmly establish VAC*TRAX as a potential treatment technology for contaminated vermiculite, treatability tests were performed on more Pantex vermiculite samples to gain supplemental operational data and experience. The treatability tests on these additional Pantex vermiculite samples are the subject of this Appendix.

VAC*TRAX was demonstrated through this portion of treatability testing to be capable of removing organic constituents from vermiculite contaminated with mixed waste. Treatability test residual concentrations of all RCRA-regulated organic constituents were below RCRA treatment standards.

D.2 Test Objectives

The primary objective of the VAC*TRAX treatability tests is to remove volatile chemical constituents from nonvolatile, radioactive material. A successful test is one that results in treatment residuals that can be readily disposed. At a minimum, this means that the solid portion of the treated waste meets the RCRA treatment standards for the RCRA hazardous constituents present in the original sample and that it can be treated or disposed of at an existing facility. Because the vermiculite samples treated in this series of treatability tests did not contain any RCRA-regulated heavy metals that would stay with the solid residuals, the solids can be easily disposed following removal of the regulated volatile material.

A secondary objective of these treatability tests was to augment the experience and data obtained about treating mixed-waste contaminated vermiculite during the original treatability tests. The additional experience and data increase the probability of success of the full-scale mobile treatment unit.

D.3 Waste Stream Tested

The Pantex waste stream sample consisted of eight drums containing plastic bags filled with vermiculite. The vermiculite was contaminated with liquid from scintillation cocktails intended for tritium analysis. The principle organic constituents specified by the generator, in order of concentration, were pseudocumene, xylene, and toluene. Because of the low concentrations of toluene and xylene relative to the concentration of pseudocumene, the GJPO Analytical Laboratory was unable to quantify the amounts of toluene and xylene present in the feed samples. The only specified radioactive contaminant of this waste stream was tritium. Physical appearance of the vermiculite ranged from dry and friable to very moist. Three 40-milliliter glass vials were observed in the vermiculite. Loss of weight on drying on a wet basis, calculated from weight of the feed and condensate, ranged from 3 to 39 percent for the vermiculite and from 2 to 15 percent for the plastic materials.

This waste stream sample was somewhat unique in that both the chemical constituents (toluene and xylene) and the radiological constituent (tritium) are volatile. Pseudocumene, an organic compound less volatile than toluene and xylene, was the major organic compound present. Pseudocumene is not a RCRA listed compound and therefore has no treatment standard.

D.4 General Procedures

General procedures followed to complete treatability testing on the Pantex vermiculite waste stream sample were:

- Obtain a sample of the waste stream from the generator and follow recordkeeping requirements of the RCRA treatability test categorical exclusion permit.
- Examine the sample and divide it into separate 13-gallon charges (the capacity of the dryer).
- Sample and analyze the prepared charges to characterize the waste material, to confirm the presence of RCRA-regulated constituents, and to provide a baseline for demonstrating the effectiveness of treatment. Some samples were composites of two prepared charges.
- Process each charge in the pilot VAC*TRAX unit at conditions and duration sufficient to remove target constituents to the extent that RCRA treatment standards are met.
- Sample and analyze the processed solid product for residual contaminants to demonstrate the effectiveness of removing the RCRA target constituents. Sample and analyze the condensate to quantify tritium.

During the original treatability tests performed with PTX-1574, the VAC*TRAX hot-oil system was heated to 500 °F and dryer vacuum was raised to the maximum (approximately 22 inches mercury [Hg]), which resulted in rapid vaporization of a heavy petroleum distillate that clogged the primary filters. Because the petroleum distillate is not regulated by RCRA, final operating conditions of 350 °F for the hot-oil system and a maximum dryer vacuum of 5 to 10 inches Hg were specified in the run plans for these additional Pantex vermiculite treatability tests to purposely vaporize only the pseudocumene, toluene, and xylene.

In prior treatability tests, analytical samples of the processed material were collected from the dryer after allowing the dryer contents to cool and prior to agitation. Samples collected using that sampling method were later found not to be representative. In an effort to obtain a representative sample during these

Pantex vermiculite runs, the dryer contents were agitated for 15 minutes prior to taking feed or product samples.

The Pantex waste stream sample was prepared, processed, unloaded, and sampled in accordance with the *Pilot Thermal Desorption Treatability Test Operation and Maintenance Procedure* (DOE 1995d) and run plans specific for vermiculite. In addition to safe work practices detailed in the *Health and Safety Plan for Thermal Desorption Treatability Test Feed Preparation* (DOE 1995a) and the *Health and Safety Plan for Thermal Desorption Treatability Testing* (DOE 1995b), an Industrial Hygiene Work Permit and a Radiological Work Permit were prepared for this portion of treatability testing to ensure all safety issues were addressed prior to engaging in work activities.

D.5 Feed Preparation

The purpose of feed preparation is to divide a waste stream sample into multiple 13-gallon charges and ensure that no material is introduced to the VAC*TRAX unit that could potentially damage it.

After a safety briefing, the eight parent drums of Pantex vermiculite were taken into a walk-in exhaust hood, opened, and the contents examined. Each drum contained one to four bags of up to 15 gallons of vermiculite. The bags were weighed and the volume of each was estimated to determine which bags could be combined to make a 13-gallon charge. The weight of the charges varied due to the differing quantities of liquid sorbed to the vermiculite. Seventeen charges were prepared for processing.

The plastic bags in which the vermiculite was contained held small amounts of residue of the contaminated vermiculite after the charge was loaded into the dryer. The bags were stored until all but one vermiculite charge was run. The bags were then size reduced with scissors to increase the probability that all surfaces would be exposed to treatment conditions during processing. During the initial treatability tests on PTX-1574, it was determined that size reduction of the plastic is necessary to avoid forming balls or clumps that mechanically trap the volatile material. Nine charges of plastic were prepared for processing. Two charges (PTX-PLASTIC-6 and -7) were small and combined into Run 22. Charge PTX-PLASTIC-9 was not processed.

Table D-1 summarizes the segregation of the contents of each drum into individual charges and the fate of each charge. Each charge was labeled using PTX as a prefix, the last five digits of the parent drum number specified by Pantex, the four-digit internal (GJPO) tracking number specified by Rust Geotech, and a single number indicating the order of the bag as it was removed from the parent drum. The plastic bag charges are designated as PTX-PLASTIC.

Table D-1. Summary of Pantex Vermiculite Charges

Bag	Weight (g)	Fate	Process Date
PTX-73773-1599-1	11,570	Treatability Test, Run 1	10/10/95
PTX-73773-1599-4	11,826	Treatability Test, Run 1	10/10/95
PTX-73773-1599-2	3,840	Treatability Test, Run 2	10/11/95
PTX-73773-1599-3	19,267	Treatability Test, Run 2	10/11/95
PTX-73774-1600-1	7,986	Treatability Test, Run 3	10/12/95
PTX-73774-1600-2	14,131	Treatability Test, Run 3	10/12/95

Table D-1 (continued). Summary of Pantex Vermiculite Charges

PTX-73776-1601-2	7,950	Treatability Test, Run 4	10/13/95
PTX-73776-1601-3	9,659	Treatability Test, Run 4	10/13/95
PTX-73776-1601-1	3,280	Treatability Test, Run 5	10/16/95
PTX-73776-1601-4	10,150	Treatability Test, Run 5	10/16/95
PTX-73777-1602-1	10,133	Treatability Test, Run 6	10/17/95
PTX-73780-1604-2	23,000	Treatability Test, Run 7	10/18/95
PTX-84135-1606-1	13,330	Treatability Test, Run 8	10/19/95
PTX-84135-1606-2	6,035	Treatability Test, Run 8	10/19/95
PTX-84134-1605-1	8,116	Treatability Test, Run 9	10/20/95
PTX-84134-1605-2	9,205	Treatability Test, Run 9	10/20/95
PTX-73774-1600-3	23,454	Treatability Test, Run 10	10/23/95
PTX-84135-1606-3	22,285	Treatability Test, Run 11	10/24/95
PTX-84134-1605-3	17,360	Treatability Test, Run 12	10/25/95
PTX-73779-1603-1	9,764	Treatability Test, Run 13	10/26/95
PTX-73779-1603-2	7,155	Treatability Test, Run 13	10/26/95
PTX-73779-1603-3	8,021	Treatability Test, Run 14	10/27/95
PTX-73780-1604-1	12,406	Treatability Test, Run 15	10/30/95
PTX-73780-1604-3	1,680	Treatability Test, Run 15	10/30/95
PTX-73779-1603-4	10,909	Treatability Test, Run 16	10/31/95
PTX-PLASTIC-1	3,980	Treatability Test, Run 17	11/2/95
PTX-PLASTIC-2	4,170	Treatability Test, Run 18	11/3/95
PTX-PLASTIC-3	3,727	Treatability Test, Run 19	11/6,7/95
PTX-PLASTIC-4	4,780	Treatability Test, Run 20	11/8/95
PTX-PLASTIC-5	4,387	Treatability Test, Run 21	11/9/95
PTX-PLASTIC-6	2,273	Treatability Test, Run 22	11/10/95
PTX-PLASTIC-7	2,727	Treatability Test, Run 22	11/10/95
PTX-PLASTIC-8	3,850	Treatability Test, Run 23	11/13/95
PTX-84135-1606-4	12,375	Treatability Test, Run 24	11/14/95
PTX-PLASTIC-9	578	Not processed	

In general, vermiculite charges were processed in order of decreasing moisture content. The plastic bags that contained the first vermiculite charges processed were not completely empty due to wet vermiculite that adhered to the bag. Since the bags from early vermiculite runs contained a significant amount of vermiculite after loading the dryer, the bags did not satisfy the requirements of an empty container as defined by RCRA. The plastic bags comprising the PTX-PLASTIC-9 charge contained less than 5 grams of vermiculite after the bags were emptied into the dryer and thus clearly satisfy the RCRA requirements of an empty container. PTX-PLASTIC-9 was the only set of bags clearly empty by RCRA standards, thus it was the only bag not processed in the VAC*TRAX unit.

D.6 Treatability Test Runs

The objective of treatability test runs is to process each charge at a sufficient combination of temperature, time, and applied vacuum until the target RCRA constituents are removed to meet RCRA standards. The basic strategy used in these treatability tests was to process the charge until the condensate rate dropped below 20 milliliters per half hour then continue to process the charge for at least 30 minutes at the same temperature and at the maximum vacuum achievable. Removal of the bulk liquid was judged complete by observing the expected decrease in condensate rate as the charge approached dryness. The additional period of processing time was included to address uncertainties of the process such as matrix effects and the degree of removal needed.

The general procedure for volatilizing the liquid content of a charge was to initially set the dryer temperature and vacuum so that a majority of the vapor was condensed in the first condenser while minimizing condensate formed in the second condenser. The temperature was initially lower than the final operating temperature (225 °F versus 350 °F) to control the rate of volatilization. This procedure was established because the dryer is capable of volatilizing more vapor than the first condenser can condense.

The Pantex vermiculite treatability tests started October 10, 1995, and continued through November 13, 1995. A total of 24 runs were made during these treatability tests, including 17 runs of vermiculite and 7 runs of the plastic bags that originally contained the vermiculite. A total of 72,757 grams of condensate was collected from 294,887 grams of vermiculite. A total of 1,189 grams of condensate were collected from 29,894 grams of plastic material. Each run is summarized in Table D-2.

D.6.1 Vermiculite Runs

The bulk of the liquid in the vermiculite charges was volatilized using the procedure detailed above. Operating conditions were then set to ensure all contaminants of concern were removed to below RCRA standards. Final dryer operating conditions varied from 325 to 375 °F and up to 21 inches Hg vacuum, although the majority of the runs were kept at 10 inches Hg. The dryer was not required to be completely discharged between runs; however, less than 1 percent of vermiculite carried over between runs. Figure D-1 presents a sample vermiculite run plan. Each charge had an individual run plan due to the differences in moisture content between samples.

D.6.2 Plastic Material Runs

Final operating conditions for the plastic material charges were 235°F and vacuum varied from 15 to 20 inches Hg vacuum. The decrease in condensate rate at the end of a run was effectively used to determine the end of a vermiculite run, as shown by analytical data in Table D-2, and was therefore used to indicate the end of the plastic material runs. Organic vapor readings in the dryer before unloading a processed charge indicated that there were still organic materials present at the end of the run. However, the organic vapor was most likely the result of remaining non-RCRA-regulated organics that are less

RUST GEOTECH INC.

MEMO TO: Distribution
FROM: R. J. Mancik
DATE: October 26, 1995
SUBJECT: TD Treatability Test Run Plan: PTX-73779-1603-3

Thermal Desorption Mixed Waste Treatability Project (TD MWTP)

This memo contains details needed to perform a thermal desorption treatability test run on a portion of the Pantex vermiculite waste sample. This memo supplements the Thermal Desorption Treatability Test Plan (Plan) and the Thermal Desorption Treatability Test Sampling and Analysis Plan (SAP).

This will be the fourteenth run on the additional Pantex vermiculite waste samples that were received at GJPO on October 5, 1995. This waste sample was shipped from Pantex to GJPO in eight 55 gallon drums having GJPO drums numbers 1599 through 1606. The total volume of Pantex vermiculite waste sample in all 8 drums will be sufficient for 16 test runs in the pilot VAC*TRAX unit.

This run will use Bag 3 from Drum 1603 which contains scintillation cocktail solvents and tritium absorbed into vermiculite. Subtracting the tare weight of the bags will result in a charge weight of about 7,800 grams of waste sample.

Analytical results from this material have not yet been obtained, but it is known the material is vermiculite used to absorb scintillation cocktails. The vermiculite contains xylenes, tritium, and may also contain toluene, and pseudocumene (trimethylbenzene). The material carries RCRA waste codes D001 for ignitability, and F003 for spent xylene solvent. If toluene is present, the material would also carry RCRA waste code F005 for spent toluene solvent. There may be very little water in the waste sample. Vermiculite is a mineral based absorbent and is quite refractory.

Pseudocumene has a boiling point of about 228 degrees F at 20 inches Hg gauge vacuum and 307 degrees F at 5 inches Hg gauge vacuum. Pseudocumene is not a RCRA regulated solvent compound. Xylene is the least volatile target constituent for this run. It has a boiling point of about 181 degrees F at 20 inches Hg gauge vacuum and 255 degrees F at 5 inches Hg gauge vacuum.

The plan for this run will be to set a moderate dryer vacuum and then increase the hot oil temperature to 350 degrees. Full vacuum and temperature will not be used. There may be enough water to form a 2 phase condensate.

The procedure should be as follows:

Charge the dryer with the contents of PTX-73779-1603-Bag 3. Estimate the total volume of the charge.

Figure D-1. Vermiculite Run Plan

Rotate the dryer paddle without heat for at least 15 minutes to mix the sample and then take a feed sample directly from the dryer. Label and archive this sample.

Set the dryer vacuum to a vacuum of only 5 to 10 inches Hg gauge.

Bring the hot oil temperature up to 350 degrees F while monitoring the rate of condensation. Increment to the next hot oil set point after the previous set point temperature is reached. Hold at a hot oil temperature of 350 degrees F and a dryer vacuum between 5 and 10 inches Hg until at least an hour after condensation rate has fallen to less than 20 ml per 30 minute or until the end of the 2nd shift. If the condensation rate is too high to manage, reduce the applied vacuum.

Collect data on the data log sheets. Weigh the condensate for accuracy. For a check on condensate volumes, note on the condensate log when a new condensate collection jar is started. Record the final weights and volumes of each condensate jar.

Use this alternate shut down procedure:

- 1) After completing Step 4 of the normal shut down procedure from the Operations & Maintenance Procedure, wait until the hot oil temperature falls to 150 degrees F and then continue with the normal shut down procedure.
- 2) Close the condenser inlet valve (V43) prior to stopping the vacuum pump.
- 3) Complete the rest of the existing shut down procedure.

Take samples as follows:

Feed sample: Archive a sample large enough for tritium and total VOC for xylenes and toluene.

Treated solids: Archive a sample large enough for tritium and total VOC for xylenes and toluene.

Product condensate (each phase): No sample at this time. A composite sample will be taken after completion of all the Pantex vermiculite runs.

Intermediate product samples: None for this run.

Consult the SAP for sample sizes and preservative methods.

Approved for use by

R. R. Bloom, Project Manager

Date

rjm/jeh
Distribution
Bob Bloom
Larbi Bounini

Figure D-1 (continued). Vermiculite Run Plan

volatile than toluene and xylene. At the end of the plastic material runs, the plastic was manually removed from the dryer shaft. After the bulk of the debris was unloaded, the remaining debris was unloaded using a cloth wiper.

D.7 Results

The condensate resulting from the Pantex vermiculite treatability tests contained tritium in addition to the organic contaminants of concern. The solid product can be managed as a radioactive waste and the liquid product, which was significantly less voluminous than the original sample, can be treated at an existing facility. The VAC*TRAX treatability test results indicate successful removal of toluene and xylene to below RCRA treatment standards from the Pantex vermiculite waste stream sample. Toluene and xylene analytical data for each processed treatability sample are summarized in Table D-3, which shows that the universal treatment standards, 30 and 10 mg/kg respectively, were met. Even though pseudocumene is not a RCRA-regulated compound, pseudocumene data are included in Table D-2 because it was the most prevalent compound in the waste stream sample and the information is useful in predicting the effectiveness of the VAC*TRAX unit on other compounds with comparable vapor pressures.

The 73,946 grams of condensate collected consisted of approximately 85 percent organic phase and 15 percent aqueous phase. Tritium concentration was 107 pCi/mL in the organic phase and 14,013 pCi/mL in the aqueous phase, which represents a total of 162,157,574 pCi. Tritium concentration in a composite sample of all processed vermiculite was 34 pCi/g.

Samples of product from the first two runs were individually submitted for analysis to verify that toluene and xylene were removed to below the RCRA treatment standards. After analytical results of the first two runs indicated that the RCRA treatment standards for toluene and xylene were met, product samples from subsequent runs were submitted as composites. Composite samples of the feed were submitted for analysis for the first six runs when it was determined that toluene and xylene could not be quantified because the high concentration of pseudocumene present.

The plastic bags that originally contained the vermiculite were not sampled before or after processing because of the difficulty in obtaining a representative sample. RCRA does not require sampling of debris that consists primarily of pieces greater than 2.5 inches to prove that organic constituents have been removed to below RCRA treatment standards. There is little probability that toluene and xylene, which are highly volatile, would remain in the debris after being exposed to the operating conditions of the VAC*TRAX unit.

Table D-2. DOE-GJPO VAC*TRAX Treatability Test Runs and Results (Pantex Vermiculite)

Waste Stream Sample	Run No.	Date	Load Weight (g)	Organic Concentration		Maximum Hot Oil Temp.	Maximum Dryer Vacuum (" Hg)	Run Time (Hr)	Condensate Collected (g)
				Feed (mg/kg)	Product (mg/kg)				
PTX-73773-1599-1,4	1	10/10/95	23,396	Toluene: < 860 Xylene: < 180 Pseudocumene: 47,000	< 9 < 3 4.8	350	7.2	11.5	6,591
PTX-73773-1599-2,3	2	10/11/95	23,107	Toluene: < 860 Xylene: < 180 Pseudocumene: 47,000	< 30 < 7 22	350	7.5	10.5	5,340
PTX-73774-1600-1,2	3	10/12/95	22,117	Toluene: < 760 Xylene: < 160 Pseudocumene: 16,000	< 22 < 5 21	350	7.8	10.5	6,426
PTX-73776-1601-2,3	4	10/13/95	17,609	Toluene: < 760 Xylene: < 160 Pseudocumene: 16,000	< 22 < 5 21	350	8.0	10.0	469
PTX-73776-1601-1,4	5	10/16/95	13,430	Toluene: < 200 Xylene: < 42 Pseudocumene: 63,000	< 15 < 4 15	350	8.0	11.0	2,284
PTX-73777-1602-1	6	10/17/95	10,133	Toluene: < 200 Xylene: < 42 Pseudocumene: 63,000	< 15 < 4 15	350	8.8	8.0	430
PTX-73780-1604-2	7	10/18/95	23,000	NA	< 15 < 5 < 7.1	370	9.8	14.0	9,034
PTX-84135-1606-1,2	8	10/19/95	19,365	NA	< 15 < 3 42	370	7.2	13.0	5,213
PTX-84134-1605-1,2	9	10/20/95	17,321	Toluene: < 188 Xylene: < 39 Pseudocumene: 7,700	< 15 < 3 64	350	8.7	14.0	3,271

Table D-2 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results (Pantex Vermiculite)

Waste Stream Sample	Run No.	Date	Load Weight (g)	Organic Concentration		Maximum Hot Oil Temp.	Maximum Dryer Vacuum (" Hg)	Run Time (Hr)	Condensate Collected (g)
				Feed (mg/kg)	Product (mg/kg)				
PTX-73774-1600-3	10	10/23/95	23,454	NA	< 30 < 7 < 15	370	9.2	12.0	7,905
PTX-84135-1606-3	11	10/24/95	22,285	Toluene: < 300 Xylene: < 62 Pseudocumene: 12,000	< 15 < 3 < 8	370	7.6	13.0	6,841
PTX-84134-1605-3	12	10/25/95	17,360	NA	< 30 < 7 27	370	7.3	12.0	4,434
PTX-73779-1603-1,2	13	10/26/95	16,919	NA	< 30 < 7 29	370	8.2	12.0	5,142
PTX-73779-1603-3	14	10/27/95	8,021	NA	< 30 < 7 29	370	8.5	9.5	892
PTX-73780-1604-1,3	15	10/30/95	14,086	NA	< 30 < 7 20	370	7.8	9.0	2,091
PTX-73779-1603-4	16	10/31/95	10,909	NA	NA	350	9.5	8.0	2,528
PTX-PLASTIC-1	17	11/2/95	3,980	NA	NA	225	17.8	5.0	133
PTX-PLASTIC-2	18	11/3/95	4,170	NA	NA	225	18.4	5.0	109
PTX-PLASTIC-3 (Restart on 11/7)	19	11/6/95	3,727	NA	NA	235 235	19.0 19.0	7.0 8.5	576
PTX-PLASTIC-4	20	11/8/95	4,780	NA	NA	235	17.3	4.5	112

Table D-2 (continued). DOE-GJPO VAC*TRAX Treatability Test Runs and Results (Pantex Vermiculite)

Waste Stream Sample	Run No.	Date	Load Weight (g)	Organic Concentration		Maximum Hot Oil Temp.	Maximum Dryer Vacuum (" Hg)	Run Time (Hr)	Condensate Collected (g)
				Feed (mg/kg)	Product (mg/kg)				
PTX-PLASTIC-5	21	11/9/95	4,387	NA	NA	235	19.5	6.0	94
PTX-PLASTIC-6,7	22	11/10/95	5,000	NA	NA	236	20.0	6.0	133
PTX-PLASTICS-8	23	11/13/95	3,850	NA	NA	235	20.0	6.0	32
PTX-84135-1606-4	24	11/14/95	12,375	NA	NA	350	15.0	7.0	3,866