20030210188

Best Available Copy

DTIC FILE COPY

Approved for public release;
distribution unlimited

AD-A222 253

USATHAMA

U.S. Army Toxic and Hazardous Materials Agency

DRXTH-TE-CR

Task Order 4
Determination of Thermal Oxidation of JP-4 and Other Fuels Burn Cells at Tinker Air Force Base Oklahoma City, Oklahoma

Contract Number DAAA15-88-D-0010

March 1990

Prepared for
COMMANDER, U.S. ARMY TOXIC AND HAZARDOUS
MATERIALS AGENCY
ATTN: DRXTH-ES-A
Aberdeen Proving Ground, MD 21010-5401

Prepared by
WESTON

DTIC
ELECTE
MAY 30 1990
C D

90 05 29 088

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial products. This report may not be cited for purposes of advertisement.

REPRODUCTION QUALITY NOTICE

This document is the best quality available. The copy furnished to DTIC contained pages that may have the following quality problems:

- Pages smaller or larger than normal.
- Pages with background color or light colored printing.
- Pages with small type or poor printing; and or
- Pages with continuous tone material or color photographs.

Due to various output media available these conditions may or may not cause poor legibility in the microfiche or hardcopy output you receive.

☐ If this block is checked, the copy furnished to DTIC contained pages with color printing, that when reproduced in Black and White, may change detail of the original copy.

FINAL REPORT

TASK ORDER - 4
DEMONSTRATION OF THERMAL STRIPPING OF JP-4 AND OTHER VOCs FROM SOILS AT TINKER AIR FORCE BASE OKLAHOMA CITY, OKLAHOMA

Contract Number DAAA15-88-D-0010

March 1990

Peter J. Marks
Program Manager

John W. Noland
Deputy Program Manager

Roger K. Nielson
Project Manager

Prepared for:

COMMANDER, U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
Aberdeen Proving Ground (Edgewood Area),
Maryland 21010-5401

Prepared by:

Roy F. Weston, Inc. (WESTON)
West Chester, Pennsylvania 19380

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution Unlimited Approved for Public Release
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) CETHA-TE-CR-90026
6a. NAME OF PERFORMING ORGANIZATION ROY F. WESTON, INC.	6b. OFFICE SYMBOL (If applicable)
	7a. NAME OF MONITORING ORGANIZATION U.S. Army Toxic and Hazardous Materials Agency
6c. ADDRESS (City, State, and ZIP Code) One Weston Way West Chester, PA 19380	7b. ADDRESS (City, State, and ZIP Code) Attn: CETHA-TS-D Aberdeen Proving Ground, MD 21010-5401
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Toxic and Hazardous Materials Agency	8b. OFFICE SYMBOL (If applicable) CETHA-TS-D
	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAAIS-88-D-0010 Task 4
8c. ADDRESS (City, State, and ZIP Code) Attn: CETHA-TS-D Aberdeen Proving Ground, MD 21010-5401	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO. T.O.4

11. TITLE (Include Security Classification)
Demonstration of Thermal Stripping of JP-4 and other VOCs from Soils at Tinker Air Force Base, Oklahoma City, Oklahoma

12. PERSONAL AUTHOR(S)
Peter J. Marks, John W. Noland, Roger K. Nielson

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final Report	FROM 9/88 TO 3/90	March 1990	402

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Volatile Organic Compounds, Fuel, Thermal Treatment, Trichloroethene, Low Temperature Thermal Treatment,

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The patented Low Temperature Thermal Treatment (LT^3) System was previously proven to be successful in treating soils contaminated with volatile organic compounds and petroleum hydrocarbons. This demonstration broadened the applicability to include soils contaminated with aviation fuel and other halogenated solvents.

Several test were conducted to verify the effectiveness of the LT^3 System. While meeting all goal cleanup objectives, a processing rate of 20,000 lb/hr was demonstrated with a projected LT^3 System processing cost of $86/ton.

A number of system changes and process improvements are recommended. The system proved to be an efficient, cost-effective, and commercially available remediation alternative for decontaminating soils.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Craig A. Myler	22b. TELEPHONE (Include Area Code) 301-671-2054
	22c. OFFICE SYMBOL CETHA-TS-D

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

WESTON

TABLE OF CONTENTS

Section	Title	Page
1	EXECUTIVE SUMMARY	1-1
2	INTRODUCTION	2-1
2.1	Background	2-1
2.2	Purpose	2-1
2.3	Objectives of the demonstration	2-1
2.4	Report organization	2-2
3	TEST SITE	3-1
3.1	Test site location and description	3-1
3.2	Waste/soil characteristics	3-1
3.2.1	General	3-1
3.2.2	Stratigraphy	3-1
3.3	Excavation activities	3-7
3.3.1	Buried drums found during excavation activities	3-7
3.3.2	Personnel protection for drum handling	3-11
3.4	Environmental permitting	3-13
4	DESCRIPTION OF THE PROCESS EQUIPMENT	4-1
4.1	Introduction	4-1
4.2	Soil Treatment	4-1
4.2.1	Soil feed system	4-1
4.2.2	Thermal processor	4-7
4.2.3	Processed soil handling system	4-15
4.2.4	Hot oil system	4-15
4.3	Emissions control system	4-15
4.3.1	Fabric filter	4-15
4.3.2	Condenser	4-16
4.3.3	Afterburner	4-16
4.3.4	Continuous emissions monitoring (CEM) system	4-16
4.3.5	Bleed air	4-16
4.3.6	Scrubber	4-16
4.3.7	Caustic supply system	4-19
4.4	Water treatment system	4-19
4.4.1	Oil/water separator	4-19
4.4.2	Carbon adsorption	4-19
4.4.3	Fresh water system	4-19
4.5	Utilities	4-19
4.5.1	Electrical power	4-23
4.5.2	Propane fuel	4-23
4.5.3	Process water	4-23

DTIC QUALITY INSPECTED 4

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

WESTERN

TABLE OF CONTENTS
(continued)

Section	Title	Page
5	DEMONSTRATION FRAMEWORK	5-1
5.1	Criteria for a successful demonstration	5-1
5.1.1	Analytical	5-1
5.1.2	Operational	5-1
5.2	Original Test Plan	5-1
5.3	Modified Test Plan	5-1
5.3.1	Test 1	5-8
5.3.2	Test 2	5-8
5.3.3	Test 3	5-8
5.3.4	Test 4	5-8
5.3.5	Tests 5 and 6	5-8
5.3.6	Test 7	5-8
5.3.7	Test 8	5-8
5.3.8	Test 9	5-10
6	TYPICAL SITE ACTIVITIES	6-1
6.1	Daily routine	6-1
6.1.1	Pretest activities	6-1
6.1.1.1	Equipment startup and stabilization	6-1
6.1.1.2	Excavation activities	6-1
6.1.1.3	Materials handling	6-7
6.1.1.4	Sampling equipment	6-7
6.1.2	System stabilization and test initiation	6-7
6.1.3	Post-test activities	6-8
6.1.3.1	Equipment shutdown	6-8
6.1.3.2	Securing the area	6-8
6.2	Project closure activities	6-8
6.2.1	Excavation area	6-9
6.2.2	Processing area	6-9
7	TEST VARIABLES	7-1
7.1	Independent variables	7-1
7.1.1	Ambient air temperature	7-1
7.1.2	Ambient air relative humidity	7-1
7.1.3	Ambient air VOC concentrations	7-1
7.1.4	Feed soil contaminant concentrations	7-1
7.1.5	Feed soil moisture content	7-1
7.1.6	Feed soil temperature	7-1
7.2	Control variables	7-5
7.2.1	Control variables held constant	7-5
7.2.1.1	Feed soil preparation and handling	7-5

TABLE OF CONTENTS
(continued)

Section	Title	Page
	7.2.1.2 Thermal processor draft	7-5
	7.2.1.3 Thermal processor discharge gas temperature	7-5
	7.2.1.4 Condenser discharge gas temperature	7-5
	7.2.1.5 Afterburner discharge gas temperature	7-5
	7.2.1.6 Afterburner discharge draft	7-5
	7.2.1.7 Scrubber inlet gas temperature	7-6
	7.2.1.8 Scrubber liquor recirculation flow rate	7-6
	7.2.1.9 Scrubber liquor pH	7-6
	7.2.2 Variables controlled to various levels	7-6
	7.2.2.1 Soil residence time in the thermal processor	7-6
	7.2.2.2 Oil temperature	7-6
	7.3 Response variables	7-6
	7.3.1 Feed soil mass flow rate	7-6
	7.3.2 Processed soil discharge temperature	7-7
	7.3.3 Processed soil contaminant concentrations	7-7
	7.3.4 Processed soil moisture content	7-7
	7.3.5 Soil contaminant removal efficiency	7-7
	7.3.6 Return oil temperature	7-7
	7.3.7 Fabric filter dust composition	7-7
	7.3.8 Fabric filter dust mass flow rate	7-7
	7.3.9 Condensate mass flow rate	7-7
	7.3.10 Afterburner inlet gas temperature	7-8
	7.3.11 Afterburner discharge gas composition	7-8
8	SAMPLING TECHNIQUES AND ANALYTICAL METHODS	8-1
	8.1 Sampling techniques	8-1
	8.1.1 Feed soil	8-1
	8.1.2 Processed soil	8-1
	8.1.3 Fabric filter dust	8-11
	8.1.4 Ambient air	8-11
	8.1.5 Afterburner outlet	8-11
	8.2 Analytical methods	8-12
	8.3 Sample transport and custody	8-12

WESTON

TABLE OF CONTENTS
(continued)

Section	Title	Page
9	DATA ANALYSIS	9-1
	9.1 Field data	9-1
	9.2 Analytical data	9-1
	9.3 Effectiveness of the LT^3 System	9-1
	9.3.1 Goal cleanup levels (GCLs)	9-1
	9.3.2 Contaminant removal efficiency	9-5
	9.4 Impact on system performance by adding a stripping agent	9-5
	9.5 Continuous emissions monitoring (CEM) results	9-7
	9.6 Scrubber liquor pH	9-7
	9.7 Optimum range of operational parameters for testing contaminated soils	9-7
	9.8 Results of PCB contamination	9-12
	9.8.1 Decontamination criteria for LT^3 Equipment	9-15
	9.8.2 Decontamination criteria for washwater holding tanks	9-15
	9.8.3 Cleanup criteria for soil from stockpile and equipment placement areas	9-15
	9.8.4 Results of PCB analyses	9-15
	9.9 System economics	9-27
	9.9.1 Fixed costs	9-27
	9.9.2 Variable costs	9-32
	9.9.3 Total costs	9-32
10	DESIGN CONSIDERATIONS	10-1
	10.1 Excavation, storage, blending, and feed preparation	10-1
	10.2 Feed hopper	10-2
	10.3 Thermal processors	10-3
	10.4 Oil heater	10-3
	10.5 Discharge conveyors and soil conditioner	10-4
	10.6 Sweep gas control	10-4
	10.7 Exhaust gas from the processors	10-4
	10.8 Fabric filter	10-5
	10.9 Condenser	10-5
	10.10 Oil/water separator	10-5
11	CONCLUSIONS	11-1
	REFERENCES	

WESTON

TABLE OF CONTENTS
(continued)

Title

APPENDIX A - EQUIPMENT DECONTAMINATION PLAN

APPENDIX B - EXIT PLAN

APPENDIX C - THEORETICAL RESIDENCE TIME CALCULATION

APPENDIX D - ANALYTICAL METHODS FOR ON-SITE ANALYSES

APPENDIX E - DESCRIPTION OF THE CEM SAMPLING SYSTEM

APPENDIX F - SAMPLING AND ANALYTICAL METHODS FOR AFTERBURNER OUTLET GAS TESTING

APPENDIX G - SUMMARY TABLES OF FIELD DATA AND ANALYTICAL RESULTS

APPENDIX H - ANALYTICAL DATA

APPENDIX I - PERMIT DOCUMENTS

WESTON

LIST OF TABLES

Table No.	Title	Page
3-1	Summary of soil excavation at Tinker Air Force Base Landfill 3 site	3-10
3-2	Summary of drums found in excavation area	3-12
5-1	Contaminant concentrations in Landfill 3 soil borings and cleanup objectives	5-2
5-2	Summary of tests runs	5-9
7-1	Summary of test variables for the demonstration	7-2
8-1	Summary of parameters in the sampling/analytical program	8-3
8-2	Volatile and semivolatile organics included in the on-site analyses	8-4
8-3	Sampling and analysis procedures for the feed soil	8-6
8-4	Sampling and analysis procedures for the processed soil	8-7
8-5	Sampling and analysis procedures for the dust from the fabric filter	8-8
8-6	Sampling and analysis procedures for the ambient air samples	8-9
8-7	Sampling and analysis procedures for the afterburner outlet gas	8-10
8-8	Specifications for the electrochemical analyzer used to monitor oxygen content	8-13
8-9	Specifications for the gas phase correlation filter analyzer to monitor carbon monoxide	8-14
8-10	Specifications for the nondispersive infared gas analyzer to monitor carbon dioxide	8-15
8-11	Specifications for the CEM flame ionization detector used to monitor total hydrocarbons	8-16

WESTON

LIST OF TABLES
(continued)

Table No.	Title	Page
9-1	Summary of processed soil concentrations for the contaminants with assigned goal cleanup levels	9-2
9-2	Contaminant removal efficiences for detected compounds	9-6
9-3	Performance of tests	9-13
9-4	Summary of the variable cost elements and the basis for estimation	9-31

WESTON

LIST OF FIGURES

Figure No.	Title	Page
3-1	Map of base location in Oklahoma	3-3
3-2	Tinker Air Force Base project location map	3-5
3-3	Enlarged view of the landfill area	3-6
3-4	Landfill 3 excavation area cross section (North-South)	3-8
3-5	Tinker Air Force Base Landfill 3 - LT^3 System site after excavation	3-9
4-1	Flow diagram for the LT^3 System	4-2
4-2	Mobile low temperature thermal treatment	4-5
5-1	Test matrix for determination of optimum operating conditions	5-4
5-2	Decision tree to identify optimum operating conditions	5-5
5-3	Modified test matrix for determination of optimum operating conditions	5-7
6-1	Typical schedule of daily on-site activities	6-2
6-2	Overall project schedule	6-3
8-1	Sampling locations for the LT^3 System	8-2
9-1	Afterburner outlet oxygen concentration	9-8
9-2	Afterburner outlet carbon monoxide concentration	9-8
9-3	Afterburner outlet total hydrocarbon concentration	9-10
9-4	Scrubber liquor pH level	9-11
9-5	Optimum operating range for the LT^3 System	9-14
9-6	LT^3 System variable costs for various processing rates	9-33
9-7	LT^3 System total costs for various processing rates as a function of the total tonnage	9-34

LIST OF PHOTOGRAPHS

Photograph No.	Title	Page
Photograph No. 1.	LT^3 System -- thermal processor, febric filter, and motor control center being transported to Tinker Air Force Base	4-3
Photograph No. 2.	Installed LT^3 System showing the inclined feed conveyor, the feed hopper, and the exhaust ducts	4-9
Photograph No. 3.	Intermeshed screws of the lower processor	4-11
Photograph No. 4.	Variable-speed drives on the LT^3 System	4-13
Photograph No. 5.	CEM instrumentation	4-17
Photograph No. 6.	Oil/water separator	4-21
Photograph No. 7.	Excavation showing water that restricted operations	6-5
Photograph No. 8.	PCB analysis logbooks and sampling equipment	9-17
Photograph No. 9.	Preparing PCB-contaminated material for placement in an overpack	9-19
Photograph No. 10.	Wipe testing potentially contaminated equipment	9-21
Photograph No. 11.	Steam cleaning a PCB-contaminated trailer	9-23
Photograph No. 12.	Steam cleaning the weigh scale	9-25
Photograph No. 13.	Decontamination equipment in the holding area pending laboratory analysis of wipe samples	9-29

SECTION 1

EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

The patented Roy F. Weston, Inc. (WESTON) Low Temperature Thermal Treatment (LT^{3}™) System (U.S. Patent No. 4,738,206) had previously been proven at the pilot scale to be a successful technology for treating soils contaminated with volatile organic compounds (VOCs) and petroleum hydrocarbons. A full-scale demonstration at Tinker Air Force Base broadened the proven applicability to include soils contaminated with aviation fuel and other halogenated solvents. The only modification to the LT^{3} System required to treat these types of contaminants was the addition of a scrubber system to control acid gas emissions to ensure compliance with Federal, State, and local air standards.

Tinker Air Force Base was chosen as the project site for the demonstration because it had soils and contaminants representative of Department of Defense (DOD) installations across the United States and abroad. The demonstration showed the contaminated soils at Tinker Air Force Base were effectively treated, reducing the concentrations of the designated compounds, as measured in the TCLP leachate, below detection limits or goal cleanup levels.

Several tests were planned and executed during the demonstration to evaluate the LT^{3} System. Tests with varying operating conditions were performed to determine the optimum range of operation. The optimum operating conditions, within the range tested, were at a production rate of 20,000 lbs/hr, and a processed soil temperature of 215°F. As a result, projected LT^{3} System processing costs are $86/ton. Fixed costs for mobilization, startup, and demobilization are approximately $150,000.

The experience gained through this demonstration has resulted in a number of recommended changes and process improvements. With these improvements, the system will provide an efficient, cost-effective, commercially available remediation alternative for Department of Defense installations.

SECTION 2

INTRODUCTION

2. INTRODUCTION

2.1 Background. Jet propulsion fuel (JP-4) and chlorinated organic compounds, such as trichloroethene (TCE), are prevalent soil contaminants and threats to groundwater sources at many Department of Defense installations. Contamination migration control and cleanup are major challenges to installation personnel.

Previous work has been performed using bench-, pilot-, and full-scale LT^3 Systems to demonstrate the removal of volatile organic compounds (VOCs) from contaminated soil. These tests have shown favorable results in treating soils contaminated with VOCs and semivolatile organic compounds. Reports summarizing these studies are listed in the reference section.

The United States Army Toxic and Hazardous Materials Agency (USATHAMA) is evaluating technologies to treat soils contaminated with organic compounds including JP-4 and TCE. USATHAMA commissioned WESTON to conduct a demonstration of a full-scale LT^3 Process on soils at Tinker Air Force Base in Oklahoma City, Oklahoma. The demonstration was conducted from 17 July to 18 August 1989. The program was discontinued after discovering polychlorinated biphenyls (PCBs) in the feed and processed soils.

2.2 Purpose. The purpose of this report is to present the results and conclusions of the demonstration that evaluated the performance of the LT^3 System for stripping JP-4, TCE, and other VOCs from contaminated soil.

2.3 Objectives of the demonstration. The objectives of the demonstration were to evaluate the LT^3 Process for the following:

- The effectiveness of the LT^3 Technology in removing JP-4 and chlorinated solvents from soils.
- The impact on system performance caused by varying operational parameters (i.e., oil temperature and soil residence time).
- The impact on system performance caused by adding a stripping agent (e.g., hexane or water) to aid in decontaminating the soils.
- The optimum range of operational parameters for treating the contaminated soils.
- The ability to comply with Federal, State, and local air emissions requirements.

2.4 Report organization. The following sections of this report are organized as follows:

Section	Title
3	Test Site
4	Description of the Process Equipment
5	Demonstration Framework
6	Typical Site Activities
7	Test Variables
8	Sampling Techniques and Analytical Methods
9	Data Analysis
10	Design Considerations
11	Conclusions

PCBs were unexpectedly found in the feed and processed soils during the demonstration. The program was discontinued at that point because the system was not designed to process PCBs. The PCB laboratory analysis data and the methods used will be presented in a separate report.

SECTION 3

TEST SITE

3. TEST SITE

3.1 Test site location and description. The feed soils were excavated from the Landfill 3 sludge dump area, located in the southwestern portion of Tinker Air Force Base, between Crutcho Creek to the north and Landfill Road to the south. Figure 3-1 is a map of central Oklahoma showing Oklahoma City and the location of Tinker Air Force Base. A map of the base with an outline of the project area is shown in Figure 3-2. An enlarged view of the landfill area is shown in Figure 3-3, which also shows the excavation area.

The sludge dump was in operation from 1961 to 1968. It is reported to contain waste oils and liquids from industrial operations at Tinker Air Force Base.

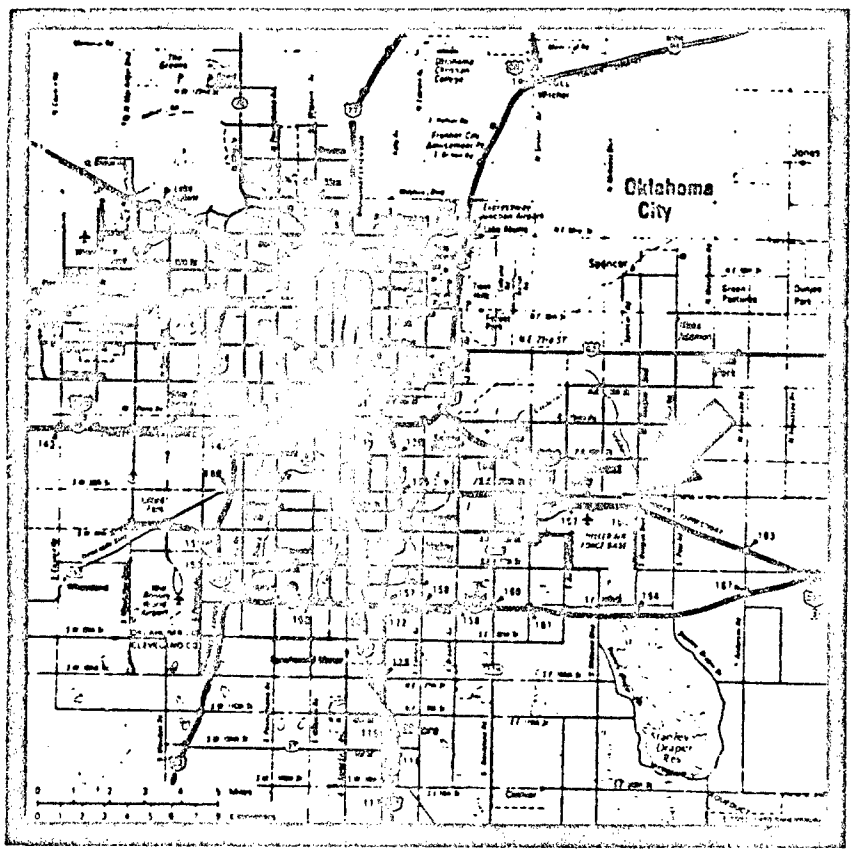
3.2 Waste/soil characteristics.

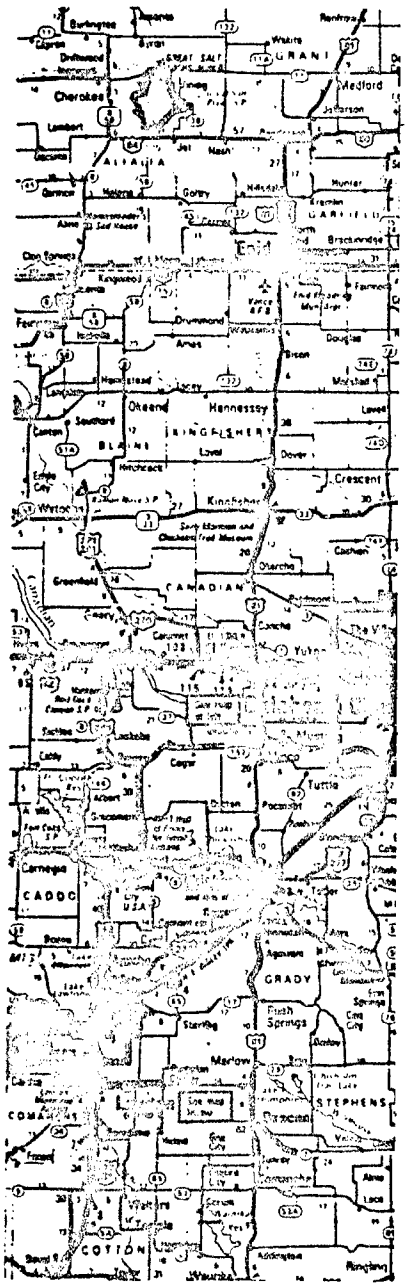
3.2.1 General. As a part of the Installation Restoration Program, a remedial investigation was conducted in March 1988 to investigate the extent of soil and water contamination in the landfill area (Reference No. 1). Analytical results indicate that contamination was extensive and varied in composition. Solvents and constituents of fuels commonly used on the base indicated that this would be an ideal location to demonstrate the applicability of the new LT^3 Technology to a wide range of contaminants.

During the investigation, a 10- to 12-inch thick layer of floating hydrocarbons was discovered on the groundwater in the Landfill 3 sludge dump area. Laboratory analyses indicated the presence of high concentrations of solvents, primarily TCE and other hydrocarbons, in the soil and water. Some of the detected hydrocarbons closely resembled constituents of JP-4 fuel. The highest individual contaminant concentration detected was for TCE at 6,100 ppm. Total petroleum hydrocarbons concentrations up to 23,600 ppm (Reference No. 1) were detected in some soil samples. A final investigation was conducted in May 1988 to delineate the boundary of the sludge dump area. The study concluded that the soil was contaminated with petroleum hydrocarbons and solvents to a depth of 12 feet.

During the LT^3 System demonstration conducted by WESTON in July and August 1989, PCBs were unexpectedly discovered in feed and processed soils. Since the permits issued did not address PCBs, all site activities were immediately suspended.

3.2.2 Stratigraphy. During the field investigations conducted in May 1988, four types of materials were encountered in the Landfill 3 sludge dump area: overburden or fill, a crumbled asphalt concrete mixed with some clay, a sludge marbled with native red clay, and a dry red clay. At no time was water or a saturated layer encountered at depths of less than 14 feet.


Oklahoma
City


Cherokee
Medford
Enid
Hennessey
Kingfisher
Crescent
Canadian
Tuttle
Caddo
Grady
Stephens
Cotton
CO
NM
TX

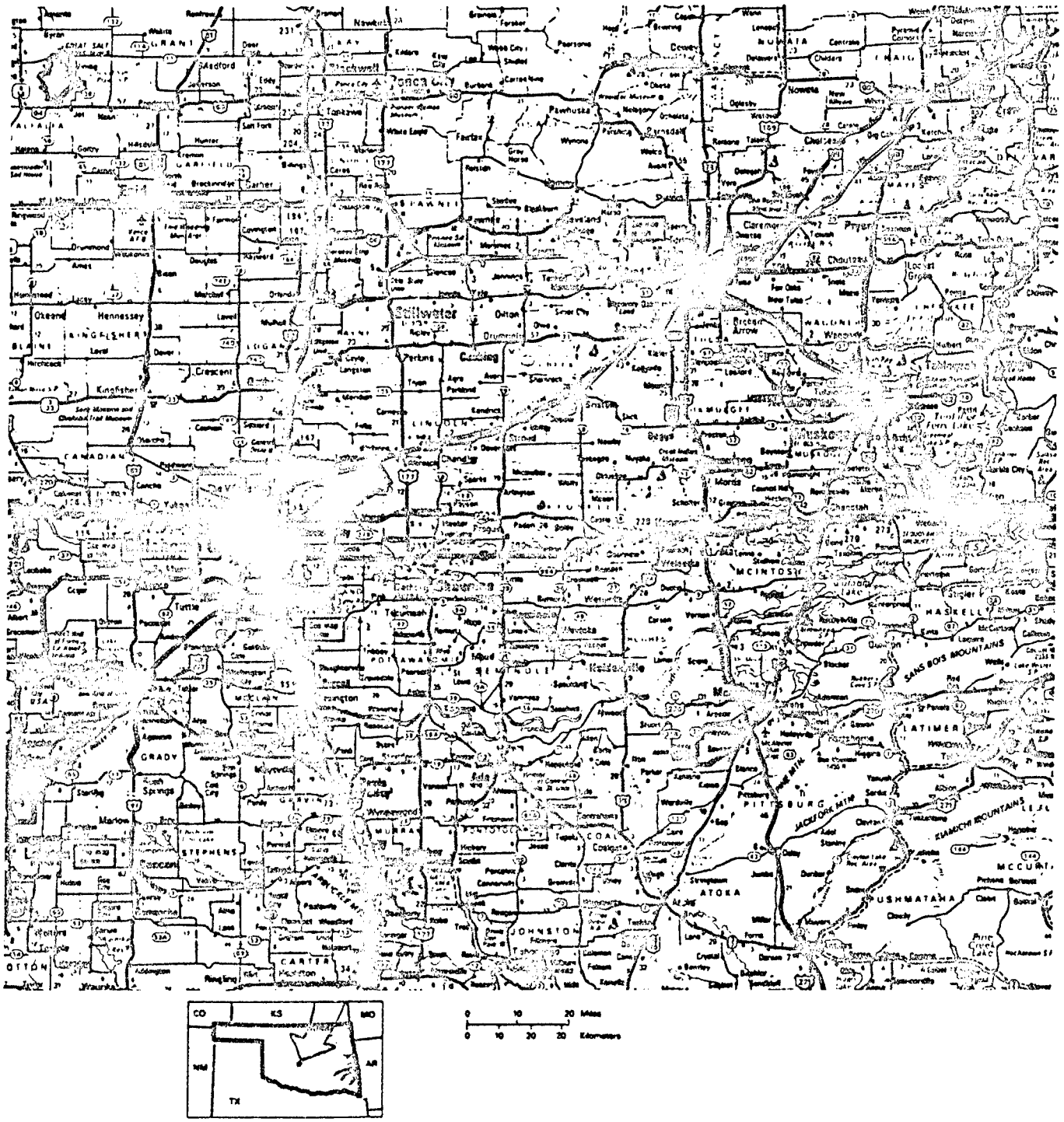


Figure 3-1. Map of base location in Oklahoma.

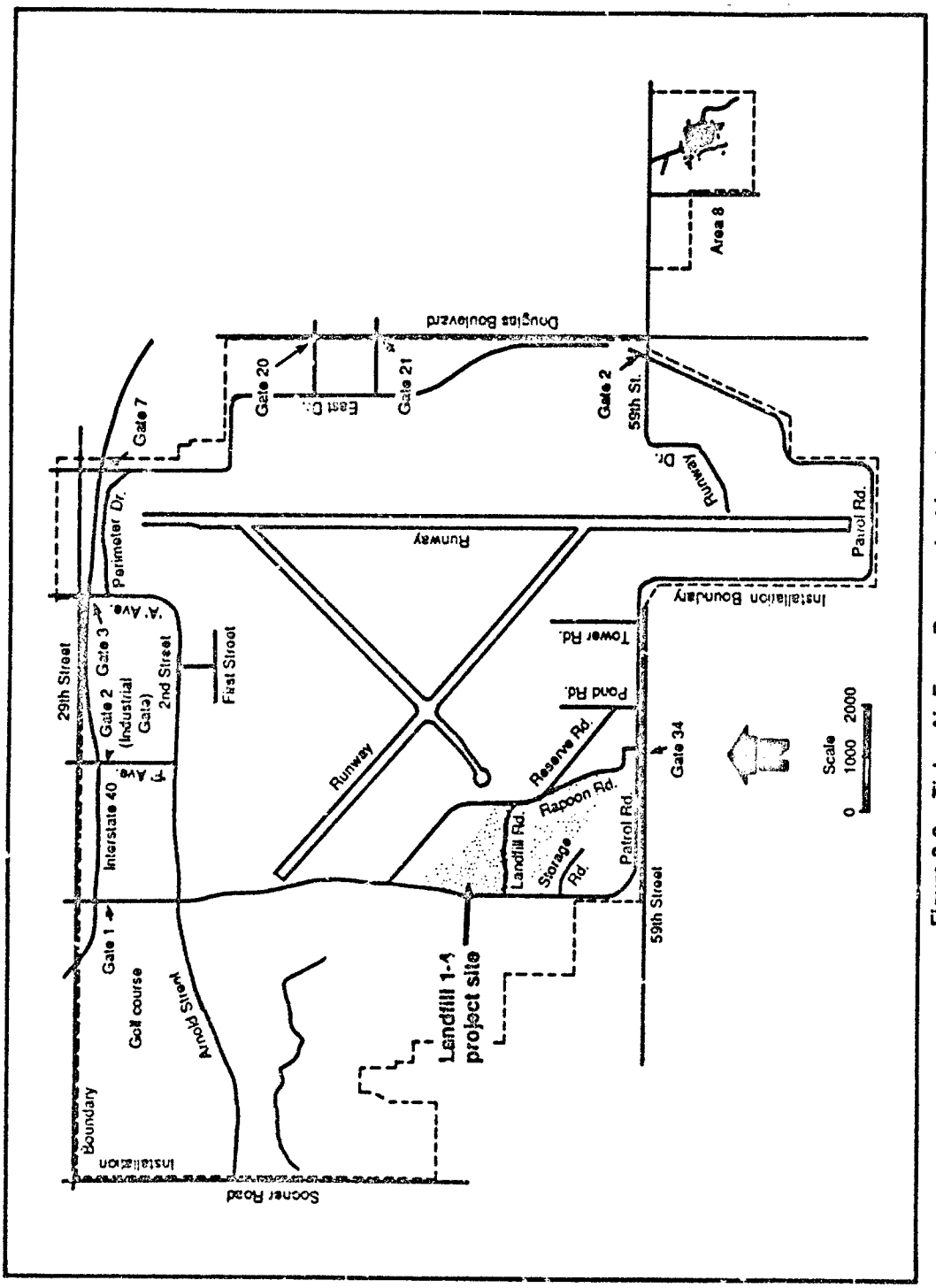


Figure 3-2. Tinker Air Force Base project location map.

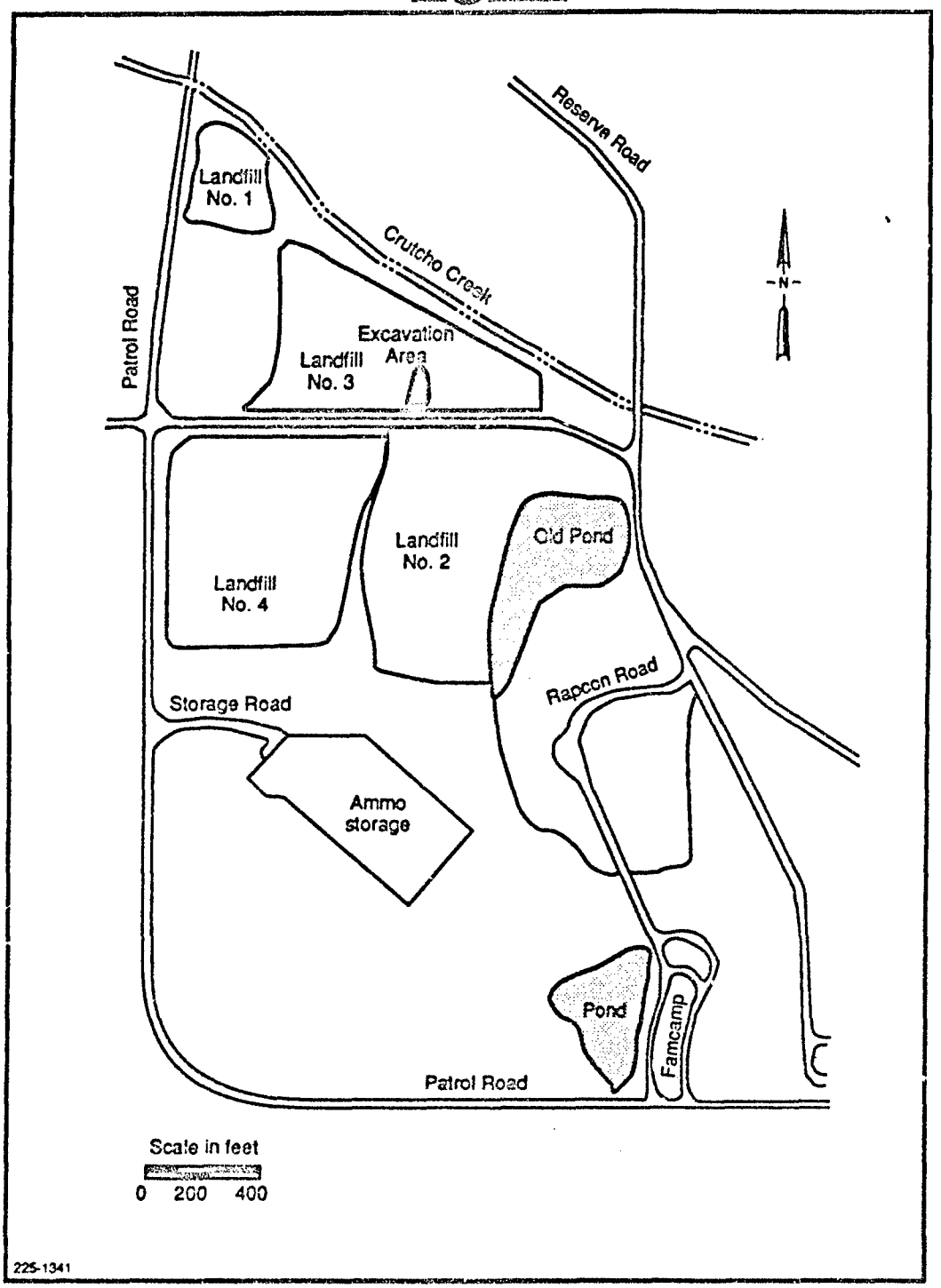


Figure 3-3. Enlarged view of the landfill area.

Overburden The overburden consisted of soil that had been stored temporarily at the site to be removed as needed for construction or landscaping.

Asphalt material A black asphalt material was encountered in most of the sludge dump area. This material is unsaturated and consists of black crumbled asphalt and gravel, and is occasionally mixed with clay. The material is found at the surface or up to 3 feet below the overburden and is 1 to 6 feet thick. Laboratory results indicate petroleum hydrocarbon concentrations of thousands of ppm and TCE concentrations of less than 2 ppm.

Sludge/clay mixture This layer consists of a thick black sludge (with a strong solvent odor) mixed with native red or brown clay. This material is found at a depth of 2 to 15 feet below the surface and is 1 to 12 feet thick. This material is considered to be the source of the contamination.

Red clay This material is a dry native red clay/weathered shale. The red clay can be found 3 to 13 feet below the surface and continues to a depth of approximately 25 feet.

Soils from the sludge/clay mixture layer and some of the red clay layer were processed during the demonstration. Moisture contents of feed material varied from 13 percent to 23 percent.

Contaminant concentrations and the stratigraphy of the excavation are shown in Figure 3-4, which is a cross section of the excavation area from north to south. The excavation area was chosen based on soil boring results from the remedial investigation in March and May 1988. During the excavation activities, most of the sludge/clay mixture and the material overlying this layer were removed.

3.3 Excavation activities. During the demonstration the excavated material consisted of the clay cap followed by loose asphalt and then by contaminated soil. Approximately 3,000 cubic yards of material was excavated during the operation. Figure 3-5 shows the excavation areas as a result of LT^3 System operations and the PCB concentrations determined via discrete samples. Table 3-1 indicates the quantity of soil stockpiled, the status of the material, and the PCB contamination levels at each of the locations in the Landfill 3 area.

3.3.1 Buried drums found during excavation activities. Five buried drums were uncovered during the excavation of the Landfill 3 area. The drums were discovered in location 2 (see Figure 3-5) of the main excavation area. Tinker Air Force Base records indicate that explosives were not present in the Landfill 3 area; therefore, the drum-handling program included procedures generally used for sampling drums of unknown content.

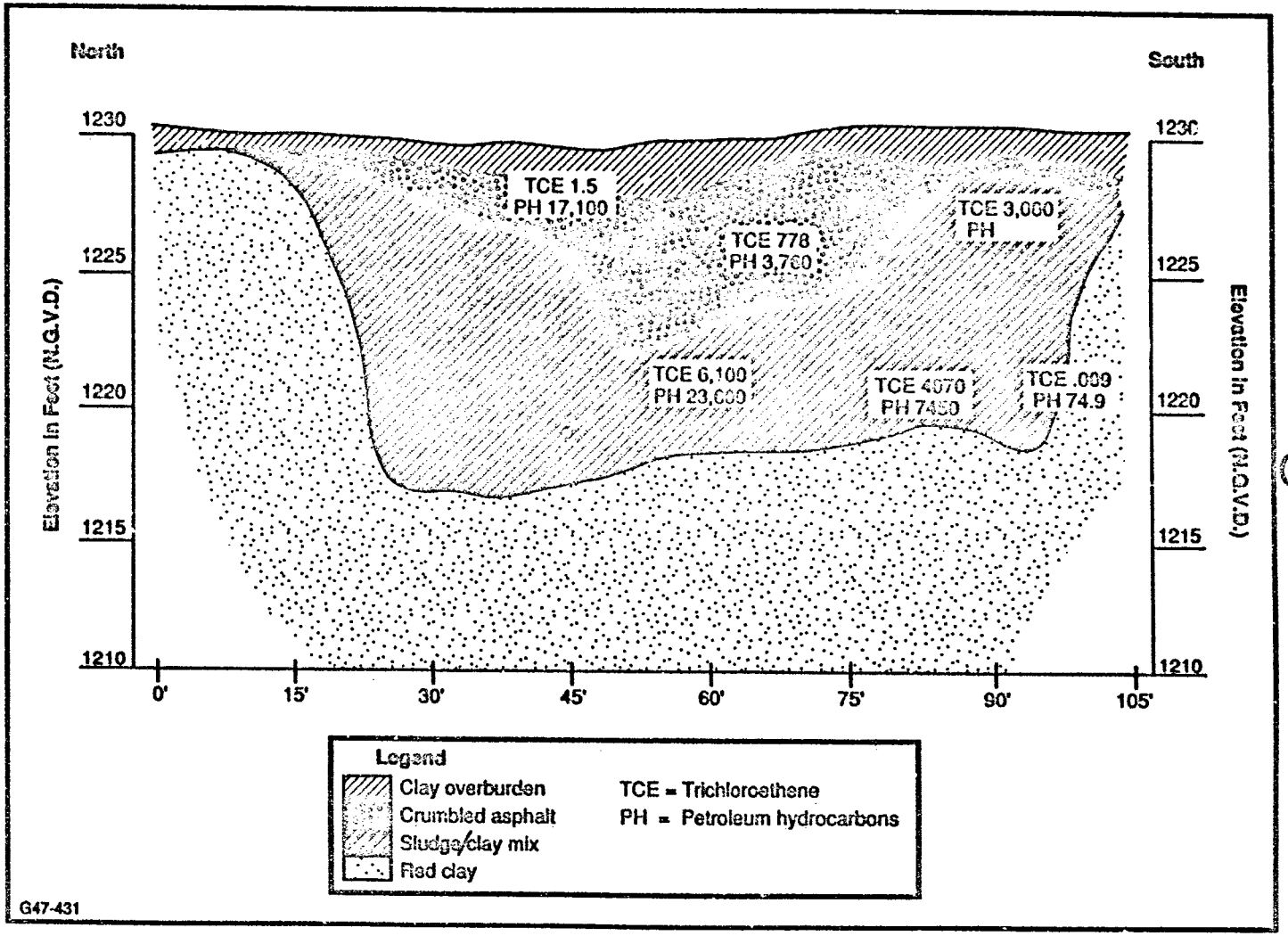


Figure 3-4. Landfill 3 excavation area cross section (North-South).

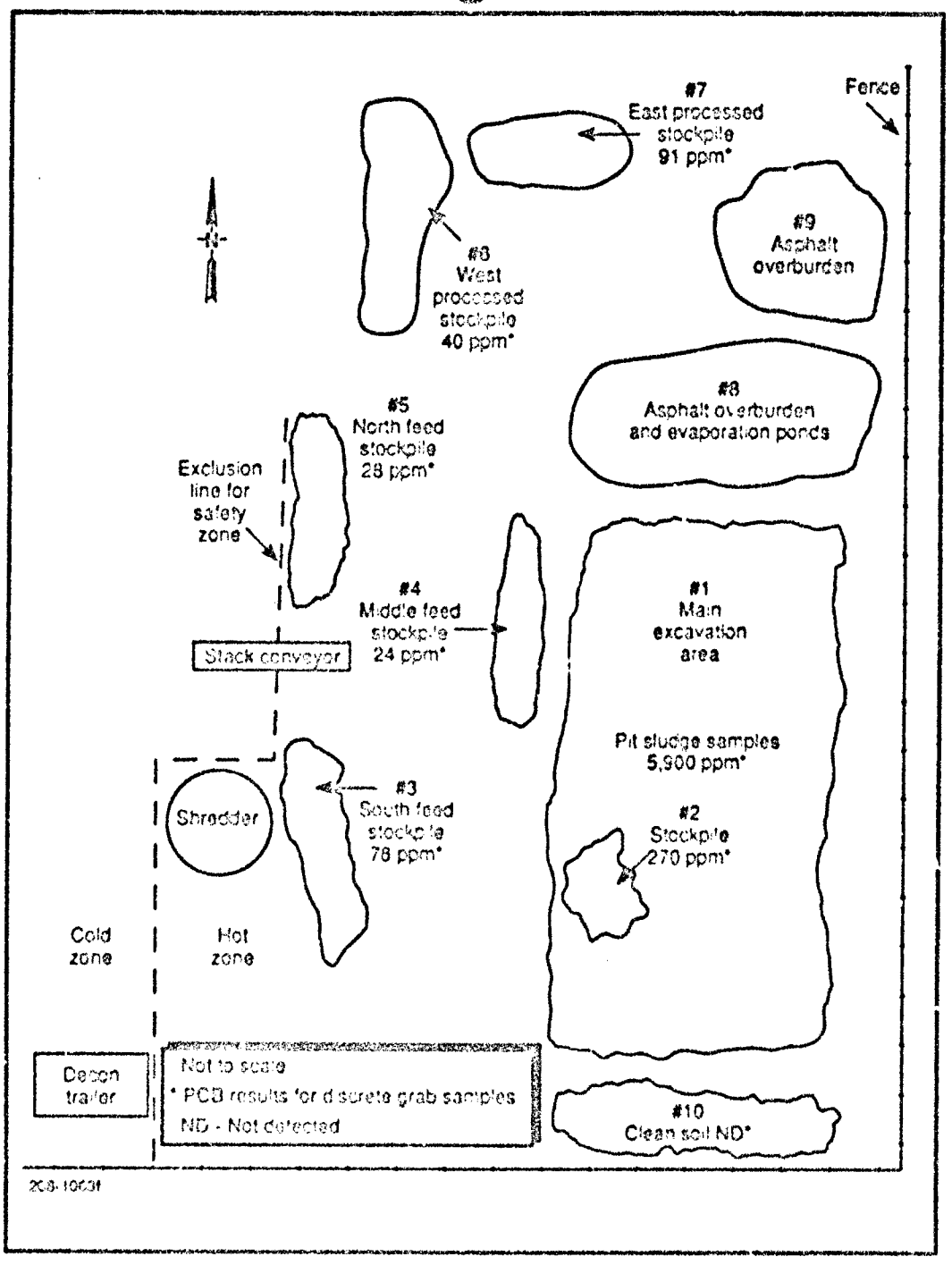


Figure 3-5. Tinker Air Force Base Landfill 3 LT^{3}M System site after excavation.

Table 3-1. Summary of soil excavation at Tinker Air Force Base Landfill 3 site

Location Number	Description	Volume (cubic yds)	PCB Concentration (ppm)	Status
1	Main excavation area	3,500	NA	Excavation hole; contains some sludge
1	Sludge in main excavation area	---	5,900[a]	---
2	Excavation area stockpile	50	270	Pending treatment
3	South feed stockpile	200	78	Pending treatment
4	Middle feed stockpile	30	24	Pending treatment
5	North feed stockpile	300	28	Pending treatment
6	West processed stockpile	50	40	Processed through LT[3] System
7	East processed stockpile	20	91	Processed through LT[3] System
8	Asphalt overburden and evaporation ponds	1,200	b	Some asphalt material was used to construct evaporation ponds
9	Asphalt overburden	350	b	Assumed to be PCB-contaminated due to proximity to contaminated soil
10	Clean soil	800	c	Clay cap over the asphalt cap

a Sludge samples analyzed.
b Not sampled; impractical to analyze for PCBs due to interference from polynuclear aromatic hydrocarbons (PAHs) in asphalt.
c None detected.
NA - Not applicable.

The base fire department supervised the first drum removal and overpacking. Drums 2, 3, and 4 were removed using the same procedure. The fifth drum found was left unopened in the excavation area. Excavation was discontinued once PCBs were found in the excavated soil.

The procedure for drum handling and removal was as follows:

- During soil excavation, the trackhoe uncovered the drum.
- Field personnel working in the excavation area wore Level B personnel protection equipment. Organic vapors were continuously monitored while the drums were exposed.
- The drum was visually inspected for signs of overpressure or corrosion.
- WESTON field personnel opened and sampled the drum. Samples were given to Tinker Air Force Base personnel for analysis.
- The drum was placed in an overpack drum for disposal by Tinker Air Force Base personnel.
- The trackhoe removed the overpacked drum from the excavation area and placed it on the eastern side of Landfill 3.

The status of each drum is listed in Table 3-2.

3.3.2 Personnel protection for drum handling. During drum inspection and handling, WESTON personnel wore Level B personnel protection equipment consisting of the following:

- Self-contained breathing apparatus (MSHA-/NIOSH-approved).
- Steel toe/shank boots.
- Latex boot covers.
- Cotton cloth coveralls (inner).
- Saranex coveralls.
- Surgical inner gloves.
- Nitrile outer gloves.
- Hard hat with splash shield.

Table 3-2. Summary of drums found in excavation area

Discovery Date	Drum	Status of Drum
19 July 1989	1	Overpacked drum -- oil adsorbent, rags, oil layer on bottom (2 to 3 gallons)
21 July 1989	2	Overpacked drum -- oil adsorbent, rags.
22 July 1989	3	Overpacked drum -- oil adsorbent, rags.
22 July 1989	4	Overpacked drum -- oil adsorbent, rags.
22 July 1989	5	Unopened drum left in excavation area -- unknown contents.

3.4 Environmental Permitting. The U.S. EPA, Region VI, issued a Research, Development, and Demonstration (RD&D) Permit under which the demonstration was conducted. The Test Plan and the Health and Safety Plan prepared for the demonstration served as the technical submittal for the permit, as indicated on the letter to the EPA from Col. R. D. Reaves (see Appendix I). The permit that was issued for this demonstration is also contained in Appendix I.

Although no State permits were required, the Oklahoma State Department of Health placed the following stack emissions restrictions:

- Less than 4 pounds per hour hydrogen chloride.
- Less than 25 parts per million carbon monoxide.
- Less than 0.08 grains particulate per dry standard cubic foot corrected to 12 percent carbon dioxide.
- Less than 100 parts per million total hydrocarbons.

Once PCBs were discovered on-site, the demonstration was discontinued because the RD&D permit did not allow processing of PCB-contaminated soil. A Decontamination Plan and an Exit Plan for the site were prepared and submitted to EPA Region VI. These plans were subsequently approved and are contained in Appendices A and B, respectively.

SECTION 4

DESCRIPTION OF THE PROCESS EQUIPMENT

4. DESCRIPTION OF THE PROCESS EQUIPMENT

4.1 Introduction. WESTON's LT^3℠ Process (U.S. Patent No. 4,738,206) is a demonstrated technology that provides evaporation of VOCs from contaminated soil without heating the soil matrix to combustion temperatures.

The primary element of the LT^3 Technology is the thermal processor, an indirect heat exchanger used to dry and heat contaminated soils. Heating the soils sufficiently evaporates or strips the moisture and VOCs from the soil. The organic vapors are then processed independent of the soil in an afterburner (fume incinerator).

The LT^3 Process can be described by separating the system into three main areas: soil treatment, emissions control, and water treatment. A schematic diagram of the LT^3 Process is shown in Figure 4-1. The LT^3 Process Equipment is mounted on three tractor trailer beds for transportation and operation. The unit is suitable for highway transport and can be mobilized on-site in 1 week without oversize load permits. Photograph 1 shows the heaviest trailer traveling to Tinker Air Force Base. This trailer contains the disassembled feed hoppers, processors, fabric filter, and motor control center.

The general arrangement of the process equipment and the placement of the trailers during operation is shown in Figure 4-2. A brief description of the process equipment follows.

4.2 Soil treatment.

4.2.1 Soil feed system. Approximately 3,000 cubic yards of soil was excavated from the Landfill 3 sludge area after removing a clay cap and an asphalt covering. The excavated soil was stockpiled adjacent to the LT^3 Process Equipment area. The soil was staged on a 40-mil high-density polyethylene (HDPE) liner to avoid contamination of the underlying soil. The stockpile was covered with visqueen plastic, which was anchored to prevent fugitive emissions. The landfill area was surrounded by fencing to prevent wildlife or site personnel from inadvertently entering the excavation or processing areas.

Soil was transported to the system by a front-end loader. During treatment operations, soil was deposited directly on a power shredding device, which also acted as a classifier. The shredder was driven by a 60-horsepower (hp) motor. Classified soil with a top size of less than 2 inches passed through the shredder into the feed conveyor. Oversized material was removed, stockpiled on a 40-mil HDPE liner, and covered with plastic for replacement into the excavation area at the completion of the project.

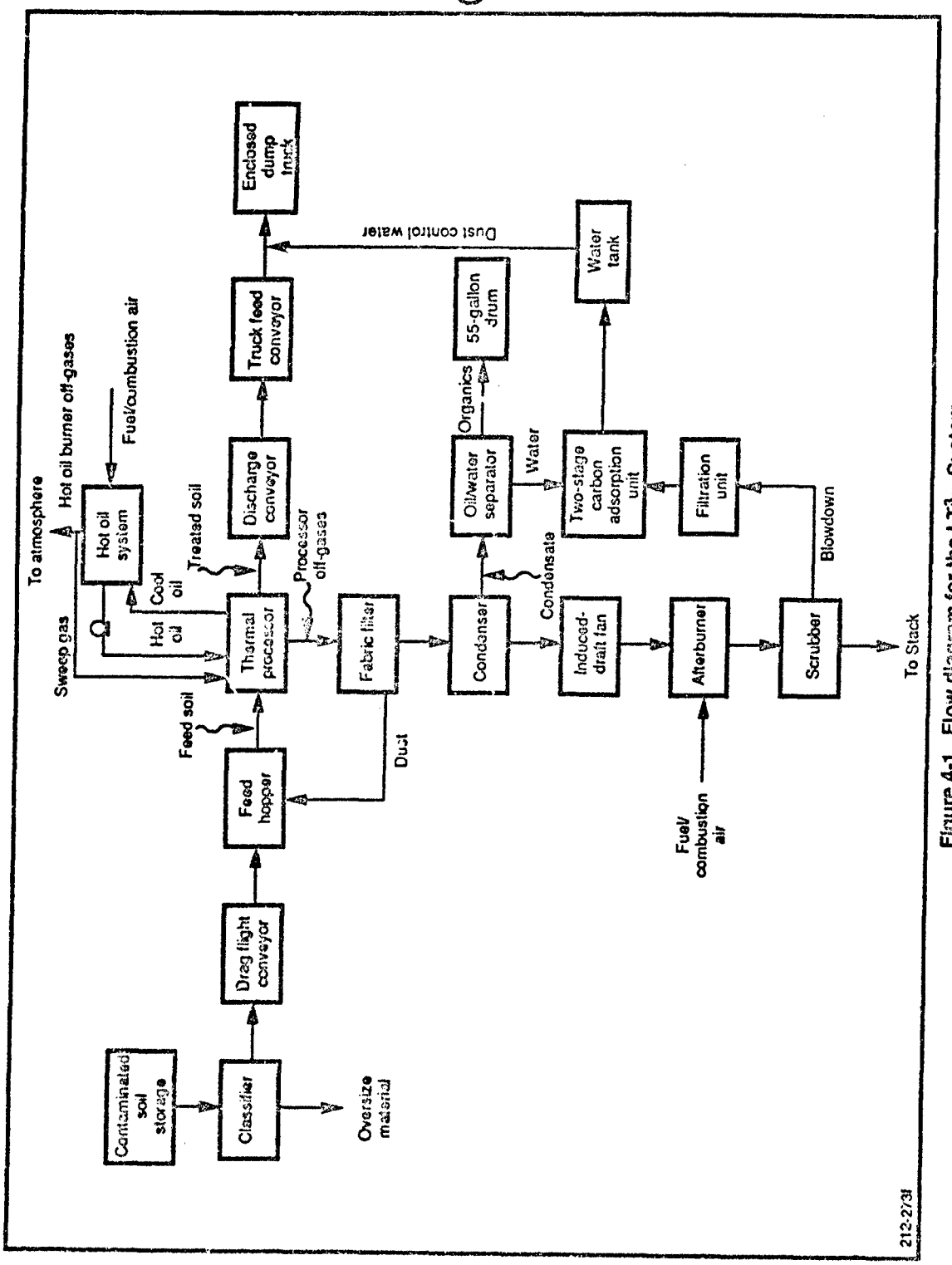
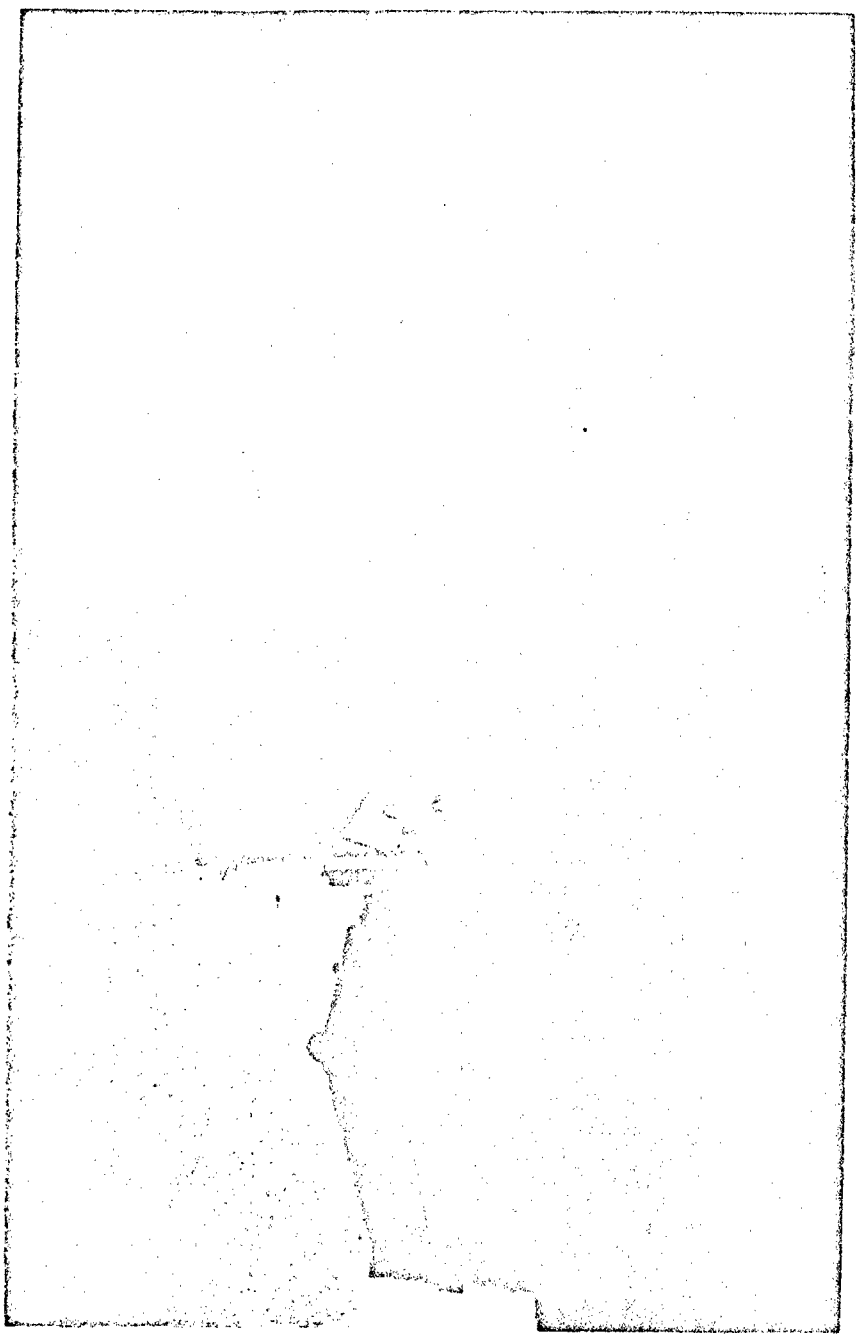
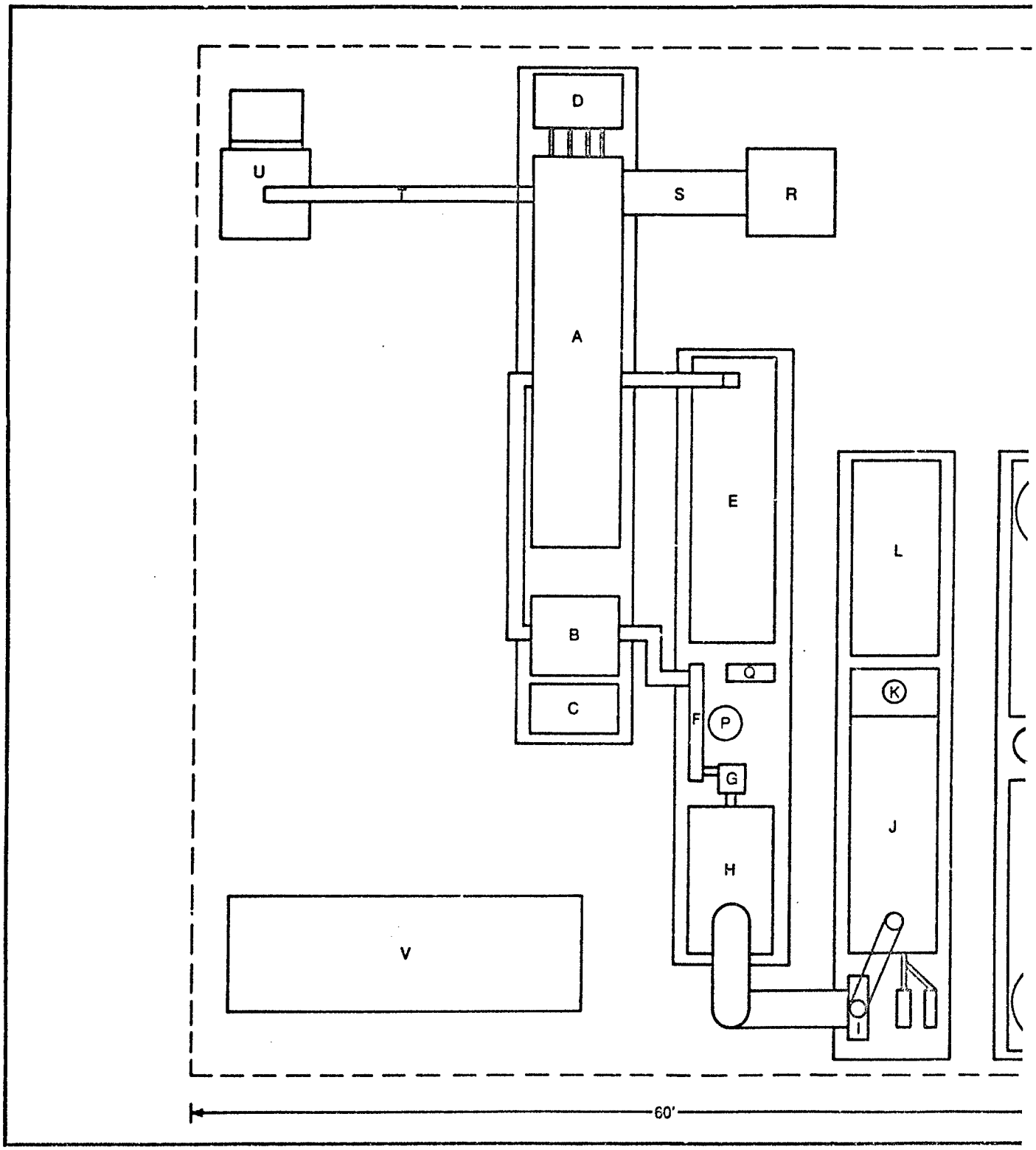
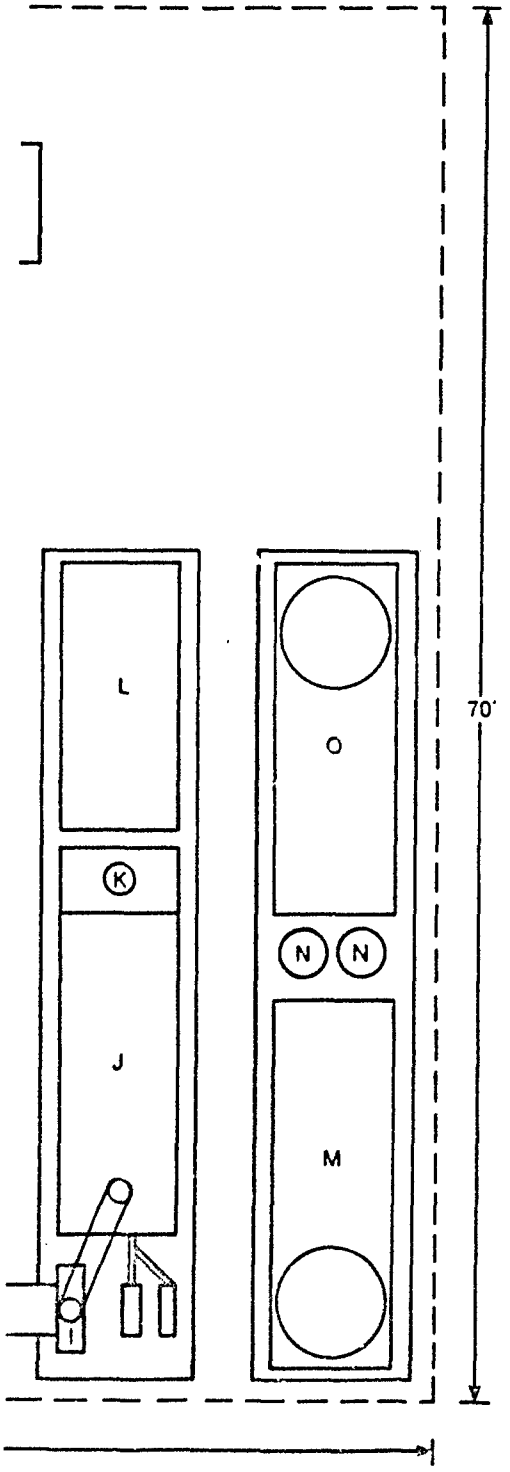


Figure 4-1. Flow diagram for the LT³℠ System.



Photograph No. 1. LT³ SM System - thermal processor, fabric filter, and motor control center being transported to Tinker Air Force Base.


D
U
S
R
A
E
L
B
Q
K
C
F
P
G
J
H
V
I
60'



Equipment

A. Thermal Processors
B. Fabric Filter
C. Motor Control Center
D. Thermal Processor Drive Units
E. Hot Oil System
F. Condenser
G. Induced-Draft Fan
H. Afterburner
I. Scrubber ID Fan
J. Scrubber System
K. Exhaust Stack
L. Caustic Storage Tank
M. Fresh Water System
N. Two-Stage Carbon Adsorption Unit
O. Blowdown System
P. Recycle Water Tank and Pump
Q. Oil/Water Separator
R. Classifier
S. Flight Conveyor
T. Discharge Conveyor
U. Dump Truck
V. Continuous Emissions Monitoring (CEM) Trailer

Figure 4-2. Mobile low temperature thermal treatment system.

The feed conveyor is an enclosed drag conveyor that is 24 inches wide and 40 feet long. It is mounted at a 60° angle and is driven by a 5-hp motor. The conveyor is designed to convey 15,000 pounds per hour (lbs/hr) of soil on a wet basis. The conveyor discharges into a feed hopper located above the thermal processor. The soil is fed into the LT^3 System at regular intervals to maintain the feed hopper seal.

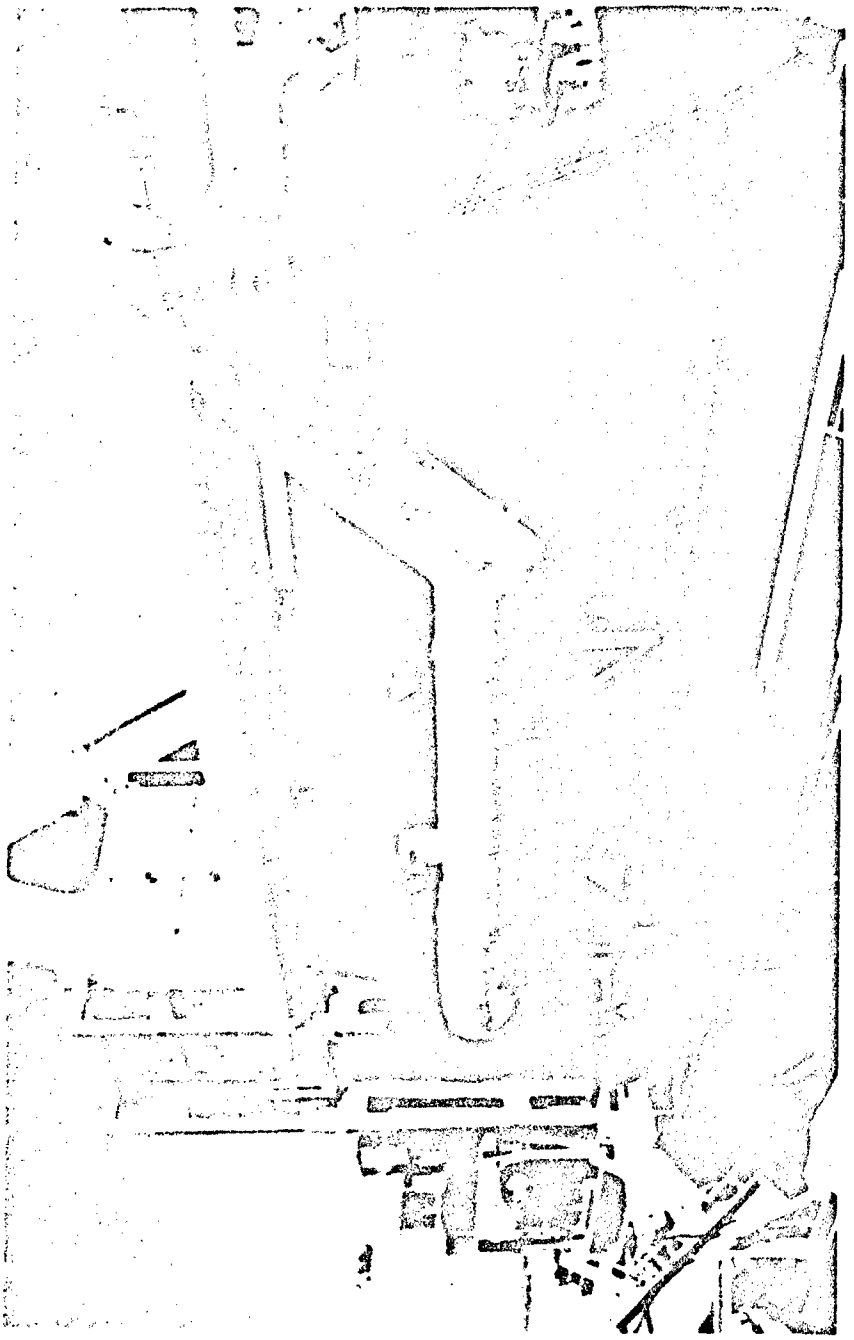
The feed hopper is 5 feet wide by 5 feet long and holds approximately 8,000 pounds of soil, providing feed for approximately 20 to 30 minutes of operation, depending on the soil residence time. The screws of the thermal processor extend into the bottom of the feed hopper, withdrawing feed material to create a live-bottom-hopper effect. The feed hopper also provides a seal over the thermal processor to minimize air infiltration.

4.2.2 Thermal processor. The thermal processor consists of two jacketed troughs tiered in a piggyback fashion (one above the other). Photograph 2 shows the LT^3 System thermal processors mounted in a double tier at Tinker Air Force Base. Also shown are the inclined feed conveyor, feed hopper, and exhaust ducts. Each processor tier houses four intermeshed screw conveyors. Photograph 3 shows the intermeshed screws of the lower processor. Soil is carried across the upper tier of the processor by the screws. When the soil reaches the discharge end of the upper tier, it drops to the second tier via gravity. The soil moves in the opposite direction across the second tier and then exits the processor at the same end that it entered, directly under the hopper.

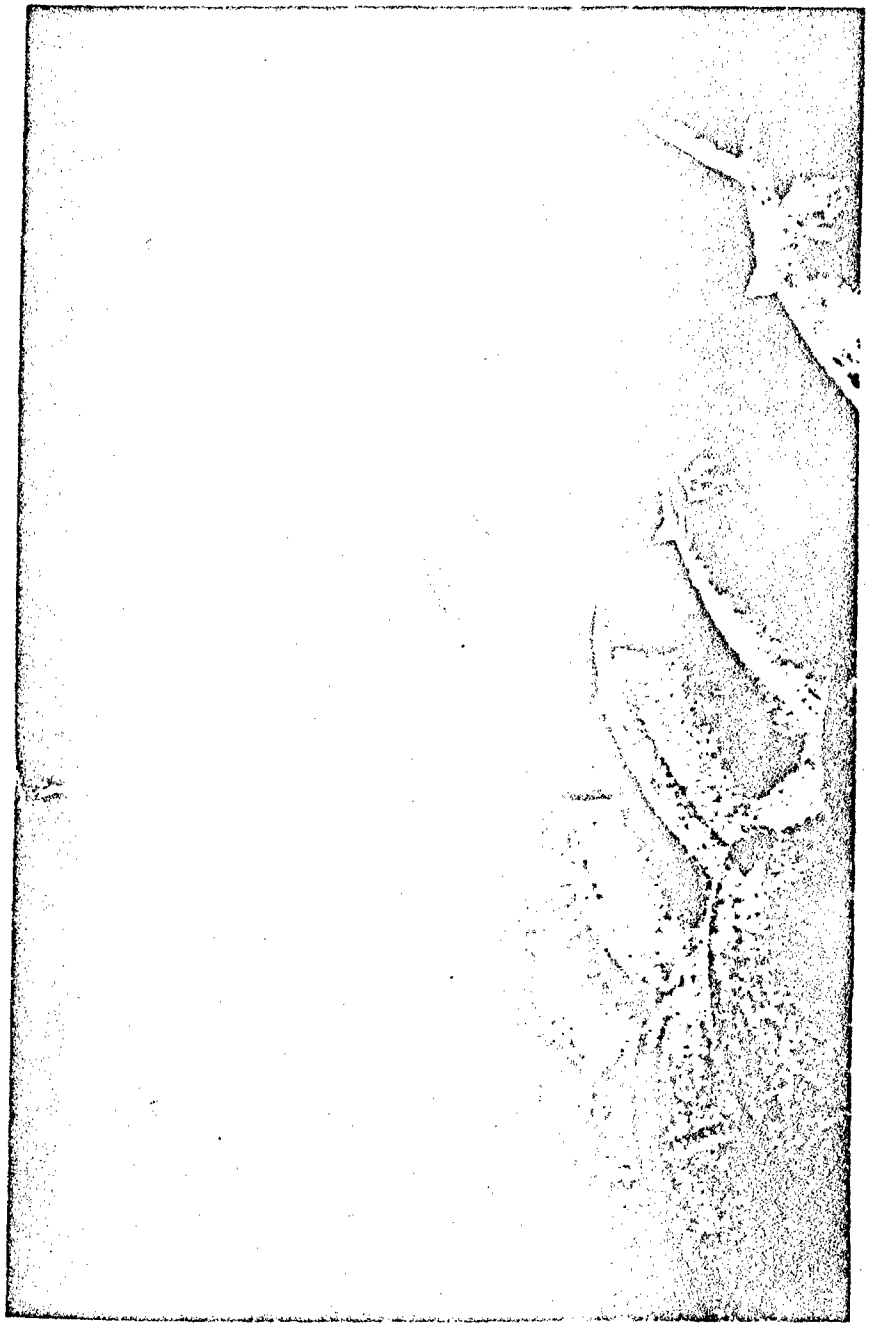
The shafts and flights of the screw conveyors and the trough jackets are hollow to allow circulation of a heat transfer fluid (i.e., hot oil). The function of each screw conveyor is to move soil forward through the processor and to thoroughly mix the material, providing indirect contact between the heat transfer fluid and the soil.

Each screw conveyor is 18 inches in diameter and runs the entire length of the trough, which is 20 feet long. The screw conveyors are intermeshed to break up soil clumps, which improves heat transfer. The four screws of each processor are driven by a 10-hp, variable-speed drive mechanism. Photograph 4 shows the variable-speed drives at Tinker Air Force Base. Residence time and soil temperature in the thermal processor are adjusted by varying the rotational speed of the screws and the oil temperature setting, respectively. The heat transfer fluid is pumped through the screw shafts, flights, and trough jacket by one of two 25-hp centrifugal pumps. The second pump is available as a standby unit.

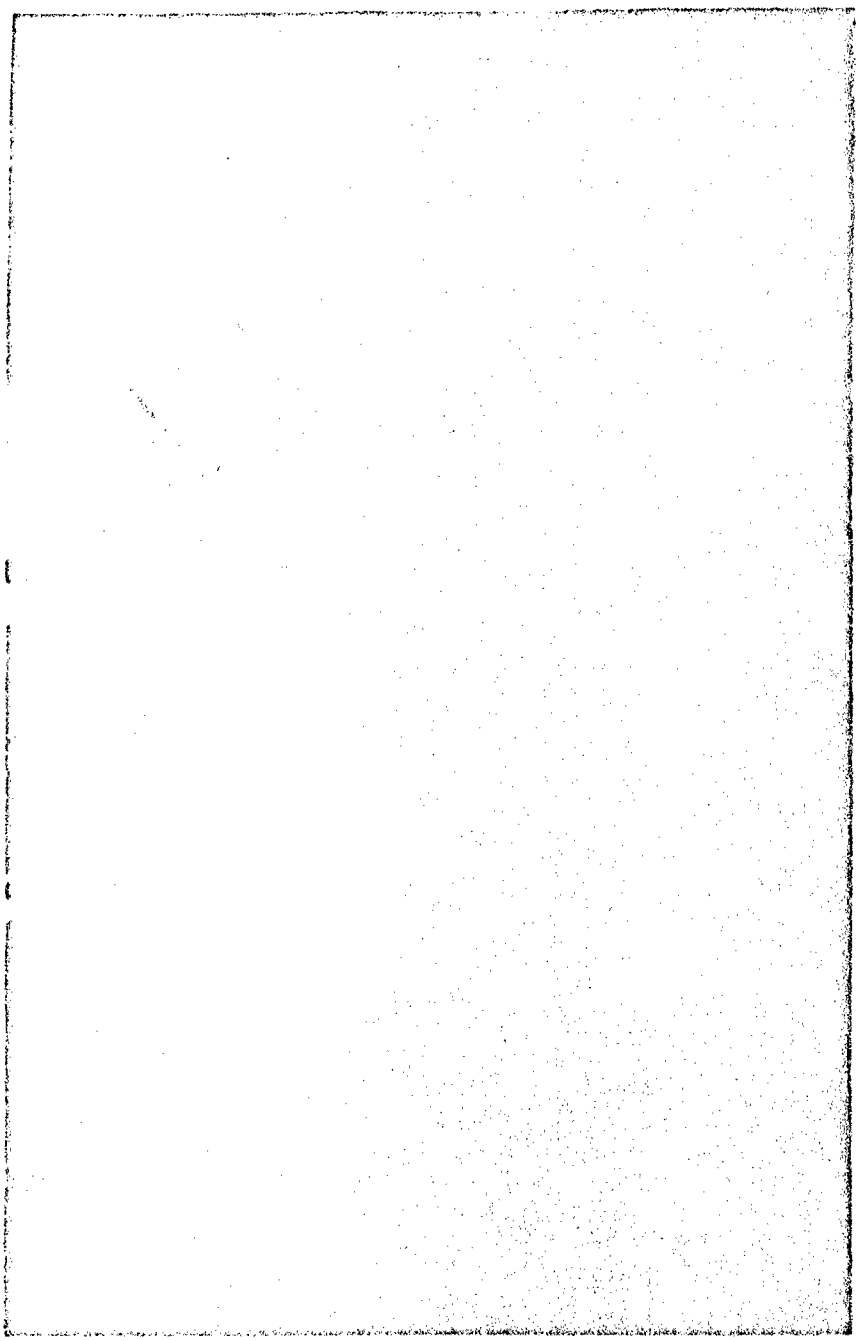
VOCs in the soil are vaporized and are drawn out of the thermal processor by an induced-draft (ID) fan.



Photograph No. 2. Installed LT³™ System showing the inclined feed conveyor, the feed hopper, and the exhaust ducts.



Photograph No. 3. Intermeshed screws of the lower processor.



Photograph No. 4. Variable speed drives on the LT[1]™ System.

4.2.3 Processed soil handling system. Soil is discharged from the thermal processor into a horizontal discharge screw conveyor driven by a 1.5-hp motor. The conveyor is approximately 8 feet long and is designed to convey 20,000 lbs/hr of material. The collecting screw conveyor discharges to a second screw conveyor, or conditioner, driven by a 5-hp motor. The conditioner is 5 feet long with a diameter of 9 inches. Water spray nozzles are installed in the conditioner housing to cool the processed soil and to minimize fugitive dust emissions. The conditioner discharges onto an inclined stacker belt conveyor. Soil is carried to the top of the inclined stacker belt and is discharged into an enclosed dump truck. The truck transports the material to a processed soil staging area, where it is placed on visqueen plastic and covered.

4.2.4 Hot oil system. The hot oil system is a self-contained unit consisting of a 7.2 million British thermal units per hour (Btu/hr) gas-fired burner, flame supervisory system, oil reservoir, hot oil pumps, and associated controls.

The hot oil system burner provides the thermal energy to maintain the temperature of the heat transfer oil used to liberate organics from the soil. The heat transfer fluid used is Dowtherm® HT, produced by Dow Chemical. The maximum recommended oil temperature for continuous operation is 650°F.

A portion of the combustion gases released from the hot oil system is used as sweep gas in the thermal processor. The warm sweep gas (i.e., 700°F and very low oxygen content) is introduced to maintain an exhaust gas temperature from the processor of about 300°F to avoid contaminant condensation. The sweep gas also provides an inert atmosphere to avoid exceeding the lower explosive limit (LEL) of contaminants within the thermal processor and downstream equipment.

4.3 Emissions control system.

4.3.1 Fabric filter. Sweep air and volatiles from the thermal processor are drawn by the ID fan into a fabric filter for particulate (dust) removal. The fabric filter is designed to handle 1,872 actual cubic feet per minute (acfm) of exhaust gas. The fabric filter is of the jet-pulse design, where high-pressure [80 pounds per square inch gauge (psig)] air periodically (every 6 seconds) pulses to remove dust that has accumulated on the bags. Dust drops to the bottom of the fabric filter and is collected in two collection bins. Dust is manually removed on a daily basis and is combined with the contaminated soil for reprocessing. The maximum allowable pressure drop across the fabric filter (because of accumulated material on the bags) is 15 inches of water column. The temperature of the gases exiting the fabric filter is approximately 300°F.

4.3.2 Condenser. The exhaust gas from the fabric filter is drawn into a condenser by the ID fan. The air-cooled condenser is used to remove condensable water vapor and organics from the exhaust gas. Cooling (ambient) air is supplied across the condenser tubes by four 2-hp axial-blade fans. The ambient air cools the gases to approximately 125°F. Condensed liquid is collected in a trap and is pumped to the water treatment system. Condenser offgases are directed to the afterburner.

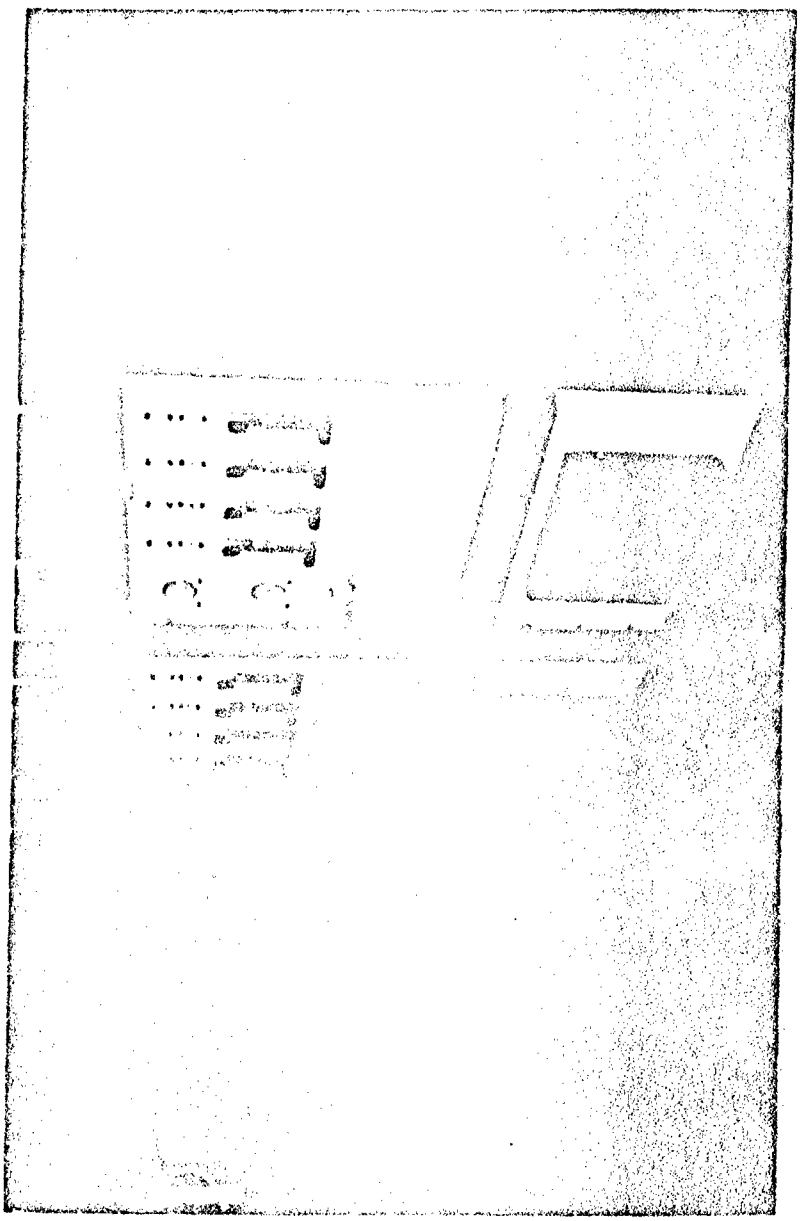
4.3.3 Afterburner. The process gas from the condenser passes through the ID fan. The gases are directed under a positive pressure into an afterburner. The afterburner is a 3.5 million Btu/hr gas-fired fume incinerator that operates at approximately 1,800°F. The afterburner is on-line at all times while the thermal processor is operating. The afterburner is used to destroy organics that remain in the exhaust gases. The afterburner is an "elbow-shaped" chamber with a horizontal section leading into a vertical section. Each section is 8 feet in diameter and 8 feet in length. Both sections provide a total passage length of 16 feet, providing a 2-second retention time in the chamber. The afterburner is lined with a soft-wall fiber refractory.

The afterburner is equipped with a combustion air fan that maintains a minimum of 3 percent excess oxygen exiting the afterburner. Also included with the afterburner is a control system for burner management, i.e., flame detector, and system temperature controller.

4.3.4 Continuous emissions monitoring (CEM) system. An extractive-type continuous emissions monitoring system is used to monitor afterburner exhaust gases for oxygen, carbon monoxide, carbon dioxide, and total hydrocarbons. The CEM system also monitors the exhaust gases from the condenser for oxygen and total hydrocarbons to ensure the exhaust gases remain below LEL conditions. Photograph 5 shows the dual train of instruments in the CEM system. The second system provides a standby unit for reliability.

4.3.5 Bleed air. Gases exit the afterburner at 1,800°F. Bleed air is pulled into the system by a second ID fan drawing ambient air through an air inlet damper on top of the afterburner stack. The ambient air mixes with the afterburner exhaust gases and cools the gases to approximately 500°F. The gases are then drawn into the scrubbing system by the second ID fan.

4.3.6 Scrubber. Gases enter the acid gas scrubber at approximately 500°F. In the first stage of the scrubber, the quench chamber, the gases are cooled to saturation temperature, approximately 180°F. In the second stage, the packed-bed absorber, acidic gases such as hydrogen chloride (HCl) are neutralized to sodium chloride (salt) and water using a sodium hydroxide (caustic) solution. The scrubber is designed for a



Photograph No. 5. CEM Instrumentation.

minimum HCl removal efficiency of 99 percent. Since salts are generated through the neutralization process, a small purge (blowdown) stream is maintained to prevent the buildup of salts. The scrubber blowdown liquor is collected for on-site treatment in the water treatment system and reuse, as described in Subsection 4.4.

4.3.7 Caustic supply system. The caustic supply tank holds approximately 2,000 gallons of 25 percent sodium hydroxide. Caustic solution is supplied to the scrubber by a variable-frequency pump designed to deliver 1.0 gallon per minute (gpm). Proportionate feed of caustic allows control of the recirculating scrubber liquor pH.

4.4 Water treatment system.

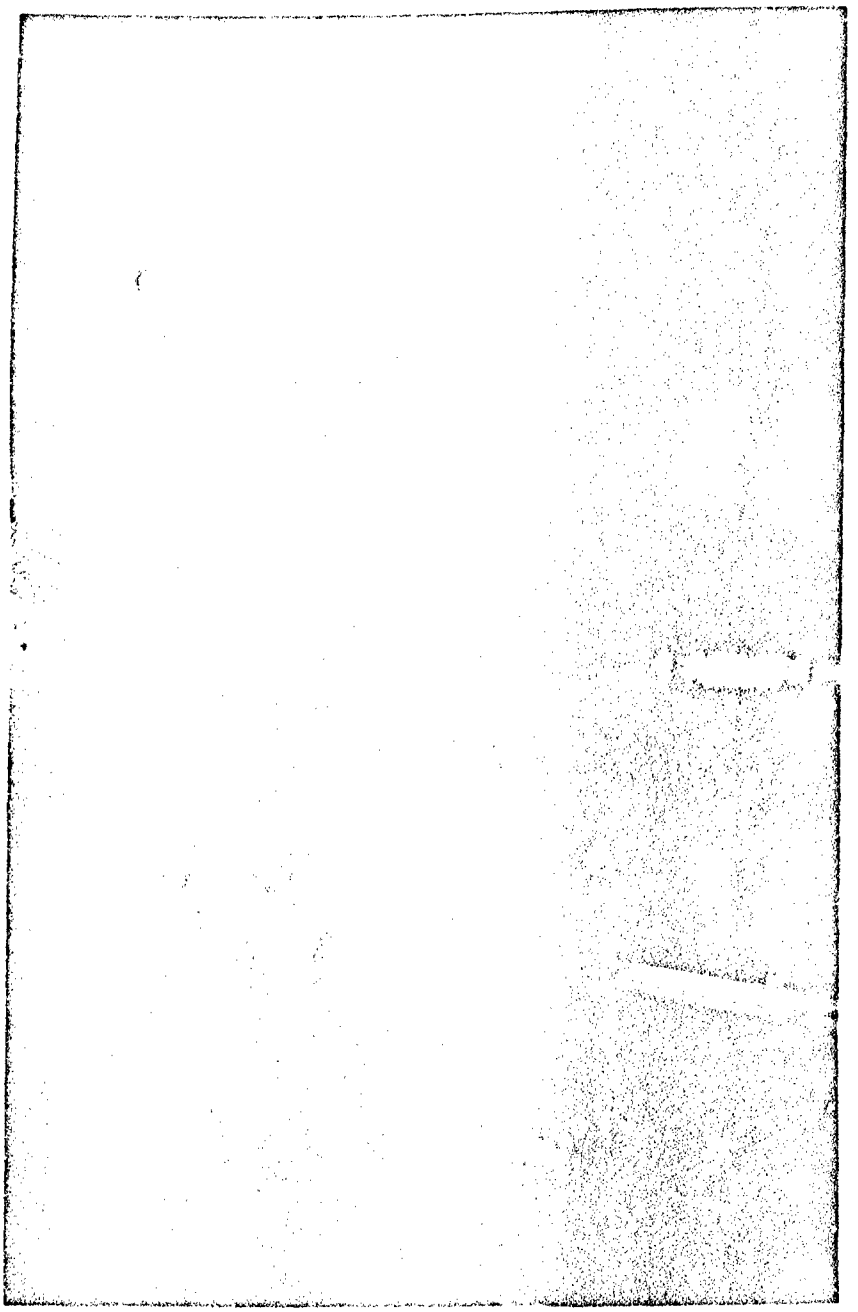
4.4.1 Oil/water separator. Liquid exiting the condenser is collected and pumped to an oil/water separator. The oil/water separator operates by gravity. It consists of a 50-gallon vessel that allows the insoluble, light organic components to separate from the water. The light organic phase is removed by a skimmer. The water phase flows out of the separator and is directed to carbon adsorption columns. The organic phase removed in the oil/water separator was stored in 55-gallon drums for off-site disposal, coordinated by WESTON through Tinker Air Force Base for manifesting and proper disposal. Photograph 6 shows the LT^3 System/oil/water separator during erection at Tinker Air Force Base.

For contaminants heavier than water (e.g., TCE) modifications need to be made as described in Subsection 10.10. At the Tinker demonstration, heavy liquids were siphoned out with the water and were filtered in the carbon system.

4.4.2 Carbon adsorption. The water removed from the oil/water separator and the scrubber blowdown liquor are directed through two carbon adsorption units in series for removal of soluble organics. The liquid stream between the two carbon columns is sampled continuously and analyzed by a hydrocarbon analyzer to detect breakthrough in the first carbon column. After leaving the carbon columns, the water is stored in a fresh water tank for use in dust control.

4.4.3 Fresh water system. An 80-gallon fresh water tank is used for intermediate storage of processed water. The water is withdrawn by a 2-gpm centrifugal pump and is sprayed on the treated soil for dust control. No water is discharged from the LT^3 Process.

4.5 Utilities. Operating the LT^3 System requires the following utilities:



Photograph No. 6. Oil/water separator.

- Electrical power.
- Propane fuel.
- Process water.

4.5.1 Electrical power. The electrical power requirements for the system are as follows:

- System requirements (oil heater, scrubber, fans, motors, afterburner, motor control center, control circuits, etc.) -- 460V/3-phase/600-amp power.

- CEM trailer -- 240V/3-phase/100-amp power.

4.5.2 Propane fuel. Propane at 15 psig is used for the burners in the oil heater and afterburner. Total consumption for both burners is a maximum of 10.7 million Btu/hr. A vaporizer is used to prepare the liquid propane for delivery to the burners at 15 psig.

4.5.3 Process water. Process water is required primarily for makeup water to the acid gas scrubber and dust control. Up to 7.5 gpm may be required because of evaporative losses and blowdown. Additional water is also needed for sampling and decontamination purposes. The water was supplied by an existing on-site fire hydrant at Tinker Air Force Base.

SECTION 5

DEMONSTRATION FRAMEWORK

5. DEMONSTRATION FRAMEWORK

5.1 Criteria for a successful demonstration.

5.1.1 Analytical. The demonstration was successful since the analytical results from the processed soil from all of the test runs indicate that the goal cleanup level (GCL) of the contaminants has been achieved. Table 5-1 lists the feed soil contaminant concentrations (based on previous investigations [see Reference No. 1]) and indicates the GCL for each contaminant. Some tests were intended to be failures to determine the upper and lower operating limits for soil residence time and oil temperature. However, no tests failed, based on analytical results.

5.1.2 Operational. The primary goal of the demonstration was to determine the optimum operating conditions that effectively decontaminate the soil, i.e., the shortest residence time and the lowest oil temperature.

Other operational criteria would have been considered if stack tests had been conducted. Stack emissions limitations were required by the Oklahoma State Department of Health and are listed in Subsection 3.4. The demonstration program was discontinued when PCBs were discovered in the feed and processed soil; therefore, no stack tests were conducted.

5.2 Original Test Plan. According to the original Test Plan, 15 tests were to be conducted; 9 tests in a 3 x 3 matrix consisting of 3 residence times (30, 45, and 60 minutes) and 3 oil temperatures (400°, 500°, and 600°F) as shown in Figure 5-1. The objective of the matrix of tests was to determine optimum operating conditions for soil decontamination. Two of the remaining tests were to verify the optimum conditions while simultaneously conducting stack sampling. The objective of the final four tests was to determine the effect of adding a solvent to the feed soil to enhance stripping and volatilization. Since the longest residence time that could be achieved was 40 minutes, the original matrix was adjusted during the demonstration.

5.3 Modified Test Plan. Test 1 was conducted at the longest achievable soil residence time of 40 minutes and an oil temperature of 600°F. Since analyses of the samples from Test 1 indicate that the GCL was met for all contaminants, the original matrix for the test program was adjusted to accommodate a maximum soil residence time of 40 minutes.

The logic used to determine the operating limits and to modify the test matrix is shown in the decision tree sequence in Figure 5-2. The modified matrix is shown in Figure 5-3.

WESTON

Table 5-1. Contaminant concentrations in Landfill 3 soil borings and cleanup objectives

Contaminant	Contaminant Concentration (ug/kg) Max	Avg	Goal Cleanup Level in TCLP Extract (ug/L)
Trichloroethene	6,100,000	743,270	70 a
trans-1,2-Dichloroethene	370,000	115,875	NA
Tetrachloroethene	446,900	76,266	50 b
Toluene	270,000	39,341	330 b
1,2-Dichlorobenzene	570,000	37,066	125 b
Bis(2-ethylhexyl) phthalate	120,000	30,000	NA
2-Butanone	97,000	18,218	750 b
4-Methyl-2-pentanone	117,320	16,192	NA
Total xylenes	131,000	13,044	150 b
1,4-Dichlorobenzene	59,000	12,085	10,800 a
Methylene chloride	84,740	11,152	960 b
4-Methylphenol	43,000	10,750	NA
1,2,4-Trichlorobenzene	24,000	6,675	NA
2-Methylnaphthalene	19,000	4,750	NA
2,4-Dimethylphenol	19,000	4,750	NA
2-Methylphenol	19,000	4,750	NA
1,3-Dichlorobenzene	52,000	4,309	NA
Fluoranthene	17,000	4,250	140 c
2-Hexanone	13,000	3,250	NA
2-Chloroethyl vinyl ether	9,200	3,064	NA
Ethylbenzene	19,280	2,710	53 b
Acetone	5,700	2,083	NA
Naphthalene	6,800	1,700	NA
Diethyl phthalate	3,800	950	NA
Chlorobenzene	3,200	621	50 b
1,1-Dichloroethene	2,200	550	100 a
1,1,1-Trichloroethane	980	352	410 b
Vinyl chloride	1,200	314	50 a
Vinyl acetate	1,000	250	NA
1,2-Dichloroethane	680	233	400 a

a - Source: Remedial Design Bog Creek Farm Site, Superfund Project, Howell Township, New Jersey, U.S. Army Corps of Engineers, DACW 41-88-R-0162.

b - Source: California List, 40 CFR Part 268, Subpart D.

c - Source: Substances Toxic to Aquatic Life, Support B: General Use Water Quality Standards of Illinois (February, 1986).

ND - None detected.

NA - Not assigned.

WESTON

Table 5-1. (continued)

Contaminant	Contaminant Concentration (ug/kg) Max	Avg	Goal Cleanup Level in TCLP Extract (ug/L)
Benzene	490	123	70 a
Chloroform	11	3	70 a
Carbon disulfide	5	1	4,810 b
Benzo(a)anthracene	ND	ND	8.7 c
Benzo(a)pyrene	ND	ND	15 c
Benzo(b)fluoranthene	ND	ND	12 c
Chrysene	ND	ND	100 c
Dibenzo(a,h)anthracene	ND	ND	20 c
Acenaphthene	ND	ND	1,200 c
Acenaphthylene	ND	ND	660 c
Anthracene	ND	ND	660 c
Benzo(g,h,i)perylene	ND	ND	51 c
Benzo(k)fluoranthene	ND	ND	11 c
Fluorene	ND	ND	140 c
Indeno(1,2,3-c,d)pyrene	ND	ND	29 c
Phenanthrene	ND	ND	660 c
Pyrene	ND	ND	180 c

a - Source: Remedial Design Bog Creek Farm Site, Superfund Project, Howell Township, New Jersey, U.S. Army Corps of Engineers, DACW 41-88-R-0162.
b - Source: California List, 40 CFR Part 268, Subpart D.
c - Source: Substances Toxic to Aquatic Life, Support B: General Use Water Quality Standards of Illinois (February, 1986).
ND - None detected.
NA - Not assigned.

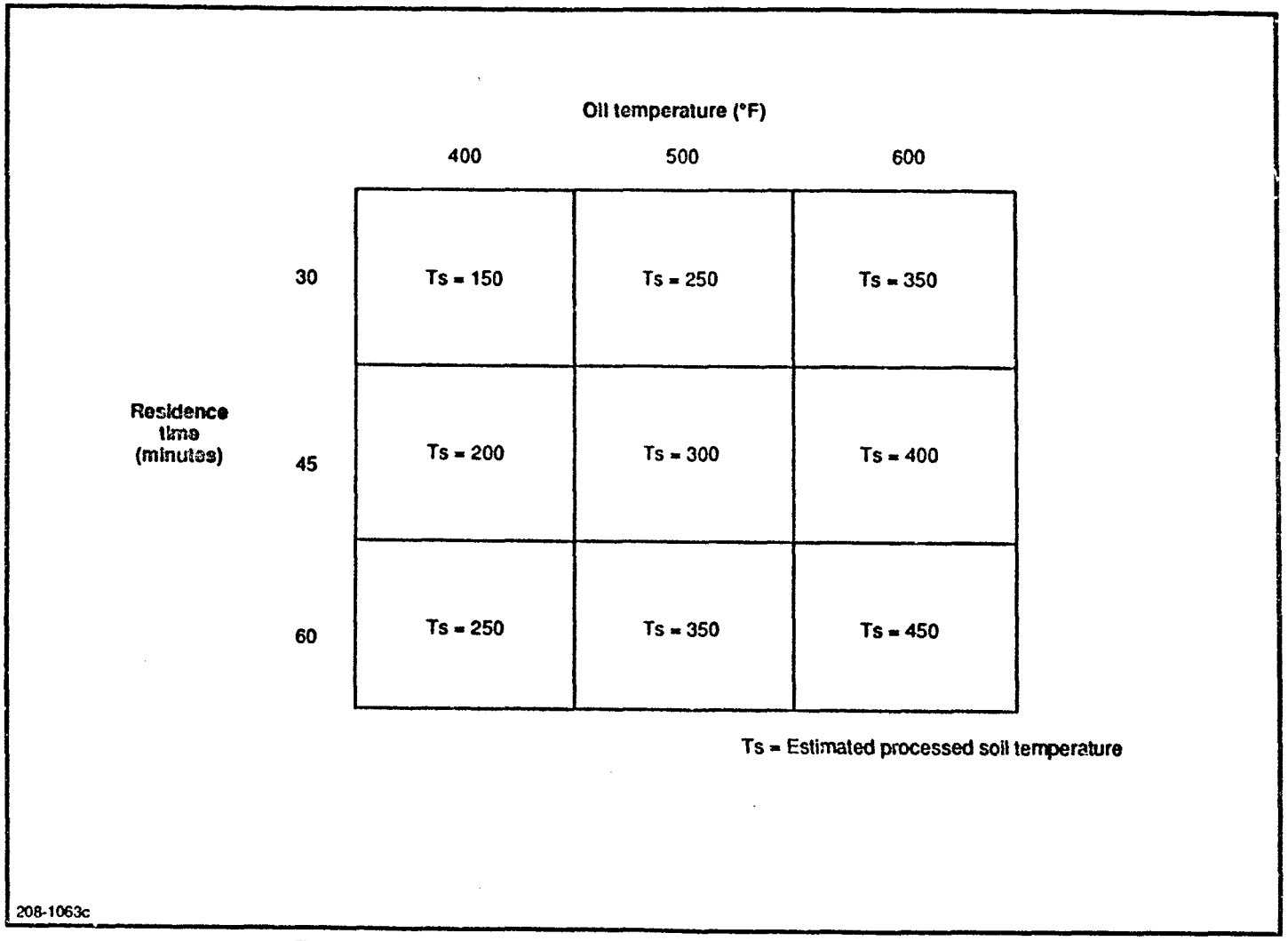
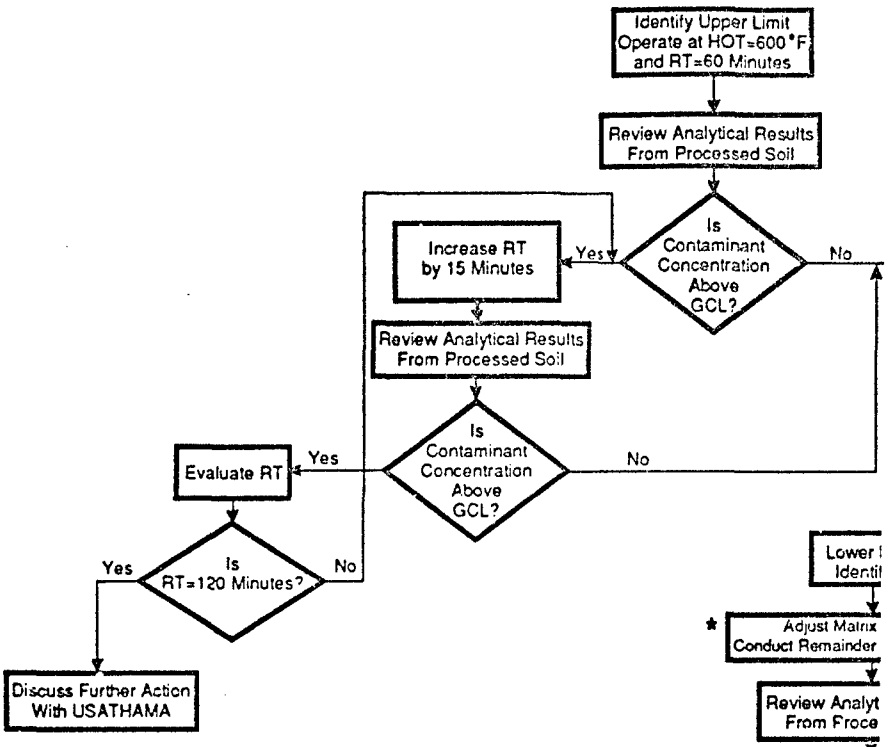


Figure 5-1. Test matrix for determination of optimum operating conditions.



Legend

RT - Residence Time
HOT - Hot Oil Temperature
u - Upper Limit
ℓ - Lower Limit
Opt - Optimum Operating Conditions
GCL - Goal Clean-Up Level (e.g. ppb contaminants)

★ Test program was discontinued after this step due to PCB contamination.

22-302

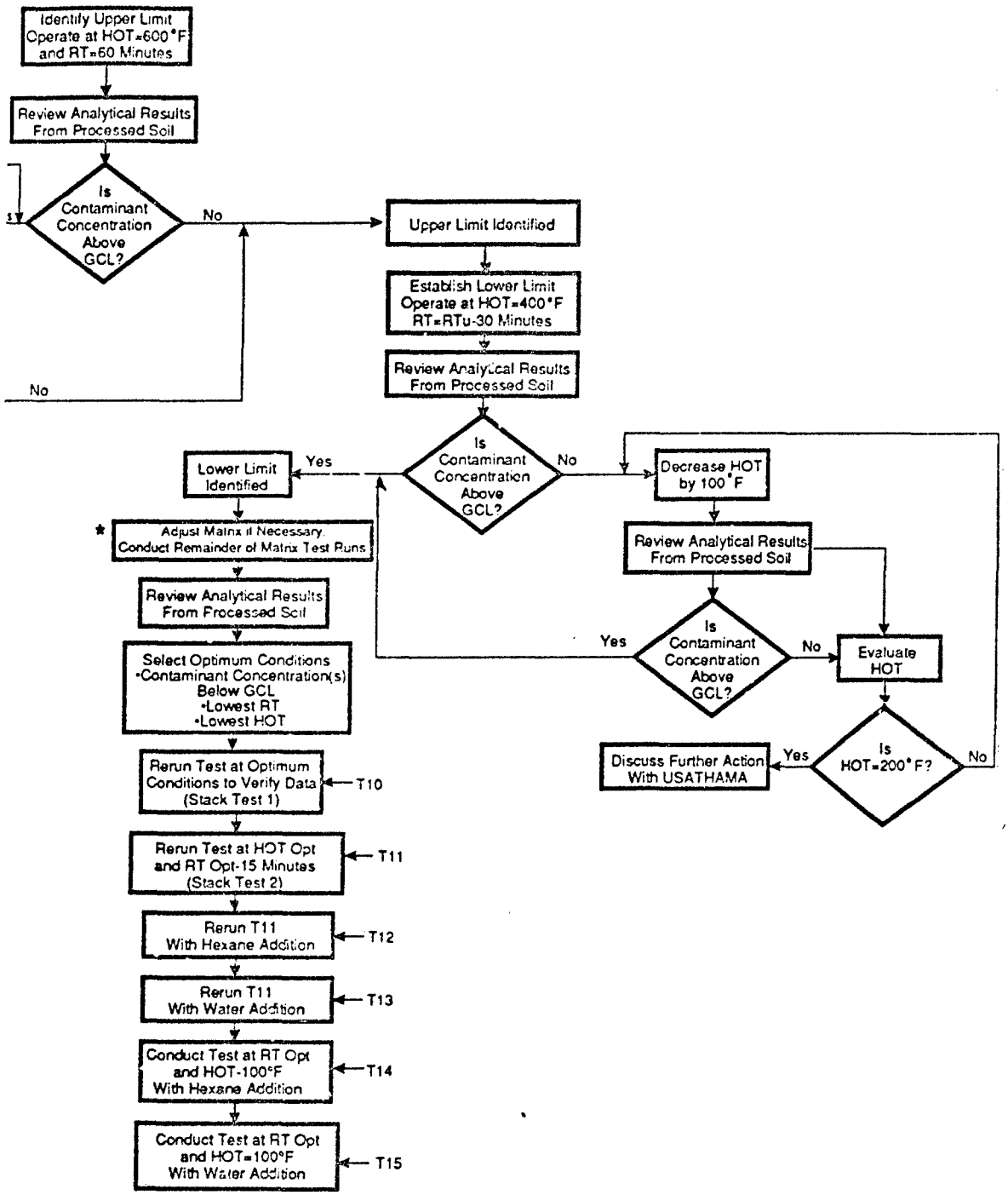


Figure 5-2. Decision tree to identify optimum operating conditions.

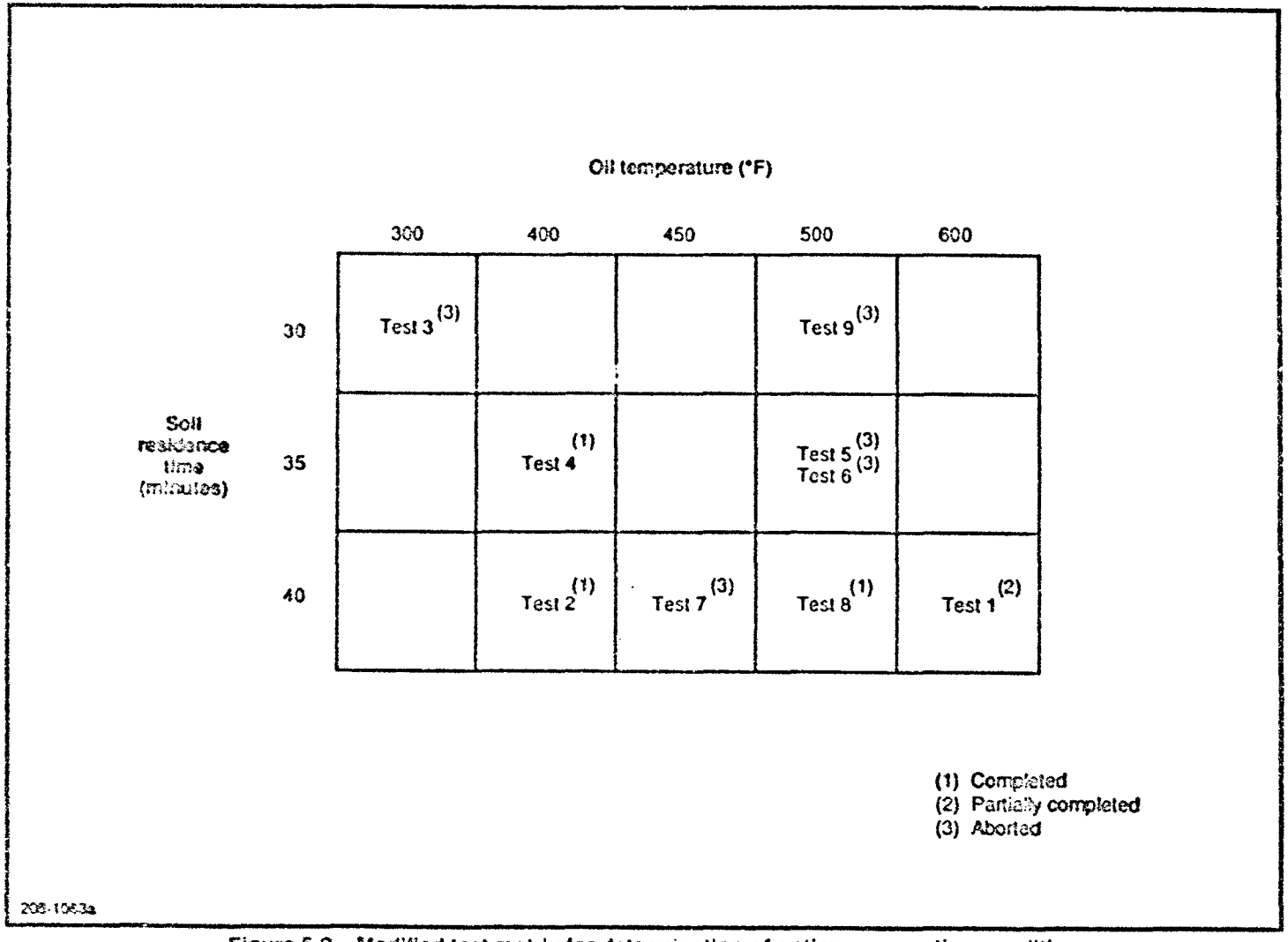


Figure 5-3. Modified test matrix for determination of optimum operating conditions.

WESTON

Table 5-2 presents a summary of the test run conditions. A brief description of each test follows.

5.3.1 Test 1. Test 1 was conducted with an oil temperature of 600°F and a soil residence time of 40 minutes. The test was aborted after 6 hours of operation due to the excessive generation of dust and accumulation of condensate and soil in the soil conditioner. The discharge soil temperature was 380°F. Analyses of the processed soil samples taken during the operation indicate that the GCL was met for all contaminants.

5.3.2 Test 2. Test 2 was conducted with an oil temperature of 400°F and a residence time of 40 minutes. The test was completed with no condensate accumulation in the soil conditioner. The soil discharge temperature was 224°F, thereby reducing steam generation. Analyses of processed soil samples indicate that the GCL was met for all contaminants.

5.3.3 Test 3. Test 3 was attempted with an oil temperature of 300°F and a residence time of 30 minutes. The test was aborted due to jamming at the soil discharge conveyor and lower processor. The soil was not being removed, causing caking and subsequent jamming of the discharge conveyor. No samples were collected.

5.3.4 Test 4. Test 4 was successfully completed with an oil temperature of 400°F and a retention time of 35 minutes. The temperature of the processed soil was 214°F. Samples were collected, and analyses show that the GCL was met for all contaminants.

5.3.5 Tests 5 and 6. Tests 5 and 6 were attempted with an oil temperature of 500°F and a residence time of 35 minutes. Test 5 was aborted since the stacker conveyor was jamming and because of draft problems. It was noticed during Test 6 that the bags in the fabric filter were caked and approximately 75 percent of the ductwork was filled with dust. Positive pressure was recorded during both Tests 5 and 6. The positive pressure may have resulted from excessive steam formation in the processor causing dust carryover into the ductwork, which may have restricted flow and decreased the draft. Therefore, Test 7 was conducted at a reduced oil temperature to reduce the rate of steam production.

5.3.6 Test 7. Test 7 was attempted at an oil temperature of 450°F and a residence time of 40 minutes. Since there was no improvement in system draft, the test was aborted.

5.3.7 Test 8. Test 8 was successfully completed with an oil temperature of 500°F and a residence time of 40 minutes. The processed soil temperature was 269°F. Soil samples indicate that the GCL was met.

Table 5-2 Summary of test runs

Test Number	Field Code	Test Date	Soil Residence Time (min.)	Oil Temperature (°F)	Processed Soil Temperature (°F)	Status
1	T-9	07/17/89	40	600	380	Partially completed (only 3 samples collected)
2	T-1	07/19/89	40	400	224	Completed
3	TK-03	07/27/89	30	300	197	Aborted
4	LT^3-04	08/01/89	35	400	214	Completed
5	LT^3-05	08/03/89	35	500		Aborted
6	LT^3-06	08/03/89	35	500		Aborted
7	LT^3-07	08/04/89	40	450		Aborted
8	LT^3-08	08/09/89	40	500	269	Completed
9	LT^3-09	08/10/89	30	500		Aborted

5.3.8 Test 9. Test 9 was attempted with an oil temperature of 500°F and a residence time of 30 minutes. The test was aborted at the beginning because the soil was very wet and sticky, causing plugging of the clay shredder and the feed conveyor.

During sample analyses after Test 9, the presence of PCBs was suspected in the feed and processed soils. PCB-contamination was confirmed by further analyses. The demonstration test program was suspended at that point until further instructions were provided.

SECTION 6

TYPICAL SITE ACTIVITIES

6. TYPICAL SITE ACTIVITIES

The LT^3 System arrived on-site in November 1988. Installation of the process equipment began on 18 January 1989, but was temporarily suspended on 6 February 1989 to obtain a Resource Conservation and Recovery Act (RCRA) RD&D permit. The RD&D permit was received on 19 June 1989, and LT^3 System installation resumed. Tests began on 17 July 1989 and continued through 18 August 1989. The demonstration was aborted when PCB contamination was detected in the feed and processed soil.

The daily schedule of on-site activities is presented in Figure 6-1. The overall project schedule is presented in Figure 6-2.

6.1 Daily routine. The regular operating crew (including laboratory analysts) consisted of the following personnel:

- Site manager/field safety officer (1)
- Plant operator (1)
- Field technicians/equipment operators (2)
- CEM technician (1)
- Sampling technician (1)
- Chemists (3)

6.1.1 Pretest activities.

6.1.1.1 Equipment startup and stabilization. The plant operator arrived on-site at approximately 6:00 a.m. for equipment startup and stabilization. To comply with the adopted safety protocol (i.e., a minimum of two persons required on-site at all times), the sampling technician also arrived at 6:00 a.m. The plant operator performed routine system checks prior to igniting the afterburner. The afterburner temperature was gradually raised to 1,800°F. Depending upon the selected test run conditions for the thermal processor, the hot oil system was ignited by the operator, and the oil temperature was gradually increased to the appropriate setpoint. To accommodate the desired soil residence time, the speed of the screws was adjusted to the appropriate setpoint. The site manager/safety officer, field technicians, and CEM technician normally arrived onsite at 7:00 a.m. The analysts were available for sample logging and analyses, as appropriate.

6.1.1.2 Excavation activities. Excavation of feed soil was performed when technicians were available, i.e., process equipment was shut down and/or field technicians were not needed for operation. Photograph 7 shows the excavation and some of the water that restricted excavation operations. Precipitation accumulating in the excavation was pumped to temporary lined holding/evaporation ponds, allowing the excavation area to dry. In this way, excavations were made such that the moisture content of the feed soil could be kept to a minimum.

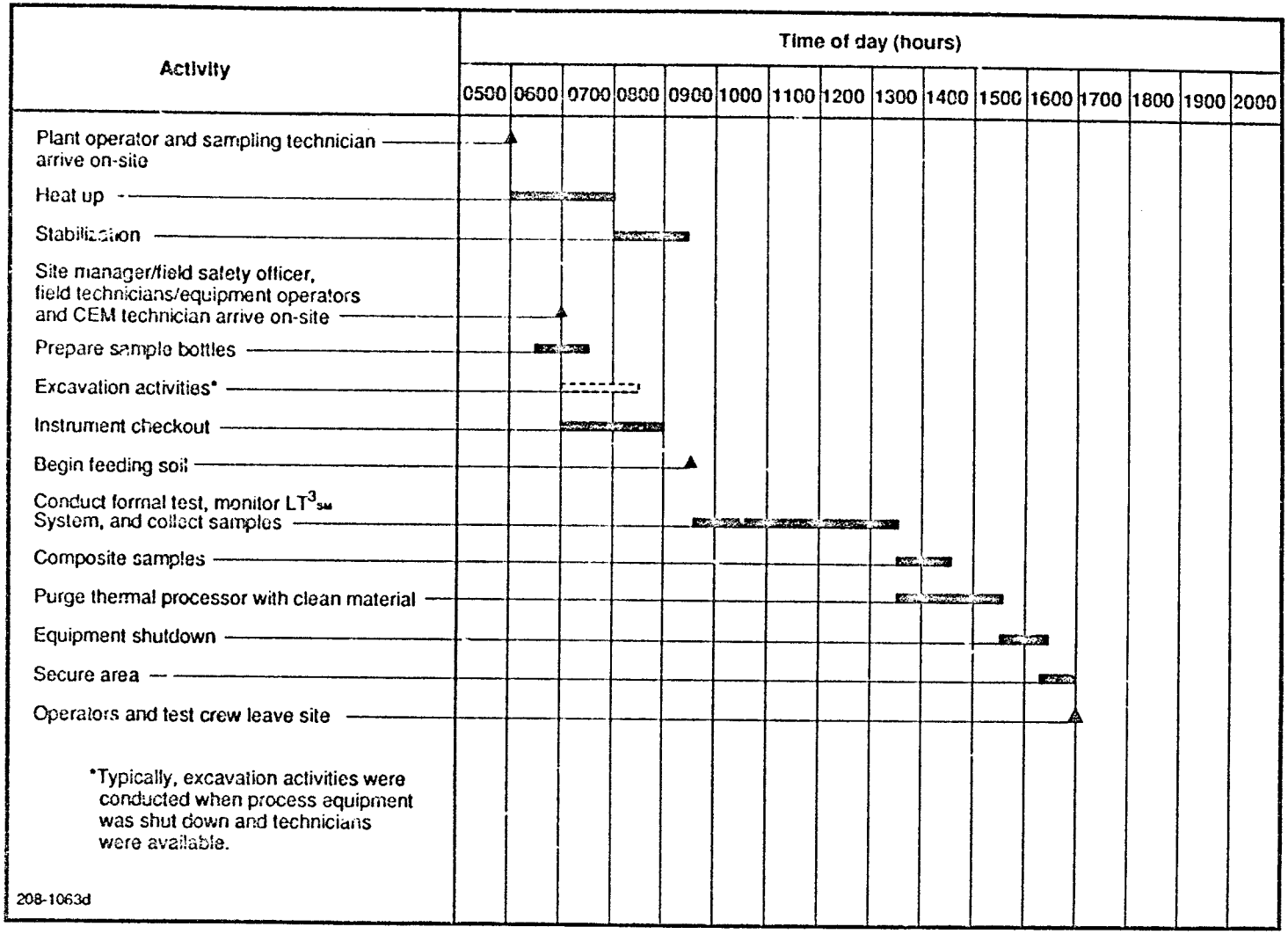


Figure 6-1. Typical schedule of daily on-site activities.

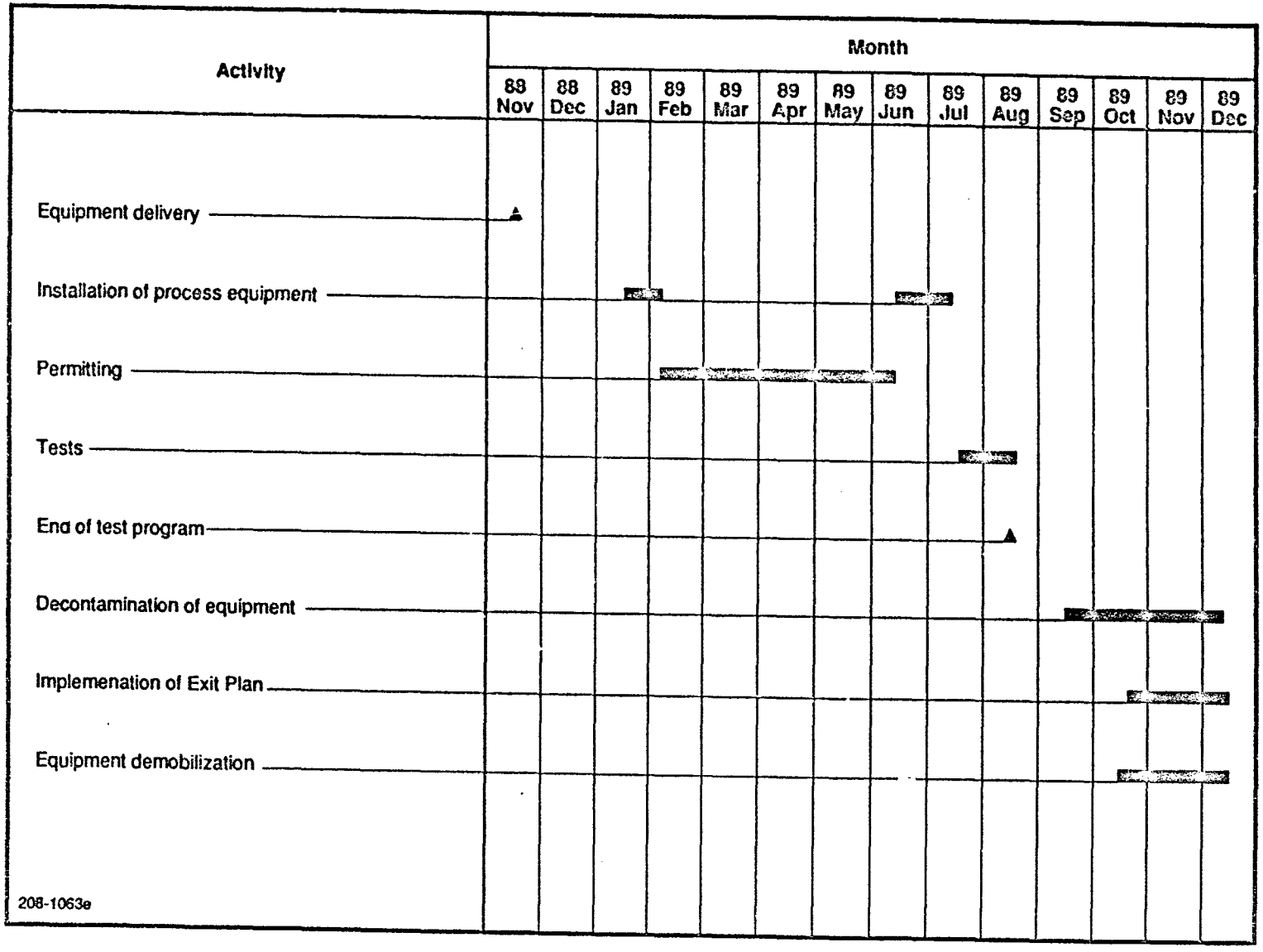
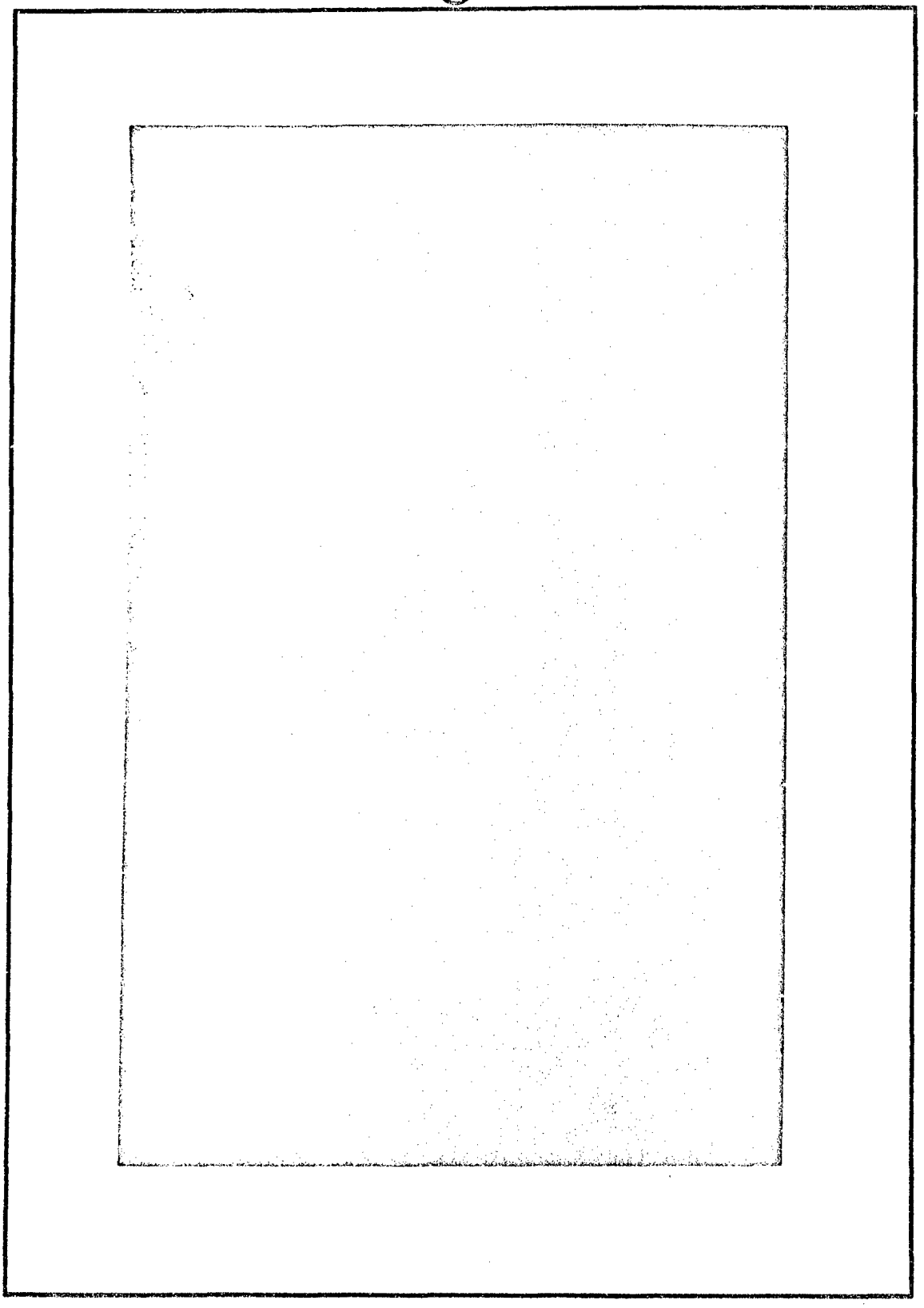


Figure 6-2. Overall project schedule.



Photograph No. 7. Excavation showing water that restricted operations.

Contaminated soil was excavated to a depth of 10 feet. The excavation dimensions were approximately 120 feet long, 75 feet wide, and 10 feet deep at the completion of excavation activities.

6.1.1.3 Materials handling. The excavated soils were transported to the processing area by a front-end loader. When the process equipment reached steady-state temperatures under appropriate operating conditions, the equipment operator began feeding contaminated soil to the shredder. The equipment operator loaded the shredder approximately 10 times per hour. The feed soil was weighed (on a truck scale) prior to its deposition in the shredder.

One feed soil sample was collected each hour from the feed hopper. Discrete samples were placed in separate buckets with lids. The buckets were stored in separate refrigerators to inhibit fugitive VOC losses and cross-contamination. Hourly samples were composited after each test run.

6.1.1.4 Sampling equipment. Sample containers were prepared and labeled prior to each test run.

6.1.2 System stabilization and test initiation. To simulate continuous operations, where soil would be processed under consistent conditions, the LT^3 System was thermally stabilized prior to each test. Stabilization allowed the system to be operated in near steady-state conditions and allowed the soil to undergo processing that closely approximated actual processing conditions.

At the beginning of each test, clean soil was fed into the system. After two residence periods of clean soil were processed under steady-state conditions, the system was considered to be stabilized. Stabilization is achieved when the system and the soil have reached steady-state.

In this way, the soil temperature profile would not be a factor in the performance, and the assumption could be made that the test was representative of normal 24-hour per day operations.

Two residence periods of material were determined to be necessary because the first residence period allowed the material, process equipment, and the hot oil system to come to steady-state. The second residence period exposed processed soil to a full residence period in the process equipment under steady-state conditions. Thus, the soil discharging from the process at the end of two residence periods closely approximated soil that would be discharged under continuous operating conditions.

A test run started with the feeding of contaminated soil when the following conditions were met:

- Discharged soil reached appropriate temperature.
- All systems were mechanically functioning.
- O&M readings were within permit conditions.

6.1.3 Post-test activities. The formal test run duration was a function of the desired residence time, the time required to collect samples, and the stabilization period.

6.1.3.1 Equipment shutdown. The objectives during the post-test shutdown period were to purge the system of contaminated material and to prevent fugitive emissions of partially processed gases.

Immediately after the last sample was taken, the hot oil heater was turned off, but the hot oil continued to circulate. The hot oil was circulated for several hours while it cooled to a temperature at which the oil was not in danger of crystallizing if circulation stopped.

At the same time, clean soil was fed into the processor to purge and scour out residual contaminated material. Approximately one residence period of clean soil was used to purge the contaminated soil. The processors were operated until the clean soil was removed from the system. The drive motors were then shut down.

The afterburner was maintained at 1,800°F while contaminated soil remained in the system. After contaminated soil was purged from the system, the afterburner cool down started. The temperature was reduced in 100-degree increments until 1,000°F was reached, at which time the system was completely shut down.

6.1.3.2 Securing the area. The excavation area was covered, and the fence was secured. Feed soil stockpiles were covered with visqueen, and HDPE liners were checked for rips or tears.

6.2 Project closure activities. As previously mentioned, PCB contamination was detected in feed and processed soils during the demonstration.

A Closure Plan was developed to minimize the potential for off-site PCB contamination. The complete Equipment Decontamination Plan and Exit Plan are presented in Appendices A and B, respectively. A brief description of closure activities at the excavation and processing areas is discussed in the following subsections.

6.2.1 Excavation area. Contaminated stockpiles in the Landfill 3 area were backfilled in the main excavation (Zone 1, shown in Figure 3-4). After backfilling was completed, soil samples from the top layer of the contaminated stockpile areas were collected and analyzed for PCB concentrations. Upon confirming that the top layer contained less than 25 ppm PCBs, the main excavation (Zone 1) was covered with a clay cap that consists of material from clean soil stockpile No. 10. Upon completion, plastic covers that were used to cover stockpiles were drummed in 85-gallon overpack drums for disposal in an off-site permitted PCB incinerator.

6.2.2 Processing area. Equipment in the processing area was decontaminated according to the Equipment Decontamination Plan. Wipe samples were taken from the decontaminated equipment to confirm decontamination. After confirming that the process equipment met the cleanup levels of 10 ug per 100 square centimeters, sampling equipment was drummed for shipment to a permitted PCB incinerator. Spent carbon from the carbon adsorption system used to treat accumulated rain water was also shipped to an off-site incinerator. The carbon adsorption system was shipped off-site for incineration.

SECTION 7

TEST VARIABLES

7. TEST VARIABLES

The test variables of the demonstration can be classified as follows:

- Independent variables -- values that are not affected by test operations. No attempts were made to modify or control independent variables.
- Control variables -- values that were selected and maintained during test operations.
- Response variables -- values that were a function of the selected operating conditions.

Table 7-1 provides a summary of test variables associated with the demonstration. Descriptions of the variables measured follow.

7.1 Independent variables. As shown in Table 7-1, there were six independent variables associated with the demonstration. Those variables are described in the following subsections.

7.1.1 Ambient air temperature. The temperature of the ambient air varied with local weather conditions. The ambient air temperature was measured daily.

7.1.2 Ambient air relative humidity. The relative humidity of the ambient air varied with local weather conditions, time of day, etc. Air relative humidity content was measured daily.

7.1.3 Ambient air VOC concentrations. Ambient air VOC concentrations were monitored continuously and recorded on a strip-chart recorder.

7.1.4 Feed soil contaminant concentrations. The initial concentrations of JP-4, TCE, and other contaminants in the soil varied, based on the location from which the soil was excavated. The feed soil was sampled from the feed hopper. The soil was analyzed to record initial contaminant concentrations.

7.1.5 Feed soil moisture content. The initial moisture content of the feed soil varied with local weather conditions (e.g., rain) and the location of the excavation. The feed soil was analyzed for initial moisture content for each test.

7.1.6 Feed soil temperature. The temperature of the feed soil varied with ambient temperature. The soil temperature was measured once daily.

Table 7-1. Summary of test variables for the demonstration

A. Independent Variables

- Ambient air conditions
  - Temperature
  - Relative humidity
  - VOC concentrations
- Feed soil
  - Contaminant concentrations
  - Moisture content
  - Temperature

B. Control Variables

Held Constant

- Feed soil
  - Preparation and handling (including shredding and conveying procedures)
- Thermal processor
  - Draft (i.e., static pressure)
  - Discharge gas temperature
- Condenser
  - Discharge gas temperature
- Afterburner
  - Discharge gas temperature
  - Discharge draft
- Scrubber
  - Inlet gas temperature
  - Scrubber liquor recirculation flow rate
  - Blowdown volumetric flow rate*
  - Scrubber liquor pH

*Not measured during demonstration.

Table 7-1. (continued)

Controlled to Various Levels

- Feed soil
  - Residence time in processor (i.e., feed rate)
  - Type of solvent addition (i.e., hexane or water)*
  - Solvent addition rate*
- Oil heater
  - Oil temperature

C. Response Variables

- Feed soil
  - Mass flow rate (i.e., tons per hour)
- Processed soil
  - Discharge temperature
  - Contaminant concentration
  - Moisture content
- Oil heater
  - Return oil temperature
- Thermal processor
  - Sweep air temperature*
  - Sweep air volumetric flow rate*
  - Sweep air composition*
- Fabric filter
  - Dust composition
  - Dust mass flow rate
- Condenser
  - Condensate mass flow rate
  - Condensate composition*

*Not measured during demonstration.

Table 7-1. (continued)

• Afterburner
– Composition of inlet gases*
– Flow rate of inlet gases*
– Inlet gas temperature
– Discharge gas composition
• Scrubber
– Composition of blowdown liquor*
• Stack outlet
– Discharge gas temperature*
– Composition of stack gases*
– Flow rate of stack gases*
– HCl emissions*
– Particulate concentration*
– Moisture content*

*Not measured during demonstration.

7.2 Control variables. As shown in Table 7-1, there were nine control variables to be held constant throughout the test runs. Two variables were controlled at various levels throughout each test.

7.2.1 Control variables held constant.

7.2.1.1 Feed soil preparation and handling. All feed soil was prepared and handled in the same manner. Preparation and handling procedures included the following:

- Excavation and transportation by a front-end loader.
- Shredding to a top size of 2 inches.
- Transport by drag conveyor to the feed hopper.

7.2.1.2 Thermal processor draft. To mitigate the release of fugitive emissions from the thermal processor, a slightly negative pressure or draft was maintained. The draft was controlled by adjusting the ID fan damper. The draft was monitored and recorded continuously on a strip-chart recorder. Hourly readings were also recorded manually.

7.2.1.3 Thermal processor discharge gas temperature. The discharge gas temperature from the thermal processor was controlled by regulating the amount of sweep air admitted to the system. The temperature was monitored and recorded continuously on a strip-chart recorder. Hourly readings were also recorded manually.

7.2.1.4 Condenser discharge gas temperature. The condenser exit gas temperature was maintained by controlling the cooling air fans. The fans supply air across the condenser tubes. The temperature was manually measured and recorded on an hourly basis.

7.2.1.5 Afterburner discharge gas temperature. The temperature of the gases discharging the afterburner chamber was maintained at approximately 1,800°F to ensure complete destruction of the organic vapors in the thermal processor exhaust gases. The temperature was controlled automatically by the burner control system.

The temperature of the afterburner gases was monitored continuously by a strip-chart recorder and was recorded manually on an hourly basis.

7.2.1.6 Afterburner discharge draft. The discharge draft from the afterburner was controlled using the ID fan damper. This draft was maintained at a slightly negative pressure and was recorded continuously on a strip-chart recorder.

7.2.1.7 Scrubber inlet gas temperature. The scrubber inlet gas temperature was maintained during each test by admitting bleed air (ambient air) through a damper at the afterburner outlet. Temperature was manually recorded on an hourly basis.

7.2.1.8 Scrubber liquor recirculation flow rate. The recirculation flow rate of the scrubber liquor was maintained by adjusting flow control valves. The rate was sufficient to cool the afterburner discharge gases to saturation temperature and to neutralize the pH while minimizing the amount of makeup water required. The flow rate was continuously monitored and recorded on a strip-chart recorder. Readings were also recorded manually on an hourly basis.

7.2.1.9 Scrubber liquor pH. The pH of the scrubber liquor was maintained by adding caustic scrubbing solution (25 percent NaOH) to neutralize acidic gases. The pH of the scrubber liquor was continuously monitored and recorded on a strip-chart recorder.

7.2.2 Variables controlled to various levels. There were four variables in this category. Two of the four variables (soil residence time and oil temperature) were controlled at preselected levels, as illustrated in Subsection 5.3 and summarized in Table 5-2.

7.2.2.1 Soil residence time in the thermal processor. The thermal processor screw conveyors were controlled to maintain target soil residence times in the processor. The target soil residence times of 30, 45, and 60 minutes were theoretically calculated. The screw speed was set for each test run as close as possible to the desired residence time. A sample calculation of theoretical residence time is presented in Appendix C.

7.2.2.2 Oil temperature. The oil temperature was maintained during each test, depending on the selected test conditions within the matrix. The oil temperature was controlled by the burner fuel firing rate. The temperature was monitored continuously and recorded hourly.

7.3 Response variables. Table 7-1 lists the 11 response variables that were monitored during some or all of the test runs. Those variables are discussed briefly in the following subsections.

7.3.1 Feed soil mass flow rate. The mass flow rate of feed soil introduced to the LT^3 System varied, based on the soil residence time in the processor as controlled by the speed of the processor screws. This rate was monitored by weighing the amount of material fed to the system.

7.3.2 Processed soil discharge temperature. The temperature of the soil discharging the thermal processor is dependent on the soil residence time in the processor and the oil temperature. The temperature was manually recorded hourly.

7.3.3 Processed soil contaminant concentrations. The discharged soil was sampled hourly from the discharge conveyor throughout each test run. Those samples were composited and analyzed daily.

7.3.4 Processed soil moisture content. Discrete samples of discharged soil were collected hourly from the discharge conveyor throughout each test run. Those samples were composited and analyzed daily for soil moisture content.

7.3.5 Soil contaminant removal efficiency. The contaminant removal efficiency was calculated from the initial and final soil analyses using the following equation:

$$RE = \frac{M1 - M2}{M1} \times 100 \text{ percent}$$

where:

RE = Contaminant removal efficiency for the specific contaminant and process conditions.

M1 = Initial mass of contaminant in the soil.

M2 = Final mass of contaminant in the soil.

7.3.6 Return oil temperature. The temperature of the oil returning from the thermal processor varied, based on initial oil temperature, soil residence time, moisture content, and contaminant concentration. The temperature of the return oil was manually monitored hourly.

7.3.7 Fabric filter dust composition. A dust sample was collected from the fabric filter at the end of each test run. The sample was analyzed for contaminants. Since condensation occurred in the fabric filter, the dust sample was a slurry of dust mixed with condensed water.

7.3.8 Fabric filter dust mass flow rate. The mass flow rate of the dust from the fabric filter was determined for each test run.

7.3.9 Condensate mass flow rate. The rate of condensation of the gas stream in the condenser depends on the temperature of the gas stream inlet and the ambient temperature. An approximate rate was estimated daily, based on the amount of liquid collected in the condensate tank at the discharge of the condenser.

7.3.10 Afterburner inlet gas temperature. The temperature of the inlet gases was manually monitored and recorded hourly. The afterburner inlet temperature varied slightly during each test.

7.3.11 Afterburner discharge gas composition. The discharge gas composition from the afterburner varied, based on the feed soil composition and the amount of bleed air admitted to the system. The composition of the gas stream was monitored and recorded continuously by the CEM system.

SECTION 8

SAMPLING TECHNIQUES AND ANALYTICAL METHODS

8. SAMPLING TECHNIQUES AND ANALYTICAL METHODS

Samples of the soils and the process streams were collected by WESTON personnel. Most of the samples were analyzed at the on-site laboratory. Feed and processed soil samples from Test 4 were transported to the WESTON Analytics Laboratory in Lionville, Pennsylvania, for PCB analyses. The analytical methods for the on-site laboratory are described in Appendix D.

8.1 Sampling techniques. The locations of the sampling points, according to the original test plan, are shown in Figure 8-1. Samples were collected from five sampling points during the demonstration. A summary of the parameters for sample analyses during the demonstration is presented in Table 8-1. A list of VOCs and semivolatile organic compounds included in the on-site analyses is presented in Table 8-2. A brief discussion of the sampling and analysis procedures for each sample point is included in the following subsections. Descriptions of the parameters to be tested, analytical methods, and sampling procedures for each sampling location are presented in Tables 8-3 through 8-7.

8.1.1 Feed soil. (Sampling point 1 in Figure 8-1.) Contaminated soil entering the thermal processor was sampled once each hour throughout the test. Discrete samples were composited into one sample. Each sample was collected using a stainless steel spoon. Samples were taken from the feed hopper and deposited in a covered 5-gallon bucket. The bucket was stored in a refrigerator. At the end of the test, the samples were composited into two 250-milliliter (mL) wide-mouth glass bottles. Composite samples were extracted and analyzed on-site to determine the initial contaminant concentrations and moisture content. Feed soil samples collected during Test 4 were also transported to the Lionville laboratory for PCB analyses.

The mass flow rate of the soil fed to the system was monitored by weighing (on a truck scale) each load carried by the front-end loader to the shredder.

8.1.2 Processed soil. (Sampling point 2 in Figure 8-1.) Processed soil exiting the thermal processor was sampled hourly throughout each test run. Discrete samples were composited. The samples were collected from the discharge conveyor in the same manner as feed soil samples.

The processed soil samples were analyzed to determine the final moisture content and composition exiting the system. Samples were analyzed in the on-site laboratory for volatile and semivolatile organics and moisture content for all test runs.

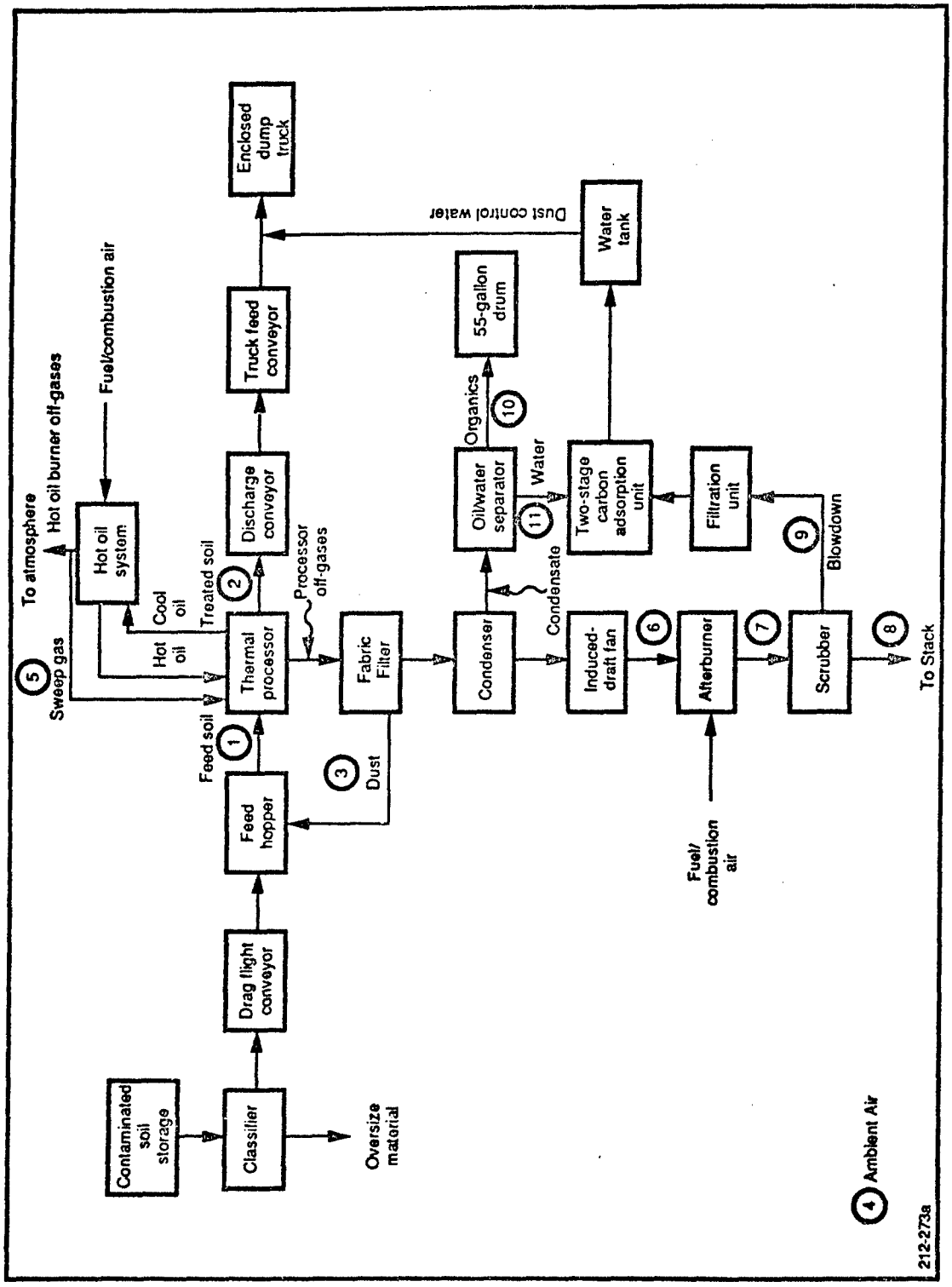


Figure 8-1. Sampling locations for the LT³SM System.

Table 8-1. Summary of parameters in the sampling/analytical program.

Parameters Sampled and Analyzed	Feed Soil	Processed Soil	Dust	Ambient Air	Afterburner Outlet
Volatiles	(1) [a]	(1) [a]	(1) [a]	(1) [d]	
Semivolatiles	(1) [a]	(1) [a]	(1) [a]		
PCBs (3)	(2) [b]	(2) [b]			
Oxygen					(1) [c]
Carbon Monoxide					(1) [c]
Carbon Dioxide					(1) [c]
Total Hydrocarbons					(1) [c]
Moisture Content	(1) [a]	(1) [a]		(1) [e]	

Key

(1) - Tests 1, 2, 4, and 8.
(2) - Test 4.
(3) - Wipe, water and soil samples were also analyzed for PCBs during equipment decontamination and exit periods.

a - On-site laboratory
b - Lionville laboratory
c - Continuous emissions monitoring (CEM) system
d - FID with a strip-chart recorder
e - Manual recording (described in Subsection 8.1.4)

207-1097a

Table 8-2. Volatile and semivolatile organics included in the on-site analyses

Volatile Organics
Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Dichloromethane
Trichlorofluoromethane
Acetone
1,1-Dichloroethene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
2-Chloroethyl vinyl ether
Benzene*
Bromoform
Tetrachloroethene
1,1,2,2-Tetrachloroethane
Toluene*
Chlorobenzene*
Ethylbenzene*
o-Xylene*
m-Xylene*
p-Xylene*

*May be a constituent of jet propulsion fuel (JP-4).

Table 8-2. (continued)

Semivolatile Organics
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
Naphthalene*
4-Chloroaniline
2-Methylnaphthalene*
2-Chloronaphthalene*
Acenaphthylene*
Acenaphthene*
Fluorene*
Phenanthrene*
Anthracene*
Fluoranthene*
Pyrene*
Benzo(a)anthracene*
Chrysene*
Benzo(b)fluoranthene*
Benzo(k)fluoranthene*
Benzo(a)pyrene*
Indeno(1,2,3-c,d)pyrene*
Dibenzo(a,h)anthracene*
Benzo(g,h,i)perylene*

*May be a constituent of jet propulsion fuel (JP-4).

Table 8-3. Sampling and analysis procedures for the feed soil

Sampling Point Number	1 (Feed Soil)				
Test Objective:	Determine Initial Composition of Feed Soil				
Sampling Objective:	Collect a Representative Sample				
Parameters to be Tested:	Volatile Organics (On-Site) [1]	Semivolatile Organics (On-Site) [1]	PCBs (Lionville)	Moisture Content	Mass Flow Rate
Test Runs Sampled:	Tests 1, 2, 4 and 8		Test 4	Tests 1, 2, 4 and 8	
Reporting Limit	Determined On-Site [2]	Determined On-Site [2]	<1 ppm	0.1%	20 lb
Sampling or Monitoring Method	Grab Sample Collected From Feed Hopper Every Hour. Composited Into a Single Sample for Analysis				Continuous
Sample Extraction/ Analysis Method(s):	EPA Methods 5030 8010 8020 and TCLP for Volatiles	Modified USATHAMA Method for Semivolatile Organics in Soil	EPA Methods 3540 8080	ASTM Method D2216	Weigh Scale Data

Key

[1]- Analytical methods for on-site laboratory are presented in Appendix D.

[2]- Determined on-site based on the concentrations encountered and the dilution factors.

207-1087b

Table 8-4. Sampling and analysis procedures for the processed soil

Sampling Point Number	2 (Processed Soil)				
Test Objective	Determine Final Composition of Processed Soil				
Sampling Objective:	Collect a Representative Sample				
Parameters to be Tested	Volatile Organics [1] (On-Site)	Semivolatile Organics [1] (On-Site)	PCBs (Lionville)	Moisture Content	Temperature
Test Runs Sampled	Tests 1, 2, 4 and 8		Test 4	Tests 1, 2, 4 and 8	
Detection Limit	Determined On-Site [2]	Determined On-Site [2]	<1 ppm	0.1%	1°F
Sampling or Monitoring Method	Grab Sample Collected From Discharge Conveyor Every Hour. Composited Into a Single Sample for Analysis				Continuous
Sample Extraction/ Analysis Method(s)	EPA Methods 5030 8010 8020 and TCLP for Volatiles	Modified USATHAMA Method for Semivolatile Organics and TCLP	EPA Methods 3540 8080	ASTM Method D2216	Thermo-couple

Key

[1] Analytical methods for on site laboratory are presented in Appendix D

[2] Determined on-site based on the concentrations encountered and the dilution factors.

/07 1087c

Table 8-5. Sampling and analysis procedures for the dust from the fabric filter

Sampling Point Number	3 (Fabric Filter)			
Test Objective:	Determine Composition of Dust from Fabric Filter			
Sampling Objective:	Collect a Representative Sample			
Parameters to be Tested:	Volatile Organics (On-Site) [1]	Semivolatile Organics (On-Site) [1]	PCBs (Lionville)	Mass Flow Rate
Test Runs Sampled:	Tests 1, 2, 4 and 8		Test 4	Tests 1, 2, 4 and 8
Detection Limit:	Determined On-Site [2]	Determined On-Site [2]	<1 ppm	20 lb
Sampling or Monitoring Method	Grab Sample Collected From Fabric Filter Daily			
Sample Extraction/ Analysis Method(s)	EPA Methods 5030 8010 8020 and TCLP for Volatiles	Modified USATHAMA Method for Semivolatile Organics and TCLP	EPA Methods 3540 8080	Weigh Scale Data

Key

1. Analytical methods for on site laboratory are presented in Appendix D
2. Determined on-site based on the concentrations encountered and the dilution factors.

207 1087d

Table 8-6. Sampling and analysis procedures for the ambient air samples

Sampling Point Number	4 (Ambient Air)		
Test Objective:	Determine Characteristics of Ambient Air		
Sampling Objective:	Collect a Representative Sample		
Parameters to be Tested:	Volatile Organics [1] (On-Site)	Moisture Content	Temperature
Test Runs Sampled:	Tests 1, 2, 4 and 8		
Sampling or Monitoring Frequency	Continuous	Daily	Daily
Sample Extraction/ Monitoring Method	Flame Ionization Detector (FID)	Sling Psychrometer	Sling Psychrometer (Dry Bulb)

Key

[1] - Strip-chart recorder

207-1087e

Table 8-7. Sampling and analysis procedures for the afterburner outlet gas

Sampling Point Number	7 (Afterburner Outlet)				
Test Objective:	Determine Composition of Afterburner Outlet Gas				
Sampling Objective:	Collect a Representative Sample				
Parameters to be Tested:	Total Hydrocarbons	Carbon Dioxide	Carbon Monoxide	Oxygen	Temperature
Test Runs Sampled:	Tests 1, 2, 4 and 8				
Detection Limit:	1 ppm as Methane	0.1%	1 ppm	0.1%	1°F
Sampling or Monitoring Method:[1]	EPA Method 25A	EPA Method 3	EPA Method 10	EPA Method 3A	EPA Method 2
Sample Extraction/ Analysis Method(s):	Flame Ionization Detector	Non-Dispersion Infrared Absorption	Gas Phase Correlation Filter	Electro-chemical Cell	K-Type Thermo-couple

Key

[1] - Sampling and analytical procedures are presented in Appendix E.

207-1087f

Samples were also extracted in the on-site laboratory according to the Toxicity Characteristic Leaching Procedure (TCLP) and analyzed for volatiles and semivolatiles. In addition, samples from Test 4 were transported to the Lionville laboratory for PCB analyses. The temperature of the processed soil was continuously monitored by a thermocouple during all test runs.

8.1.3 Fabric filter dust. (Sampling point 3 in Figure 8-1.) Dust (or particulate carryover) collected in the fabric filter was sampled for analysis. At the completion of each test run, one grab sample was collected using a stainless steel spoon. The samples were placed in wide-mouth glass bottles. The samples were extracted and analyzed in the on-site laboratory. In addition, the samples collected during Test 4 were transported to the Lionville laboratory for PCB analyses. The mass flow rate of the dust from each test run was determined by collecting the dust from the fabric filter and weighing the dust when the test was complete.

8.1.4 Ambient air. (Sampling point 4 in Figure 8-1). Ambient air was sampled daily to determine moisture content and temperature. A sling psychrometer was used to measure the wet-bulb and dry-bulb temperatures. Temperatures and a psychrometric chart were used to determine the ambient air moisture content. The moisture content and the temperature were manually recorded. An organic vapor analyzer (OVA) was used to continuously measure VOCs in the ambient air surrounding the excavation area. VOC readings were continuously recorded on a strip-chart recorder. If VOC readings exceeded 5 units above background, personnel protective equipment was upgraded in the excavation area.

8.1.5 Afterburner outlet. (Sampling point 7 in Figure 8-1.) Continuous emissions monitoring of afterburner exhaust gases was conducted during all test runs, including:

- Oxygen.
- Carbon monoxide.
- Carbon dioxide.
- Total hydrocarbons.

The CEM system uses an extractive-type probe to withdraw samples from the afterburner outlet duct. The probe is designed to maintain sample integrity and to provide a clean, dry gas stream to the CEM analyzers. The sample is filtered and cooled in a sample conditioning system and is then directed to the analyzers.

Oxygen was measured by an electrochemical cell sensing current induced by the oxygen in the sample. Carbon monoxide and carbon dioxide were measured by a non-dispersive infrared absorption (NDIR) technique. Total hydrocarbons were monitored by employing a flame ionization detector (FID). Descriptions

of the CEM sampling system, calibration procedures, and data collection system are presented in Appendix E. Tables 8-8 through 8-11 list the specifications for the CEM analyzers (i.e., oxygen, carbon dioxide, carbon monoxide, and total hydrocarbons).

Continuous temperature monitoring of the afterburner outlet gases was conducted using a thermocouple. These readings were manually recorded every hour.

8.2 Analytical methods. Samples from feed soil, processed soil, and fabric filter dust were collected for Tests 1, 2, 4, and 8 and were analyzed on-site for VOCs and semivolatile organic compounds. The samples were extracted according to TCLP technique and analyzed for volatile and semivolatile organic compounds. In addition, samples collected during Test 4 were sent to the Lionville laboratory for PCB analyses. Equipment wipe, water, and soil samples taken during the decontamination and closure activities were also sent to the Lionville laboratory for PCB analyses. The analytical methods employed are summarized as follows:

Parameter	Analytical Method
Volatile organic compounds	EPA Methods 5030, 8010, and 8020, Toxicity Characteristic Leaching Procedure (TCLP)
Semivolatile organic compounds	Modified USATHAMA method for semivolatile organics, TCLP
Polychlorinated biphenyls (PCBs)	EPA methods 3540 and 8080

The ambient air was monitored during the excavation using a flame ionization detector. The afterburner outlet gas was continuously sampled and analyzed for total hydrocarbons, carbon dioxide, carbon monoxide, and oxygen content by the CEM system. The analytical procedures for the parameters monitored by the CEM system are presented in Appendix F.

8.3 Sample transport and custody. Chain-of-custody procedures document the history of samples and constitute a crucial part of sampling and analysis programs. Chain-of-custody documentation assists and enables the identification and tracing of a sample from the time of collection through the time of analysis.

When sample bottles were supplied by the laboratory, chain-of-custody forms accompanied the containers to the field. As

Table 8-8. Specifications for the electrochemical analyzer used to monitor oxygen content

Accuracy:	±2 percent of full scale at 72°F -- all ranges
Response Time:	30 seconds for 90 percent response, 10 seconds typical for small step change
Stability:	±2 percent of full scale over 30 days typical

Table 8-9. Specifications for the gas phase correlation filter analyzer to monitor carbon monoxide

Accuracy	±0.1 ppm
Linearity	±1 percent full scale
Minimum Detectable Limit	0.1 ppm
Zero Drift	±1 percent full scale/24 hours
Span Drift	±1 percent full scale/24 hours
Rejection Ratio	Negligible interference from water vapor and carbon dioxide
Response Time	95 percent of reading in 1 minute with 30-second integration period
Recorder Output	0 to 10 volts

Table 8-10. Specifications for the nondispersive infrared gas analyzer to monitor carbon dioxide

Reliability/ Accuracy:	±1 percent of full scale
Linearity:	±1 percent of full scale
Noise Level:	±1 percent of full scale
Zero Drift:	±1 percent of full scale/24 hours
Span Drift:	±1 percent of full scale/24 hours
Response Time:	90 percent of reading in 30 seconds
Recorder Output:	0 to 100 millivolts (mv)

Table 8-11. Specifications for the CEM flame ionization detector used to monitor total hydrocarbons

Analysis Method:	Flame ionization detector
Sensitivity:	Maximum: 1 ppm hydrocarbons
Response Time:	90 percent of full scale in less than 1 second
Zero Drift:	±1 percent of full scale per 24 hours
Span Drift:	±1 percent of full scale per 24 hours
Linearity:	±1 percent of selected range
Ranges:	Any three of the following: 0 to 10; 0 to 100; 0 to 1,000; 0 to 10,000; or 0 to 1,000,000 ppm
Outputs:	0 to 10 volts DC
Display:	Analog meter in ppm hydrocarbons

samples were collected, entries were made on the chain-of-custody forms. Data that were noted on the chain-of-custody forms and on the sample bottle labels include the following:

- Date.
- Samples.
- Sample description.
- Client/program.
- Container and preservatives.
- Analyses required.
- Special instructions/notes.
- Signatures tracking chain-of-custody.

Feed soil, processed soil, and dust samples collected during Test 4 were sent to the off-site laboratory in Lionville, Pennsylvania, for PCB analyses. Wipe, water, and soil samples collected during equipment decontamination/closure activities also were sent to the off-site laboratory for PCB analyses. All sample bottles were stored on ice. When samples were received at the laboratory, the sample custodian verified each sample against the chain-of-custody forms, noted any discrepancies or loss of samples, and then signed for receipt of the samples. Samples remained under the control of the sample custodian until the samples were transferred to the analysts for processing.

WESTERN

SECTION 9

DATA ANALYSIS

9. DATA ANALYSIS

9.1 Field data. The demonstration classified the process variables into independent, control, and response variables. A summary of test data associated with the demonstration test is presented in Appendix G, Table G-1.

9.2 Analytical data. Feed and processed soils were analyzed for the VOCs and semivolatile organic compounds listed in Table 8-2. All contaminants with concentrations higher than GCLs shown in Table 5-1 were selected for analysis. In addition, contaminants that are potential constituents of JP-4 fuel were included in the analyses.

After observing tentatively identified compounds (TICs) during the semivolatile analyses, on-site PCB contamination was suspected. Feed and processed soil samples of Test 4 were analyzed for PCBs to confirm suspected contamination. During the equipment decontamination period, wipe samples from the LT^3 Process Equipment, water from the wash tanks, and soil samples from backfill and process equipment areas were also collected and analyzed for PCBs.

A detailed listing of the analytical results is presented in Appendix H. For convenience, contaminant concentrations of feed and processed soils, contaminant removal efficiencies, and GCLs for semivolatiles and VOCs from the demonstration are presented in Tables G-2 through G-5.

9.3 Effectiveness of the LT^3 System.

9.3.1 Goal cleanup levels (GCLs). A summary of Toxic Characteristic Leachate Procedure (TCLP) concentrations of the contaminants with assigned GCLs for feed and processed soils is presented in Table 9-1. Cleanup levels for the compounds that were expected at the site were set based on TCLP extract concentrations. The reason for this is that cleanup standards are usually based on leachable concentrations of the contaminants of concern.

Several days are required to obtain the TCLP results. Because the test run sequence was dependent on the analytical results of the previous day's test, a quick estimating method was used to conservatively project the concentrations of the leached contaminants from the sample. This expedited the testing program.

The estimated value was determined by analyzing the soil samples by the GC/MS method, and dividing that value by the leachate dilution factor of 20. The improbable but conservative assumption implied by this procedure is that 100 percent of the contaminant would be leached.

Table 9-1. Summary of processed soil concentrations for the contaminants with assigned goal cleanup levels.

Analyte	Test 1 Oil Temperature 600°F Residence Time 40 min.		Test 2 Oil Temperature 400°F Residence Time 40 min.		Test 4 Oil Temperature 400°F Residence Time 35 min.		Test 8 Oil Temperature 500°F Residence Time 40 min.		Goal Cleanup Level (ug/L)
	Soil Concentration		Soil Concentration		Soil Concentration		Soil Concentration		
	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	
Volatiles									
Vinyl chloride	<3,500	0.2	<3,600	0.2	<1,600	0.2	<1,600	0.2	50
Dichloromethane	<1,800	0.1	<1,800	0.1	<800	0.1	<800	0.1	960
1,1-Dichloroethene	<1,800	0.1	<1,800	0.1	<800	0.1	<800	0.1	100
Chloroform	140 J	0.1	180 J	0.1	<800	0.1	<800	0.1	70
1,2-Dichloroethane	<1,800	0.1	<1,800	0.1	<800	0.1	<800	0.1	400
1,1,1-Trichloroethane	<1,800	0.1	<1,800	0.1	<800	0.1	<800	0.1	410
Trichloroethene	37,250	0.3	111,000 (b)	0.3	10,575	1.2	8,500	2.3	70
Tetrachloroethene	2,760 J	0.1	3,985 J	0.1	613 J	0.0	650 J	0.1	50
2-Butanone	<11,000	0.6	<11,000	0.6	<4,800	0.6	<4,800	0.6	750
Benzene*	<1,800	0.1	<1,800	0.1	745 J	0.1	136 J	0.4	75
Toluene*	<1,800	0.1	8,300	0.1	200 J	0.1	18 J	0.0	330
Chlorobenzene*	<1,800	0.1	<1,800	0.1	<800	0.1	<800	0.1	50
Ethylbenzene*	<1,800	0.1	960 J	0.1	<800	0.1	<800	0.1	53

(a) TCLP concentrations. TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).

(b) Higher than detection range, estimated value. Replicate indicated an estimated value less than detection limit, however, sample replicate integrity is suspect.

* - Potential constituent of JP-4 fuel.

< - Not detected at the specified detection limit.

J - Less than detection limit, estimated value.

8632B

Table 9-1. (continued)

Analyte	Test 1 Oil Temperature 600°F Residence Time 40 min.		Test 2 Oil Temperature 400°F Residence Time 40 min.		Test 4 Oil Temperature 400°F Residence Time 35 min.		Test 8 Oil Temperature 500°F Residence Time 40 min.		Goal Cleanup Level (ug/L)
	Soil Concentration		Soil Concentration		Soil Concentration		Soil Concentration		
	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	Feed (ug/kg)	Processed (ug/L)(a)	
Semivolatiles									
1,2-Dichlorobenzene	35,000	6 J	15,000	10 J	53,000	6 J	13,500	4 J	125
1,4-Dichlorobenzene	8,700	6 J	3,600 J	<100	14,750	1 J	4,300 J	1 J	10,800
Fluoranthene*	<3,300	<10	2,900 J	<100	1,750 J	10 J	705 J	<20	140
Benzo(a)anthracene*	<3,300	<10	<3,800	<100	<3,900	<10	<4,300	<20	8.7
Benzo(a)pyrene*	<3,300	<10	<3,800	<100	<3,900	<10	<4,300	<20	15
Benzo(b)fluoranthene*	<3,300	<10	<3,800	<100	<3,900	<10	<4,300	<20	12
Chrysene*	<3,300	<10	<3,800	<100	<3,900	10 J	<4,300	<20	100
Dibenzo(a,h)anthracene*	<3,300	<10	<3,800	<100	<3,900	10 J	<4,300	<20	20
Acenaphthene*	<3,300	<10	<3,800	<100	<3,900	10 J	<4,300	<20	1,200
Acenaphthylene*	<3,300	<10	<3,800	<100	370 J	10 J	<4,300	<20	660
Anthracene*	60 J	<10	770 J	<100	120 J	10 J	<4,300	<20	660
Benzo(g,h,i)perylene*	<3,300	<10	<3,800	<100	<3,900	<10	<4,300	<20	51
Fluorene*	<3,300	<10	<3,800	<100	325 J	<10	<4,300	<20	140
Indeno(1,2,3-c,d)pyrene*	<3,300	<50	<3,800	<500	<20,000	<50	<22,000	<100	29
Phenanthrene*	790 J	<10	820 J	<100	960 J	1 J	320 J	<20	600
Pyrene*	280 J	<10	90 J	<100	785 J	<10	185 J	<20	180
Benzo(k)fluoranthene*	<3,300	<10	<3,800	<100	<3,900	<10	<4,300	<20	11

(a) TCLP concentrations. TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).

(b) Higher than detection range, estimated value. Replicate indicated an estimated value less than detection limit, however, sample replicate integrity is suspect.

* - Potential constituent of JP-4 fuel.

< - Not detected at the specified detection limit.

J - Less than detection limit, estimated value.

86328

The estimated values were verified for semivolatiles when the TCLP extract was analyzed. For volatiles, no TCLP was conducted; however, the results from the quick estimating method indicated that the concentrations were below goal cleanup levels.

To illustrate this procedure and its conservative nature, examine the results for 1,2-dichlorobenzene in Test 1. The concentration of 1,2-dichlorobenzene in the soil determined by the GC/MS method was 540 ug/kg. Dividing this value by the dilution factor of 20 provides an estimate for the leachate concentration of 27 ug/L. The concentration of 1,2-dichlorobenzene determined by GC/MS analysis of the leachate was 6 ug/L thus, demonstrating the conservative characteristic of the estimating procedure.

Goal cleanup levels were readily met for all VOCs, including TCE, during all four tests. This can be seen by comparing the results for volatiles for each test in Table 9-1 with the GCLs listed.

The goal cleanup levels for semivolatiles also were achieved in most cases; however, in some cases, the GCLs were below the analytical detection limit. When this occurred, it was not possible to claim that goal cleanup levels were met. In these cases, the compound was not detected even in the feed soil. A specific discussion of the compounds where this occurred follows.

Benzo(a)anthracene had a GCL of 8.7 ug/L, and the analytical results of both the feed and processed soils, and their leachates, did not detect this compound. The results of tests 1,2,4, and 8 showed that benzo(a)anthracene was at concentrations of <10, <100, <10, and <20 ug/L, respectively. These results represent detection limits and indicate only the lowest level for which a quantitative analysis can be made. The compound was not detected at this level.

Benzo(a)pyrene had a GCL of 15 ug/L and was not detected in the feed or processed soil leachates for Tests 1 and 4. Similarly, it was not detected in Tests 2 and 8, but the detection limits in the analysis for these tests were higher due to dilution factors. Because the detection limits for Tests 2 and 8 were higher than the GCL, no claim can be made that the GCL was achieved.

In Test 4, at lower temperatures and shorter residence times, the GCL was met and, therefore, it logically follows that the GCL would have been met if measurements at lower detection limits would have been made.

Benzo(a)fluoranthene had a GCL of 12 ug/L and was not detected in the feed or processed soils or in the leachates in any of the tests. Because the GCL is lower than the detection

limit, it cannot be said that the GCL was met, although the presence of this compound at any level is doubtful.

Indeno(1,2,3-c,d)pyrene had a GCL of 29 ug/L and was not detected in feed or processed soils or in the leachates, but detection limits in all cases were greater than GCL.

The concentrations of semivolatiles, where present, were reduced to at least as low as the respective detection limits. In addition, the compounds (where it was possible to measure down to or below the GCL results) indicate that goal cleanup levels were achieved. Comparison of goal cleanup levels for semivolatiles and analytical results are presented in Table 9-1.

Within the detectable range for volatiles and semivolatiles, no discernable difference is indicated in removing these compounds for the test conditions of the demonstration. All test results indicate that the tests were successful and no statement can be made that one test was more successful than another. Therefore, the optimum test conditions are those that are most economical. These conditions were successfully demonstrated in Test 4, with a residence time of 35 minutes and a processed soil temperature of approximately 215°F.

9.3.2 Contaminant removal efficiency. Table 9-2 lists contaminant removal efficiencies for those contaminants detected in the feed soil. Contaminant removal efficiencies for most of the VOCs, including TCE, were greater than 99 percent. The lowest VOC removal efficiency was 92 percent for o,p-xylenes during Test 8.

Semivolatile results also indicate substantial removal efficiencies for most of the contaminants. In cases where relatively low removal efficiencies are recorded, the concentrations in the feed soil were significantly small.

The contaminant removal efficiencies of VOCs and semivolatiles show no significant sensitivity toward the oil temperatures or residence times of the tests conducted. The residence times and oil temperatures tested were sufficient to meet the GCLs.

9.4 Impact on system performance by adding a stripping agent. Because the test program was discontinued, due to the detection of PCBs in feed and processed soils, stripping agents were not used during the demonstration.

At the time the demonstration was discontinued, consideration was being given to determine the most suitable solvent and the method and location of solvent addition. No resolution was reached, but the primary concern was for any potential safety hazard that might be associated with the solvent selected, for example hexane. The introduction of a flammable solvent into a

WESTON

Table 9-2. Contaminant removal efficiencies for detected compounds.

Test Number	1	2	4	8
Oil Temperature (°F)	600	400	400	500
Residence Time (min)	40	40	35	40
Analyte	**Contaminant Removal Efficiency**			
Volatiles				
Trichlorofluoromethane	>99.43	>99.39	ND	>99.03
trans-1,2-Dichloroethene	>99.74	>99.75	>99.03	>97.84
Chloroform	>98.57	>98.89	ND	ND
Trichloroethene	99.986	>99.995	99.78	99.46
Tetrachloroethene	>99.93	>99.95	>99.92	>99.89
Benzene	ND	ND	>99.83	>93.60
Toluene	ND	>99.98	>99.45	>94.86
Ethylbenzene	ND	>99.79	ND	>99.74
m-Xylene	>99.89	>99.94	ND	>99.98
o,p-Xylenes	>99.82	>99.91	ND	>91.58
Semivolatiles				
1,2-Dichlorobenzene	>98.46	>93.67	>98.93	>97.78
1,4-Dichlorobenzene	>63.22	>93.89	>98.95	>20.93
2-Methylnaphthalene	ND	ND	>87.98	>82.00
1,3-Dichlorobenzene	>8.57	>93.33	>46.88	ND
Fluoranthene	>48.48	ND	>45.71	>4.40
Naphthalene	>96.98	>97.40	>96.25	>93.17
Anthracene	ND	ND	>66.67	ND
Benzo(g,h,i)perylene	ND	ND	>98.72	ND
Fluorene	ND	>94.74	>52.31	ND
Phenanthrene	>41.77	>18.29	>48.96	>6.25
Pyrene	ND	ND	>48.41	ND
4-Chloroaniline	ND	ND	>17.72	ND

ND - Could not be determined from analysis.

> - Greater than

heated environment where sparking from metal to metal contact could occur, needs further consideration.

9.5 Continuous emissions monitoring (CEM) results. Oxygen, carbon monoxide, carbon dioxide, and total hydrocarbons were continuously monitored at the afterburner exit.

Figure 9-1 graphically depicts the oxygen concentrations at the afterburner outlet for the four tests conducted. A minimum of 3 percent excess oxygen at the outlet was required by permit conditions. This condition was met during all tests. An elevated oxygen concentration was recorded during Test 8. The unusual reading was apparently caused by an air leak in the system, allowing the ambient air to enter. All connections were subsequently checked and tightened.

The carbon monoxide concentration requirement was less than 25 ppm by volume. As shown in Figure 9-2, this condition was achieved throughout the demonstration, except in one instance, where the recorded level was 34 ppm. The elevated level must have been instantaneous. If it had lasted for a prolonged period, the feed system would have been automatically shut down due to the exceedence of the rolling average limitation.

Figure 9-3 depicts total hydrocarbons concentrations at the afterburner outlet. The required upper limit of 20 ppm by volume was not exceeded during any tests.

9.6 Scrubber liquor pH. The scrubber liquor pH levels are shown in Figure 9-4. A pH of 7 or above was maintained during Tests 1, 4, and 8. During Test 2, a pH of 6.8 was recorded during the early stages of the test. The high peak seen toward the end of the test may have been the response resulting from raising the 6.8 pH reading.

9.7 Optimum range of operational parameters for testing contaminated soils. As discussed in Subsection 9.3, all four completed tests indicate similar results regarding GCLs and removal of VOCs and semivolatiles from contaminated soil. All tests demonstrated a high performance level in achieving clean-up objectives; however, none of the tests indicate a significant difference in their final results. This similarity indicates that the limiting conditions of the operating parameters, with respect to contaminant removal, are outside the range of the tests performed.

Taking all attempted tests into consideration, it is possible to establish a lower limit as a result of the physical performance, i.e., a lower oil temperature and corresponding processed soil temperature, and a lower residence time. Accordingly, the lower limit during the demonstration was an oil temperature of 400°F, a processed soil temperature of 215°F, and a residence time of 35 minutes.

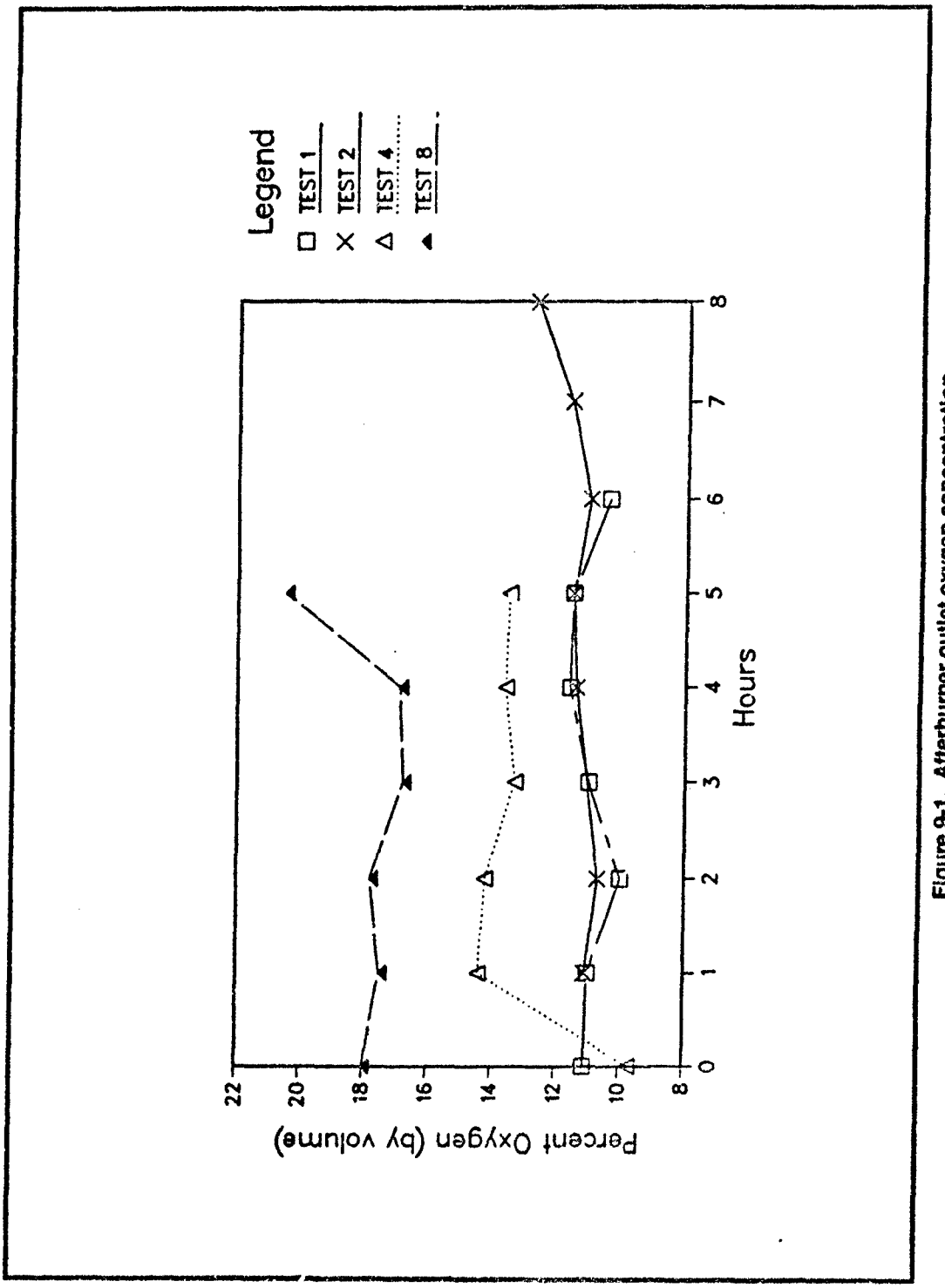


Figure 9-1. Afterburner outlet oxygen concentration.

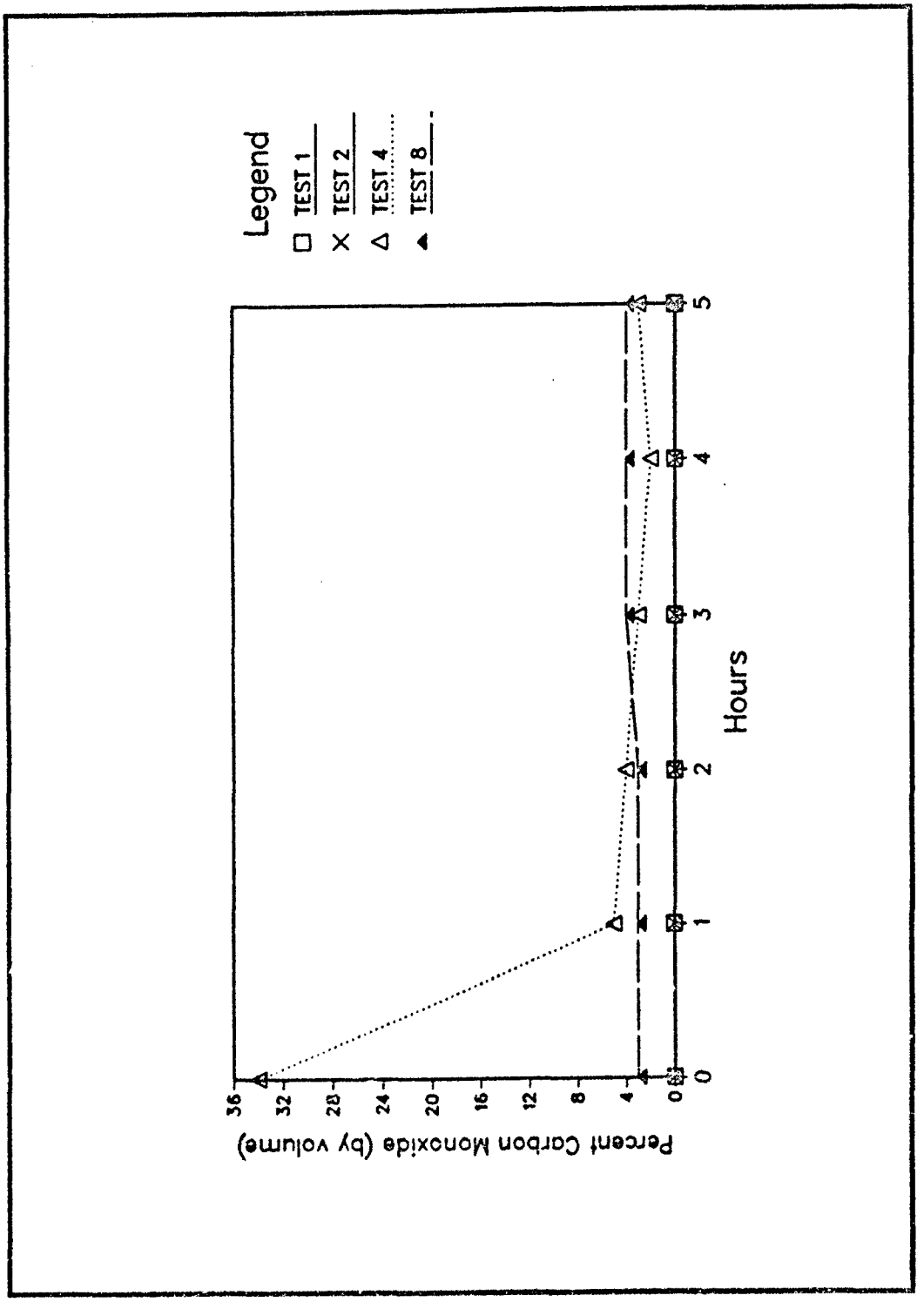


Figure 9-2. Afterburner outlet carbon monoxide concentration.

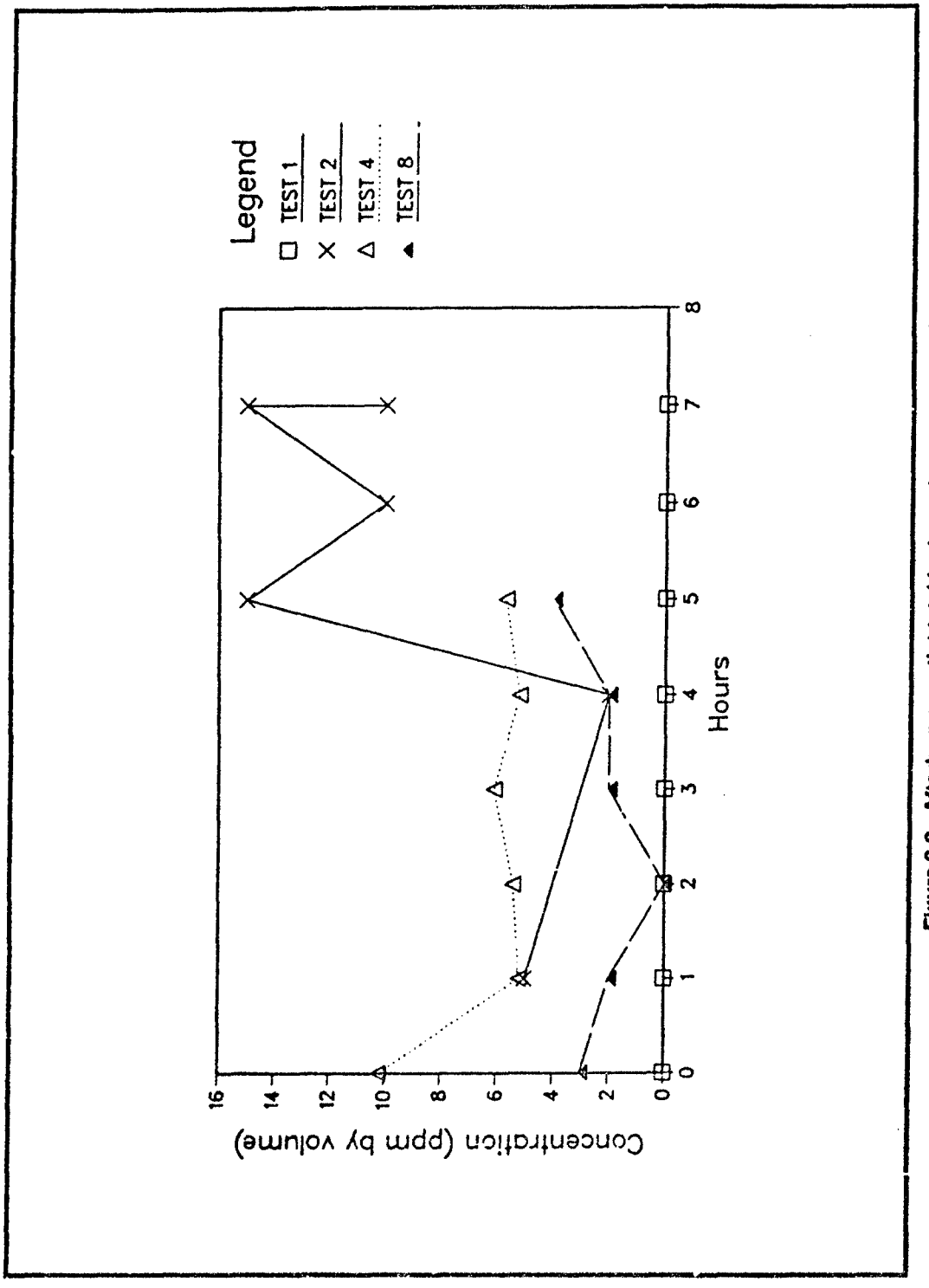


Figure 9-3. Afterburner outlet total hydrocarbon concentration.

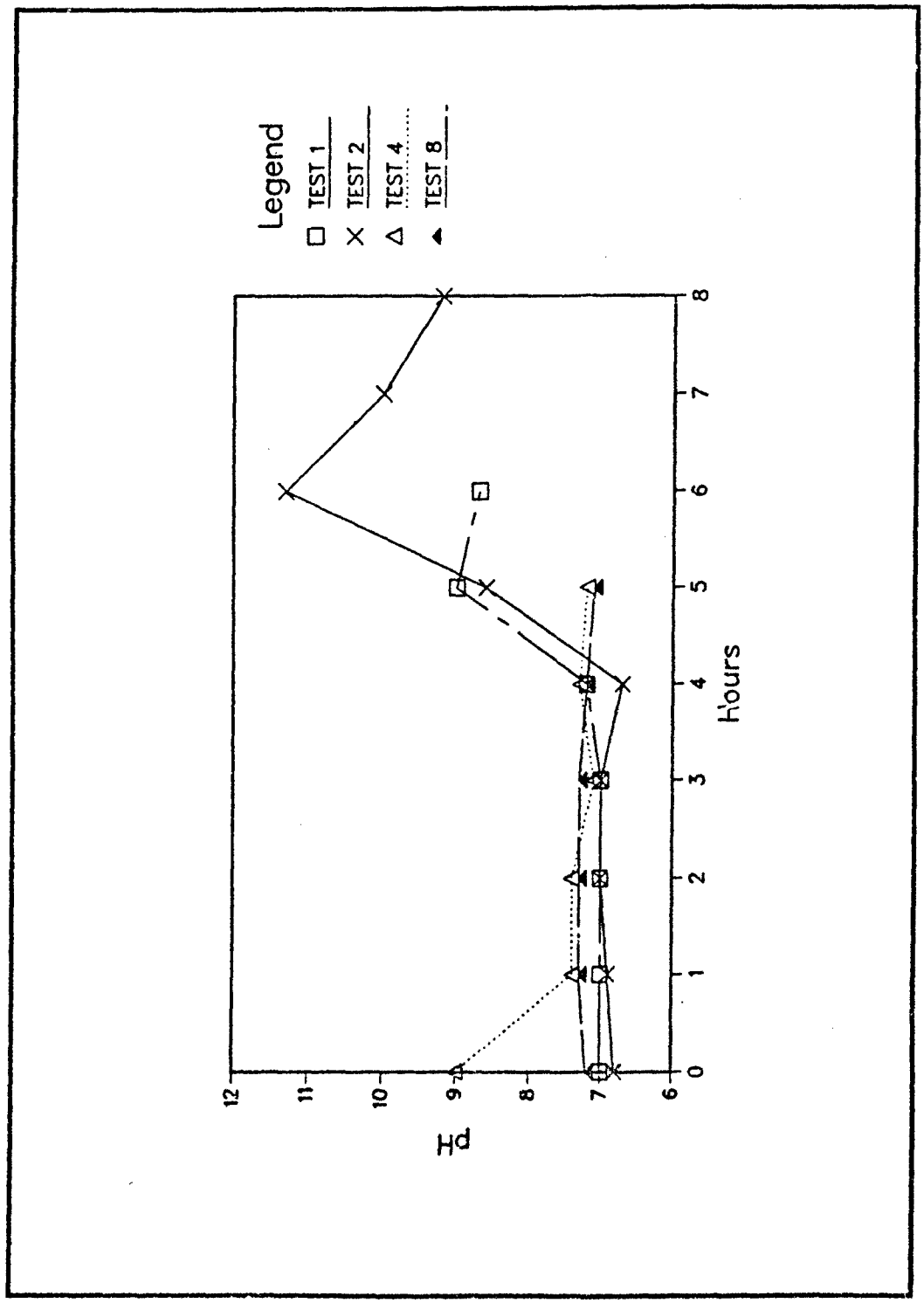


Figure 9-4. Scrubber liquor pH level.

A summary of chemical and physical performance of each test is presented in Table 9-3. The chemical performance is evaluated by comparing the GCLs to the analytical results. The physical performance is denoted by the material handling characteristics, i.e., too wet, steam formation, draft problems, etc.

During Tests 5, 6, and 7, a positive pressure was measured in the thermal processor, possibly caused by excessive steam formation. The steam may have been introduced by the soil conditioner due to the absence of a seal between the discharge conveyor and the thermal processor. This problem is representative of the mechanical limitations of the system; however, it can not be considered as a failure to meet cleanup objectives. Seals have been installed in the system and further improvements are planned to eliminate this condition. Test 9 was not conducted since the feed soil was too wet to process, plugging the chute beneath the clay shredder.

The only test that indicated a definite mechanical failure was Test 3. Soil was plugged in the conditioner, and the discharge conveyor was jammed. The cause for the failure is probably due to the combination of low oil temperature (300°F), low processed soil temperature (197°F), and short residence time (30 min). Therefore, the lower cutoff limits for operating the LT^3 System, based on physical/mechanical conditions, are an oil temperature of 300°F and a residence time of 30 minutes.

Since the four completed tests demonstrate similar performance in achieving cleanup objectives, the upper limit may be established at levels associated with the most economical operating conditions. Test 4 was successfully completed with the lowest temperature (400°F) and the lowest residence time (35 min), thereby expending the least amount of energy and achieving the maximum throughput (lowest residence time). During Test 4, throughputs of 22,100 lbs/hr during the stabilization period and 20,000 lbs/hr during the processing period were achieved. These rates are significantly higher than the design processing rate of 15,000 lbs/hr.

The optimum operating range, based on the results of the demonstration test as discussed, is shown in Figure 9-5. This range could be further defined if more tests are conducted. Conclusively, the best operating conditions for successful LT^3 System operation to decontaminate contaminated soil lie within the shaded area of the figure.

9.8 Results of PCB decontamination. During the demonstration test, PCBs were suspected in feed and processed soils. As a result, Test 4 soil samples were analyzed for PCBs. The test results confirmed the presence of PCBs in the feed and processed soils.

Table 9-3. Performance of tests

Test No.	Oil Temperature (°F)	Residence Time (min)	Processed Soil Temperature (°F)	Performance		
				Chemical	Physical	
1	600	40	380	Passed	Passed	
2	400	40	224	Passed	Passed	
3	300	30	197	(b)	Failed	-- discharge conveyor was jamming; plugging in soil conditioner.
4	400	35	214	Passed (a)	Passed	
5	500	35		(b)	Failed	-- stack conveyor jamming; positive pressure.
6	500	35		(b)	Failed	-- positive pressure; fabric filters caked.
7	450	40		(b)	Failed	-- positive pressure.
8	500	40	269	Passed	Passed	
9	500	30		(b)	(c)	-- feed soil was too wet to process, plugged feed system.

(a) PCBs were detected in feed and processed soils.
(b) Not sampled due to mechanical failures preventing completion of the test.
(c) Test was not started.

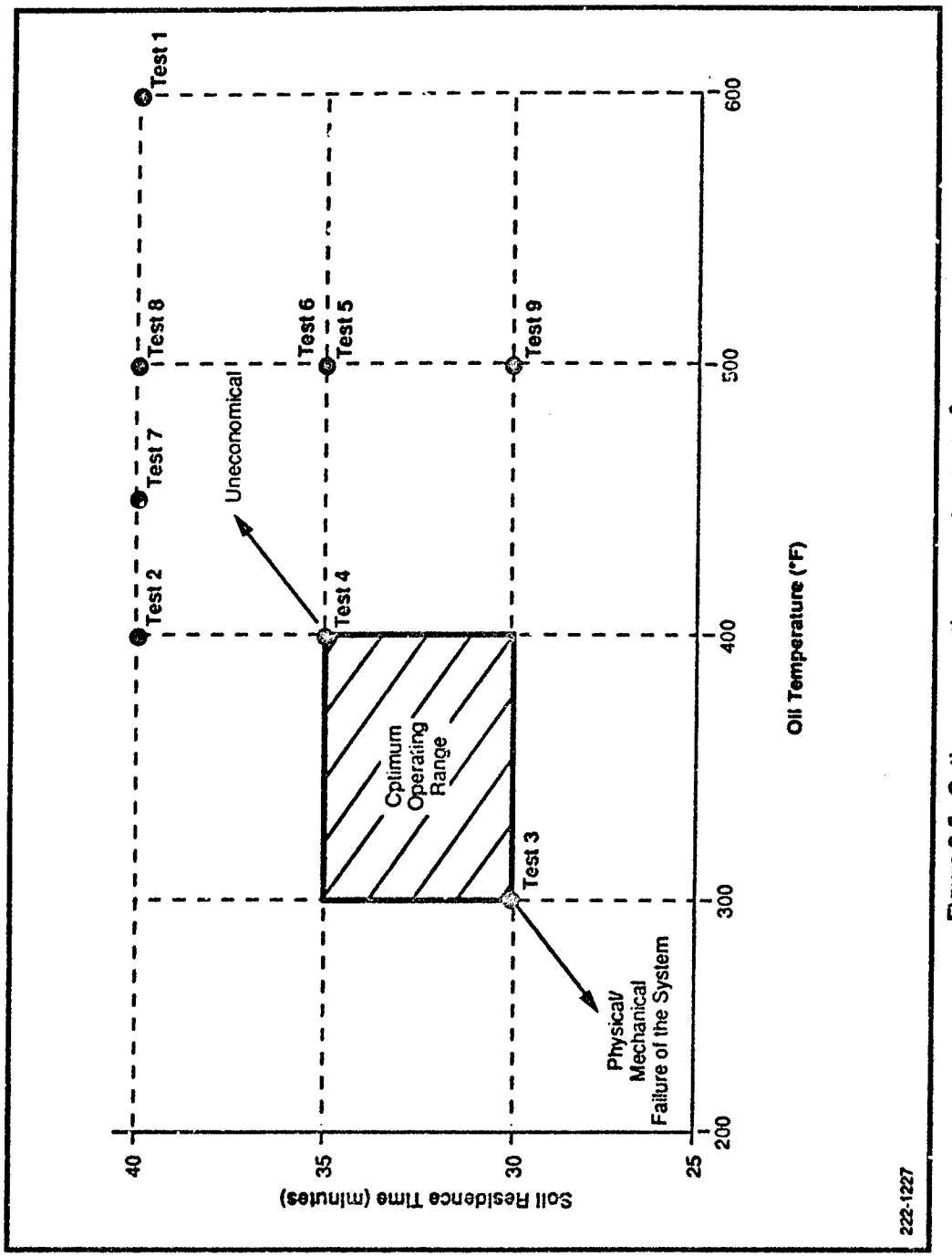


Figure 9-5. Optimum operating range for the LT^{3}SM System.

Following the discovery of PCBs in the soil and the subsequent cancellation of the remaining tests, an equipment decontamination operation was conducted to decontaminate LT^3 Process Equipment and site trailers. Appendix A contains the Equipment Decontamination Plan that was approved by EPA Region VI and Tinker Air Force Base. Protective measures were also taken to minimize the potential for off-site contamination, as described in the Exit Plan, presented in Appendix B. According to the Exit Plan, scattered PCB-contaminated soil stockpiles were excavated, stockpiled again on plastic liners, and permanently covered with a clay cap. Subsequently, soil samples were collected from stockpile areas and process equipment placement areas and analyzed for PCBs.

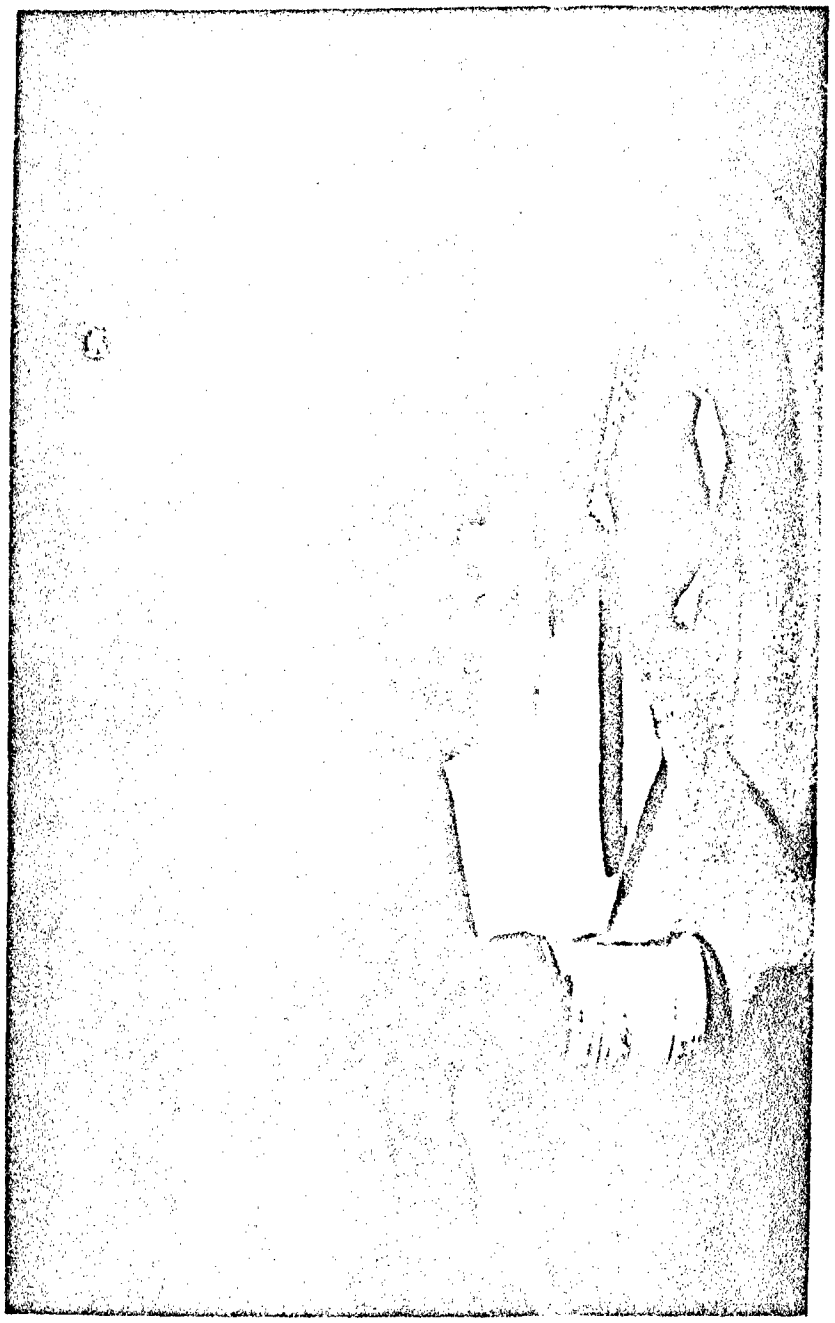
9.8.1 Decontamination criteria for LT^3 Equipment. Wipe samples were collected from various locations on the process equipment and analyzed for PCBs. A goal decontamination level of 10 micrograms per 100 square centimeters was specified, per 40 CFR 761.125.c.4, "Requirements for Decontaminating Spills in Non-Restricted Areas." If the wipe test results exceeded the decontamination criteria, the item was decontaminated again, and resampled.

9.8.2 Decontamination criteria for washwater holding tanks. After all the process equipment and site trailers were decontaminated and certified, the three 1,000-gallon tanks used to process and store washwater were decontaminated. The sequence of the tank decontamination is described in Subsection 1.4 of Appendix A. The designated goal decontamination level for washwater was 50 parts per billion (ppb).

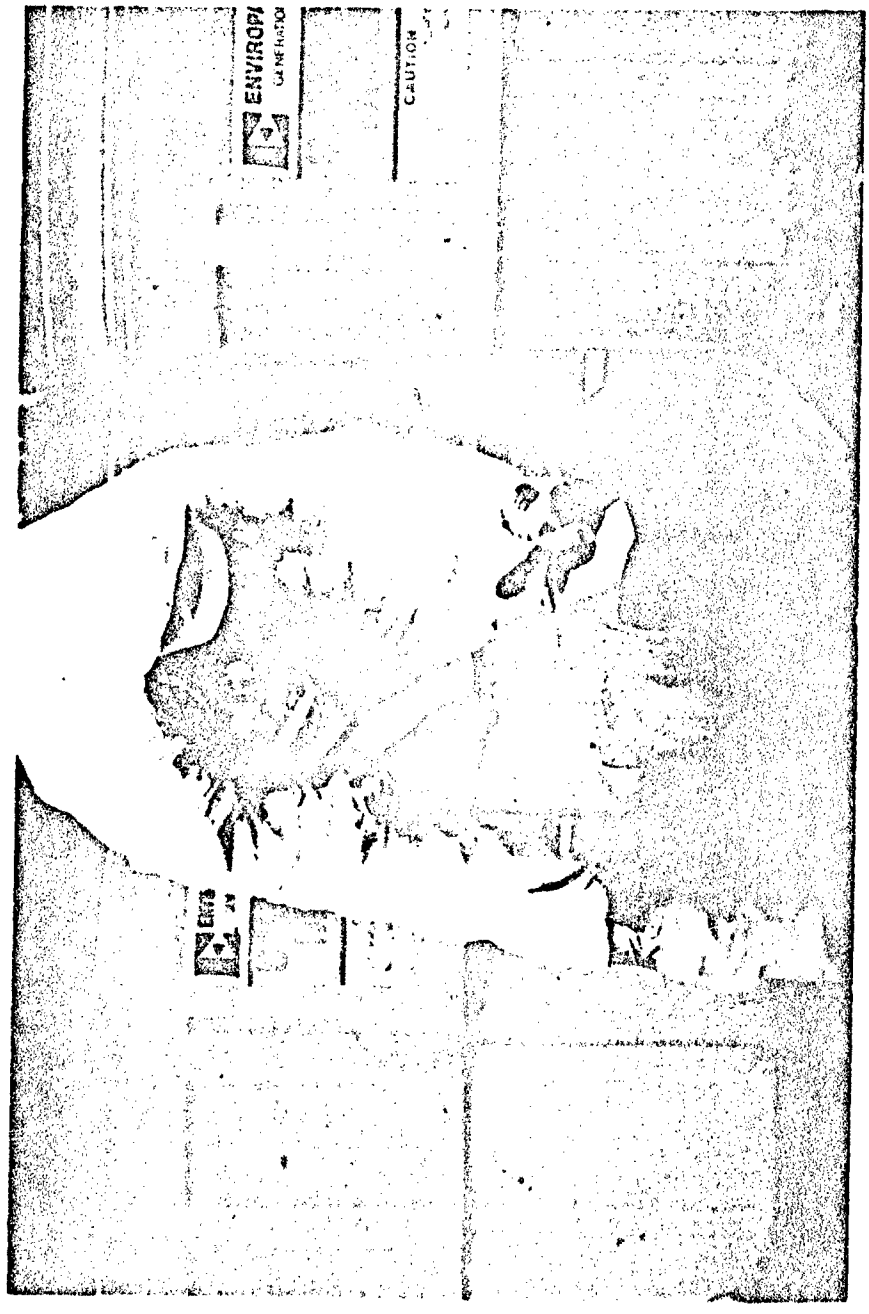
9.8.3 Cleanup criteria for soil from stockpile and equipment placement areas. As described in the Exit Plan, 2 inches of soil was scraped from the process equipment placement areas and stockpile areas 3 through 9 as shown in Figure B-1. Areas were then divided into grids for confirmation of surface quality. Procedures described in EPA document 560/5-86-017, "Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanups," were employed for sampling and analysis. PCB concentrations below 25 ppm were required to certify a clean grid. If a grid was not confirmed clean, another 2 to 6 inches was scraped off, and the sampling procedure was repeated.

9.8.4 Results of PCB analyses. Designated PCB cleanup criteria were met for wipe, water, and soil samples, specified in Subsections 9.8.1 through 9.8.3. Repeat operations were conducted in certain cases, as appropriate, until the cleanup objectives were met. Sample collection was documented and detailed records were kept. Photograph 8 shows the logbooks and sampling equipment.

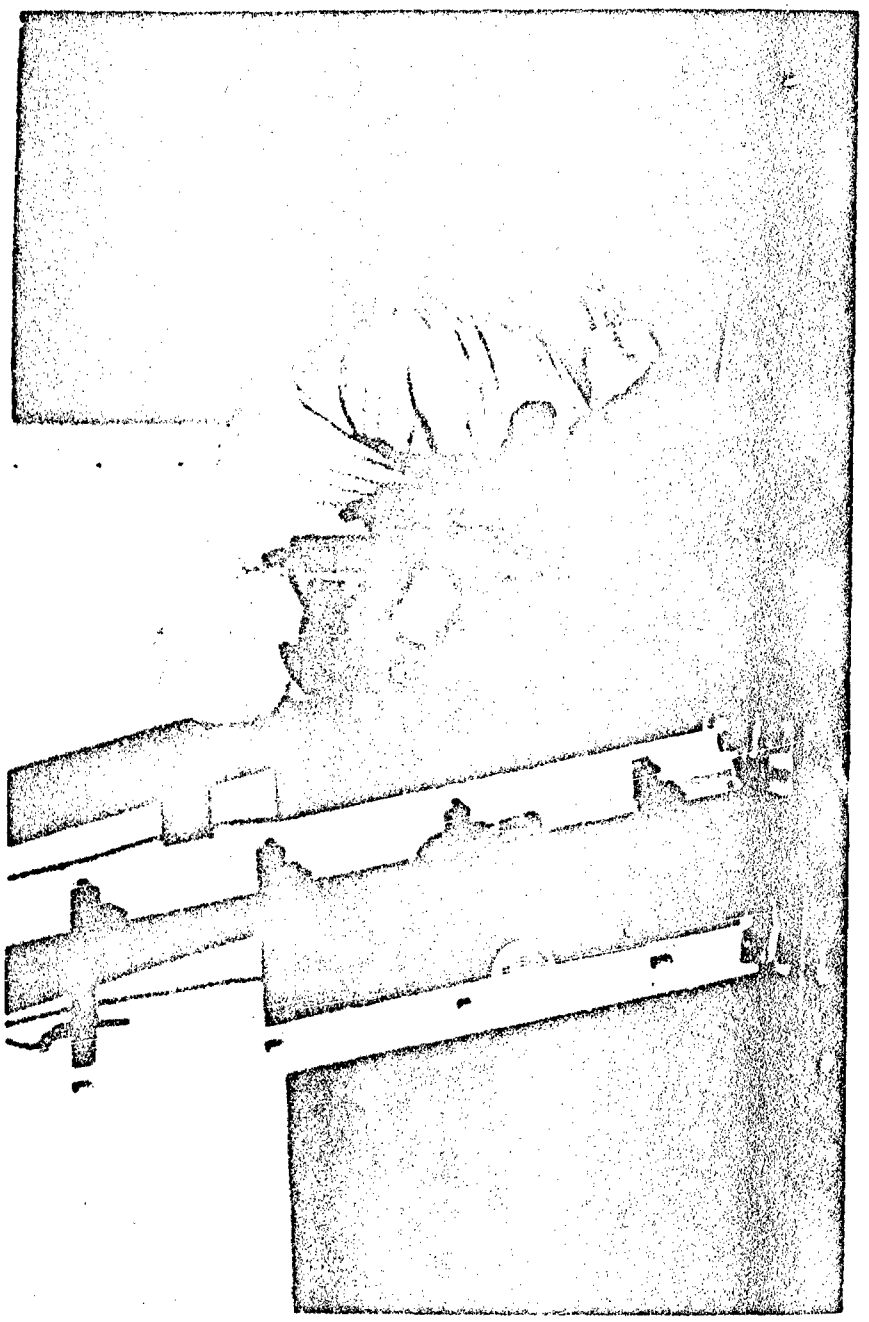
All samples were analyzed at the WESTON Analytics Laboratory in Lionville, Pennsylvania. Photographs 9, 10, 11, and 12 show personnel preparing material for placement in overpacks,



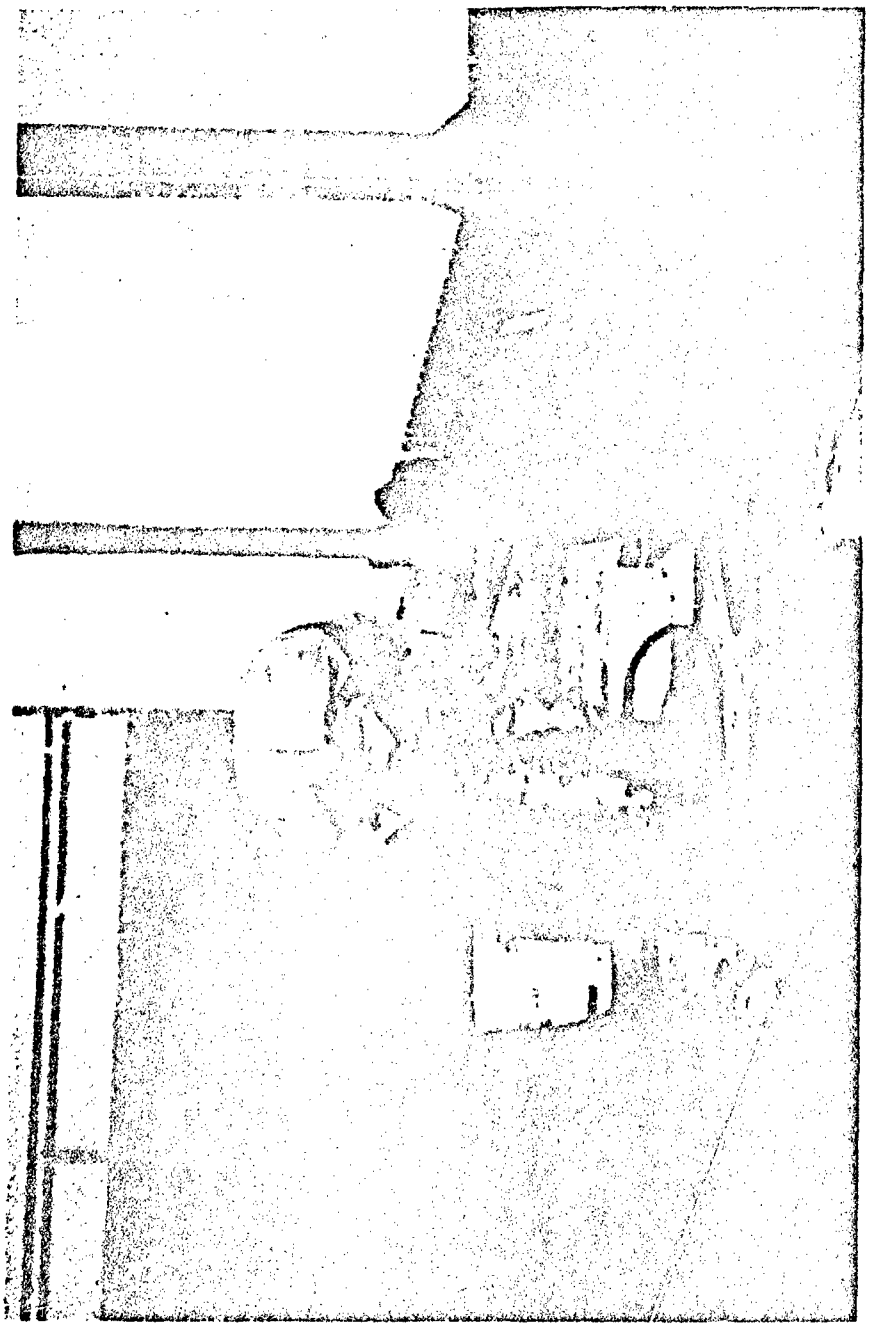
Photograph No. 8. PCB analysis logbooks and sampling equipment.



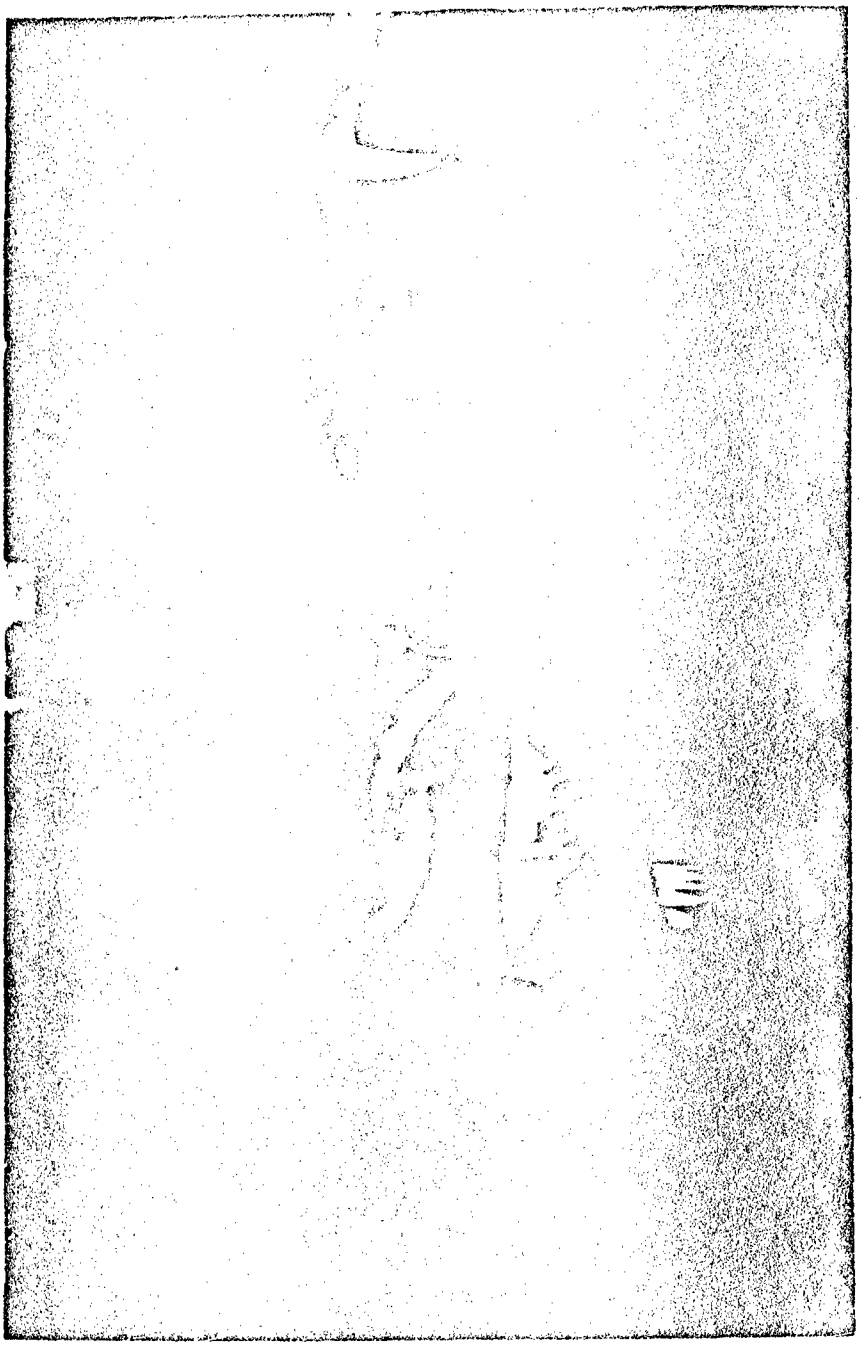
Photograph No. 9. Preparing PCB-contaminated material for placement in an overpack.



Photograph No. 10. Wipe testing potentially contaminated equipment.



Photograph No. 11. Steam cleaning a PCB-contaminated trailer.



Photograph No. 12. Steam cleaning the weigh scale.

wipe testing, and steam cleaning equipment during decontamination activities, respectively. Photograph 13 shows decontaminated material in a holding area pending confirmation that it was clean.

9.9 System Economics The objective of this subsection is to present a preliminary economic analysis of the LT^3 Process for treating JP-4 and chlorinated organic contaminated soil. This section presents estimated costs for a contractor-owned and operated LT^3 System. The economic analysis approach was selected since it is consistent with current DOD procurement practices for remedial action projects under the Installation Restoration Program (IRP). It is also consistent with the manner in which WESTON and other competitors in this marketplace currently bid site remediation projects.

With this approach, equipment capital costs are included in an equipment usage fee that is established to allow straight-line equipment depreciation over a 7-year life, interest payments on the outstanding capital, and an appropriate annual equipment maintenance allowance. Using this approach, all costs can be divided into two categories:

- Fixed Costs -- Include all costs that are constant regardless of the quantity treated. These costs include mobilization, utility connections, site preparation, equipment startup, and shakedown. The fixed costs also include demobilization and returning the site to prework conditions following the completion of site operations.

- Variable Costs -- Include all costs that are dependent upon the number of tons treated. These costs include the system usage fee and all of the operational costs during site operations. Some of these costs vary with days of operation (e.g., labor, equipment rental, etc.), and some vary with the quantity treated (e.g., fuel, carbon usage, etc.). Table 9-4 provides a summary of the variable cost elements and the basis for estimation.

9.9.1 Fixed costs. The fixed costs for the LT^3 Process are sensitive to a number of factors such as:

- Site location.
- Site preparation required.
- Availability of utilities.
- Local per diem rates.
- Scrubber system requirements.

Typically, total fixed costs range from $100,000 to $120,000 without a scrubber, and from $130,000 to $150,000 with a scrubber. This range assumes a remote installation with propane tanks for fuel storage and electrical power available at

Photograph No. 13. Decontaminated equipment in the holding area pending laboratory analysis of wipe samples.

WESTEN

Table 9-4. Summary of the variable cost elements and the basis for estimation

Variable Cost	Cost Estimating Basis
Propane (10.7 mm Btu/hr)	Per ton processed
Electric power (600 amps)	Hourly rate
Loader fuel	Hourly rate
Front-end loader	Monthly lease rate
Carbon and disposal	Per ton processed
Separator disposal	Per ton processed
Miscellaneous expenses	Daily rates
Dump trucks	Monthly lease rate
Propane tanks	Monthly lease rate
Calibration gases	Daily rate
Caustic	Per ton processed
Out-of-town expenses	Daily rate
Sanitary facilities and phone	Monthly lease rate
Office Labor	Hours worked
Field labor	Hours worked
Equipment usage fee	Weekly usage fee

the site. For this analysis, it is conservatively assumed that a scrubber will be required and the total fixed costs will be $150,000. The fixed costs do not include environmental permitting, which must be considered on a site-specific basis.

9.9.2 Variable costs. The estimated LT^3 System variable costs are presented in Figure 9-6. These costs do not include costs for any required laboratory analyses to comply with permit conditions. As shown in the figure, the incremental variable costs on a dollars/ton basis are sensitive to the LT^3 System processing rate. The maximum sustained processing rate demonstrated while meeting all established goal cleanup levels was 10 tons/hr. The estimated variable costs associated with a processing rate of 10 tons/hr is approximately $71/ton. However, it is not practical to assume that a maximum processing rate can be sustained on a 24-hour per day, 7-day per week basis. WESTON typically assumes an 80 percent availability factor for sustained operations. Using this assumption, with a sustained average operating rate of 8 tons/hr, the estimated LT^3 System variable costs are approximately $86/ton.

This cost is a considerable improvement over the anticipated processing costs. Prior to this program, WESTON had conservatively assumed that the maximum design processing rate was 7.5 tons/hr, with a sustained average processing rate of 6 tons/hr. As shown in Figure 9-6, this throughput corresponds to a variable cost of approximately $111/ton. Therefore, this demonstration program has resulted in approximately a 23 percent reduction in estimated LT^3 System variable costs.

9.9.3 Total costs. Figure 9-7 provides a summary of the total costs, which are the sum of the estimated fixed costs of $150,000 divided by the total quantity of soil, and the variable costs at the assumed processing rates. For convenience, Figure 9-7 provides estimated total costs (on a dollars/ton basis) for sustained average processing rates of 6, 8, and 10 tons/hr. As discussed above, based on the results of the Tinker Air Force Base demonstration, a processing rate of 8 tons/hr is a reasonable assumption. The 6 tons/hr curve represents the anticipated total costs prior to this demonstration program. The 10 tons/hr curve represents the potential room for improvement with the implementation of LT^3 System modifications proposed in this report.

Figure 9-7 presents the estimated total costs for sites with soil quantities of 1,000 to 10,000 tons. As shown in the figure, as the quantity of soil increases, the impact of the fixed cost diminishes, and the total costs asymptotically approach the unit variable costs.

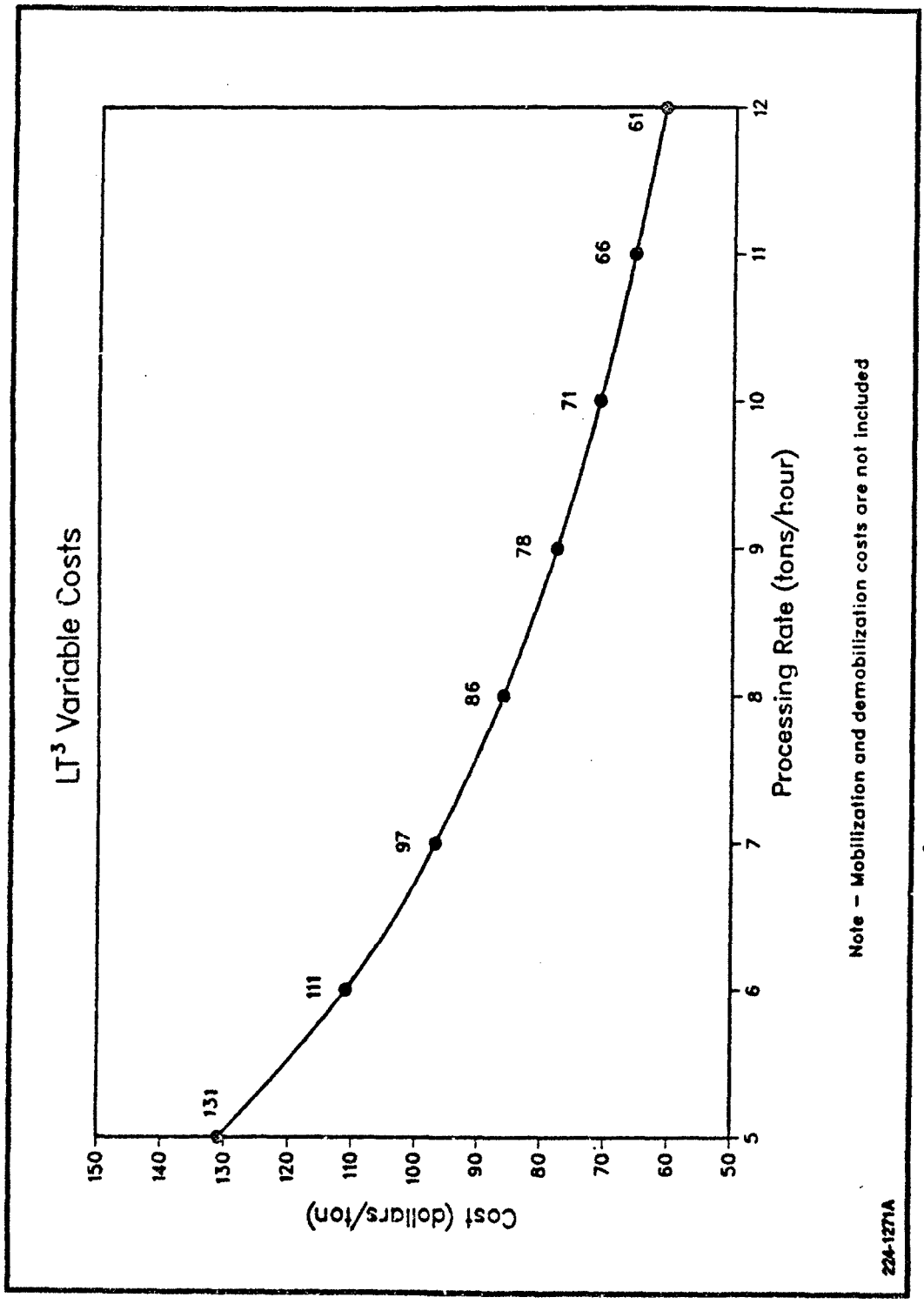


Figure 9-6. LT³ System variable costs for various processing rates.

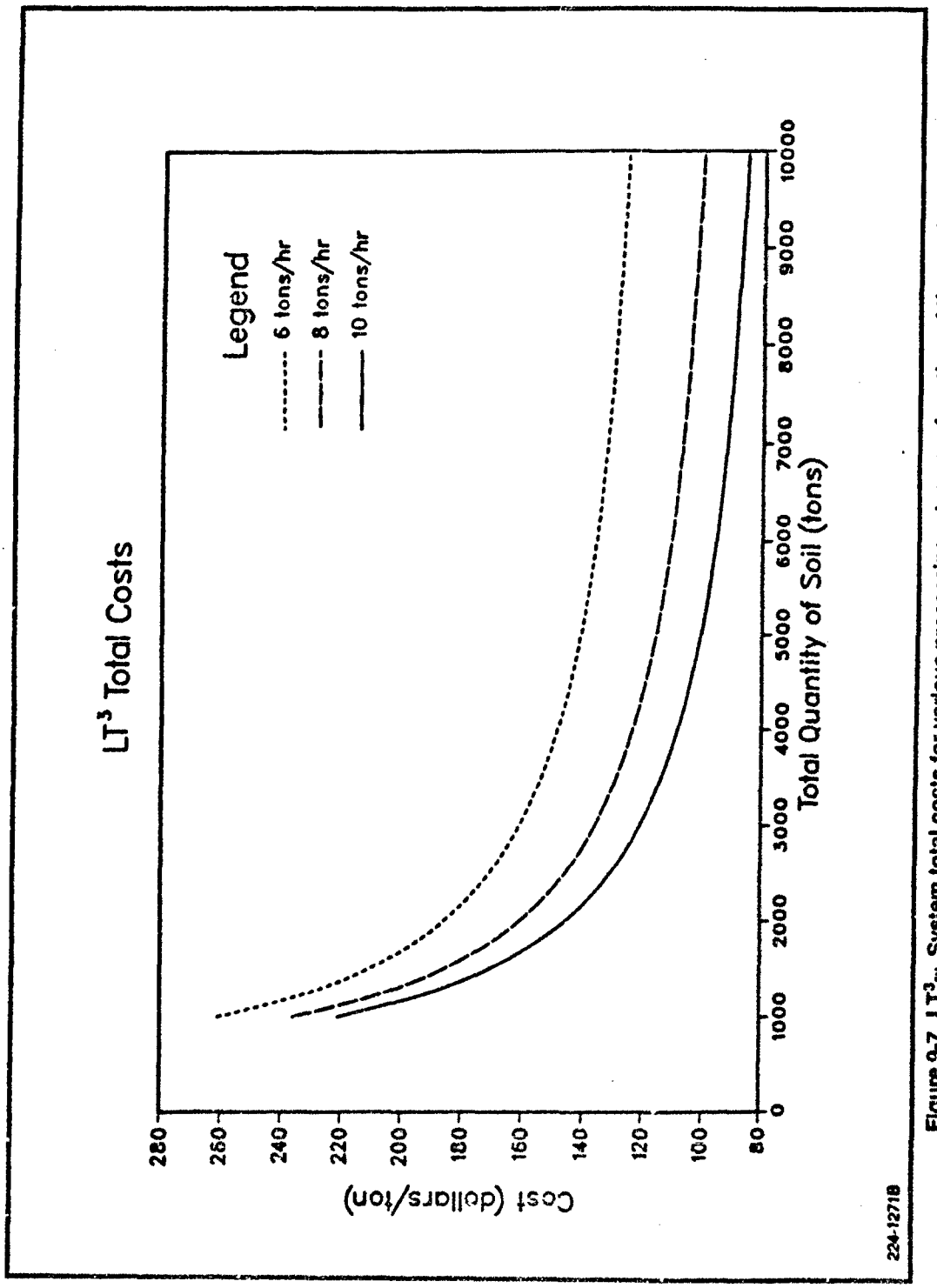


Figure 9-7. LT³™ System total costs for various processing rates as a function of the total tonnage.

SECTION 10

DESIGN CONSIDERATIONS

10. DESIGN CONSIDERATIONS

The Low Temperature Thermal Treatment System used at Tinker Air Force Base was designed to process 15,000 lbs/hr. In previous operations, the LT^3 System has been proven to be an effective transportable plant for decontaminating soils, including clays with high moisture contents.

One of the goals of the demonstration at Tinker Air Force Base was to determine the operating limits of the system. The system was intentionally operated beyond its design capacity until mechanical failures occurred to determine those limits.

The system's capability to process soils was expected to be limited by its ability to meet goal cleanup levels; however, the system experienced mechanical problems that limited the production rate. Therefore, material handling capabilities, and not contaminant removal capabilities, became the limiting factors that established the operating limits.

The system was operated at processing rates of 18,000 to 20,000 lbs/hr on a sustained basis and up to 22,000 lbs/hr for shorter periods. This additional 5,000 lbs/hr per hour was the source of many of the problems, as discussed in this section.

Increased production rates reduce unit operating costs. With the demonstrated higher production rates and lower operating costs, this system becomes increasingly attractive for remediation of Department of Defense sites.

Some of the problems that resulted, primarily due to the increase of the processing rate, are discussed in the following subsections. It is recommended that these improvements be considered for future Department of Defense remediation projects.

Experience gained during the demonstration at Tinker Air Force Base provided information to establish new operating procedures, equipment configurations, and designs to enhance the efficiency and versatility of the LT^3 System. Operations may be improved, more efficient use of manpower and machinery may be employed, and therefore, costs may be reduced. Specific recommendations for improvements are discussed in the following subsections.

10.1 Excavation, storage, blending, and feed preparation. The soil excavation rate may be significantly increased and excavation equipment requirements may be reduced if all the soil can be excavated prior to processing. Appropriately sized and selected excavation equipment will ensure efficient excavation regardless of processing rate or downtime considerations.

WESTERN

The anticipated soil moisture content should be considered for soil excavation. Problems that might arise because of debris, extraneous material, and oversized objects should also be considered. Provisions should be made to handle oversized objects to minimize impact on the processing rate.

Adequate storage areas should be provided to allow room for storage of the entire quantity of soil to be processed. Excavation can be accomplished faster than material can be processed; thus, the inability to store excavated material unnecessarily restricts the excavation rate.

Storage areas should also be established to allow blending of soil, if required. Blending provides a consistent feed material with respect to contaminant concentrations and soil moisture content. The processor will operate more efficiently and more predictably given a consistent feed material. The feed preparation equipment will also run more smoothly with a consistent feed material.

10.2 Feed hopper. An important function of the feed hopper, and the material it holds, is to provide a positive seal enabling the processors to be maintained at negative pressure. When the material level in the feed hopper is reduced, such that a positive seal is no longer possible, air will be pulled into the processors. The negative pressure on the system is lost and the system interlocks automatically shut down the system.

The feed hopper can not be completely emptied because the processors will shut down as a result of losing the processor seal. One solution to this problem is to feed "clean" material at the end of a process cycle to allow the contaminated soil to be purged from the system. This is the procedure that was adopted for this demonstration.

One drawback to this approach is that clean material must be readily available. If it cannot be obtained on the site, it must be trucked in from off-site. After it is used to purge the system, it must be sampled and analyzed to ensure that the clean material was not contaminated. The system cannot be shut down until all the "clean" material is processed. Therefore, fuel is consumed in both the afterburner and in the hot oil heater while processing "clean" material.

One inexpensive solution to this problem is to design and to install a slide gate closure at the top of the feed hopper to slide shut at the end of a process cycle or whenever there is the possibility of breaking the seal formed by the material in the hopper. This alternative would provide a positive seal, preventing the system pressure from becoming positive, and thus shutting down the processors.

10.3 Thermal processors. The configuration of the processors provides a maximum heat transfer area in a minimal footprint and keeps all material handling at one end of the process system. For these reasons the processor design works well under normal operating conditions.

Consideration should be given to the possible need to decontaminate or remove material from the inside of the processors. In the event that a material that should not be processed is fed to the system, the system must be decontaminated. Better access to the interior of the processors is desired. A mechanical failure of the system may leave the processor full of partially processed and, therefore, contaminated soil. A method to easily empty and decontaminate the system is desired.

An option currently offered by the manufacturer of the processors is a drop bottom feature that provides a hinged bottom so that the processors can be completely opened from the bottom providing easy access. One drawback to this solution is that adequate headroom must be provided in the system configuration to allow these hinged doors to open. This may considerably increase the height requirements of the process trailer, and the "portable" feature of the system may be compromised.

Another option is to provide larger explosion vents or access doors on the sides and ends of the units so that personnel could more easily access the interior of the processors.

10.4 Oil heater. The system is equipped with an oil heater that uses an "on/off" type burner control. When the set point temperature is reached, the heater, normally operated on high fire, shuts down and restarts on high fire after the temperature drops below the setpoint.

An alternative to this type of burner control is to modulate the firing rate as a function of oil temperature. The temperature control provides more accurate and stable temperatures by modulating the burner operation.

Better temperature control is not required for this system, but an assurance that the burner will operate when required is needed. Several times during the demonstration, the burner failed to restart as the oil temperature dropped. The burner failure was noticed when the soil discharge temperature decreased significantly. Several attempts were required to restart the burner.

Oil heater burner failures may occur as a result of inefficiently and insufficiently decontaminated material, requiring subsequent rehandling and reprocessing.

The recommended burner control may be more expensive, but the higher capital investment will provide long term benefits.

10.5 Discharge conveyors and soil conditioner. The discharge conveyors and the soil conditioning system were designed to handle a larger quantity of material than the primary processor design. The objective for oversizing the systems was to prevent downstream equipment from reducing the soil processing rate. Since the thermal processors contribute largely to the capital cost of the LT^3 System, maximum use of the processors is desired. Economics dictate that the limiting factor in processing capacity should be the thermal capacity of the LT^3 System.

In the original design, all components of the system were balanced and could process the original design production rate of 15,000 lbs/hr. The system was able to process in excess of 30 percent more than originally anticipated. As a result of the Tinker Air Force Base demonstration, the material handling capability of the LT^3 System, specifically the discharge conveyors and soil conditioning equipment, should be redesigned to increase the capacity of these units.

The capacity of the feed system, screens, and clay shredder should also be carefully reviewed and considered when projecting production rates.

10.6 Sweep gas control. Exhaust gases from the hot oil heater are used to provide an inert gas in the processors. The sweep gas should be controlled to maintain processor temperatures, draft, and gas content within the processors. Currently, gases are partially diverted using a manually controlled butterfly valve that directs part of the exhaust gases into the processors.

Automatic control of the exhaust gas valve is required because the feed conditions change continually, requiring varying sweep gas. Poor sweep gas control may result in excess sweep gas increasing pressure (reducing draft) in the thermal processors, thereby, affecting the automatic shut down feature of the interlock system.

Poor sweep gas control may also result in insufficient sweep gas causing the organic content of the processor atmosphere to potentially enter the lower explosive limit.

10.7 Exhaust gas from the processors. Gases exiting the processors contain the contaminants and moisture from the processed soil. Exhaust gases are drawn into the emission control system under a slight negative pressure. The exhaust system should be sealed maintaining draft, temperatures, and oxygen content of the exhaust gas. The exhaust temperature must be maintained to prevent condensation of contaminants or moisture on the process equipment.

Heat tracing should be installed on the ducts between the processors and the fabric filter to eliminate condensation in this area.

10.8 Fabric filter. The fabric filter appears to perform its design function, but because PCBs were found on-site, no specific stack testing was done to numerically specify the performance of this unit.

Dust collected by the fabric filter was minimal. Since condensation occurred in the fabric filter, a slurry resulted instead of dry fly ash. The condensation resulted in fouling of the fabric material and possible reduction in system draft. To prevent condensation and fouling, the fabric filter should be insulated and heat traced. Temperatures should be maintained to prevent condensation.

10.9 Condenser. The most significant pressure drop in the system occurred across the condenser. The large pressure drop may be attributed to the design of the condenser and to the inadequate duct work exiting the fabric filter leading into the condenser. Part of the ducting is constructed of flexible tubing with a high pressure-loss coefficient. In addition, the tubing sagged, allowing the accumulation of condensate, which further restricted flow.

Modifications and future designs should consider larger diameter condenser tubes to reduce pressure drop and should minimize flexible connections and potential locations for condensate accumulations. If low points cannot be avoided, drip legs should be provided and regularly serviced.

The additional time and manpower required to install hard connections between system trailers may be justified by improved system draft and smoother operations. A number of tests were aborted during the demonstration program due to draft problems.

10.10 Oil/water separator. The oil/water separator in the current system provides sufficient two-phase separation. A gross separation of organics and water is effectively and economically achieved. The separator reduces the load on the downstream carbon and results in significant savings.

When processing three-phase systems, such as at Tinker Air Force Base, a floating layer of hydrocarbons forms on top of an aqueous phase containing dissolved organics. A third layer of heavier TCE forms beneath the aqueous layer. A three-phase separator would be required for efficient separation. Economic operation of downstream pollution control equipment may be accomplished if both layers of contaminants can be separated from the middle layer of water.

The contaminants in the upper and lower layers can then be separately recovered or treated, as appropriate. As a result, decontamination of the middle aqueous layer can be more effectively accomplished.

SECTION 11

CONCLUSIONS

11. CONCLUSIONS

By comparing the results of the demonstration at Tinker Air Force Base with the original test objectives, as stated in Subsection 2.3, the following conclusions are reached.

The primary objective of the demonstration was to evaluate the effectiveness of the LT^3 Process for removing JP-4 and chlorinated solvents from contaminated soils. The demonstration showed conclusively that the LT^3 Technology was effective in reducing the concentrations of not only JP-4 but also all the compounds originally specified in the Test Plan. The primary finding of this demonstration program was that all goal cleanup levels could be met by heating the processed soil above 215°F. This is a considerably lower critical temperature than anticipated, based upon the boiling points of the contaminants present in the soil. As a result, all goal cleanup levels were met while processing at rates approximately 25 percent in excess of the design capacity.

One of the original objectives was to evaluate the effect of varying the operational parameters (the oil temperature and the residence time) on meeting the goal cleanup levels. This was only partially accomplished because the performance of the process so exceeded expectations that physical limitations of the equipment became the limiting factor. The demonstration showed that a 600°F oil temperature was not necessary to meet goal cleanup levels, nor was an extended residence time of 1 hour required. An oil temperature of 400°F met cleanup objectives with a residence time of 35 minutes. This corresponds to a system feed rate of greater than 20,000 lbs/hr and a processed soil temperature of approximately 215°F. The demonstration was aborted when PCBs were discovered in the feed and processed soils and before a lower operating temperature and shorter residence time could be demonstrated.

Although an evaluation of the effectiveness of stripping agents in the removal of the compounds of concern was an original objective, the system performed so well that the need for solvents or stripping agents never materialized. The demonstration was discontinued, and an evaluation of stripping agents was not performed. There may be an economic advantage to using stripping agents to remove compounds at lower temperatures and shorter residence periods; however, this was not investigated.

At the optimum operating range, the LT^3 System achieved a processing rate 25 percent greater than the expected processing rate. A lower temperature and shorter residence time for meeting the goal cleanup level was not established because physical limitations and early cancellation of the demonstration prevented a complete evaluation.

Although definitive stack testing was not conducted to verify system performance, all Federal, State, and local emissions standards, as specified in the RCRA RD&D permit, were met as measured by the continuous emissions monitoring system.

The unit cost for processing and decontaminating soils with similar contaminants is $86 per ton of soil at an average processing rate of 8 tons per hour. This rate of 8 tons per hour may be maintained on a sustained basis 7 days per week, 24 hours per day. Total estimated costs, including mobilization and demobilization, to process 5,000 tons would be $116.00 per ton.

The LT^3 Process has been proven to be an effective technology for treating soils contaminated with chlorinated solvents and JP-4. All goal cleanup levels were met at lower operating temperatures (400°F oil and 215°F processed soil) and at higher production rates (20,000 lbs/hr) than previously expected. This finding in turn means that sites with similar conditions can now be remediated at lower costs.

REFERENCES

WESTERN

REFERENCES

1. U.S. Army Corps of Engineers, Tulsa District, "Landfill 3 Sludge Dump Contaminated Soil (Information for Soil Removal and Decontamination)," Tinker Air Force Base, Oklahoma. Prepared for Environmental Management Directorate, Dept. of the Air Force, Headquarters Oklahoma City Air Logistics Center, Final Report, January 1989.

2. Test Plan for a Pilot Investigation of Low Temperature Thermal Stripping of Volatile Organic Compounds from Soil at Letterkenny Army Depot, June 1985, Prepared for U.S. Army Material Command, U.S. Army Toxic and Hazardous Materials Agency, Contract DAAK11-82-C-0017, Task Order Number 11.

3. Economic Evaluation of Low Temperature Thermal Stripping of Volatile Organic Compounds from Soil, August 1986, Prepared for U.S. Army Toxic and Hazardous Materials Agency, Contract DAAK11-85-C-0007.

4. Pilot Investigation of Low Temperature Thermal Stripping of Volatile Organic Compounds (VOCs) from Soil, May 1986, Prepared for U.S. Army Toxic and Hazardous Materials Agency, Report Number AMXTH-TE-CR-86074.

5. Safety Plan for Task Order 04 - Pilot Test of Thermal Stripping of JP-4 and Other VOCs from Soils at Tinker Air Force Base, November 1988, Prepared for U.S. Army Toxic and Hazardous Materials Agency, Contract DAAA15-88-D-0010.

6. Demonstration Test Plan for Task Order 04 - Pilot Test of Thermal Stripping of JP-4 and Other VOCs from Soils at Tinker Air Force Base, November 1988, Prepared for U.S. Army Toxic and Hazardous Materials Agency, Contract DAAA15-88-D-0010.

APPENDIX A

EQUIPMENT DECONTAMINATION PLAN

Revised 1 September 1989

EQUIPMENT DECONTAMINATION PLAN

1.0 General Decontamination Rational

The purpose of the decontamination activities is to remove residual contaminants that may exist on the equipment so that the equipment can be removed from the site. The decontamination work will proceed as follows:

1. Install a 50' X 20' concrete decontamination pad.
2. Power wash exterior and interior surfaces of equipment that have potentially been exposed to PCBs on the decontamination pad.
3. Perform wipe test sampling at select locations to confirm the effectiveness of the decontamination activities.
4. Evaluate the wipe test results and repeat steps 2 and 3 as required.

1.1 Decontamination Pad

The decontamination (decon) pad will consist of a 50' x 20' concrete pad with 6" high curb with sump (See Figure 1). The pad will slope toward the sump to collect all wash water. Underlying the concrete pad will be a layer of sand 6" thick, a layer of 40 mil high density polyethylene (HDPE), and another layer of sand 12" thick. The HDPE liner will catch any splash or overflow that may occur. Following equipment decontamination, the decon pad will be cleaned for subsequent reuse or disposal.

1.2 Decontamination

Material or equipment to be decontaminated will be transported to the decontamination pad where each item will be washed using a soapy, hot water pressure washer to remove all foreign substances, soils, and films. Equipment will be allowed to air dry to the extent practical.

Small equipment will be transferred to decontamination zone

(decontamination pad) via overhead crane for the decontamination process.

Trailers (Processor, Heater and Support trailers) will be towed to decontamination pad for final decontamination.

Workers using pressure washers to decontaminate equipment will wear outer protective clothing consisting of PVC or neoprene boots, gloves, and rainsuits, and the appropriate level of respiratory protection. Worker decontamination procedures will be as specified in the site safety plan.

1.3 Decontamination Criteria

The proposed decontamination criteria is 10 micrograms (ug) per 100 cm^2.(1) The wipe test procedure is described in Section 5.3 of this plan. If the wipe test results exceed 10 ug/100 cm^2, the item will be decontaminated further and wipe tested again.

1.4 Wash Water Holding Tanks

Three (3) 1,000 gallon tanks will be used to process and store wash water. The tanks will be either plastic or fiberglass to permit ease of decontamination once all process equipment and site trailers are decontaminated and certified.

Tank #1 will receive all wash water from the Decon pad, Decon trailer, or other wash down activity.

The wash water will be processed through the on-site carbon filter system to Tank #2. When Tank #2 has reached capacity, the processed water will then be diverted to Tank #3. Tank #2 will then be tested for the presence of PCBs. Once certified that PCB concentrations are less than 50 ppb, Tank

(1) The Decontamination objective of 10 Mg/100 cm^2 is based on 40 CFR 761.125.C.4 - "Requirements for Decontaminating Spills in Non-Restricted Access Areas".

#2 will be used for wash water at the Decon pad and/or for dust control in the contaminated zone. When Tank #3 has reached capacity with processed water, it will be tested for PCBs. Once certified, Tank #3 will be used for wash water at the Decon pad and/or dust control. Tanks #2 and #3 will alternately be used as holding tanks, then as wash water supply. This will reduce the need for make-up water.

2.0 DECONTAMINATION PROCEDURES

All equipment identified as needing decontamination will be decontaminated using one or more of the following procedures.

2.1 Brushing/Sweeping/Scraping

This method involves the physical removal of dust particles from the equipment surfaces. Sweeping and brushing will be used to clear coarse debris. Scraping will be used as needed to remove buildup of scale and other materials from the various surfaces. Appropriate Health and Safety procedures outlined in the Health and Safety Plan will be followed.

Packed/caked dirt or grit which has accumulated on the soil excavating, screening, and handling equipment will be physically removed using dry, stiff brushes, shovels, or scrappers prior to decontamination.

2.2 Power Washing

Power washing is an effective way of cleaning the equipment surfaces. Power washing will be accomplished with high-pressure water. A cleaning detergent will also be used (if required). All rinsate waters generated from power washing will be transferred to the wash water storage tank (Tank #1).

Prior to using any of the tanks, a visual inspection of the tank and its foundation will be conducted to assess its integrity. All outlet/inlet pipes to the tank will be sealed-off with the exception of one fill pipe for the rinsate water and one drain pipe fitted with a valve. The rinsate tank will be properly marked and posted with signs.

2.3 Steam Cleaning

Steam cleaning may be used on specific surfaces if the wipe test results indicate that power washing does not sufficiently

remove the PCB's.

2.4 Decontamination Residuals Disposals

The debris generated from decontamination will be collected, drummed, manifested and transported to a licensed PCB incinerator. The rinsate water generated from decontamination will be collected and treated with the on-site carbon adsorption system to meet the clean-up objective of less than 50 ppb of PCB's.

3.0 EQUIPMENT PREPARATION FOR DECONTAMINATION

3.1 General

Some equipment will require preparation before actual decontamination can take place. All material handling equipment will be run to exhaust remaining soil from the unit. The processor will be run "cold" to remove any soil in the unit. All soil from the unit will be collected and placed in the processed soil pile and covered.

3.2 Propane Tank

The propane tank will be hand wiped with solvent dampened rags and wipe tested. No water, solvent, or decontamination debris will be allowed on the surrounding ground. When certified, the remaining fuel will be pumped out and the tank returned to owner. This area will then become the Decon pad location.

3.3 Thermal Processor

The thermal processor drives will be removed and placed on plastic to await decontamination. All explosion vents and access doors will be removed to allow access for decontamination of the interior of the unit. All duct work will be removed, stripped of insulation and stored on plastic to await decontamination. The insulation removed will be drummed, manifested and transported to a licensed PCB incinerator.

The Motor Control Center (MCC) and control panels will be removed, decontaminated by hand washing and placed in the control trailer.

3.4 Conveyors and Ash Conditioner

All conveyors, ash conditioner, and material handling equipment will be disassembled and placed on plastic to await decontamination. When certified, all equipment will be

reassembled and shipped off-site.

3.5 Bag House

The nomex bags will be removed, drummed, manifested and transported to a licensed PCB incinerator. The bag support structure and air pulse piping will be disassembled and placed on plastic to await decontamination.

3.6 Oil/Water Separator

Any liquid or sludge that may remain in the oil water separator will be drummed, manifested and transported to a licensed PCB incinerator. The separator will be decontaminated along with the heater trailer when it is moved to the Decon pad.

3.7 Afterburner

The tee, upper portion of the afterburner, and associated duct work will be disassembled and stored on plastic to await decontamination.

4.0 MAJOR EQUIPMENT DECONTAMINATION

4.1 Caustic Scrubber

The scrubber packing will be removed, drummed, manifested, and transported to a licensed PCB incinerator. The mist eliminator will be disassembled and decontaminated. The scrubber will be moved to the Decon pad, washed and moved to the holding area and stored on plastic awaiting confirmation.

4.2 Miscellaneous Equipment

All of the smaller equipment will be moved to the Decon pad, as space allows, decontaminated and stored on plastic in the holding area awaiting confirmation.

4.3 Heater Trailer

The heater trailer will be moved to the Decon pad for decontamination. The opening in the top lower half of the afterburner will be sealed to prevent any wash water from entering the interior of the afterburner. The core of the condenser will be removed and stored on plastic. The core will be cut into pieces, drummed, manifested and transported to a licensed PCB incinerator. The heater trailer will remain on the Decon pad until the results from the wipe tests are known.

4.4 Processor Trailer

The processor trailer will be moved to the Decon pad for decontamination. The interior of the processor will first be washed using only water at 40 to 50 psi to remove any soil that may remain in the unit. When all the soil has been washed from the unit, the interior and exterior will be decontaminated. When the results of the wipe tests certify the unit the processor will be sealed. The processor trailer will remain on the pad until the results from the wipe tests

are known.

4.5 Storage Shed

The storage shed is skid mounted and will be moved to the Decon pad for decontamination. It will then be moved to the holding area and stored on plastic.

4.6 Baghouse

Baghouse filter bags will be drummed, manifested and transported to a hazardous waste landfill for disposal. The interior of the baghouse will be disassembled pressure washed and wipe tested. Upon certification the baghouse will be reassembled. The exterior baghouse will remain on the processor trailer during decontamination.

4.7 Material Feed and Discharge Equipment

The feed and discharge augers and conveyor belts will be disassembled, decontaminated and certified. Upon certification all equipment will be re-assembled and shipped off-site.

4.8 Duct Work

Insulation from all duct work will be removed, drummed, manifested and transported to a hazardous waste landfill. The ductwork will then be decontaminated and certified. Upon certification the ductwork will be insulated and replaced on the certified unit.

4.9 Afterburner

The K-O wool insulation on the interior of the afterburner will be removed, drummed, manifested and transported to a licensed PCB incinerator. The interior surface will then be wipe tested to determine if gritblasting will be required. If the interior of the afterburner can be certified without

gritblasting, the afterburner will be insulated in accordance with the manufacturer's recommendations.

4.10 Hot Oil Heater

Only the exterior of the oil heater will be decontaminated. No decontamination of interior is anticipated since it was not exposed to the PCB's.

4.11 Excavation Equipment

All excavation equipment (front-end loaders, backhoe, etc) used on-site will be decontaminated and certified. After decontamination the equipment will be returned to the respective owners of the equipment.

4.12 Liquid Phase Carbon Adsorption Unit

After all decontamination wash water has been processed, the liquid phase carbon adsorption unit will be disconnected. The carbon will be shipped via an appropriate transporter to a licensed PCB incinerator. Precise transport arrangements will be finalized during the last few days of the project.

4.13 Personal Protective Materials

Disposable personal protective equipment (tyveks, gloves, rainwear) will be collected, and drummed, manifested, and transported to a licensed PCB incinerator.

4.14 Decon Pad

The decon pad will be power washed, certified clean and left on-site pending subsequent site closure activities.

4.15 Fence

The fence will be left as is on-site.

5.0 DECONTAMINATION CERTIFICATION

5.1 Wipe Test Sampling

Wipe testing will be conducted after decontamination to insure that decontamination procedures have been effective.

5.2 Sampling Method

The following equipment will be used to collect wipe samples:

- A metric ruler to measure the area to be wiped.
- Disposable surgical gloves to be changed prior to handling clean gauze, sample bottle, or solvent.
- Sterile, wrapped gauze pad (3" x 3").
- Clean stainless steel forceps.
- Appropriate grade solvent (hexane or other solvent material suggested by analyzing laboratory).
- Sample bottles or jars, preferably 240 milliliter (ml), with Teflon liner caps.
- Appropriate chain of custody and sample location materials.

The wipe test sample collection procedure will incorporate the following steps:

(1) A representative area will be located and a 100centimeter square (cm^2) area will be marked.

(2) A gauze pad (3" x 3") will be soaked in 15 to 20 ml of solvent. The gauze will be used to wipe the selected 10 cm x 10 cm area.

(3) The entire area will be wiped firmly once horizontally and once vertically.

(4) After the wiping is complete, the gauze pad is placed into a previously sterilized sample bottle.

(5) One field blank sample will be collected for each of the analytical methods. The field blank sample will be prepared by soaking the gauze in a measured amount of solvent and placing it directly into the pre-sterilized

sample bottle.

5.3 Documentation

Detailed records of surface condition, sample locations, and chain custody will be kept, as discussed below.

After preserving sample in a pre-sterilized glass bottle and preparing chain of custody materials, the sample bottle will be turned over to the on site lab.

Maintaining proper records is a significant aspect of the sample collection program. The entire sampling process is designed and conducted in a manner that provides samples suitable for the intended analyses and are properly documented to assure comparability at a later date. At the time samples are obtained, the following information will be recorded by the sampling team:

1. Sample site location
2. Depth or position of sample
3. Date and time of sampling
4. Sample identification number
5. Identification of sampler
6. Analyses required

In addition to preserving pertinent information regarding the sampling, the sample team will initiate chain-of-custody procedures, describe the sample site in adequate detail to allow analytical results to be properly interpreted, and collect necessary duplicate samples to allow evaluation of precision and representativeness. The sample will utilize pre-printed labels and standardized record forms to expedite this documentation effort in the field and to ensure uniformity of records. The sampling protocols and record keeping requirements for the techniques are given in the QAPP

for each sampling technique. Additional requirements may also be established on a site-specific basis based upon information obtained during sampling episodes. All sampling equipment will either be decontaminated or drummed for shipment to a licensed PCB incinerator.

5.4 Wipe Test Samples Analyses

The wipe samples collected will be analyzed for PCB's using U.S. EPA Method 8080. The results of the wipe test samples will be transmitted to the site within 72 hours.

APPENDIX B

EXIT PLAN

Revised 1 September 1999

Contract DAAA 15-88-D-0010
USATHTMA TASK ORDER NO. 4

EXIT PLAN

1.0 PURPOSE:

The purpose of the exit plan is to provide an immediate response action to minimize the potential for off-site contamination.

2.0 BACKGROUND:

A demonstration for removal of volatile organic compounds (VOCs) from contaminated soil employing WESTON's low temperature thermal treatment (LT^3) was being performed at Landfill #3, Tinker Air Force Base, Oklahoma City, Oklahoma. During this demonstration it was determined that the soil is also contaminated with Polychlorinated Biphenyls (PCBs). The permits issued do not address PCBs and all work at the site was immediately stopped when the possibility of PCB contamination was reported by the on-site chemist. It has subsequently been confirmed that TSCA regulated PCB waste is present at the site.

Landfill #3 excavated area consisted of a clay cap, followed by loose asphalt, then by the contaminated soil. Approximately 3000 cubic yards of material was excavated. Figure B-1 illustrates the number of stock piles, distinct excavation areas and relative location of each. For ease of discussion each has been designated a number as follows:

NUMBER	DESCRIPTION
#1	Main Excavation Area: This excavation hole is approximately one hundred and twenty feet by seventy five feet by ten feet deep (120'L X 75'W X 10' D) or approximately 3,500 cubic yards in volume. In this hole there is a small stock pile of excavated contaminated soil (See #2). This area also contains a sludge that was sampled and analyzed for PCBs.
#2	Stock Pile in Excavation Area: This material (approximately 50 cubic yards) was excavated from the main excavation area, below the asphalt layer. It was stock piled in the excavation area pending processing. It was intended for future treatment.

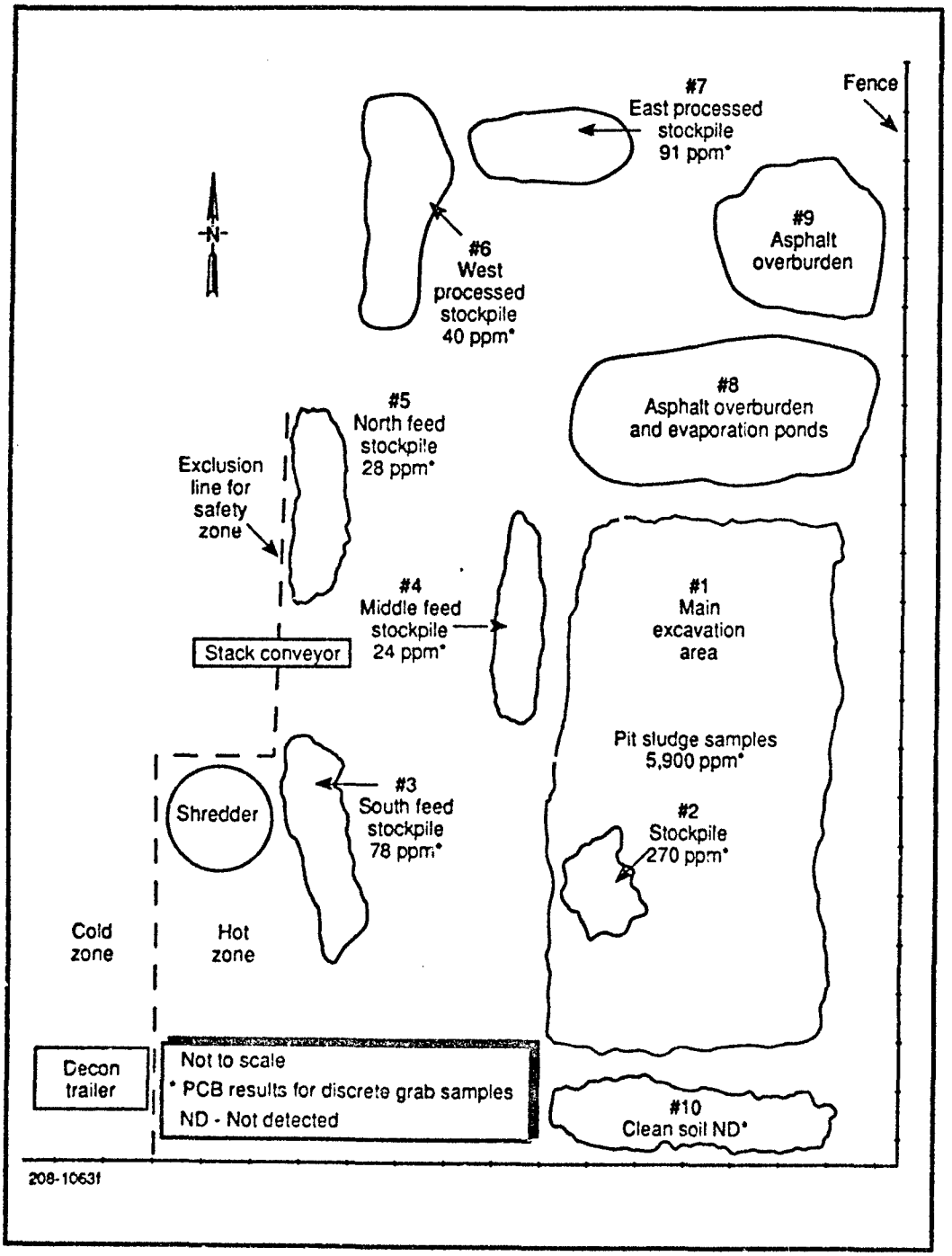


Figure B-1. Tinker Air Force Base Landfill 3 LT^3$_{sm}$ System site after excavation.

#3 South Feed:
This material (approximately 200 cubic yards) was excavated from the main excavation area below the asphalt layer. It is stock piled on 40 mil HDPE. It was also to be treated. It is covered with visqueen.

#4 Middle Feed:
This material (approximately 30 cubic yards) was excavated from the main excavation area, below the asphalt area. It is stock piled on 40 mil HDPE. It was also to be treated. It is covered with visqueen.

#5 North Feed:
This material (approximately 300 cubic yards) was excavated from the main excavation area also from below the asphalt layer. It is stock piled on 40 mil HDPE. It was also to be treated. It is covered with visqueen.

#6 West Processed:
Approximately 50 cubic yards of soil which has been processed through the LT[3] and deposited. There is no liner underneath and it is covered with visqueen.

#7 East Processed:
Same as #6. Approximately 20 yards.

#8 Asphalt Overburden & Evaporation Ponds:
This loose asphalt is from the excavation area under the clay cap. The volume of this material is approximately 1,200 cubic yards. Some of the material was formed to construct two evaporation ponds. One pond bottom is HDPE, the other is visqueen. These ponds where used to hold the rain water pumped out of the excavation hole.

#9 Asphalt Overburden:
This loose asphalt material was the lower twelve (12") inches of asphalt cover. It was considered to be in contact with the contaminated soil, and it was assumed to be contaminated. Approximately 350 cubic yards of this material was placed on 40 mil HDPE and covered with visqueen.

#10 Clean Soil:
This material was the clay cap over the asphalt cap. Approximately 800 cubic yards of material was excavated and assumed, (later confirmed) to be clean. It is not on a liner nor is it covered.

3.0 PROCEDURE:

1. For compaction, the backfill will be placed in six inch depth increments. WESTON will document on a scaled site map with known reference points the location and depth of the placement of each of the piles #2 - #9 above within the backfilled Area #1. Plastic material used for liners and covers will be used to cover Area #1 at the end of each work day during the backfilling operation. If rain water accumulates overnight on the plastic, it will be pumped out and treated by the on-site carbon absorption system to meet the clean-up objective of 50 ppb. The plastic will be removed at the beginning of the work day. This will continue until the clay overburden is backfilled. At that time the plastic cover will be drummed in 85 gallon overpacks for disposal in an off-site permitted PCB incinerator.

2. Soil that has not been processed through the LT^3 will be backfilled first. These areas, #2, #3, #4 and #5 will be backfilled in number sequence.

3. Processed soil, areas #6 and #7, will be backfilled next.

4. Water in area #8 will be pumped out and treated in the on-site carbon absorption system.

5. Asphalt overburden in Area #8 will then be backfilled.

6. Asphalt overburden in Area #9 will then be backfilled.

7. A two inch (2") undercut will then be scraped from the processing equipment placement area and stock pile areas #3 through #9.

8. The site, with the exception of Area #1, #2, and #10, will then be divided into grids for confirmation of surface soil quality. Procedures described in "Field Manual for Grid Sampling of PCB Spill Sites to verify Clean Ups", EPA document #560/5-86-017, will be employed for sampling and analysis. Grid samples analyzed under 25 ppm PCBs will confirm a clean grid. A composite sample from Area #10 will be collected and analyzed to ensure it is suitable for capping.

9. If a grid is not confirmed clean, another two to six inches will be scraped off the top layer and sampling repeated. Subsequent failure will require review of the procedure and subsequent revision to the plan.

10. Once the grids are confirmed to be clean, the clay cap material from Area #10 will be used to cover Area #1.

11. Construction equipment will then be decontaminated on the decontamination pad. Carbon from the carbon absorption system will be prepared and shipped to an off site permitted incinerator. The carbon absorption system will be confirmed to be clean and shipped to another WESTON site.

4.0 SITE APPEARANCE UPON EXIT:

Upon WESTON's exit from the site, the site fencing and decon pad will remain. The site will be essentially level with the exception of Area #1. This area will be approximately five feet higher.

APPENDIX C

THEORETICAL RESIDENCE TIME CALCULATION

C. THEORETICAL RESIDENCE TIME CALCULATION

The residence time in the thermal processors can be theoretically calculated based on system geometries and assumptions about the flow of the soil.

The theoretical residence time, in minutes, can be calculated with either of the following formulas:

residence time = (trough volume x 60 x bulk weight)/(feed rate)

or

residence time = (60 x trough volume)/(.75 x speed x TCC)

where: trough volume is expressed in cubic feet (ft^3)

bulk weight is expressed in lbs per cubic foot (lb/ft^3)

feed rate is expressed in lbs per hour (lb/hr)

speed is expressed in revolutions per minute (rpm)

theoretical conveyance capacity (TCC) is expressed in cubic feet per hour-rpm (ft^3/hr-rpm).

The trough volume for the combined processors in the LT^3 System is 212.4 ft^3. The theoretical conveyance capacity is 183 ft^3/hr-rpm. Therefore, for a speed of 1 rpm, the residence time is:

(60 x 212.4)/(0.75 x 1 x 183) = 92.85 minutes

The 0.75 factor used in the denominator is an empirically determined factor based on the flow characteristics of the material. Historically a "rule of thumb" value of 0.75 has been used if soil flow characteristics are not known.

A corrected value for the TCC may be empirically determined by weighing the material fed to the processor and using the bulk weight of the soil in the first equation above to determine the residence time. Then all adjustments can be made in the TCC so that both methods agree.

During the testing, the bulk weight of soil varied significantly with moisture content, grain size distribution, and degree of compaction. It was not feasible to determine a representative value for use during the program since the material changed daily. Therefore, it was determined that an estimated residence time would be reported based on theoretical calculations assuming a conveyance factor of 0.75.

Several attempts were made to verify this factor and the calculated residence time by timing the flow of material through the system. Since the mixing and agitation created by the intermeshing screws is significant, the estimate of marker materials such as lime and sand could not be accurately measured and, therefore, could not be used to verify the calculated residence time in the processors.

After several attempts, this method of verifying the residence times was abandoned in favor of a more direct method to monitor, control, and vary the residence time of material in the processors. Residence time is directly related to the rotational speed of the screws and, therefore, the time it took for the screws to make one revolution was monitored.

The test plan as originally planned included the use of residence time as a control variable. This was abandoned in favor of the more easily measured and monitored rotational speed of the processor screws. Residence times are reported for the tests, but they have not been verified and a more accurate standard is to compare speeds.

APPENDIX D

ANALYTICAL METHODS FOR ON-SITE ANALYSES

- EPA METHOD 5030
- EPA METHOD 8010
- EPA METHOD 8020
- SEMIVOLATILE PRIORITY POLLUTANT ORGANICS-WATER
- SEMIVOLATILE PRIORITY POLLUTANT ORGANICS-SOIL AND LEACHATES
- TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)

EPA METHOD 8000

METHOD 5030

PURGE-AND-TRAP

1.0 SCOPE AND APPLICATION

1.1 This method describes sample preparation and extraction for the analysis of volatile organics by a purge-and-trap procedure. The gas chromatographic determinative steps are found in Methods 8010, 8015, 8020, and 8030. Although applicable to Method 8240, the purge-and-trap procedure is already incorporated into Method 8240.

1.2 Method 5030 can be used for most volatile organic compounds that have boiling points below 200°C (vapor pressure is approximately equal to mm Hg @ 25°C) and are insoluble or slightly soluble in water. Volatile water-soluble compounds can be included in this analytical technique; however, quantitation limits (by GC or GC/MS) are approximately ten times higher because of poor purging efficiency. The method is also limited to compounds that elute as sharp peaks from a GC column packed with graphitized carbon lightly coated with a carbowax. Such compounds include low-molecular-weight halogenated hydrocarbons, aromatics, ketones, nitriles, acetates, acrylates, ethers, and sulfides.

1.3 Water samples can be analyzed directly for volatile organic compounds by purge-and-trap extraction and gas chromatography. Higher concentrations of these analytes in water can be determined by direct injection of the sample into the chromatographic system.

1.4 This method also describes the preparation of water-miscible liquids, solids, wastes, and soil/sediments for analysis by the purge-and-trap procedure.

2.0 SUMMARY OF METHOD

2.1 The purge-and-trap process: An inert gas is bubbled through the solution at ambient temperature, and the volatile components are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the volatile components are adsorbed. After purging is completed, the sorbent column is heated and backflushed with inert gas to desorb the components onto a gas chromatographic column.

2.2 If the above sample introduction techniques are not applicable, a portion of the sample is dispersed in methanol to dissolve the volatile organic constituents. A portion of the methanolic solution is combined with water. ~~in a specially designed purging chamber.~~ It is then analyzed by purge-and-trap GC following the normal water method.

3.0 INTERFERENCES

3.1 Impurities in the purge gas and from organic compounds out-gassing from the plumbing ahead of the trap account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by running laboratory reagent blanks. The use of non-TFE plastic coating, non-TFE thread sealants, or flow controllers with rubber components in the purging device should be avoided.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal of the sample vial during shipment and storage. A field reagent blank prepared from reagent water and carried through sampling and handling protocols serves as a check on such contamination.

3.3 Contamination by carryover can occur whenever high-level and low-level samples are analyzed sequentially. Whenever an unusually concentrated sample is analyzed, it should be followed by an analysis of reagent water to check for cross-contamination. The trap and other parts of the system are subject to contamination; therefore, frequent bake-out and purging of the entire system may be required.

3.4 The laboratory where volatile analysis is performed should be completely free of solvents.

4.0 APPARATUS AND MATERIALS

4.1 Microsyringes: 10-uL, 25-uL, 100-uL, 250-uL, 500-uL, and 1,000 uL: These syringes should be equipped with a 20-gauge (0.006-in I.D.) needle having a length sufficient to extend from the sample inlet to within 1 cm of the glass frit in the purging device. The needle length will depend upon the dimensions of the purging device employed.

4.2 Syringe valve: Two-way, with Luer ends (three each), if applicable to the purging device.

4.3 Syringe: 5-mL, gas-tight with shutoff valve.

4.4 Balance: Analytical, capable of accurately weighing 0.0001 g, and a top-loading balance capable of weighing 0.1 g.

4.5 Glass scintillation vials: 20-mL, with screw-caps and Teflon liners or glass culture tubes with a screw-cap and Teflon liner.

4.6 Volumetric flasks: 10-mL and 100-mL, class A with ground-glass stoppers.

4.7 Vials: 2-mL, for GC autosampler.

4.8 Spatula: Stainless steel.

4.9 Disposable pipets: Pasteur.

4.10 Purge-and-trap device: The purge-and-trap device consists of three separate pieces of equipment: the sample purger, the trap, and the desorber. Several complete devices are commercially available.

4.10.1 The recommended purging chamber is designed to accept 5-mL samples with a water column at least 3 cm deep. The gaseous headspace between the water column and the trap must have a total volume of less than 15 mL. The purge gas must pass through the water column as finely divided bubbles with a diameter of less than 3-mm at the origin. The purge gas must be introduced no more than 5 mm from the base of the water column. The sample purger, illustrated in Figure 1, meets these design criteria. Alternate sample purge devices may be used, provided equivalent performance is demonstrated.

4.10.2 The trap must be at least 25 cm long and have an inside diameter of at least 0.105 in. Starting from the inlet, the trap must contain the following amounts of adsorbents: 1/3 of 2,6-diphenylene oxide polymer, 1/3 of silica gel, and 1/3 of coconut charcoal. It is recommended that 1.0 cm of methyl silicone-coated packing be inserted at the inlet to extend the life of the trap (see Figures 2 and 3). If it is not necessary to analyze for dichlorodifluoromethane or other fluorocarbons of similar volatility, the charcoal can be eliminated and the polymer increased to fill 2/3 of the trap. If only compounds boiling above 35°C are to be analyzed, both the silica gel and charcoal can be eliminated and the polymer increased to fill the entire trap. Before initial use, the trap should be conditioned overnight at 180°C by backflushing with an inert gas flow of at least 20 mL/min. Vent the trap effluent to the hood, not to the analytical column. Prior to daily use, the trap should be conditioned for 10 min at 180°C with backflushing. The trap may be vented to the analytical column during daily conditioning; however, the column must be run through the temperature program prior to analysis of samples.

4.10.3 The desorber should be capable of rapidly heating the trap to 180°C for desorption. The polymer section of the trap should not be heated higher than 180°C, and the remaining sections should not exceed 220°C during bake-out mode. The desorber design illustrated in Figures 2 and 3 meet these criteria.

4.10.4 The purge-and-trap device may be assembled as a separate unit or may be coupled to a gas chromatograph, as shown in Figures 4 and 5.

4.10.5 Trap Packing Materials

4.10.5.1 2,6-Diphenylene oxide polymer: 60/80 mesh, chromatographic grade (Tenax GC or equivalent).

4.10.5.2 Methyl silicone packing: OV-1 (3%) on Chromosorb-W, 60/80 mesh or equivalent.

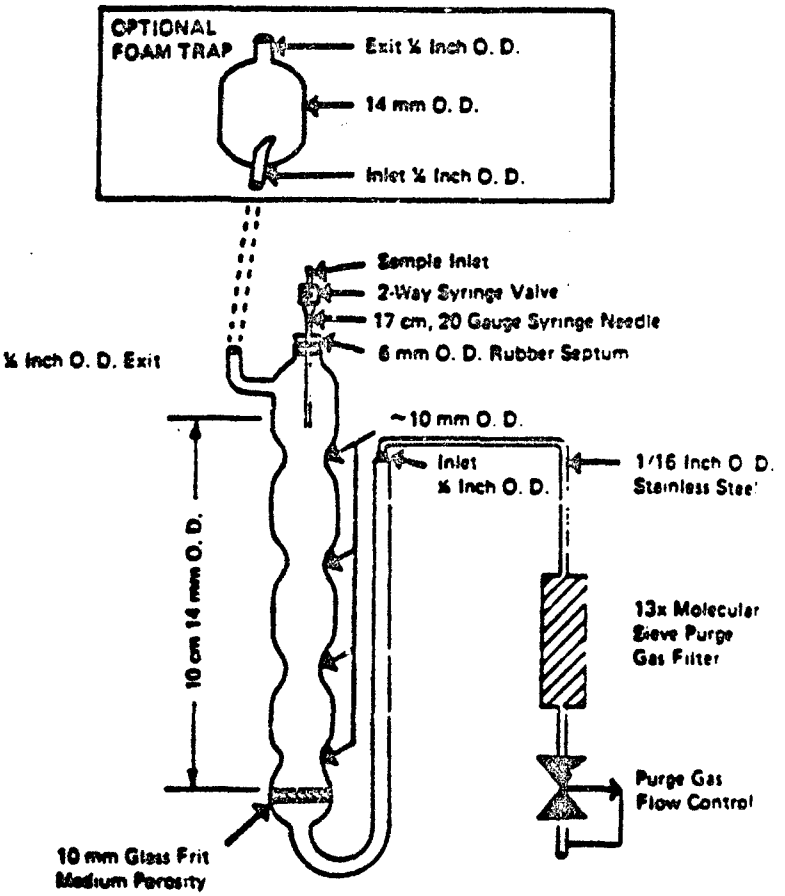


Figure 1. Purging chamber.

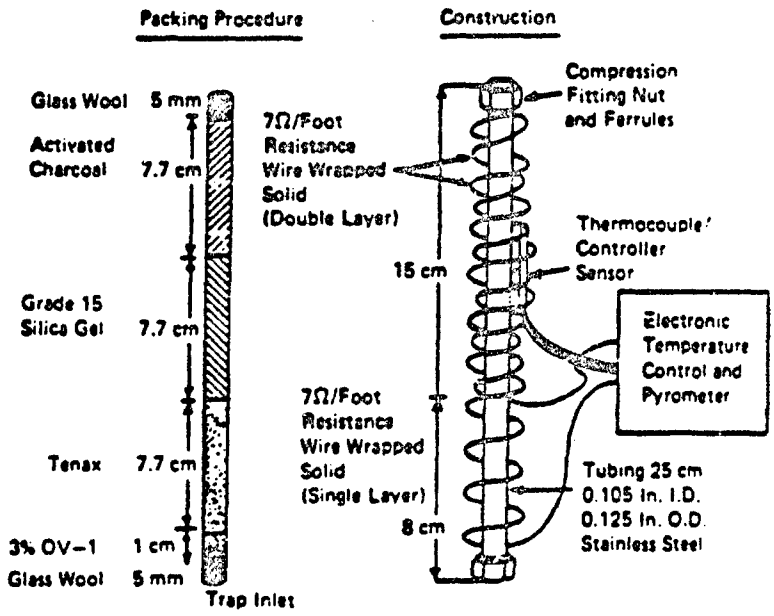


Figure 2. Trap packings and construction for Method 8010.

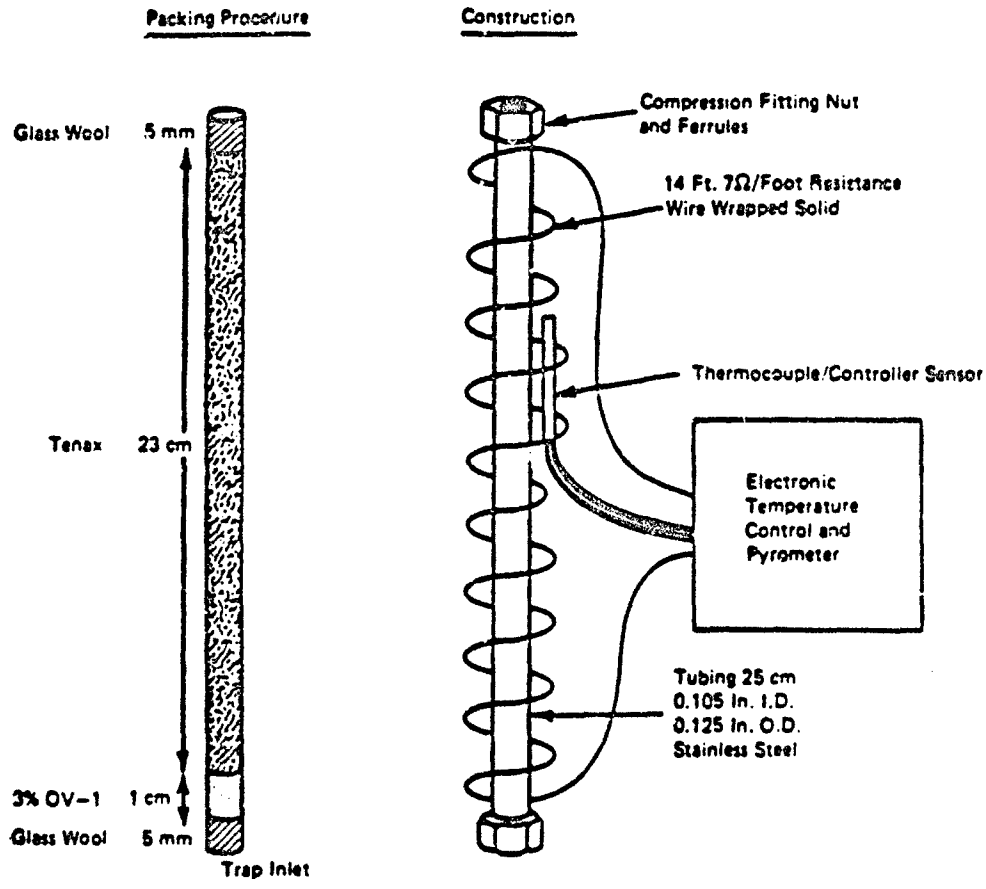


Figure 3. Trap packing and construction for Methods 8020 and 8030.

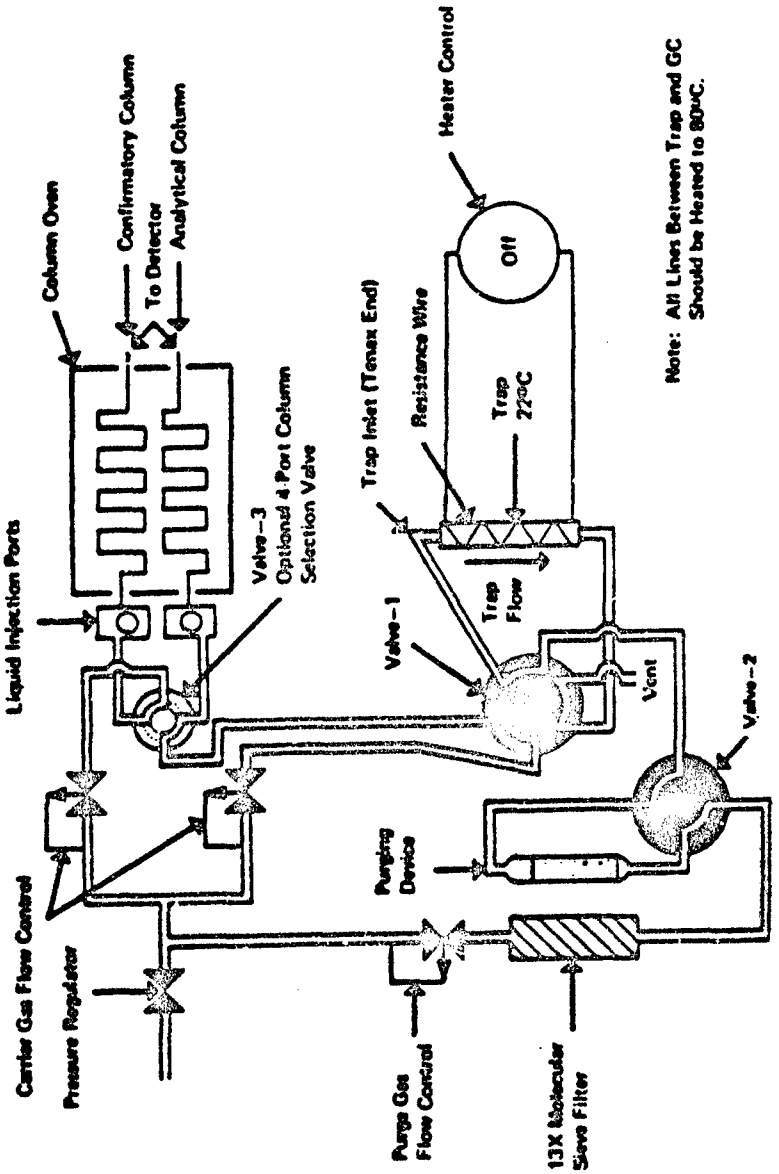


Figure 4. Purge-and-trap system, purge-sorb mode, for Methods 8010, 8020, and 8030.

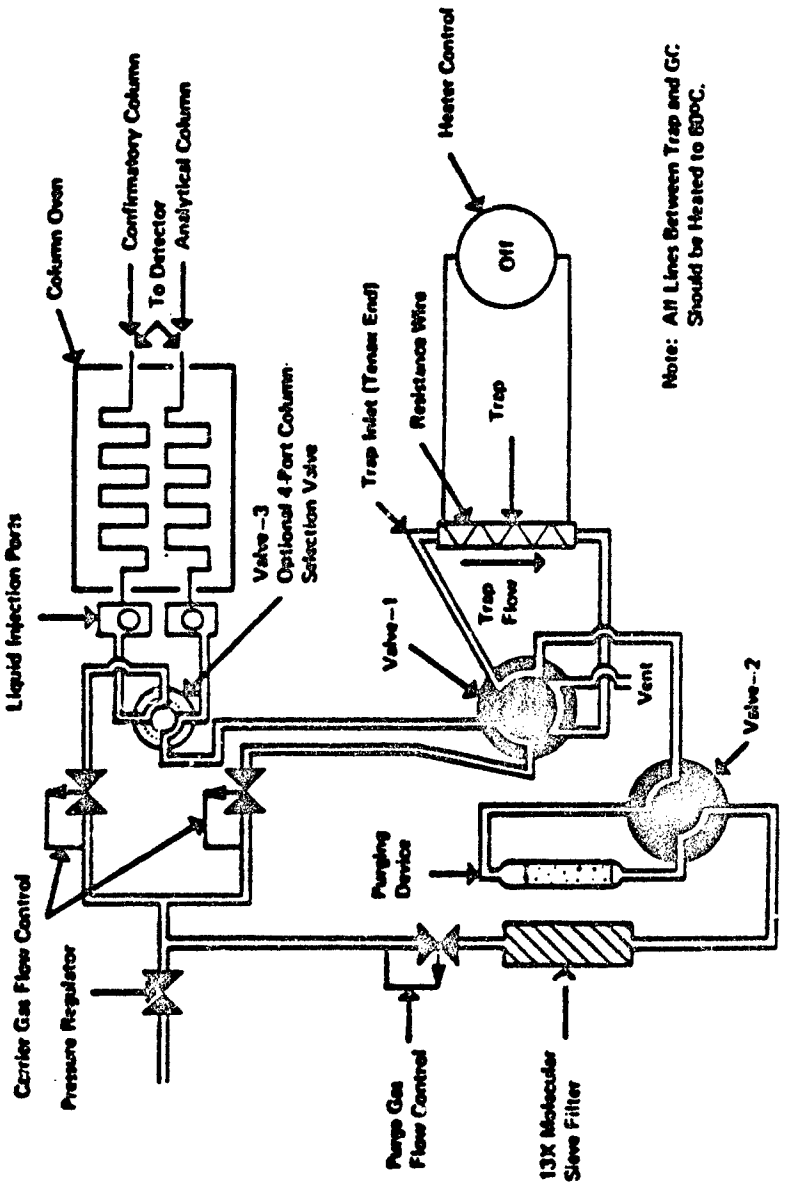


Figure 5. Purge-and-trap system, desorb mode, for Methods 8010, 8020, and 8030.

4.10.5.3 Silica gel: 35/60 mesh, Davison, grade 15 or equivalent.

4.10.5.4 Coconut charcoal: Prepare from Barnebey Cheney, CA-580-26 lot #M-2649, by crushing through 26 mesh screen.

4.11 Heater or heated oil bath: Should be capable of maintaining the purging chamber to within 1°C over a temperature range from ambient to 100°C.

5.0 REAGENTS

5.1 Reagent water: Reagent water is defined as water in which an interferent is not observed at the method detection limit of the compounds of interest.

5.1.1 Reagent water may be generated by passing trap water through a carbon filter bed containing about 500 g of activated carbon (Calgon Corp., Filtrasorb-300 or equivalent).

5.1.2 A water purification system (Millipore Super-Q or equivalent) may be used to generate reagent water.

5.1.3 Reagent water may also be prepared by boiling water for 15 min. Subsequently, while maintaining the water temperature at 90°C, bubble a contaminant-free inert gas through the water for 1 hr. While still hot, transfer the water to a narrow-mouth screw-cap bottle and seal with a Teflon-lined septum and cap.

5.2 Methanol: Pesticide quality or equivalent. Store away from other solvents.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Refer to the introductory material to this chapter, Organic Analytes, Section 4.1.

7.0 PROCEDURE

7.1 Initial calibration: Prior to using this introduction technique for any GC method, the system must be calibrated. General calibration procedures are discussed in Method 8000, Section 7.4, while the specific determinative methods and Method 3500 give details on preparation of standards.

7.1.1 Assemble a purge-and-trap device that meets the specification in Section 4.10. Condition the trap overnight at 180°C in the purge mode with an inert gas flow of at least 20 mL/min. Prior to use, condition the trap daily for 10 min while backflushing at 180°C with the column at 220°C.

7.1.2 Connect the purge-and-trap device to a gas chromatograph.

7.1.3 Prepare the final solutions containing the required concentrations of calibration standards, including surrogate standards, directly in the purging device. Add 5.0 mL of reagent water to the purging device. The reagent water is added to the purging device using a 5-mL glass syringe fitted with a 15-cm 20-gauge needle. The needle is inserted through the sample inlet shown in Figure 1. The internal diameter of the 14-gauge needle that forms the sample inlet will permit insertion of the 20-gauge needle. Next, using a 10-uL or 25-uL microsyringe equipped with a long needle (Paragraph 4.1), take a volume of the secondary dilution solution containing appropriate concentrations of the calibration standards. Add the aliquot of calibration solution directly to the reagent water in the purging device by inserting the needle through the sample inlet. When discharging the contents of the microsyringe, be sure that the end of the syringe needle is well beneath the surface of the reagent water. Similarly, add 10 uL of the internal standard solution. Close the 2-way syringe valve at the sample inlet.

7.1.4 Carry out the purge-and-trap analysis procedure using the specific conditions given in Table 1.

7.1.5 Calculate response factors or calibration factors for each analyte of interest using the procedure described in Method 8000, Section 7.4.

7.1.6 The average RF must be calculated for each compound. A system performance check should be made before this calibration curve is used. If the purge-and-trap procedure is used with Method 8010, the following five compounds are checked for a minimum average response factor: chloromethane; 1,1-dichloroethane; bromoform; 1,1,2,2-tetrachloroethane; and chlorobenzene. The minimum acceptable average RF for these compounds should be 0.300 (0.250 for bromoform). These compounds typically have RFs of 0.4-0.6 and are used to check compound instability and check for degradation caused by contaminated lines or active sites in the system. Examples of these occurrences are:

7.1.6.1 Chloromethane: This compound is the most likely compound to be lost if the purge flow is too fast.

7.1.6.2 Bromoform: This compound is one of the compounds most likely to be purged very poorly if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response.

7.1.6.3 Tetrachloroethane and 1,1-dichloroethane: These compounds are degraded by contaminated transfer lines in purge-and-trap systems and/or active sites in trapping materials.

7.2 On-going calibration: Refer to Method 8000, Sections 7.4.2.3 and 7.4.3.4 for details on continuing calibration.

TABLE 1. PURGE-AND-TRAP OPERATING PARAMETERS

	Analysis Method			
	8010	8015	8020	8030
Purge gas	Nitrogen or Helium	Nitrogen or Helium	Nitrogen or Helium	Nitrogen or Helium
Purge gas flow rate (mL/min)	40	20	40	20
Purge time (min)	11.0 ± 0.1	15.0 ± 0.1	12.0 ± 0.1	15.0 ± 0.1
Purge temperature (°C)	Ambient	85 ± 2	Ambient	85 ± 2
Desorb temperature (°C)	180	180	180	180
Backflush inert gas flow (mL/min)	20-60	20-60	20-60	20-60
Desorb time (min)	4	1.5	4	1.5

7.3 Sample preparation:

7.3.1 Water samples:

7.3.1.1 Screening of the sample prior to purge-and-trap analysis will provide guidance on whether sample dilution is necessary and will prevent contamination of the purge-and-trap system. Two screening techniques that can be utilized are: the use of an automated headspace sampler (modified Method 3810), interfaced to a gas chromatograph (GC), equipped with a photo ionization detector (PID), in series with an electrolytic conductivity detector (ECD); and extraction of the sample with hexadecane (Method 3820) and analysis of the extract on a GC with a PID and/or an ECD.

7.3.1.2 All samples and standard solutions must be allowed to warm to ambient temperature before analysis.

7.3.1.3 Assemble the purge-and-trap device. The operating conditions for the GC are given in Section 7.0 of the specific determinative method to be employed.

7.3.1.4 Daily GC calibration criteria must be met (Method 8000, Section 7.4) before analyzing samples.

7.3.1.5 Adjust the purge gas flow rate (nitrogen or helium) to that shown in Table 1, on the purge-and-trap device. Optimize the flow rate to provide the best response for chloromethane and bromoform, if these compounds are analytes. Excessive flow rate reduces chloromethane response, whereas insufficient flow reduces bromoform response.

7.3.1.6 Remove the plunger from a 5-mL syringe and attach a closed syringe valve. Open the sample or standard bottle, which has been allowed to come to ambient temperature, and carefully pour the sample into the syringe barrel to just short of overflowing. Replace the syringe plunger and compress the sample. Open the syringe valve and vent any residual air while adjusting the sample volume to 5.0 mL. This process of taking an aliquot destroys the validity of the liquid sample for future analysis; therefore, if there is only one VOA vial, the analyst should fill a second syringe at this time to protect against possible loss of sample integrity. This second sample is maintained only until such time when the analyst has determined that the first sample has been analyzed properly. Filling one 20-mL syringe would allow the use of only one syringe. If a second analysis is needed from a syringe, it must be analyzed within 24 hr. Care must be taken to prevent air from leaking into the syringe.

7.3.1.7 The following procedure is appropriate for diluting purgeable samples. All steps must be performed without delays until the diluted sample is in a gas-tight syringe.

7.3.1.7.1 Dilutions may be made in volumetric flasks (10-mL to 100-mL). Select the volumetric flask that will allow for the necessary dilution. Intermediate dilutions may be necessary for extremely large dilutions.

7.3.1.7.2 Calculate the approximate volume of reagent water to be added to the volumetric flask selected and add slightly less than this quantity of reagent water to the flask.

7.3.1.7.3 Inject the proper aliquot of samples from the syringe prepared in Paragraph 7.3.1.5 into the flask. Aliquots of less than 1-mL are not recommended. Dilute the sample to the mark with reagent water. Cap the flask, invert, and shake three times. Repeat the above procedure for additional dilutions.

7.3.1.7.4 Fill a 5-mL syringe with the diluted sample as in Paragraph 7.3.1.5.

7.3.1.8 Add 10.0 uL of surrogate spiking solution (found in each determinative method, Section 5.0) and, if applicable, 10 uL of internal standard spiking solution through the valve bore of the syringe; then close the valve. The surrogate and internal standards may be mixed and added as a single spiking solution. Matrix spiking solutions, if indicated, should be added (10 uL) to the sample at this time.

7.3.1.9 Attach the syringe-syringe valve assembly to the syringe valve on the purging device. Open the syringe valves and inject the sample into the purging chamber.

7.3.1.10 Close both valves and purge the sample for the time and at the temperature specified in Table 1.

7.3.1.11 At the conclusion of the purge time, attach the trap to the chromatograph, adjust the device to the desorb mode, and begin the gas chromatographic temperature program and GC data acquisition. Concurrently, introduce the trapped materials to the gas chromatographic column by rapidly heating the trap to 180°C while backflushing the trap with inert gas between 20 and 60 mL/min for the time specified in Table 1.

7.3.1.12 While the trap is being desorbed into the gas chromatograph, empty the purging chamber. Wash the chamber with a minimum of two 5-mL flushes of reagent water (or methanol followed by reagent water) to avoid carryover of pollutant compounds into subsequent analyses.

7.3.1.13 After desorbing the sample, recondition the trap by returning the purge-and-trap device to the purge mode. Wait 15 sec; then close the syringe valve on the purging device to begin gas flow

through the trap. The trap temperature should be maintained at 180°C for Methods 8010 and 8020, and 210°C for Methods 8015 and 8030. Trap temperatures up to 220°C may be employed; however, the higher temperature will shorten the useful life of the trap. After approximately 7 min, turn off the trap heater and open the syringe valve to stop the gas flow through the trap. When cool, the trap is ready for the next sample.

7.3.1.14 If the initial analysis of a sample or a dilution of the sample has a concentration of analytes that exceeds the initial calibration range, the sample must be reanalyzed at a higher dilution. When a sample is analyzed that has saturated response from a compound, this analysis must be followed by a blank reagent water analysis. If the blank analysis is not free of interferences, the system must be decontaminated. Sample analysis may not resume until a blank can be analyzed that is free of interferences.

7.3.1.15 All dilutions should keep the response of the major constituents (previously saturated peaks) in the upper half of the linear range of the curve. Proceed to Method 8000 and the specific determinative method for details on calculating analyte response.

7.3.2 Water-miscible liquids:

7.3.2.1 Water-miscible liquids are analyzed as water samples after first diluting them at least 50-fold with reagent water.

7.3.2.2 Initial and serial dilutions can be prepared by pipetting 2 mL of the sample to a 100-mL volumetric flask and diluting to volume with reagent water. Transfer immediately to a 5-mL gas-tight syringe.

7.3.2.3 Alternatively, prepare dilutions directly in a 5-mL syringe filled with reagent water by adding at least 20 uL, but not more than 100-uL of liquid sample. The sample is ready for addition of surrogate and, if applicable, internal and matrix spiking standards.

7.3.3 Sediment/soil and waste samples: It is highly recommended that all samples of this type be screened prior to the purge-and-trap GC analysis. These samples may contain percent quantities of purgeable organics that will contaminate the purge-and-trap system, and require extensive cleanup and instrument downtime. See Paragraph 7.3.1.1 for recommended screening techniques. Use the screening data to determine whether to use the low-level method (0.005-1 mg/kg) or the high-level method (>1 mg/kg).

7.3.3.1 Low-level method: This is designed for samples containing individual purgeable compounds of <1 mg/kg. It is limited to sediment/soil samples and waste that is of a similar consistency (granular and porous). The low-level method is based on

purging a heated sediment/soil sample mixed with reagent water containing the surrogate and, if applicable, internal and matrix spiking standards. Analyze all reagent blanks and standards under the same conditions as the samples.

7.3.3.1.1 Use a 5-g sample if the expected concentration is <0.1 mg/kg or a 1-g sample for expected concentrations between 0.1 and 1 mg/kg.

7.3.3.1.2 The GC system should be set up as in Section 7.0 of the specific determinative method. This should be done prior to the preparation of the sample to avoid loss of volatiles from standards and samples. A heated purge calibration curve must be prepared and used for the quantitation of all samples analyzed with the low-level method. Follow the initial and daily calibration instructions, except for the addition of a 40°C purge temperature for Methods 8010 and 8020.

7.3.3.1.3 Remove the plunger from a 5-mL Luerlock type syringe equipped with a syringe valve and fill until overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust the volume to 5.0 mL. Add 10 uL each of surrogate spiking solution and internal standard solution to the syringe through the valve. (Surrogate spiking solution and internal standard solution may be mixed together.) Matrix spiking solutions, if indicated, should be added (10 uL) to the sample at this time.

7.3.3.1.4 The sample (for volatile organics) consists of the entire contents of the sample container. Do not discard any supernatant liquids. Mix the contents of the sample container with a narrow metal spatula. Weigh the amount determined in Paragraph 7.3.3.1.1 into a tared purge device. Note and record the actual weight to the nearest 0.1 g.

7.3.3.1.5 In certain cases, sample results are desired based on a dry-weight basis. When such data is desired, a portion of sample for moisture determination should be weighed out at the same time as the portion used for analytical determination. Immediately after weighing the sample for extraction, weigh 5-10 g of the sample into a tared crucible. Determine the percent moisture by drying overnight at 105°C. Allow to cool in a desiccator before weighing:

$$\frac{\text{g of sample} - \text{g of dry sample}}{\text{g of sample}} \times 100 = \% \text{ moisture}$$

7.3.3.1.6 Add the spiked reagent water to the purge device, which contains the weighed amount of sample, and connect the device to the purge-and-trap system.

NOTE: Prior to the attachment of the purge device, steps 7.3.3.1.4 and 7.3.3.1.6 must be performed rapidly and without interruption to avoid loss of volatile organics. These steps must be performed in a laboratory free of solvent fumes.

7.3.3.1.7 Heat the sample to 40°C ± 1°C (Methods 8010 and 8020) or to 85°C ± 2°C (Methods 8015 and 8030) and purge the sample for the time shown in Table 1.

7.3.3.1.8 Proceed with the analysis as outlined in Paragraphs 7.3.1.11-7.3.1.15. Use 5 mL of the same reagent water as in the reagent blank. If saturated peaks occurred or would occur if a 1-g sample were analyzed, the high-level method must be followed.

7.3.3.2 High-level method: The method is based on extracting the sediment/soil with methanol. A waste sample is either extracted or diluted, depending on its solubility in methanol. An aliquot of the extract is added to reagent water containing surrogate and, if applicable, internal and matrix spiking standards. This is purged at the temperatures indicated in Table 1. All samples with an expected concentration of >1.0 mg/kg should be analyzed by this method.

7.3.3.2.1 The sample (for volatile organics) consists of the entire contents of the sample container. Do not discard any supernatant liquids. Mix the contents of the sample container with a narrow metal spatula. For sediment/soil and waste that are insoluble in methanol, weigh 4 g (wet weight) of sample into a tared 20-mL vial. Use a top-loading balance. Note and record the actual weight to 0.1 gram and determine the percent moisture of the sample using the procedure in Paragraph 7.3.3.1.5. For waste that is soluble in methanol, weigh 1 g (wet weight) into a tared scintillation vial or culture tube or a 10-mL volumetric flask. (If a vial or tube is used, it must be calibrated prior to use. Pipet 10.0 mL of methanol into the vial and mark the bottom of the meniscus. Discard this solvent.)

7.3.3.2.2 Quickly add 9.0 mL of methanol; then add 1.0 mL of the surrogate spiking solution to the vial. Cap and shake for 2 min.

NOTE: Steps 7.3.3.2.1 and 7.3.3.2.2 must be performed rapidly and without interruption to avoid loss of volatile organics. These steps must be performed in a laboratory free from solvent fumes.

7.3.3.2.3 Pipet approximately 1 mL of the extract to a GC vial for storage, using a disposable pipet. The remainder may be disposed of. Transfer approximately 1 mL of reagent methanol to a separate GC vial for use as the method blank for each set of samples. These extracts may be stored at 4°C in the dark, prior to analysis.

7.3.3.2.4 The GC system should be set up as in Section 7.0 of the specific determinative method. This should be done prior to the addition of the methanol extract to reagent water.

7.3.3.2.5 Table 2 can be used to determine the volume of methanol extract to add to the 5 mL of reagent water for analysis. If a screening procedure was followed, use the estimated concentration to determine the appropriate volume. Otherwise, estimate the concentration range of the sample from the low-level analysis to determine the appropriate volume. If the sample was submitted as a high-level sample, start with 100 uL. All dilutions must keep the response of the major constituents (previously saturated peaks) in the upper half of the linear range of the curve.

7.3.3.2.6 Remove the plunger from a 5.0-mL Luerlock type syringe equipped with a syringe valve and fill until overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust the volume to 4.9 mL. Pull the plunger back to 5.0 mL to allow volume for the addition of the sample extract and of standards. Add 10 uL of internal standard solution. Also add the volume of methanol extract determined in Paragraph 7.3.3.2.5 and a volume of methanol solvent to total 100 uL (excluding methanol in standards).

7.3.3.2.7 Attach the syringe-syringe valve assembly to the syringe valve on the purging device. Open the syringe valve and inject the water/methanol sample into the purging chamber.

7.3.3.2.8 Proceed with the analysis as outlined in the specific determinative method. Analyze all reagent blanks on the same instrument as that used for the samples. The standards and blanks should also contain 100 uL of methanol to simulate the sample conditions.

7.3.3.2.9 For a matrix spike in the high-level sediment/soil samples, add 8.0 mL of methanol, 1.0 mL of surrogate spike solution and 1.0 mL of matrix spike solution. Add a 100-uL aliquot of this extract to 5 mL of water for purging (as per Paragraph 7.3.3.2.6).

TABLE 2. QUANTITY OF METHANOL EXTRACT REQUIRED FOR ANALYSIS OF HIGH-LEVEL SOILS/SEDIMENTS

Approximate Concentration Range	Volume of Methanol Extract[a]
500-10,000 ug/kg	100 uL
1,000-20,000 ug/kg	50 uL
5,000-100,000 ug/kg	10 uL
25,000-500,000 ug/kg	100 uL of 1/50 dilution [b]

Calculate appropriate dilution factor for concentrations exceeding this table.

[a]The volume of methanol added to 5 mL of water being purged should be kept constant. Therefore, add to the 5-mL syringe whatever volume of methanol is necessary to maintain a volume of 100 uL added to the syringe.

[b]Dilute an aliquot of the methanol extract and then take 100 uL for analysis.

7.4 Sample analysis:

7.4.1 The samples prepared by this method may be analyzed by Methods 8010, 8015, 8020, 8030, and 8240. Refer to these methods for appropriate analysis conditions.

8.0 QUALITY CONTROL

8.1 Refer to Chapter One for specific quality control procedures and Method 3500 for sample preparation procedures.

8.2 Before processing any samples, the analyst should demonstrate through the analysis of a reagent water method blank that all glassware and reagents are interference free. Each time a set of samples is extracted, or there is a change in reagents, a method blank should be processed as a safeguard against chronic laboratory contamination. The blank samples should be carried through all stages of the sample preparation and measurement.

8.3 Standard quality assurance practices should be used with this method. Field replicates should be collected to validate the precision of the sampling technique. Laboratory replicates should be analyzed to validate the precision of the analysis. Fortified samples should be carried through all stages of sample preparation and measurement; they should be analyzed to validate the sensitivity and accuracy of the analysis. If the fortified samples do not indicate sufficient sensitivity to detect <1 ug/g of the analytes in the sample, then the sensitivity of the instrument should be increased, or the sample should be subjected to additional cleanup.

9.0 METHOD PERFORMANCE

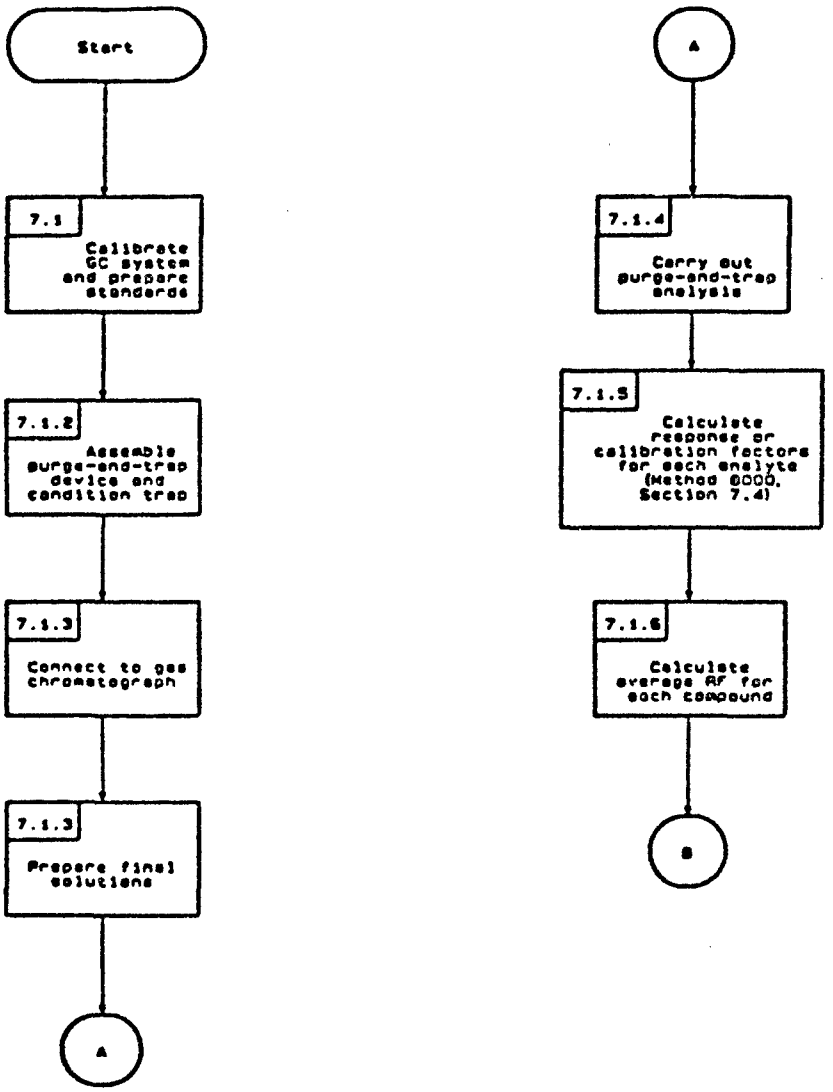
9.1 Refer to the determinative methods for performance data.

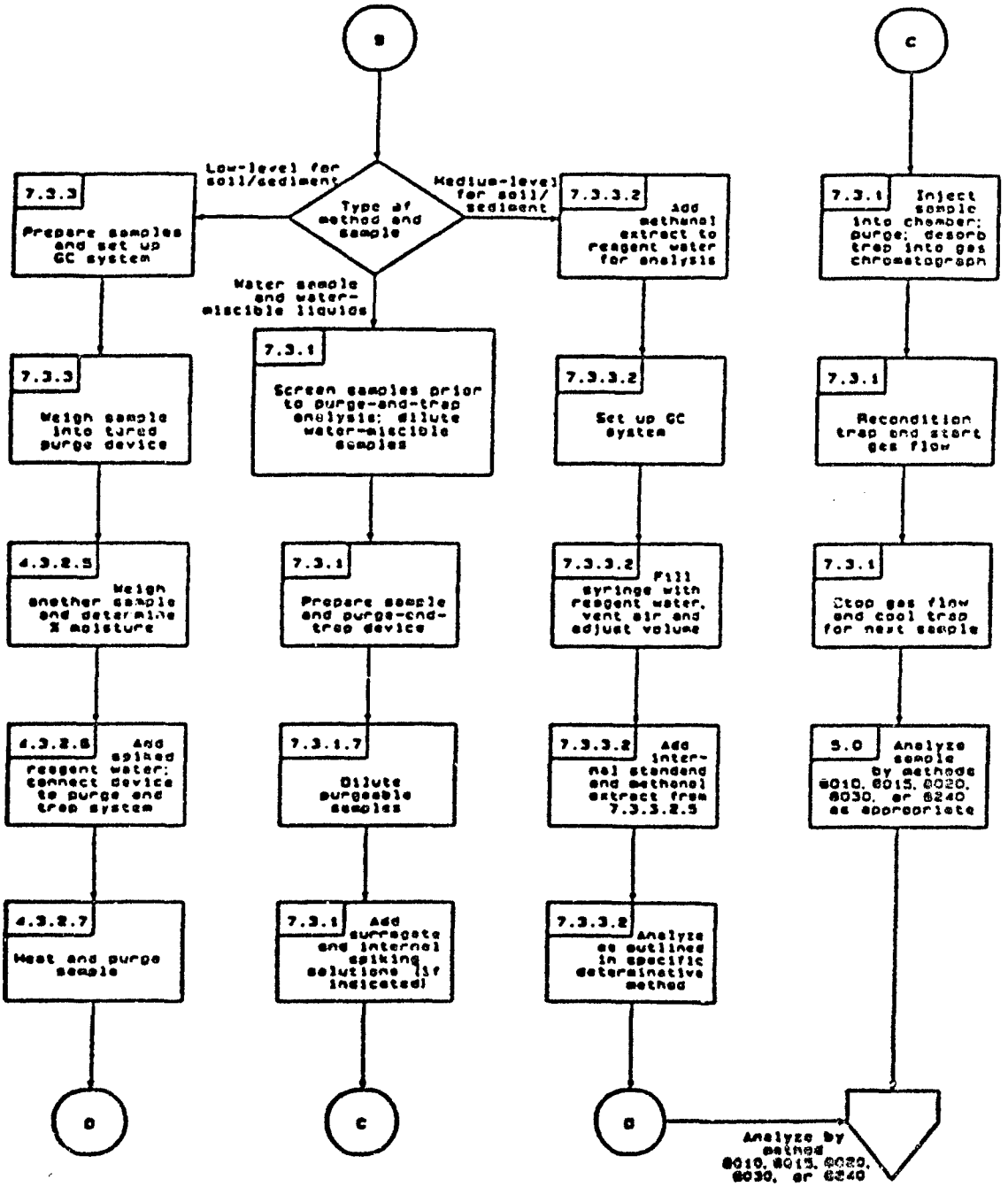
10.0 REFERENCES

1. U.S. EPA 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule," October 26, 1984.

METHOD 5030

PURGE-AND-TRAP METHOD




B
C
Type of method and sample
Low-level for soil/sediment
Medium-level for soil/sediment
Water sample and water-miscible liquids
7.3.3
Prepare samples and set up GC system
7.3.3.2
Add methanol extract to reagent water for analysis
7.3.1
Inject sample into chamber; purge; desorb trap into gas chromatograph
7.3.3
Weigh sample into tared purge device
7.3.1
Screen samples prior to purge-and-trap analysis; dilute water-miscible samples
7.3.3.2
Set up GC system
7.3.1
Recondition trap and start gas flow
4.3.2.5
Weigh another sample and determine % moisture
7.3.1
Prepare sample and purge-and-trap device
7.3.3.2
Fill syringe with reagent water, vent air and adjust volume
7.3.1
Stop gas flow and cool trap for next sample
4.3.2.6
Add spiked reagent water; connect device to purge and trap system
7.3.1.7
Dilute purgeable samples
7.3.3.2
Add internal standard and methanol extract from 7.3.3.2.5
5.0
Analyze sample by methods 8010, 8015, 8020, 8030, or 8240 as appropriate
4.3.2.7
Heat and purge sample
7.3.1
Add surrogate and internal spiking solutions (if indicated)
7.3.3.2
Analyze as outlined in specific determinative method
D
C
D
Analyze by method 8010, 8015, 8020, 8030, or 8240

EPA METHOD 6010

METHOD 8010

HALOGENATED VOLATILE ORGANICS

1.0 SCOPE AND APPLICATION

1.1 Method 8010 is used to determine the concentration of various volatile halogenated organic compounds. Table 1 indicates compounds that may be analyzed by this method and lists the method detection limit for each compound in reagent water. Table 2 lists the practical quantitation limit for other matrices.

2.0 SUMMARY OF METHOD

2.1 Method 8010 provides gas chromatographic conditions for the detection of halogenated volatile organic compounds. Samples can be analyzed using direct injection or purge-and-trap (Method 5030). Ground water samples must be analyzed using Method 5030. A temperature program is used in the gas chromatograph to separate the organic compounds. Detection is achieved by a halogen-specific detector (HSD).

2.2 The method provides an optional gas chromatographic column that may be helpful in resolving the analytes from interferences that may occur and for analyte confirmation.

3.0 INTERFERENCES

3.1 Refer to Method 5030 and 8000.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly chlorofluorocarbons and methylene chloride) through the sample container septum during shipment and storage. A field sample blank prepared from reagent water and carried through sampling and subsequent storage and handling can serve as a check on such contamination.

4.0 APPARATUS AND MATERIALS

4.1 Gas chromatograph

4.1.1 Gas Chromatograph - Analytical system complete with gas chromatograph suitable for on-column injections or purge-and-trap sample introduction and all required accessories, including detector, analytical columns, recorder, gases, and syringes. A data system for measuring peak heights and/or peak areas is recommended.

4.1.2 Columns

4.1.2.1 Column 1 - 8 ft x 0.1 in i.d. stainless steel or glass column packed with 1% SP-1000 on Carbopack-B 60/80 mesh or equivalent.

4.1.2.2 Column 2 - 6 ft x 0.1 in i.d. stainless steel or glass column packed with chemically bonded n-octane on Porasil-C 100/120 mesh (Durapak) or equivalent.

4.1.3 Detector - Electrolytic conductivity (HSD).

4.2 Sample introduction apparatus - Refer to Method 5030 for the appropriate equipment for sample introduction purposes.

4.3 Syringes - 5-mL Luerlok glass hypodermic and a 5-mL, gas-tight with shutoff valve.

4.4 Volumetric flasks - 10-, 50-, 100-, 500-, and 1,000-mL with a ground-glass stopper.

4.5 Microsyringes - 10-, 25-uL with a 0.006 in i.d. needle (Hamilton 702N or equivalent) and a 100-uL.

5.0 REAGENTS

5.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 ASTM Type II Water (ASTM D1193-77 (1983)). All references to water in the method refer to ASTM Type II unless otherwise specified.

5.3 Stock standards - Stock solutions ~~may be prepared from pure standard~~ are purchased as certified solutions. ~~Prepare stock standards in methanol using assayed liquids or gases, as appropriate. Because of the toxicity of some of the organohalides, primary dilutions of these materials should be prepared in a hood.~~

~~5.3.1 Place about 9.8 mL of methanol in a 10-mL tared ground-glass-stoppered volumetric flask. Allow the flask to stand, unstoppered, for about 10 minutes or until all alcohol-wetted surfaces have dried. Weigh the flask to the nearest 0.1 mg.~~

~~5.3.2 Add the assayed reference material, as described below.~~

5.3.2.1 Liquids - Using a 100-uL syringe, immediately add two or more drops of assayed reference material to the flask; then reweigh. The liquid must fall directly into the alcohol without contacting the neck of the flask.

5.3.2.2 Gases - To prepare standards for any compounds that boil below 30°C (e.g. bromomethane, chloroethane, chloromethane, dichlorodifluoromethane, trichlorofluoromethane, vinyl chloride), fill a 5-mL valved gas-tight syringe with the reference standard to the 5.0-mL mark. Lower the needle to 5 mm above the methanol meniscus. Slowly introduce the reference standard above the surface of the liquid. The heavy gas rapidly dissolves in the methanol. This may also be accomplished by using a lecture bottle equipped with a Hamilton Lecture Bottle Septum (#86600). Attach Teflon tubing to the side-arm relief valve and direct a gentle stream of gas into the methanol meniscus.

5.3.3 Reweigh, dilute to volume, stopper, and then mix by inverting the flask several times. Calculate the concentration in micrograms per microliter (ug/uL) from the net gain in weight. When compound purity is assayed to be 96% or greater, the weight may be used without correction to calculate the concentration of the stock standard. Commercially prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source.

5.3.4 Transfer the stock standard solution into a bottle with a Teflon lined screw-cap. Store, with minimal headspace, at -10°C to -20°C and protect from light.

5.3.5 Prepare fresh standards every 2 months for gases or for reactive compounds such as 2-chloroethylvinyl ether. All other standards must be replaced after 6 months, or sooner if comparison with check standards indicates a problem.

5.4 Secondary dilution standards - Using stock standard solutions, prepare in methanol secondary dilution standards, as needed, that contain the compounds of interest, either singly or mixed together. The secondary dilution standards should be prepared at concentrations such that the aqueous calibration standards prepared in Step 5.5 will bracket the working range of the analytical system. Secondary dilution standards should be stored with minimal headspace for volatiles and should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

5.5 Calibration standards - Calibration standards at a minimum of five concentration levels are prepared in water from the secondary dilution of the stock standards. One of the concentration levels should be at a concentration near, but above, the method detection limit. The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the GC. Each standard should contain each analyte for detection by this method (e.g. some or all of the compounds listed in Table 1 may be included). In order to prepare accurate aqueous standard solutions, the following precautions must be observed.

5.5.1 Do not inject more than 20 uL of alcoholic standards into 100 mL of water.

5.5.2 Use a 25-uL Hamilton 702N microsyringe or equivalent (variations in needle geometry will adversely affect the ability to deliver reproducible volumes of methanolic standards into water).

5.5.3 Rapidly inject the alcoholic standard into the filled volumetric flask. Remove the needle as fast as possible after injection.

5.5.4 Mix aqueous standards by inverting the flask three times only.

5.5.5 Fill the sample syringe from the standard solution contained in the expanded area of the flask (do not use any solution contained in the neck of the flask).

5.5.6 Never use pipets to dilute or transfer samples or aqueous standards.

5.5.7 Aqueous standards are not stable and should be discarded after 1 hour, unless properly sealed and stored. The aqueous standards can be stored up to 24 hours, if held in sealed vials with zero headspace.

5.6 Internal standards (if internal standard calibration is used) - To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Because of these limitations, no internal standard can be suggested that is applicable to all samples. The compounds recommended for use as surrogate spikes (Step 5.7) have been used successfully as an internal standards, because of their generally unique retention times.

5.6.1 Prepare calibration standards at a minimum of five concentration levels for each parameter of interest as described in Step 5.5.

5.6.2 Prepare a spiking solution containing each of the internal standards using the procedures described in Steps 5.3 and 5.4. It is recommended that the secondary dilution standard be prepared at a concentration of 15 ug/mL of each internal standard compound. The addition of 10 uL of this standard to 5.0 mL of sample or calibration standard would be equivalent to 30 ug/L.

5.6.3 Analyze each calibration standard according to Section 7.0, adding 10 uL of internal standard spiking solution directly to the syringe.

5.7 Surrogate standards - The analyst should monitor both the performance of the analytical system and the effectiveness of the method in dealing with each sample matrix by spiking each sample, standard, and reagent water blank with surrogate halocarbons. ~~A combination Bromochloromethane, 2-bromo-1-chloropropane, and 1,4-dichlorobutane is recommended to encompass the range of the temperature program used in this method.~~ From stock standard solutions prepared as in Step 5.3, add a volume to give 750 ug of each surrogate to 45 mL of reagent water contained in a 50-mL volumetric flask, mix, and dilute to volume for a concentration of 15 ng/uL. Add 10 uL of this surrogate spiking solution directly into the 5-mL syringe with every sample and reference standard analyzed. If the internal standard calibration procedure is used, the surrogate compounds may be added directly to the internal standard spiking solution (Step 5.6.2).

5.8 Methanol, CH_3OH. Pesticide quality or equivalent. Store away from other solvents.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 See the introductory material to this chapter, Organic Analytes, Section 4.1.

7.0 PROCEDURE

7.1 Volatile compounds are introduced into the gas chromatograph either by direct injection or purge-and-trap (Method 5030). Method 5030 may be used directly on ground water samples or low-level contaminated soils and sediments. For medium-level soils or sediments, methanolic extraction, as described in Method 5030, may be necessary prior to purge-and-trap analysis.

7.2 Gas chromatography conditions (Recommended)

7.2.1 Column 1 - Set helium gas flow at 40 mL/min flow rate. Set column temperature at 45°C for 3 minutes; then program an 8°C/min temperature rise to 220°C and hold for 15 minutes.

~~7.2.2 Column 2 - Set helium gas flow at 40 mL/min flow rate. Set column temperature at 50°C for 3 minutes; then program a 6°C/min temperature rise to 170°C and hold for 4 minutes.~~

7.3 Calibration - Refer to Method 8000 for proper calibration techniques. Use Table 1 and especially Table 2 for guidance on selecting the lowest point on the calibration curve.

7.3.1 Calibration must take place using the same sample introduction method that will be used to analyze actual samples (see Step 7.4.1).

7.3.2 The procedure for internal or external calibration may be used. Refer to Method 8000 for a description of each of these procedures.

7.4 Gas chromatographic analysis

7.4.1 Introduce volatile compounds into the gas chromatograph using either Method 5030 (purge-and-trap method) or the direct injection method (see Step 7.4.1.1). If the internal standard calibration technique is used, add 10 uL of internal standard to the sample prior to purging.

7.4.1.1 Direct injection - In very limited applications (e.g. aqueous process wastes), direct injection of the sample into the GC system with a 10 uL syringe may be appropriate. The detection limit is very high (approximately 10,000 ug/L); therefore, it is only permitted when concentrations in excess of 10,000 ug/L are expected or for water-soluble compounds that do not purge. The system must be calibrated by direct injection (bypassing the purge-and-trap device).

7.4.2 Follow Step 7.6 of Method 8000 for instructions on the analysis sequence, appropriate dilutions, establishing daily retention time windows, and identification criteria. Include a mid-level standard after each group of 10 samples in the analysis sequence.

7.4.3 Table 1 summarizes the estimated retention times on the two columns for a number of organic compounds analyzable by this method. An example of the separation achieved by Column 1 is shown in Figure 1.

7.4.4 Record the sample volume purged or injected and the resulting peak sizes (in area units or peak heights).

7.4.5 Calculation of concentration is covered in Step 7.8 of Method 8000.

7.4.6 If analytical interferences are suspected, or for the purpose of confirmation, analysis using the second GC column is recommended.

7.4.7 If the response for a peak is off-scale, prepare a dilution of the sample with reagent water. The dilution must be performed on a second aliquot of the sample which has been properly sealed and stored prior to use.

8.0 QUALITY CONTROL

8.1 Refer to Chapter One for specific quality control procedures and Method 8000 for gas chromatographic procedures. Quality control to ensure the proper operation of the purge-and-trap device is covered in Method 5030.

8.2 Mandatory quality control to validate the GC system operation is found in Method 8000, Step 8.6.

8.2.1 The quality control check sample concentrate (Method 8000, Step 8.6) should contain each parameter of interest at a concentration of 10 ug/mL in methanol.

8.2.2 Table 3 indicates the calibration and QC acceptance criteria for this method. Table 4 gives method accuracy and precision as functions of concentration for the analytes of interest. The contents of both Tables should be used to evaluate a laboratory's ability to perform and generate acceptable data by this method.

8.3 Calculate surrogate standard recovery on all samples, blanks, and spikes. Determine if recovery is within limits (limits established by performing QC procedure outlined in Method 8000, Step 8.10).

8.3.1 If recovery is not within limits, the following is required.

- Check to be sure there are no errors in calculations, surrogate solutions and internal standards. Also, check instrument performance.
- Recalculate the data and/or reanalyze the extract if any of the above checks reveal a problem.
- Reextract and reanalyze the sample if none of the above are a problem or flag the data as "estimated concentration."

9.0 METHOD PERFORMANCE

9.1 This method was tested by 20 laboratories using reagent water, drinking water, surface water, and three industrial wastewaters spiked at six concentrations over the range 8.0-500 ug/L. Single operator precision, overall precision, and method accuracy were found to be directly related to the concentration of the parameter and essentially independent of the sample matrix. Linear equations to describe these relationships are presented in Table 4.

9.2 The accuracy and precision obtained will be determined by the sample matrix, sample introduction technique, and by the calibration procedure used.

10.0 REFERENCES

1. Bellar, T.A., and J.J. Lichtenberg, J. Amer. Water Works Assoc., 66(12), pp. 739-744, 1974.

2. Bellar, T.A., and J.J. Lichtenberg, Semi-Automated Headspace Analysis of Drinking Waters and Industrial Waters for Purgeable Volatile Organic Compounds, in Van Hall (ed.), Measurement of Organic Pollutants in Water and Wastewater, ASTM STP 686, pp. 108-129, 1979.

3. Development and Application of Test Procedures for Specific Organic Toxic Substances in Wastewaters. Category 11 - Purgeables and Category 12 - Acrolein, Acrylonitrile, and Dichlorodifluoromethane. Report for EPA Contract 68-03-2635 (in preparation).

4. U.S. EPA 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule," October 26, 1984.

5. Provost, L.P., and R.S. Elder, "Interpretation of Percent Recovery Data," American Laboratory, 15, pp. 58-63, 1983.

6. "EPA Method Validation Study 23, Method 601 (Purgeable Halocarbons)," Report for EPA Contract 68-03-2856 (in preparation).

TABLE 1.
CHROMATOGRAPHIC CONDITIONS AND METHOD DETECTION LIMITS FOR
HALOGENATED VOLATILE ORGANICS

Compound	Retention time (min) Col. 1	Retention time (min) Col. 2	Method detection limit[a] (ug/L)
~~Benzyl chloride~~[b]			
~~Bis(2-chloroethoxy)methane~~[c]			
~~Bromobenzene~~			
Bromodichloromethane	13.7	14.6	0.10
Bromoform	19.2	19.2	0.20
Bromomethane			
Carbon tetrachloride	13.0	14.4	0.12
Chlorobenzene	24.2	18.8	0.25
Chloroethane	3.33	8.68	0.52
2-Chloroethyl vinyl ether	18.0		0.13
Chloroform	10.7	12.1	0.05
~~1-Chlorohexane~~			
Chloromethane	1.50	5.28	0.~~50~~
~~Chloromethylmethyl ether~~[c]			
~~Chlorotoluene~~[b]			
Dibromochloromethane	16.5	16.6	0.09
~~Dibromomethane~~			
1,2-Dichlorobenzene	34.9	23.5	0.15
1,3-Dichlorobenzene	34.0	22.4	0.32
1,4-Dichlorobenzene	35.4	22.3	0.24
Dichlorodifluoromethane[b]			
1,1-Dichloroethane	9.30	12.5	0.07
1,2-Dichloroethane	11.4	15.4	0.03
1,1-Dichloroethylene	8.0	7.72	0.13
trans-1,2-Dichloroethylene	10.1	9.38	0.10
Dichloromethane			
1,2-Dichloropropane	14.9	15.6	0.04
trans-1,3-Dichloropropylene	15.2	16.6	0.34
~~1,1,2,2-Tetrachloroethane~~	21.6		0.03
1,1,1,2-Tetrachloroethane			
Tetrachloroethylene	21.7	15.0	0.03
1,1,1-Trichloroethane	12.6	13.1	0.03
1,1,2-Trichloroethane	16.5	18.1	0.02
Trichloroethylene	15.8	13.1	0.12
Trichlorofluoromethane	7.18		
~~Trichloropropane~~			
Vinyl chloride	2.67	5.28	0.18
cis 1,3 Dichloropropene			

[a] Using purge-and-trap method (Method 5030).
[b] Demonstrated very erratic results when tested by purge-and-trap.
[c] Demonstrated poor purging efficiency.

TABLE 2.
DETERMINATION OF PRACTICAL QUANTITATION LIMITS
(PQL) FOR VARIOUS MATRICES[a]

Matrix	Factor[b]
Ground water	10
Low-level soil	10
Water miscible liquid waste	500
High-level soil and sludge	1250
Non-water miscible waste	1250

[a]Sample PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achievable.

[b]PQL = [Method detection limit (Table 1)] X [Factor (Table 2)]. For non-aqueous samples, the factor is on a wet-weight basis.

TABLE 3.
CALIBRATION AND QC ACCEPTANCE CRITERIA[a]

Parameter	Range for Q (ug/L)	Limit for s (ug/L)	Range for x (ug/L)	Range P, P_s (%)
Bromodichloromethane	15.2-24.8	4.3	10.7-32.0	42-172
Bromoform	14.7-25.3	4.7	5.0-29.3	13-159
Bromomethane	11.7-28.3	7.6	3.4-24.5	D-144
Carbon tetrachloride	13.7-26.3	5.6	11.8-25.3	43-143
Chlorobenzene	14.4-25.6	5.0	10.2-27.4	38-150
Chloroethane	15.4-24.6	4.4	11.3-25.2	46-137
2-Chloroethylvinyl ether	12.0-28.0	8.3	4.5-35.5	14-186
Chloroform	15.0-25.0	4.5	12.4-24.0	49-133
Chloromethane	11.9-28.1	7.4	D-34.9	D-193
Dibromochloromethane	13.1-26.9	6.3	7.9-35.1	24-191
1,2-Dichlorobenzene	14.0-26.0	5.5	1.7-38.9	D-203
1,3-Dichlorobenzene	9.9-30.1	9.1	6.2-32.6	7-197
1,4-Dichlorobenzene	13.9-26.1	5.5	11.5-25.5	42-143
1,1-Dichloroethane	16.8-23.2	3.2	11.2-24.6	37-132
1,2-Dichloroethane	14.3-25.7	5.2	13.0-26.5	51-147
1,1-Dichloroethene	12.6-27.4	6.6	10.2-27.3	28-167
trans-1,2-Dichloroethene	12.8-27.2	6.4	11.4-27.1	38-155
1,2-Dichloropropane	14.8-25.2	5.2	10.1-29.9	44-156
cis-1,3-Dichloropropene	12.8-27.2	7.3	6.2-33.8	22-178
trans-1,3-Dichloropropene	12.8-27.2	7.3	6.2-33.8	22-178
Methylene chloride	15.5-24.5	4.0	7.0-27.6	25-162
1,1,2,2-Tetrachloroethane	9.8-30.2	9.2	6.6-31.8	8-184
Tetrachloroethene	14.0-26.0	5.4	8.1-29.6	26-162
1,1,1-Trichloroethane	14.2-25.8	4.9	10.8-24.8	41-138
1,1,2-Trichloroethane	15.7-24.3	3.9	9.6-25.4	39-136
Trichloroethene	15.4-24.6	4.2	9.2-26.6	35-146
Trichlorofluoromethane	13.3-26.7	6.0	7.4-28.1	21-156
Vinyl chloride	13.7-26.3	5.7	8.2-29.9	28-163

Q = Concentration measured in QC check sample, in ug/L.

s = Standard deviation of four recovery measurements, in ug/L.

x = Average recovery for four recovery measurements, in ug/L.

P, P_s = Percent recovery measured.

D = Detected; result must be greater than zero.

[a]Criteria are from 40 CFR Part 136 for Method 601 and were calculated assuming a QC check sample concentration of 20 ug/L.

TABLE 4.
METHOD ACCURACY AND PRECISION AS FUNCTIONS OF CONCENTRATION[a]

Parameter	Accuracy, as recovery, x' (ug/L)	Single analyst precision, s_r' (ug/L)	Overall precision, S' (ug/L)
Bromodichloromethane	1.12C-1.02	0.11x+0.04	0.20x+1.00
Bromoform	0.96C-2.05	0.12x+0.58	0.21x+2.41
Bromomethane	0.76C-1.27	0.28x+0.27	0.36x+0.94
Carbon tetrachloride	0.98C-1.04	0.15x+0.38	0.20x+0.39
Chlorobenzene	1.00C-1.23	0.15x-0.02	0.18x+1.21
Chloroethane	0.99C-1.53	0.14x-0.13	0.17x+0.63
2-Chloroethylvinyl ether[b]	1.00C	0.20x	0.35x
Chloroform	0.93C-0.39	0.13x+0.15	0.19x-0.02
Chloromethane	0.77C+0.18	0.28x-0.31	0.52x+1.31
Dibromochloromethane	0.94C+2.72	0.11x+1.10	0.24x+1.69
1,2-Dichlorobenzene	0.93C+1.70	0.20x+0.97	0.13x+6.13
1,3-Dichlorobenzene	0.95C+0.43	0.14x+2.33	0.26x+2.34
1,4-Dichlorobenzene	0.93C-0.09	0.15x+0.29	0.20x+0.41
1,1-Dichloroethane	0.95C-1.03	0.08x+0.17	0.14x+0.94
1,2-Dichloroethane	1.04C-1.05	0.11x+0.70	0.15x+0.94
1,1-Dichloroethene	0.98C-0.87	0.21x-0.23	0.29x-0.04
trans-1,2-Dichloroethene	0.97C-0.16	0.11x+1.46	0.17x+1.46
1,2-Dichloropropane[b]	1.00C	0.13x	0.23x
cis-1,3-Dichloropropene[b]	1.00C	0.18x	0.32x
trans-1,3-Dichloropropene[b]	1.00C	0.18x	0.32x
Methylene chloride	0.91C-0.93	0.11x+0.33	0.21x+1.43
1,1,2,2-Tetrachloroethane	0.95C+0.19	0.14x+2.41	0.23x+2.79
Tetrachloroethene	0.94C+0.06	0.14x+0.38	0.18x+2.21
1,1,1-Trichloroethane	0.90C-0.16	0.15x+0.04	0.20x+0.37
1,1,2-Trichloroethane	0.86C+0.30	0.13x-0.14	0.19x+0.67
Trichloroethene	0.87C+0.43	0.13x-0.03	0.23x+0.30
Trichlorofluoromethane	0.89C-0.07	0.15x+0.67	0.26x+0.91
Vinyl chloride	0.97C-0.36	0.13x+0.65	0.27x+0.40

x' = Expected recovery for one or more measurements of a sample containing a concentration of C, in ug/L.

s_r' = Expected single analyst standard deviation of measurements at an average concentration of x, in ug/L.

S' = Expected interlaboratory standard deviation of measurements at an average concentration found of x, in ug/L.

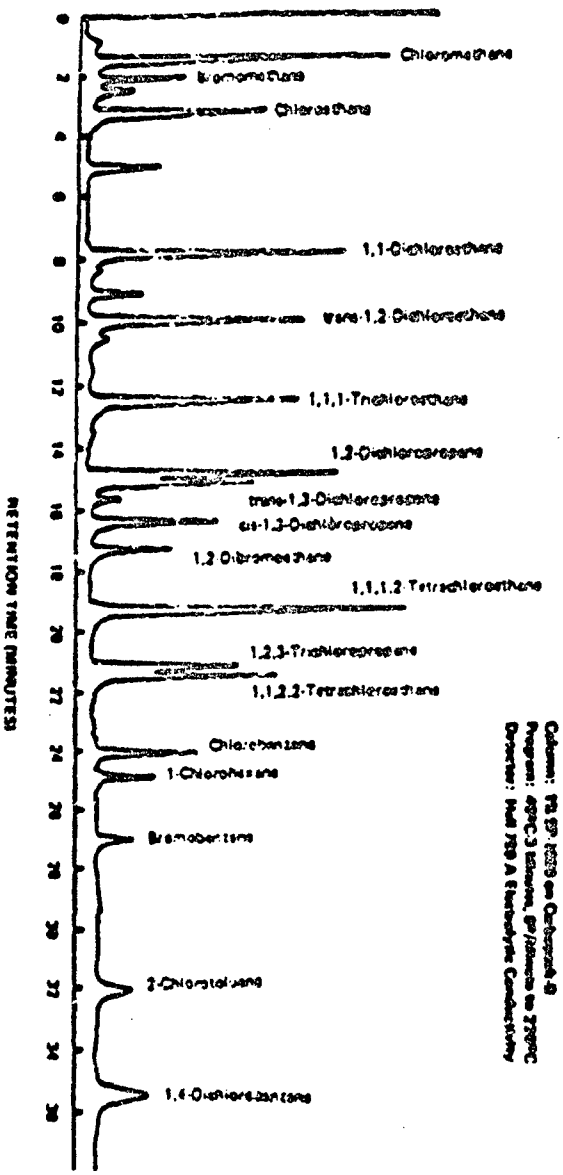
C = True value for the concentration, in ug/L.

x = Average recovery found for measurements of samples containing a concentration of C, in ug/L.

[a]From 40 CFR Part 136 for Method 601.

[b]Estimates based upon the performance in a single laboratory.

FIGURE 1.
GAS CHROMATOGRAM OF HALOGENATED VOLATILE ORGANICS



EPA METHOD 8020

METHOD 8020

AROMATIC VOLATILE ORGANICS

1.0 SCOPE AND APPLICATION

1.1 Method 8020 is used to determine the concentration of various aromatic volatile organic compounds. Table 1 indicates compounds which may be determined by this method and lists the method detection limit for each compound in reagent water. Table 2 lists the practical quantitation limit (PQL) for other matrices.

2.0 SUMMARY OF METHOD

2.1 Method 8020 provides chromatographic conditions for the detection of aromatic volatile compounds. Samples can be analyzed using direct injection or purge-and-trap (Method 5030). Ground water samples must be determined using Method 5030. A temperature program is used in the gas chromatograph to separate the organic compounds. Detection is achieved by a photo-ionization detector (PID).

2.2 If interferences are encountered, the method provides an optional gas chromatographic column that may be helpful in resolving the analytes from the interferences and for analyte confirmation.

3.0 INTERFERENCES

3.1 Refer to Method 5030 and 8000.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly chlorofluorocarbons and methylene chloride) through the sample container septum during shipment and storage. A field sample blank prepared from reagent water and carried through sampling and subsequent storage and handling can serve as a check on such contamination.

4.0 APPARATUS AND MATERIALS

4.1 Gas chromatograph:

4.1.1 Gas Chromatograph: Analytical system complete with gas chromatograph suitable for on-column injections or purge-and-trap sample introduction and all required accessories, including detectors, column supplies, recorder, gases, and syringes. A data system for measuring peak heights and/or peak areas is recommended.

TABLE 1. CHROMATOGRAPHIC CONDITIONS AND METHOD DETECTION LIMITS FOR AROMATIC VOLATILE ORGANICS

Compound	Retention time (min) Col. 1	Retention time (min) Col. 2	Method detection limit[a] (ug/L)
Benzene	3.33	2.75	0.2
Chlorobenzene	9.17	8.02	0.2
1,4-Dichlorobenzene	16.8	16.2	0.3
1,3-Dichlorobenzene	18.2	15.0	0.4
1,2-Dichlorobenzene	25.9	19.4	0.4
Ethyl Benzene	8.25	6.25	0.2
Toluene	5.75	4.25	0.2
Xylenes			

[a] Using purge-and-trap method (Method 5030).

TABLE 2. DETERMINATION OF PRACTICAL QUANTITATION LIMITS (PQL) FOR VARIOUS MATRICES[a]

Matrix	Factor[b]
Ground water	10
Low-level soil	10
Water miscible liquid waste	500
High-level soil and sludge	1250
Non-water miscible waste	1250

[a]Sample PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achievable.

[b]PQL = [Method detection limit (Table 1)] X [Factor (Table 2)]. For non-aqueous samples, the factor is on a wet-weight basis.

4.1.2 Columns:

4.1.2.1 Column 1: 6-ft x 0.082-in I.D. #304 stainless steel or glass column packed with 5% SP-1200 and 1.75% Bentone-34 on 100/120 mesh Supelcort or equivalent.

4.1.2.2 Column 2: 8-ft x 0.1-in I.D. stainless steel or glass column packed with 5% 1,2,3-Tris(2-cyanoethoxy)propane on 60/80 mesh Chromosorb W-AW or equivalent.

4.1.3 Detector: Photoionization (PID) (h-Nu Systems, Inc. Model PI-51-02 or equivalent).

4.2 Sample introduction apparatus: Refer to Method 5030 for the appropriate equipment for sample introduction purposes.

4.3 Syringes: A 5-mL Luerlok glass hypodermic and a 5-mL, gas-tight with shutoff valve.

4.4 Volumetric flask: 10-, 50-, 100-, 500-, and 1,000-mL with a ground-glass stopper.

4.5 Microsyringe: 10- and 25-uL with a 0.006-in I.D. needle (Hamilton 702N or equivalent) and a 100-uL.

5.0 REAGENTS

5.1 Reagent water: Reagent water is defined as a water in which an interferent is not observed at the method detection limit (MDL) of the parameters of interest.

5.2 Stock standards: Stock solutions may be prepared from pure standard materials or purchased as certified solutions. Prepare stock standards in methanol using assayed liquids. Because of the toxicity of benzene and 1,4-dichlorobenzene, primary dilutions of these materials should be prepared in a hood.

5.2.1 Place about 9.8 mL of methanol in a 10-mL tared ground-glass-stoppered volumetric flask. Allow the flask to stand, unstoppered, for about 10 min or until all alcohol-wetted surfaces have dried. Weigh the flask to the nearest 0.1 mg.

5.2.2 Using a 100-uL syringe, immediately add two or more drops of assayed reference material to the flask; then reweigh. The liquid must fall directly into the alcohol without contacting the neck of the flask.

5.2.3 Reweigh, dilute to volume, stopper, and then mix by inverting the flask several times. Calculate the concentration in micrograms per microliter (ug/uL) from the net gain in weight. When compound purity is assayed to be 96% or greater, the weight may be used without correction

to calculate the concentration of the stock standard. Commercially prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source.

5.2.4 Transfer the stock standard solution into a Teflon-sealed screw-cap bottle. Store, with minimal headspace, at 4°C and protect from light.

5.2.5 All standards must be replaced after 6 months, or sooner if comparison with check standards indicates a problem.

5.3 Secondary dilution standards: Using stock standard solutions, prepare in methanol secondary dilution standards, as needed, that contain the compounds of interest, either singly or mixed together. The secondary dilution standards should be prepared at concentrations such that the aqueous calibration standards prepared in Paragraph 5.4 will bracket the working range of the analytical system. Secondary dilution standards should be stored with minimal headspace for volatiles and should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

5.4 Calibration standards: Calibration standards at a minimum of five concentration levels are prepared in reagent water from the secondary dilution of the stock standards. One of the concentration levels should be at a concentration near, but above, the method detection limit. The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the GC. Each standard should contain each analyte for detection by this method (e.g., some or all of the compounds listed in Table 1 may be included). In order to prepare accurate aqueous standard solutions, the following precautions must be observed.

5.4.1 Do not inject more than 20 uL of alcoholic standards into 100 mL of reagent water.

5.4.2 Use a 25-uL Hamilton 702N microsyringe or equivalent (variations in needle geometry will adversely affect the ability to deliver reproducible volumes of methanolic standards into water).

5.4.3 Rapidly inject the alcoholic standard into the filled volumetric flask. Remove the needle as fast as possible after injection.

5.4.4 Mix aqueous standards by inverting the flask three times only.

5.4.5 Fill the sample syringe from the standard solution contained in the expanded area of the flask (do not use any solution contained in the neck of the flask).

5.4.6 Never use pipets to dilute or transfer samples or aqueous standards.

5.4.7 Aqueous standards are not stable and should be discarded after 1 hr, unless properly sealed and stored. The aqueous standards can be stored up to 24 hr, if held in sealed vials with zero headspace.

5.5 Internal standards (if internal standard calibration is used): To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Because of these limitations, no internal standard can be suggested that is applicable to all samples. The compound, alpha,alpha,alpha-trifluorotoluene recommended for use as a surrogate spiking compound (Paragraph 5.6) has been used successfully as an internal standards.

5.5.1 Prepare calibration standards at a minimum of five concentration levels for each parameter of interest as described in Section 5.4.

5.5.2 Prepare a spiking solution containing each of the internal standards using the procedures described in Sections 5.2 and 5.3. It is recommended that the secondary dilution standard be prepared at a concentration of 15 ug/mL of each internal standard compound. The addition of 10 uL of this standard to 5.0 mL of sample or calibration standard would be equivalent to 30 ug/L.

5.5.3 Analyze each calibration standard according to Section 7.0, adding 10 uL of internal standard spiking solution directly to the syringe.

5.6 Surrogate standards: The analyst should monitor both the performance of the analytical system and the effectiveness of the method in dealing with each sample matrix by spiking each sample, standard, and reagent water blank with surrogate compounds (e.g, alpha,alpha,alpha-trifluorotoluene) recommended to encompass the range of the temperature program used in this method. From stock standard solutions prepared as in Section 5.2, add a volume to give 750 ug of each surrogate to 45 mL of reagent water contained in a 50-mL volumetric flask, mix, and dilute to volume for a concentration of 15 ng/uL. Add 10 uL of this surrogate spiking solution directly into the 5-mL syringe with every sample and reference standard analyzed. If the internal standard calibration procedure is used, the surrogate compounds may be added directly to the internal standard spiking solution (Paragrapn 5.5.2).

5.7 Methanol: pesticide quality or equivalent. Store away from other solvents.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 See the introductory material to this chapter, Organic Analytes, Section 4.1.

7.0 PROCEDURE

7.1 Volatile compounds are introduced into the gas chromatograph either by direct injection or purge-and-trap (Method 5030). Method 5030 may be used directly on ground water samples or low-level contaminated soils and sediments. For medium-level soils or sediments, methanolic extraction, as described in Method 5030, may be necessary prior to purge-and-trap analysis.

7.2 Gas chromatography conditions (Recommended):

7.2.1 Column 1: Set helium gas flow at 36 mL/min flow rate. The temperature program sequences are as follows: For lower boiling compounds, operate at 50°C isothermal for 2 min; then program at 6°C/min to 90°C and hold until all compounds have eluted. For higher boiling range of compounds, operate at 50°C isothermal for 2 min; then program at 3°C/min to 110°C and hold until all compounds have eluted. Column 1 provides outstanding separations for a wide variety of aromatic hydrocarbons. Column 1 should be used as the primary analytical column because of its unique ability to resolve para-, meta-, and ortho-aromatic isomers.

7.2.2 Column 2: Set helium gas flow at 30 mL/min flow rate. The temperature program sequence is as follows: 40°C isothermal for 2 min; then 2°C/min to 100°C and hold until all compounds have eluted. Column 2, an extremely high-polarity column, has been used for a number of years to resolve aromatic hydrocarbons from alkanes in complex samples. However, because resolution between some of the aromatics is not as efficient as with Column 1, Column 2 should be used as a confirmatory column.

7.3 Calibration: Refer to Method 8000 for proper calibration techniques. Use Table 1 and especially Table 2 for guidance on selecting the lowest point on the calibration curve.

7.3.1 Calibration must take place using the same sample introduction method that will be used to analyze actual samples (see Section 7.4.1).

7.3.2 The procedure for internal or external calibration may be used. Refer to Method 8000 for a description of each of these procedures.

7.4 Gas chromatographic analysis:

7.4.1 Introduce volatile compounds into the gas chromatograph using either Method 5030 (purge-and-trap method) or the direct injection method. If the internal standard calibration technique is used, add 10 uL of internal standard to the sample prior to purging.

7.4.1.1 Direct injection: In very limited applications (e.g., aqueous process wastes), direct injection of the sample into the GC system with a 10 uL syringe may be appropriate. The detection limit is very high (approximately 10,000 ug/L); therefore, it is only permitted when concentrations in excess of 10,000 ug/L are expected or for water-soluble compounds that do not purge. The system must be calibrated by direct injection (bypassing the purge-and-trap device).

7.4.2 Follow Section 7.6 of Method 8000 for instructions on the analysis sequence, appropriate dilutions, establishing daily retention time windows, and identification criteria. Include a mid-level standard after each group of 10 samples in the analysis sequence.

7.4.3 Table 1 summarizes the estimated retention times and detection limits for a number of organic compounds analyzable using this method. An example of the separation achieved by Column 1 is shown in Figure 1. Figure 2 shows an example of the separation achieved using Column 2.

7.4.4 Record the sample volume purged or injected and the resulting peak sizes (in area units or peak heights).

7.4.5 Calculation of concentration is covered in Section 7.8 of Method 8000.

7.4.6 If analytical interferences are suspected, or for the purpose of confirmation, analysis using the second GC column is recommended.

7.4.7 If the response for a peak is off-scale, prepare a dilution of the sample with reagent water. The dilution must be performed on a second aliquot of the sample which has been properly sealed and stored prior to use.

8.0 QUALITY CONTROL

8.1 Refer to Chapter One for specific quality control procedures and Method 8000 for gas chromatographic procedures. Quality control to ensure the proper operation of the purge-and-trap device is covered in Method 5030.

8.2 Mandatory quality control to validate the GC system operation is found in Method 8000, Section 8.6.

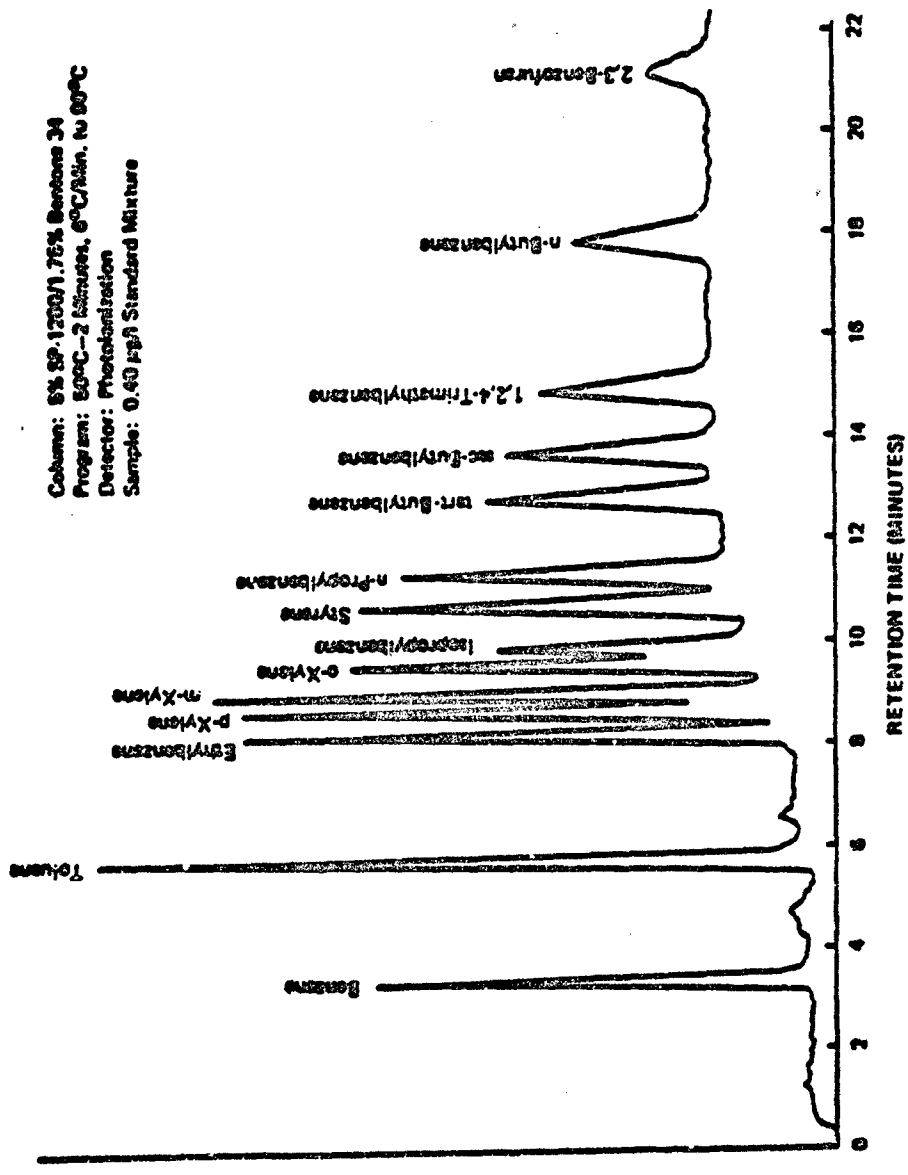


Figure 1. Chromatogram of aromatic volatile organics (column 1 conditions).

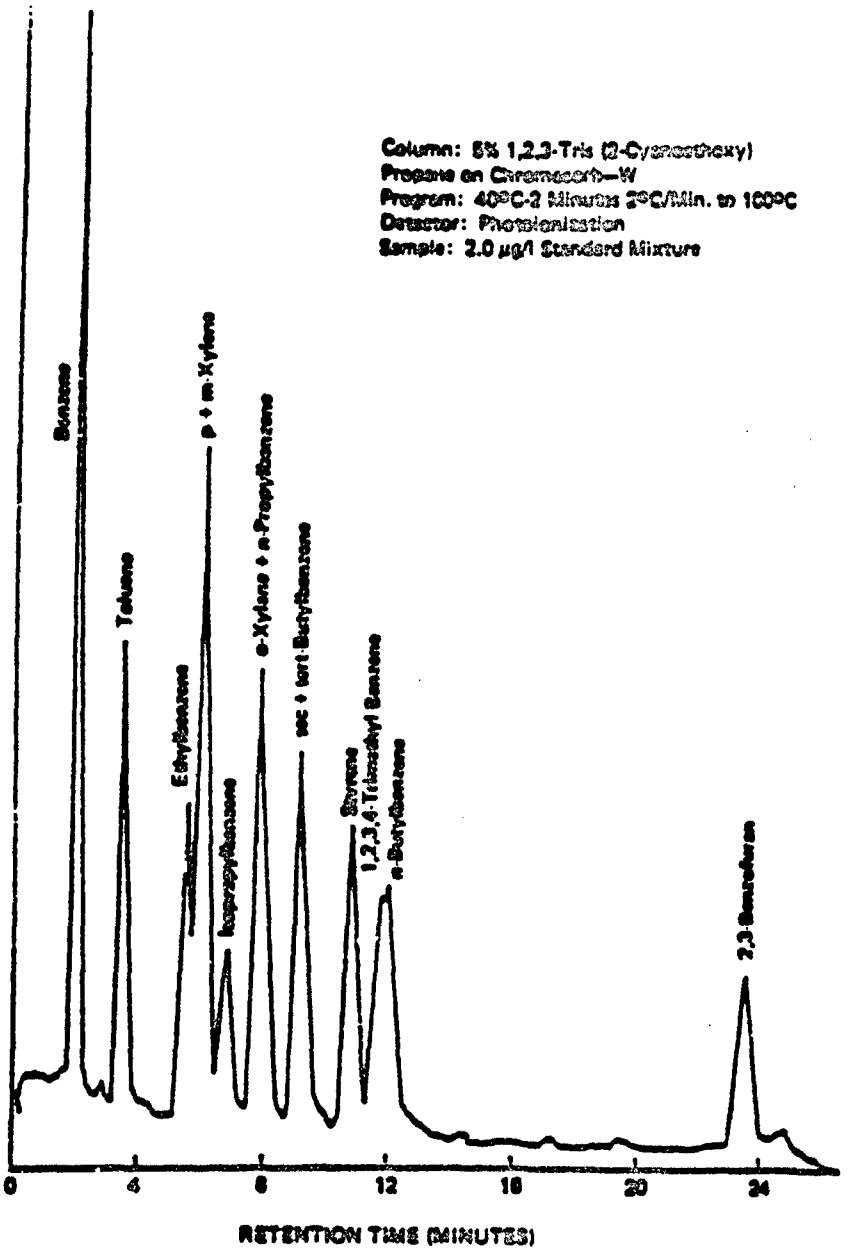


Figure 2. Chromatogram of aromatic volatile organics (column 2 conditions).

8.2.1 The quality control check sample concentrate (Method 8000, Section 8.6) should contain each parameter of interest at a concentration of 10 ug/mL in methanol.

8.2.2 Table 3 indicates the calibration and QC acceptance criteria for this method. Table 4 gives method accuracy and precision as functions of concentration for the analytes of interest. The contents of both Tables should be used to evaluate a laboratory's ability to perform and generate acceptable data by this method.

8.3 Calculate surrogate standard recovery on all samples, blanks, and spikes. Determine if recovery is within limits (limits established by performing QC procedure outlined in Method 8000, Section 8.10).

8.3.1 If recovery is not within limits, the following is required.

- Check to be sure there are no errors in calculations, surrogate solutions and internal standards. Also, check instrument performance.
- Recalculate the data and/or reanalyze the extract if any of the above checks reveal a problem.
- Reextract and reanalyze the sample if none of the above are a problem or flag the data as "estimated concentration."

9.0 METHOD PERFORMANCE

9.1 This method was tested by 20 laboratories using reagent water, drinking water, surface water, and three industrial wastewaters spiked at six concentrations over the range 2.1-500 ug/L. Single operator precision, overall precision, and method accuracy were found to be directly related to the concentration of the parameter and essentially independent of the sample matrix. Linear equations to describe these relationships are presented in Table 4.

9.2 The accuracy and precision obtained will be determined by the sample matrix, sample introduction technique, and by the calibration procedure used.

10.0 REFERENCES

1. Bellar, T.A., and J.J. Lichtenberg, J. Amer. Water Works Assoc., 65(12), pp. 739-744, 1974.

2. Bellar, T.A., and J.J. Lichtenberg, Semi-Automated Headspace Analysis of Drinking Waters and Industrial Waters for Purgeable Volatile Organic Compounds, in Van Hall (ed.), Measurement of Organic Pollutants in Water and Wastewater, ASTM STP 686, pp. 108-129, 1979.

3. Dowty, B.J., S.R. Antoine, and J.L. Laseter, "Quantitative and Qualitative Analysis of Purgeable Organics by High Resolution Gas Chromatography and Flame Ionization Detection," in Van Hall, ed., Measurement of Organic Pollutants in Water and Wastewater. ASTM STP 686, pp. 24-35, 1979.

4. Development and Application of Test Procedures for Specific Organic Toxic Substances in Wastewaters. Category 11 - Purgeables and Category 12 - Acrolein, Acrylonitrile, and Dichlorodifluoromethane. Report for EPA Contract 68-03-2635 (in preparation).

5. "EPA Method Validation Study 24, Method 602 (Purgeable Aromatics)," Report for EPA Contract 68-03-2856 (in preparation).

6. U.S. EPA 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule," October 26, 1984.

7. Provost, L.P., and R.S. Elder, "Interpretation of Percent Recovery Data," American Laboratory, 15, pp. 58-63, 1983.

TABLE 3. CALIBRATION AND QC ACCEPTANCE CRITERIA[a]

Parameter	Range for Q (ug/L)	Limit for s (ug/L)	Range for X (ug/L)	Range P, P_s (%)
Benzene	15.4-24.6	4.1	10.0-27.9	39-150
Chlorobenzene	16.1-23.9	3.5	12.7-25.4	55-135
1,2-Dichlorobenzene	13.6-26.4	5.8	10.6-27.6	37-154
1,3-Dichlorobenzene	14.5-25.5	5.0	12.8-25.5	50-141
1,4-Dichlorobenzene	13.9-26.1	5.5	11.6-25.5	42-143
Ethylbenzene	12.6-27.4	6.7	10.0-28.2	32-160
To ene	15.5-24.5	4.0	11.2-27.7	46-148

Q = Concentration measured in QC check sample, in ug/L.

s = Standard deviation of four recovery measurements, in ug/L.

X = Average recovery for four recovery measurements, in ug/L.

P, P_s = Percent recovery measured.

[a]Criteria are from 40 CFR Part 136 for Method 602 and were calculated assuming a QC check sample concentration of 20 ug/L. These criteria are based directly upon the method performance data in Table 4. Where necessary, the limits for recovery have been broadened to assure applicability of the limits to concentrations below those used to develop Table 1.

TABLE 4. METHOD ACCURACY AND PRECISION AS FUNCTIONS OF CONCENTRATION

Parameter	Accuracy, as recovery, x' (ug/L)	Single analyst precision, s_r' (ug/L)	Overall precision, S' (ug/L)
Benzene	0.92C+0.57	0.09X+0.59	0.21X+0.56
Chlorobenzene	0.95C+0.02	0.09X+0.23	0.17X+0.10
1,2-Dichlorobenzene	0.93C+0.52	0.17X-0.04	0.22X+0.53
1,3-Dichlorobenzene	0.96C-0.04	0.15X-0.10	0.19X+0.09
1,4-Dichlorobenzene	0.93C-0.09	0.15X+0.28	0.20X+0.41
Ethylbenzene	0.94C+0.31	0.17X+0.46	0.26X+0.23
Toluene	0.94C+0.65	0.09X+0.48	0.18X-0.71

x' = Expected recovery for one or more measurements of a sample containing a concentration of C, in ug/L.

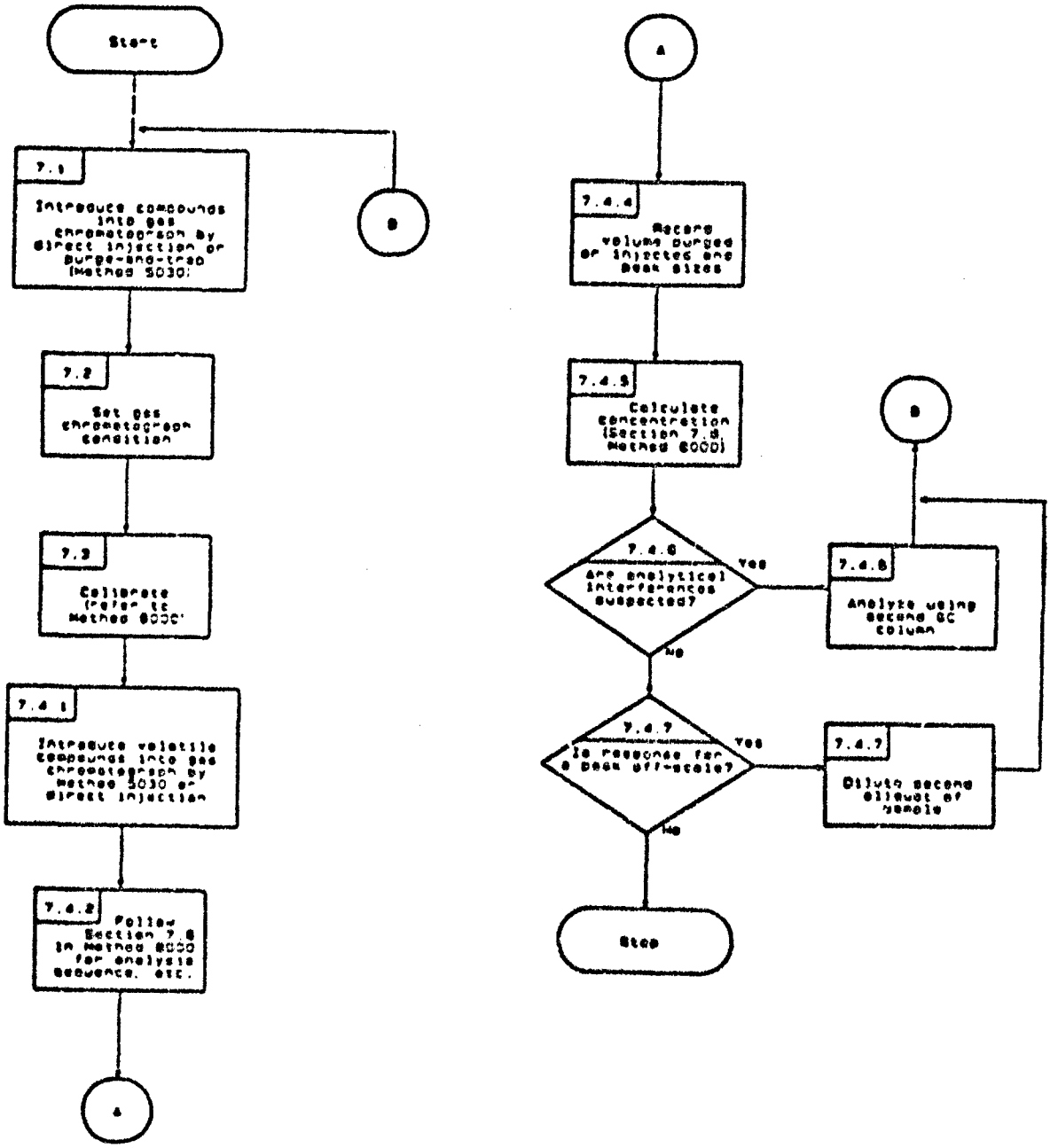
s_r' = Expected single analyst standard deviation of measurements at an average concentration of X, in ug/L.

S' = Expected interlaboratory standard deviation of measurements at an average concentration found of X, in ug/L.

C = True value for the concentration, in ug/L.

X = Average recovery found for measurements of samples containing a concentration of C, in ug/L.

METHOD 8020
AROMATIC VOLATILE ORGANICS



SEMIVOLATILE PRIORITY POLLUTANT
ORGANICS-WATER

SEMIVOLATILE PRIORITY POLLUTANT ORGANICS
WATER

I. SUMMARY

A. Analytes This method can analyze for the following compounds (*surrogates).

*2-Fluorophenol	Phenols
*2-Fluorobiphenyl	*p-Terphenyl-d14
*2,4,6-Tribromophenol	Polynuclear Aromatic
Phthalates	Hydrocarbons

B. Matrix: This method is applicable to groundwater, surface water and other sources of aqueous samples.

C. General Method

A measured volume of sample, approximately one liter, is serially extracted with methylene chloride at a pH greater than 11 and again at pH less than 2, using a separatory funnel or a continuous extractor. The methylene chloride extracts are dried and concentrated separately to a volume of 1 ml. The extract is then analyzed by GC/MS.

II. APPLICATION

A. Tested Concentration Range: 0.5 - 200 ug/L

2-Fluorophenol	0.5 - 120 ug/L
2-Fluorobiphenyl	1.5 - 120 ug/L
2,4,6-Tribromophenol	2.0 - 200 ug/L
p-Terphenyl-d14	0.5 - 160 ug/L

B.

Sensitivity Factor	Average Response
2-Fluorophenol	2.92
2-Fluorobiphenyl	2.32
2,4,6-Tribromophenol	0.33
p-Terphenyl-d14	1.55

C. Reporting Limit

To be determined on-site.

D. Interferences

Method interferences may be caused by contaminants in solvents, reagents, glassware and other sample processing hardware, that lead to discrete artifacts and/or elevated baselines in the total ion current profiles (TICPs). All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks. Matrix interferences may be caused by contaminants that are coextracted from the sample. The extent of matrix interferences will vary considerably from source to source.

E. Analysis Rate: 15 samples can be extracted in an eight-hour day, 5 sample extracts can be analyzed in an eight-hour day after instrument calibration.

F. Safety Information

No special requirements necessary for the handling of these chemicals. Chemists should adhere to good laboratory practices at all times when performing this procedure.

III. APPARATUS AND CHEMICALS

A. Glassware/Hardware

1. Separatory funnel - 2,000 ml, with teflon stopcock.

2. Drying column - 19 mm ID chromatographic column with coarse frit. (Substitution of a small pad of Pyrex glass wool for the frit will prevent cross contamination of sample extracts.)

3. Concentrator tube - Kuderna-Danish, 10 ml, graduated (Kontes K-570050-1025 or equivalent). Calibration must be checked at the volumes employed in the test. Ground glass stopper is used to prevent evaporation of extracts.

4. Evaporative flask - Kuderna-Danish, 500 ml (Kontes K-570001 0500 or equivalent). Attach to concentrator tube with springs.

5. Snyder column - Kuderna-Danish, Three-ball macro (Kontes K-503000 0121 or equivalent).

6. Snyder column - Kuderna-Danish, Two-ball micro (Kontes K569001 0219 or equivalent).

7. Vials - Amber glass, 2 ml capacity with Teflon-lined screw cap.

8. Continuous liquid-liquid extractors - Equipped with Teflon or glass connecting joints and stopcocks re quiring no lubrication (Hershberg-Wolf Extractor-Ace Glass Company, Vineland, NJ P/N 6841-10 or equivalent.)

9. Silicon carbide boiling chips - approximately 10/40 mesh. Heat to 400°C for 30 minutes or Soxhlet extract with methy lene chloride.

10. Water bath - Heated, with concentric ring cover, capable of temperature control (± 2°C). The bath should be used in a hood.

11. Balance - Analytical, capable of accurately weighing ± 0.0001 g.

12. Nitrogen evaporation device equipped with a water bath that can be maintained at 35-40°C. The N-Evap by Organomation Associates, Inc., South Berlin, MA (or equivalent) is suitable.

B. Instrumentation

1. Gas chromatograph - An analytical system complete with a temperature programmable gas chromatograph suitable for splitless injection and all required accessories including syringes, analytical columns, and gases.

2. Column - 30 m x 0.25 mm ID (or 0.32 mm) bonded-phase silicone coated fused silica capillary column (J&W Scientific DB-5 or equivalent). A film thickness of 1.0 micron is recommended because of its larger capacity. A film thickness of 0.25 micron may be used.

3. Mass Spectrometer - Capable of scanning from 35 to 500 amu every 1 second or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all required criteria when 50 ng of decafluorotriphenylphosphine (DFTPP) is injected through the GC inlet (See Table 1).

Table 1

DFTPP Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
51	30.0 - 60.0 percent of mass 198
68	less than 2.0 percent of mass 69
70	less than 2.0 percent of mass 69
127	40.0 - 60.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 1.00 percent of mass 198
441	present but less than mass 443
442	greater than 40.0 percent of mass 198
443	17.0 - 23.0 percent of mass 442

4. Data system - A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specific mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). Software must also be available that allows integrating the abundance in any EICP between specified time or scan number limits.

5. The following instrumental parameters are required for all performance tests and for all sample analyses:

Electron Energy	- 70 volts (nominal)
Mass Range	- 35 to 500 amu
Scan Time	- Not to exceed 1 sec. per scan

6. Analyze the 1.0 ml extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows. They will be adjusted as needed.

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/min.
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- 190°C
Injector-Grob type, splitless	
Sample Volume	- 2 ul
Carrier Gas	- Helium at 1 ml/minute

C. Analytes:

Compound	CAS Number	Primary Ion	Secondary Ion
2-Fluorobiphenyl	321-60-8	172	171
Terphenyl-d_{14}	92-94-4	244	122,212
2-Fluorophenol	367-12-4	112	64
2,4,6-Tribromophenol	118-79-6	330	332,141

D. Reagents and SARMS

1. Reagent water - Reagent water is defined as a water in which an interferent is not observed at or above the CRQL of each parameter of interest.

2. Sodium hydroxide solution (10N) - Dissolve 40 g NaOH in reagent water and dilute to 100 ml.

3. Sodium thiosulfate - (ACS) Granular.

4. Sulfuric acid solution (1+1) - Slowly add 50 ml of H_2SO_4 (sp gr 1.84) to 50 ml of reagent water.

5. Acetone, metnanol, methylene chloride - Pesticide quality or equivalent.

6. Sodium sulfate - (ACS) Powdered, anhydrous. Purify by heating at 400°C for four hours in a shallow tray. cool in a desiccator, and store in a glass bottle. Baker anhydrous powder, catalog #73898 or equivalent.

7. Stock standard solutions are made from EMSL-LV supplied standard materials.

Reference Standard	Source	Purity	Concentration ug/ml
2-Fluorobiphenyl	EPAQAMB	99%	5,000 ± 500
p-Terphenyl-d14	EPAQAMB	QAT	5,000 ± 500
2-Fluorophenol	EPAQAMB	QAR	5,000 ± 500

NOTES: QAR=Quality Assurance Reagent 95% - 99% Purity

QAS=Quality Assurance Standard ≥ 99% Purity

QAT=Quality Assurance Technical Materials ≤ 95% Purity

QAMB=Quality Assurance Materials Bank

RTP=Research Triangle Park

IV. CALIBRATION

A. Initial Calibration

1. Preparation of Standards

a. Calibration Standard A: Suppelco PAH standard

b. Calibration Standard B: Suppelco Phthalate standard

c. Calibration Standard C: Suppelco Phenol standard

d. Calibration Standard D:

1000 ug/ml (5.0 ml) each of 2-fluorobiphenyl, p-terphenyl-d14, 2-fluorophenol, and 2,4,6-tribromophenol prepared by combining 1 ml each of individual 5000 ug/ml standard solutions. Mix by inverting several times.

e. Calibration Standard E:

f. Calibration Standard F:

100 ug/ml (2.0 ml) each of 2-fluorobiphenyl, p-terphenyl-d_{14}, phenol-d_5, 2-fluorophenol, and 2,4,6-tribromophenol prepared by adding 0.2 ml of D to 1.8 ml of DCM. Mix by inverting several times.

g. Working Calibration Standards

Prepare calibration standards at four concentration levels by diluting the indicated volumes of calibration standards, C,D,E, and F to 1.0 ml with DCM. Mix by inverting several times.

BNA/Pest Working Calibration Standard Preparation* (*2 uL each injected onto the GC/MS)

Calibration Standard	Amount (uL) of Calibration Standard used per 1.0 mL				
C	100	80	60	25	0
D	100	80	60	25	0
E	0	0	0	0	0
F	0	0	0	0	0
DCM added:	800	840	880	950	1,000
Final Concentration (ug/mL)	100	80	60	25	Blank
Equivalent Soil Conc. (ug/g)	6.7	5.3	4.0	1.7	0

h. Great care must be taken to maintain the integrity of all standard solutions. Store all standard solutions at -10°C to -20°C in screw-cap amber bottles with Teflon liners. Fresh standards should be prepared every twelve months at a minimum. The continuing calibration standard should be prepared weekly and stored at 4°C.

2. Instrument Calibration

a. Each GC/MS system must have the hardware tuned to meet the criteria in Table 1 (see III.A.13.c.) for a 50 ng injection of decafluorotriphenylphosphine (DFTPP). This criteria must be demonstrated every 24 hours.

b. The internal standards should permit most components of interest in a chromatogram to have retention times of 0.80 to 1.20 relative to the internal standards. Use the base peak ion from the specific internal standard as the primary ion for quantification. If interferences are noted, use the next most intense ion as the secondary ion, i.e., for 1,4-dichlorobenzene-d_4, use m/z 152 for quantification.

c. The internal standards are added to all calibration standards and all sample extracts just prior to analysis by GC/MS. A 5 ul aliquot of the internal standard solution should be added to a 50 ul aliquot of calibration standards. In addition, a standard containing all of the semi-volatile priority pollutant compounds at 80 ug/ml is analyzed to enable the mass spectrometer data system to specifically search for these compounds.

3. Analysis of calibration data

a. Analyze 2 ul of each calibration standard and tabulate the area of the primary characteristic ion against the concentration for each compound including the surrogate compounds. Calculate relative response factors (RRF) for each compound using Equation 1.

Equation 1: $$RRF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x}$$

Where:

A_x = Area of the characteristic ion for the compound to be measured.

A_{is} = Area of the characteristic ion for the respective internal standard.

C_{is} = Concentration of the internal standard (ng/ul).

C_x = Concentration of the compound to be measured (ng/ul).

The average relative response factor (RRF) should be calculated for all compounds.

b. The RRF for the highest linear range calibration standard analyzed will be compared to the initial RRF and prior initial/daily calibrations. The RRF must agree within 25% of the mean.

Compound	Target Initial Calib. (ug/ml)	Target Daily Calib. (ug/ml)
2-Fluorophenol	120	100
2-Fluorobiphenyl	120	100
2,4,6-Tribromophenol	200	100
p-Terphenyl-d_{14}	160	100

The extracted ion current profile (EICP) of the internal standards must be monitored and evaluated for each standard. If EICP area for any internal standard changes by more than a factor of one-half (-50%), the mass spectrometric system must be inspected for malfunction and corrections made as appropriate.

B. Daily Calibration

1. Preparation of Standards

a. Daily calibration will consist of the analysis of one calibration standards at a concentration of 100 ug/ml for each target compound.

b. Calibration standards will be those prepared in section IV.A.1. A 50 ug/ml working calibration standard is prepared by mixing 50 ul each of calibration standards C and D with 800 ml of DCM. A 2 ul injection of this working calibration standard is equivalent to a sample concentration of 100 ug/L.

c. The calibration standards will also contain the internal standards at a concentration of 50 ug/L (section IV.A.2.c. above).

d. One of the calibration standards is analyzed at the beginning of the day; the other, at the end of the day. In addition, a standard containing all of the volatile priority

pollutant compounds at 80 ug/ml is analyzed to enable the mass spectrometer data system to specifically search for these compounds.

2. Instrument calibration is performed as described in Section IV.A.2.

3. Analysis of calibration data is performed as described in Section IV.A.3. Acceptance criteria is the specified ± 25% or two standard deviations.

4. Calibration checks: NA

V. SAMPLE HANDLING/STORAGE

A. Sampling procedure: Samples are collected in 1 L (minimum volume) glass bottles with teflon-lined caps. A full liter is needed for a single analysis. Extra volume must be collected if the laboratory is to prepare/analyze laboratory duplicates and/or spikes.

B. Containers will be amber glass with teflon-lined caps, cleaned according to USATHAMA guidelines.

C. Storage conditions: Samples are maintained at 4°C from time of collection to time of analysis. Once extracted, the extracts will be stored at 4°C.

D. Holding Time Limits

1. Sample extraction must be performed within 7 days of sample collection. Analysis of the extract must be completed within 40 days of extraction.

2. All samples/extracts will be held for a period of 30 days following report submittal, at which time COR permission must be obtained for final disposal.

E. Solution Verification

Standards for calibration and control spikes are prepared independently by different laboratory personnel. Results of the analyzed control spike samples serve to verify the solutions.

VI. PROCEDURE

A. Separations

Sample Extraction - Separatory Funnel

1. Samples will be extracted using separatory funnel techniques. If emulsions prevent acceptable solvent recovery with separatory funnel extraction, continuous extraction may be used. The separatory funnel extraction scheme described below assumes a sample volume of 1-liter.

2. Using a 1-liter graduated cylinder, measure out a 1-liter sample aliquot and place it into a 2-liter separatory funnel. Pipet 1.0 ml surrogate standard spiking solution into the separatory funnel and mix well. Check the pH of the sample with wide range pH paper and adjust to pH > 11 with 10N sodium hydroxide.

3. Add 60 ml methylene chloride to the separatory funnel and extract the sample by shaking the funnel for two minutes, with periodic venting to release excess pressure. Allow the organic layer to separate from the water phase for a minimum of 10 minutes. If the emulsion interface between layers is more than one-third the volume of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample, and may include: stirring, filtration of the emulsion through glass wool, centrifugation, or other physical methods.

4. Collect the methylene chloride extract in a 250-ml Erlenmeyer flask.

5. Add a second 60-ml volume of methylene chloride to the sample bottle and repeat the extraction procedure a second time, combining the extracts in the Erlenmeyer flask. Perform a third extraction in the same manner. Label the combined extract as the base/neutral fraction.

6. Adjust the pH of the aqueous phase to less than 2 using sulfuric acid (1+1). Serially extract three times with 60-ml aliquots of methylene chloride, as per paragraph V.A.3. Collect and combine the extracts in a 250-ml Erlenmeyer flask and label the combined extract as the acid fraction.

7. Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-ml concentrator tube to a 500-ml evaporative flask. Other concentration devices or techniques may be used in place of the K-D, if equivalency is demonstrated for all extractable organics on the target analyte list.

8. Transfer the individual base/neutral and acid pouring extracts through separate drying columns containing about 10 cm of anhydrous granular sodium sulfate, and collect the extracts in the separate K-D concentrators. Rinse the Erlenmeyer flasks and columns with 20 to 30 ml of methylene chloride to complete the quantitative transfer.

9. Add one or two clean boiling chips and attach a three-ball Snyder column to the evaporative flask. Pre-wet the Snyder column by adding about 1 ml methylene chloride to the top of the column. Place the apparatus on a hot water bath (80° to 90°C) so that the concentrator tube is partially immersed in the hot water, and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 10 to 15 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood with condensed solvent. When the apparent volume of liquid reaches 1 ml, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes. Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 1-2 ml of methylene chloride. A 5-ml syringe is recommended for this operation. Place the concentrator tube in a warm water bath (35°C) and evaporate the solvent volume to just below 1 ml using a gentle stream of clean, dry nitrogen filtered through a column of activated carbon. Caution: New plastic tubing must not be used between the carbon trap and the sample, as it may introduce interferences. The internal wall of the tube must be rinsed down several times with methylene chloride during the operation and the final volume brought to 1 ml with methylene chloride. During evaporation, the tube solvent must be kept below the water level of the bath. The extract must never be allowed to become dry.

B. Chemical Reactions

None involved with this procedure.

C. Instrumental Analysis

1. Each 1.0 ml extract will contain the combined base/neutral and acid fractions when received for analysis from extraction.

2. Internal standard solution is added to each sample extract. Add 5 uL of internal standard solution to the sample extract.

3. Analyze the extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows:

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/min.
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- according to manufacturer's specifications
Injector-Grob-type, splitless	
Sample Volume	- 1 - 2 uL
Carrier Gas	- Helium at 1 ml/min

NOTE: Make any extract dilution indicated by characterization prior to the addition of internal standards. If any further dilutions of water or soil/sediment extracts are made, additional internal standards must be added to maintain the required 40 ng/uL for each constituent in the extract volume. If the concentration of any compound exceeds the initial calibration range, the extract must be diluted and reanalyzed. Secondary ion quantitation is only allowed when there are sample interferences with the primary ion. If secondary ion quantitation is performed, the reasons must be documented in the laboratory notebook.

VII. CALCULATIONS

A. Qualitative Analysis

1. Compounds shall be identified by an analyst competent in the interpretation of mass spectra by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. Two criteria must be satisfied to verify the identifications: elution of the sample component at the same GC relative retention time as the standard component and correspondence of the sample component and standard component mass spectra.

   a. For establishing correspondence of the GC relative retention time (RRT), the sample component RRT's determined during initial calibration are used, sample RRT will be ±30%.

      For reference, the standard must be run on the same shift as the sample. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

   b. For comparison of standard and sample component mass spectra, mass spectra obtained on the contractor's GC/MS are required. Once obtained, these standard spectra may be used for identification purposes, only if the contractor's GC/MS meets the DFTPP daily tuning requirements. These standard spectra may be obtained from the run used to obtain reference RRTs.

2. The requirements for qualitative verification by comparison of mass spectra are as follows:

   a. All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum.

b. The relative intensities of ions specified in (1) must agree within plus or minus 20% between the standard and sample spectra. (Example: For an ion with an abundance of 50% in the standard spectra, the corresponding sample ion abundance must be between 30 and 70 percent.

3. If a compound cannot be verified by all of the criteria in the preceding paragraphs, but in the technical judgement of the mass spectral interpretation specialist, the identification is correct, then the analyst shall report that identification and proceed with quan- tification.

B. Quantitative Analysis

1. Target components identified shall be quantified by the internal standard method. The internal standard used shall be the one nearest the retention time to that of a given analyte. The EICP area of characteristic ions of analytes listed in this method are used.

The extracted ion current profile (EICP) of the internal standards must be monitored and evaluated for each standard. If EICP area for any internal standard changes by more than a factor of one-half (-50%), the mass spectrometric system must be inspected for malfunction and corrections made as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is necessary.

3. The relative response factor (RRF) from the daily standard analysis is used to calculate the concentration in the sample. Secondary ions may be used if interferences are present. The area of a secondary ion cannot be substituted for the area of a primary ion unless a relative response factor is calculated using the secondary ion.

a. Calculate the concentration in the sample using the relative response factor (RRF) and the following equation:

Water

$$\text{Concentration ug/L} = \frac{(A_x)(Is)(Vt)}{(i_s)(RRF)(V_o)(V_i)}$$

A_x = Area of the characteristic ion for the compound to be measured

A_{is} = Area of the characteristic ion for the internal standard

I_s = Amount of internal standard injection in nanograms (ng)

V_o = Volume of water extracted in milliliters (ml)

V_i = Volume of extract injected (ul)

V_t = Volume of total extract. (Use 2000 ul or a factor of this when dilutions are made. The 2000 ul is derived from combining half of the 1 ml BN extract and half of the 1 ml A extract.)

4. Calculate surrogate standard recovery on all samples, blanks and spikes. Determine if recovery is within limits described in Section IX.B.

   a. Calculation for surrogate recovery.

   $$\text{Percent Surrogate Recovery} = \frac{Qd}{Qa} \times 100\%$$

   Where: Qd = quantity determined by analysis
   Qa = quantity added to sample

   b. If recovery is not within limits, the following is required:

      1) Check to be sure there are no errors in calculations, surrogate solutions and internal standards. Also, check instrument performance.

      2) Reanalyze the sample if none of the above reveal a problem.

VIII. DAILY QUALITY CONTROL

A. Control Samples

1. Surrogate Standard Spike Solution: 100 ug/ml base/neutral surrogates, 100 ug/ml acid surrogates.

   a. In a 50 ml volumetric flask, add 1.0 ul of each 5,000 ug/ml base/neutral reference surrogate standard and 1.0 ml of each 5,000 ug/ml acid reference surrogate standard. Dilute to the mark with methylene chloride. Mix by inverting several times.

Surrogate Standard	Volume (ml) of 5,000 ug/ml stock	Control Spike Solution Conc. (ug/ml)
2-Fluorophenol	1.0	100
2-Fluorobiphenyl	0.5	50
2,4,6-Tribromophenol	1.0	100
p-Terphenyl-d_{14}	0.5	50

   b. All method blanks and field samples will be spiked with 0.5 ml of this 50/100 ug/ml surrogate spiking solution prior to extraction and analysis, as described in section VII. This produces an extract with 100 ug/ml base/neutral surrogate compounds and 100 ug/ml acid surrogate compounds.

2. Method blanks will be prepared using reagent water spiked with 100 mg/L each of sulfate and chloride (see Section V.A.)

IX. REFERENCES

U.S. EPA Contract Laboratory Program Statement of Work Organics Analysis, Multi-media, Multi-concentration, 10/86, revised 1/87.

X. DATA

A. Off-the-shelf Analytical Reference Material Characterization: Not applicable.

B. Initial Calibration: See attached.

1. Response vs. Concentration Data: See attached.

2. Response vs. Concentration Graphs: N/A.

C. Daily Calibration

1. Response: See attached.

2. Required percentage or two standard deviations: See attached.

XI. INSTRUMENT PARAMETERS/OPERATING CONDITIONS

GC/MS/DS:	Hewlett Packard MSD
Electron Energy:	70 volts
Scan Time:	1 sec per scan

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/ minute
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- 190°C
Injector-Grob type, splitless Sample Volume	- 2 ul
Carrier Gas	- Helium at 1 ml/minute

SEMIVOLATILE PRIORITY POLLUTANT
ORGANICS-SOIL AND LEACHATES

SEMIVOLATILE PRIORITY POLLUTANT ORGANICS
SOIL AND LEACHATES

I. SUMMARY

A. Analytes This method can analyze for the following compounds (*surrogates).

*2-Fluorophenol	Phenols
*2-Fluorobiphenyl	*p-Terphenyl-d14
*2,4,6-Tribromophenol	Polynuclear Aromatic
Phthalates	Hydrocarbons

B. Matrix: This method is applicable to aqueous, soil, and solid samples.

C. General Method

Leachate

A measured volume of sample, approximately one liter, is serially extracted with methylene chloride at a pH greater than 11 and again at pH less than 2, using a separatory funnel or a continuous extractor. The methylene chloride extracts are dried and concentrated separately to a volume of 1 ml. The extract is then analyzed by GC/MS.

Soil

A 30-gram portion of sediment is mixed with anhydrous sodium sulfate and extracted with 1:1 methylene chloride/acetone using an ultrasonic probe. A gel permeation column cleanup is used before analysis.

II. APPLICATION

A. Tested Concentration Range:

	Leachates	Soils
2-Fluorophenol	0.5 - 120 ug/L	0.017-4.0 ug/g
2-Fluorobiphenyl	1.5 - 120 ug/L	0.017-4.0 ug/g
2,4,6-Tribromophenol	2.0 - 200 ug/L	0.067-6.7 ug/g
p-Terphenyl-d14	0.5 - 160 ug/L	0.017-5.3 ug/g

B. Sensitivity Factor

	Average Response	
2-Fluorophenol	2.92	2.92
2-Fluorobiphenyl	2.32	2.32
2,4,6-Tribromophenol	0.33	0.33
p-Terphenyl-d14	1.55	1.55

C. Reporting Limit

To be determined on-site.

D. Interferences

Method interferences may be caused by contaminants in solvents, reagents, glassware and other sample processing hardware, that lead to discrete artifacts and/or elevated baselines in the total ion current profiles (TICPs). All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks. Matrix interferences may be caused by contaminants that are coextracted from the sample. The extent of matrix interferences will vary considerably from source to source.

E. Analysis Rate: 15 samples can be extracted in an eight-hour day, 5 sample extracts can be analyzed in an eight-hour day after instrument calibration.

F. Safety Information

No special requirements necessary for the handling of these chemicals. Chemists should adhere to good

laboratory practices at all times when performing this procedure.

III. APPARATUS AND CHEMICALS

A. Glassware/Hardware

1. Separatory funnel - 2,000 ml, with teflon stopcock.

2. Drying column - 19 mm ID chromatographic column with coarse frit. (Substitution of a small pad of Pyrex glass wool for the frit will prevent cross contamination of sample extracts.)

3. Concentrator tube - Kuderna-Danish, 10 ml, graduated (Kontes K-570050-1025 or equivalent). Calibration must be checked at the volumes employed in the test. Ground glass stopper is used to prevent evaporation of extracts.

4. Evaporative flask - Kuderna-Danish, 500 ml (Kontes K-570001 0500 or equivalent). Attach to concentrator tube with springs.

5. Snyder column - Kuderna-Danish, Three-ball macro (Kontes K-503000 0121 or equivalent).

6. Snyder column - Kuderna-Danish, Two-ball micro (Kontes K569001 0219 or equivalent).

7. Vials - Amber glass, 2 ml capacity with Teflon-lined screw cap.

8. Continuous liquid-liquid extractors - Equipped with Teflon or glass connecting joints and stopcocks re quiring no lubrication (Hershberg-Wolf Extractor-Ace Glass Company, Vineland, NJ P/N 6841-10 or equivalent.)

9. Silicon carbide boiling chips - approximately 10/40 mesh. Heat to 400°C for 30 minutes or Soxhlet extract with methylene chloride.

10. Water bath - Heated, with concentric ring cover, capable of temperature control (± 2°C). The bath should be used in a hood.

11. Balance - Analytical, capable of accurately weighing ± 0.0001 g.

12. Nitrogen evaporation device equipped with a water bath that can be maintained at 35-40°C. The N-Evap by Organomation Associates, Inc., South Berlin, MA (or equivalent) is suitable.

13. Ultrasonic cell disruptor, Heat System - Ultrasonics, Inc. Model 385 SONICATOR (475 Watt with pulsing capability, No. 305 3/4 inch tapped high gain "Q" disruptor horn or No. 208 3/4 inch standard solid disruptor horn), or equivalent device with a minimum of 375 Watt output capability. NOTE: In order to ensure that sufficient energy is transferred to the sample during extraction, the horn must be replaced if the tip begins to erode. Erosion of the tip is evidenced by a rough surface.

B. Instrumentation

1. Gas chromatograph - An analytical system complete with a temperature programmable gas chromatograph suitable for splitless injection and all required accessories including syringes, analytical columns, and gases.

2. Column - 30 m x 0.25 mm ID (or 0.32 mm) bonded-phase silicone coated fused silica capillary column (J&W Scientific DB-5 or equivalent). A film thickness of 1.0 micron is recommended because of its larger capacity. A film thickness of 0.25 micron may be used.

3. Mass Spectrometer - Capable of scanning from 35 to 500 amu every 1 second or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all required criteria when 50 ng of decafluorotriphenylphosphine (DFTPP) is injected through the GC inlet (See Table 1).

Table 1

DFTPP Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
51	30.0 - 60.0 percent of mass 198
68	less than 2.0 percent of mass 69
70	less than 2.0 percent of mass 69
127	40.0 - 60.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 1.00 percent of mass 198
441	present but less than mass 443
442	greater than 40.0 percent of mass 198
443	17.0 - 23.0 percent of mass 442

4. Data system - A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specific mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). Software must also be available that allows integrating the abundance in any EICP between specified time or scan number limits.

5. The following instrumental parameters are required for all performance tests and for all sample analyses:

Electron Energy	- 70 volts (nominal)
Mass Range	- 35 to 500 amu
Scan Time	- Not to exceed 1 sec. per scan

6. Analyze the 1.0 ml extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows. They will be adjusted as needed.

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/min.
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- 190°C
Injector-Grob type, splitless	
Sample Volume	- 2 ul
Carrier Gas	- Helium at 1 ml/minute

C. Analytes:

Compound	CAS Number	Primary Ion	Secondary Ion
2-Fluorobiphenyl	321-60-8	172	171
Terphenyl-d_{14}	92-94-4	244	122,212
2-Fluorophenol	367-12-4	112	64
2,4,6-Tribromophenol	118-79-6	330	332,141

D. Reagents and SARMS

1. Reagent water - Reagent water is defined as a water in which an interferent is not observed at or above the CRQL of each parameter of interest.

4336B

2. Sodium hydroxide solution (10N) - Dissolve 40 g NaOH in reagent water and dilute to 100 ml.

3. Sodium thiosulfate - (ACS) Granular.

4. Sulfuric acid solution (1+1) - Slowly add 50 ml of H_2SO_4 (sp gr 1.84) to 50 ml of reagent water.

5. Acetone, methanol, methylene chloride - Pesticide quality or equivalent.

6. Sodium sulfate - (ACS) Powdered, anhydrous. Purify by heating at 400°C for four hours in a shallow tray. cool in a desiccator, and store in a glass bottle. Baker anhydrous powder, catalog #73898 or equivalent.

7. Stock standard solutions are made from EMSL-LV supplied standard materials.

Reference Standard	Source	Purity	Concentration ug/ml
2-Fluorobiphenyl	EPAQAMB	99%	5,000 ± 500
p-Terphenyl-d14	EPAQAMB	QAT	5,000 ± 500
2-Fluorophenol	EPAQAMB	QAR	5,000 ± 500

NOTES: QAR=Quality Assurance Reagent 95% - 99% Purity

QAS=Quality Assurance Standard ≥ 99% Purity

QAT=Quality Assurance Technical Materials ≤ 95% Purity

QAMB=Quality Assurance Materials Bank

RTP=Research Triangle Park

IV. CALIBRATION

A. Initial Calibration

1. Preparation of Standards

a. Calibration Standard A: Suppelco PAH standard

b. Calibration Standard B: Suppelco Phthalate standard

c. Calibration Standard C: Suppelco Phenol standard

d. Calibration Standard D:

1000 ug/ml (5.0 ml) each of 2-fluorobiphenyl, p-terphenyl-d14, 2-fluorophenol, and 2,4,6-tribromophenol prepared by combining 1 ml each of individual 5000 ug/ml standard solutions. Mix by inverting several times.

e. Calibration Standard E:

f. Calibration Standard F:

100 ug/ml (2.0 ml) each of 2-fluorobiphenyl, p-terphenyl-d_{14}, phenol-d_5, 2-fluorophenol, and 2,4,6-tribromophenol prepared by adding 0.2 ml of D to 1.8 ml of DCM. Mix by inverting several times.

g. Working Calibration Standards

Prepare calibration standards at four concentration levels by diluting the indicated volumes of calibration standards, C,D,E, and F to 1.0 ml with DCM. Mix by inverting several times.

BNA/Pest Working Calibration Standard Preparation* (*2 uL each injected onto the GC/MS)

Calibration Standard	Amount (uL) of Calibration Standard used per 1.0 mL				
C	100	80	60	25	0
D	100	80	60	25	0
E	0	0	0	0	0
F	0	0	0	0	0

DCM added:	800	840	880	950	1,000
Final Concentration (ug/mL)	100	80	60	25	Blank
Equivalent Soil Conc. (ug/g)	6.7	5.3	4.0	1.7	0

h. Great care must be taken to maintain the integrity of all standard solutions. Store all standard solutions at -10°C to -20°C in screw-cap amber bottles with Teflon liners. Fresh standards should be prepared every twelve months at a minimum. The continuing calibration standard should be prepared weekly and stored at 4°C.

2. Instrument Calibration

a. Each GC/MS system must have the hardware tuned to meet the criteria in Table 1 (see III.A.13.c.) for a 50 ng injection of decafluorotriphenylphosphine (DFTPP). This criteria must be demonstrated every 24 hours.

b. The internal standards should permit most components of interest in a chromatogram to have retention times of 0.80 to 1.20 relative to the internal standards. Use the base peak ion from the specific internal standard as the primary ion for quantification. If interferences are noted, use the next most intense ion as the secondary ion, i.e., for 1,4-dichlorobenzene-d_4, use m/z 152 for quantification.

c. The internal standards are added to all calibration standards and all sample extracts just prior to analysis by GC/MS. A 5 ul aliquot of the internal standard solution should be added to a 50 ul aliquot of calibration standards. In addition, a standard containing all of the semi-volatile priority pollutant compounds at 80 ug/ml is analyzed to enable the mass spectrometer data system to specifically search for these compounds.

3. Analysis of calibration data

a. Analyze 2 ul of each calibration standard and tabulate the area of the primary characteristic ion against the concentration for each compound including the surrogate compounds. Calculate relative response factors (RRF) for each compound using Equation 1.

Equation 1: $$RRF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x}$$

Where:

A_x = Area of the characteristic ion for the compound to be measured.

A_{is} = Area of the characteristic ion for the respective internal standard.

C_{is} = Concentration of the internal standard (ng/ul).

C_x = Concentration of the compound to be measured (ng/ul).

The average relative response factor (RRF) should be calculated for all compounds.

b. The RRF for the highest linear range calibration standard analyzed will be compared to the initial RRF and prior initial/daily calibrations. The RRF must agree within 25% of the mean.

Compound	Target Initial Calib. (ug/ml)	Target Daily Calib. (ug/ml)
2-Fluorophenol	120	100
2-Fluorobiphenyl	120	100
2,4,6-Tribromophenol	200	100
p-Terphenyl-d_{14}	160	100

The extracted ion current profile (EICP) of the internal standards must be monitored and evaluated for each standard. If EICP area for any internal standard changes by more than a factor of one-half (-50%), the mass spectrometric system must be inspected for malfunction and corrections made as appropriate.

B. Daily Calibration

1. Preparation of Standards

a. Daily calibration will consist of the analysis of one calibration standards at a concentration of 100 ug/ml for each target compound.

b. Calibration standards will be those prepared in section IV.A.1. A 50 ug/ml working calibration standard is prepared by mixing 50 ul each of calibration standards C and D with 800 ml of DCM. A 2 ul injection of this working calibration standard is equivalent to a sample concentration of 100 ug/L.

c. The calibration standards will also contain the internal standards at a concentration of 50 ug/L (section IV.A.2.c. above).

d. One of the calibration standards is analyzed at the beginning of the day; the other, at the end of the day. In addition, a standard containing all of the volatile priority pollutant compounds at 80 ug/ml is analyzed to enable the mass spectrometer data system to specifically search for these compounds.

2. Instrument calibration is performed as described in Section IV.A.2.

3. Analysis of calibration data is performed as described in Section IV.A.3. Acceptance criteria is the specified ± 25% or two standard deviations.

4. Calibration checks: NA

V. SAMPLE HANDLING/STORAGE

A. Sampling procedure: Samples are collected in 1 L (minimum volume) glass bottles with teflon-lined caps. A full liter is needed for a single analysis. Extra volume must be collected if the laboratory is to prepare/analyze laboratory duplicates and/or spikes.

B. Containers will be amber glass with teflon-lined caps, cleaned according to USATHAMA guidelines.

C. Storage conditions: Samples are maintained at 4°C from time of collection to time of analysis. Once extracted, the extracts will be stored at 4°C.

D. Holding Time Limits

1. Sample extraction must be performed within 7 days of sample collection. Analysis of the extract must be completed within 40 days of extraction.

2. All samples/extracts will be held for a period of 30 days following report submittal, at which time COR permission must be obtained for final disposal.

E. Solution Verification

Standards for calibration and control spikes are prepared independently by different laboratory personnel. Results of the analyzed control spike samples serve to verify the solutions.

VI. PROCEDURE

A. Separations - Leachates

Sample Extraction - Separatory Funnel

1. Samples will be extracted using separatory funnel techniques. If emulsions prevent acceptable solvent recovery with separatory funnel extraction, continuous extraction may be used. The separatory funnel extraction scheme described below assumes a sample volume of 1-liter.

2. Using a 1-liter graduated cylinder, measure out a 1-liter sample aliquot and place it into a 2-liter separatory funnel. Pipet 1.0 ml surrogate standard spiking solution into the separatory funnel and mix well. Check the pH of the sample with wide range pH paper and adjust to pH > 11 with 10N sodium hydroxide.

3. Add 60 ml methylene chloride to the separatory funnel and extract the sample by shaking the funnel for two minutes, with periodic venting to release excess pressure. Allow the organic layer to separate from the water phase for a minimum of 10 minutes. If the emulsion interface between layers is more than one-third the volume of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample, and may include: stirring, filtration of the emulsion through glass wool, centrifugation, or other physical methods.

4. Collect the methylene chloride extract in a 250-ml Erlenmeyer flask.

5. Add a second 60-ml volume of methylene chloride to the sample bottle and repeat the extraction procedure a second time, combining the extracts in the Erlenmeyer flask. Perform a third extraction in the same manner. Label the combined extract as the base/neutral fraction.

6. Adjust the pH of the aqueous phase to less than 2 using sulfuric acid (1+1). Serially extract three times with 60-ml aliquots of methylene chloride, as per paragraph V.A.3. Collect and combine the extracts in a 250-ml Erlenmeyer flask and label the combined extract as the acid fraction.

7. Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-ml concentrator tube to a 500-ml evaporative flask. Other concentration devices or techniques may be used in place of the K-D, if equivalency is demonstrated for all extractable organics on the target analyte list.

8. Transfer the individual base/neutral and acid pouring extracts through separate drying columns containing about 10 cm of anhydrous granular sodium sulfate, and collect the extracts in the separate K-D concentrators. Rinse the Erlenmeyer flasks and columns with 20 to 30 ml of methylene chloride to complete the quantitative transfer.

9. Add one or two clean boiling chips and attach a three-ball Snyder column to the evaporative flask. Pre-wet the Snyder column by adding about 1 ml methylene chloride to the top of the column. Place the apparatus on a hot water bath (80° to 90°C) so that the concentrator tube is partially immersed in the hot water, and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 10 to 15 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood with condensed solvent. When the apparent volume of liquid reaches 1 ml, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes. Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 1-2 ml of methylene chloride. A 5-ml syringe is recommended for this operation. Place the concentrator tube in a warm water bath (35°C) and evaporate the solvent volume to just below 1 ml using a gentle stream of clean, dry nitrogen filtered through a column of activated carbon. Caution: New plastic tubing must not be used between the carbon trap and the sample, as it may introduce interferences. The internal wall of the tube must be rinsed down several times with methylene chloride during the operation and the final volume brought to 1 ml with methylene chloride. During evaporation, the tube solvent must be kept below the water level of the bath. The extract must never be allowed to become dry.

B. Separations - Soil/Solid Waste

1. Decant and discard any water layer on a sediment sample. Mix samples thoroughly, especially composited samples. Discard any foreign objects such as sticks, leaves, and rocks.

Determine sample pH: Transfer 50 g of soil/ sediment t a 100 mL beaker. Add 50 mL of water and stir for 1 hour. Determine the pH of sample with glass electrode and pH meter while stirring. Report pH value on appropriate data sheets. If the pH of the soil is greater than 11 or less than 5, contact the USATHAMA Project Officer cited in the contract for instructions on how to handle the sample. Method modification or alternate method is required.

Document the instructions in the laboratory notebook. Discard this portion of the sample.

2. The following steps should be performed rapidly to avoid loss of the more volatile extractables. Weigh approximately 30 g of sample to the nearest 0.1 g into a 400-mL a beaker and add 50 g of anhydrous powered sodium sulfate. Mix well. The sample should have a sandy texture at this point. Immediately, add 100 mL of 1:1 methylene chloride - acetone to the sample, then add the surrogates.

   a) Immediately after weighing the sample for extraction, weigh 5-10 g of the sediment into a tared crucible. Determine the percent moisture by drying overnight at 105°C. Allow to cool in a desiccator before weighing.

   $$\frac{\text{g of sample} - \text{of dry sample}}{\text{g of sample}} \times 100 = \% \text{ moisture}$$

   b) When using GPC, add 1.0 mL of base/neutral and acid surrogate standard to the sample.

3. Place the bottom surface of the tip of the 3/4 inch disruptor horn about 1/2 inch below the surface of the solvent but above the sediment layer.

4. Sonicate for 1-1/2 minutes with the W-385 (or 3 minutes with the W-375), using No. 208 3/4 inch standard disruptor horn with output control knob set at 10 (or No. 305 3/4 inch tapped high gain "

Q" disruptor horn at 5 and mode switch on "1 sec. pulse" and % duty cycle knob set at 50%. Do NOT use MICROTIP probe.

5. Repeat the extraction two more times with 2 additional 100 mL portions of 1:1 methylene chloride - acetone. Before each extraction, make certain that the sodium sulfaate is free flowing and not a consolidated mass. As required, break up large lumps with a clean spatula, or very carefully with the tip of the probe. Decant off the extraction solvent after each sonication. ON the final sonication, pour the entire sample into the Buchner funnel and rinse with 50 mL of 1:1 methylene chloride - acetone.

6. Transfer the extract to a Kuderna-Danish (K-D) concentrator consisting of a 10 mL concentrator tube and a 500-mL evaporative flask.

7. Add one or two clean boiling chips and attach a three-ball Snyder column to the evaporative flask. Pre-wet the Snyder column by adding about 1 mL methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80° to 90°C) so that the concentrator tube is partially immersed in the hot water, and the entire lower rounded surface of the flask is bated with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 10 to 15 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood with condensed solvent. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes, and make up to 10 mL volume with methylene chloride.

C. Chemical Reactions

None involved with this procedure.

D. Instrumental Analysis

1. Each 1.0 ml to 10 ml extract will contain the combined base/neutral and acid fractions when received for analysis from extraction.

2. Internal standard solution is added to each sample extract. Add 5 uL of internal standard solution to the sample extract.

3. Analyze the extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows:

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/min.
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- according to manufacturer's specifications
Injector-Grob-type, splitless	
Sample Volume	- 1 - 2 uL
Carrier Gas	- Helium at 1 ml/min

NOTE: Make any extract dilution indicated by characterization prior to the addition of internal standards. If any further dilutions of water or soil/sediment extracts are made, additional internal standards must be added to maintain the required 40 ng/uL for each constituent in the extract volume. If the concentration of any compound exceeds the initial calibration range, the extract must be diluted and reanalyzed. Secondary ion quantitation is only allowed when there are sample interferences with the primary ion. If secondary ion quantitation is performed, the reasons must be documented in the laboratory notebook.

VII. CALCULATIONS

A. Qualitative Analysis

1. Compounds shall be identified by an analyst competent in the interpretation of mass spectra by

comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. Two criteria must be satisfied to verify the identifications: elution of the sample component at the same GC relative retention time as the standard component and correspondence of the sample component and standard component mass spectra.

a. For establishing correspondence of the GC relative retention time (RRT), the sample component RRT's determined during initial calibration are used, sample RRT will be ±30%.

   For reference, the standard must be run on the same shift as the sample. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

b. For comparison of standard and sample component mass spectra, mass spectra obtained on the contractor's GC/MS are required. Once obtained, these standard spectra may be used for identification purposes, only if the contractor's GC/MS meets the DFTPP daily tuning requirements. These standard spectra may be obtained from the run used to obtain reference RRTs.

2. The requirements for qualitative verification by comparison of mass spectra are as follows:

   a. All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum.

   b. The relative intensities of ions specified in (1) must agree within plus or minus 20% between the standard and sample spectra. (Example: For an ion with an abundance of

50% in the standard spectra, the corresponding sample ion abundance must be between 30 and 70 percent.

3. If a compound cannot be verified by all of the criteria in the preceding paragraphs, but in the technical judgement of the mass spectral interpretation specialist, the identification is correct, then the analyst shall report that identification and proceed with quantification.

B. Quantitative Analysis

1. Target components identified shall be quantified by the internal standard method. The internal standard used shall be the one nearest the retention time to that of a given analyte. The EICP area of characteristic ions of analytes listed in this method are used.

The extracted ion current profile (EICP) of the internal standards must be monitored and evaluated for each standard. If EICP area for any internal standard changes by more than a factor of one-half (-50%), the mass spectrometric system must be inspected for malfunction and corrections made as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is necessary.

3. The relative response factor (RRF) from the daily standard analysis is used to calculate the concentration in the sample. Secondary ions may be used if interferences are present. The area of a secondary ion cannot be substituted for the area of a primary ion unless a relative response factor is calculated using the secondary ion.

a. Calculate the concentration in the sample using the relative response factor (RRF) and the following equation:

Water

$$\text{Concentration ug/L} = \frac{(A_x)(Is)(Vt)}{(A_{is})(RRF)(V_o)(V_i)}$$

A_x = Area of the characteristic ion for the compound to be measured

A_{is} = Area of the characteristic ion for the internal standard

I_s = Amount of internal standard injection in nanograms (ng)

V_o = Volume of water extracted in milliliters (ml)

V_i = Volume of extract injected (ul)

V_t = Volume of total extract. (Use 2000 ul or a factor of this when dilutions are made. The 2000 ul is derived from combining half of the 1 ml BN extract and half of the 1 ml A extract.)

b) Calculate the concentration in the sample using the relative response factor (RRF) and the following equation:

Soil/Sediment

$$\text{Concentration ug/kg} = \frac{(A_x)(I_s)(V_t)}{(A_{is})(RRF)(V_i)(W_s)(D)}$$

(Dry weight basis)

Where:

A_x = Area of characteristic ion for the compound to be measured.

A_{is} = Area of characteristic ion for the internal standard.

I_s = Amount of internal standard injection in nanograms (ng).

V_t = Volume of low level total extract (Use 1000 uL or a factor of this when dilutions are made.

If GPC cleanup is used, the volume is 2000 uL. The 1000 uL is derived from concentrating the 9.5 mL.)

V_i = Volume of extract injected (uL)

$D = \frac{100 - \%\ \text{moisture}}{100}$

W_s = Weight of sample extracted (grams)

4. Calculate surrogate standard recovery on all samples, blanks and spikes. Determine if recovery is within limits described in Section IX.B.

   a. Calculation for surrogate recovery.

   $$\text{Percent Surrogate Recovery} = \frac{Qd}{Qa} \times 100\%$$

   Where: Qd = quantity determined by analysis
   Qa = quantity added to sample

   b. If recovery is not within limits, the following is required:

      1) Check to be sure there are no errors in calculations, surrogate solutions and internal standards. Also, check instrument performance.

      2) Reanalyze the sample if none of the above reveal a problem.

VIII. DAILY QUALITY CONTROL

A. Control Samples

1. Surrogate Standard Spike Solution: 100 ug/ml base/neutral surrogates, 100 ug/ml acid surrogates.

a. In a 50 ml volumetric flask, add 1.0 ul of each 5,000 ug/ml base/neutral reference surrogate standard and 1.0 ml of each 5,000 ug/ml acid reference surrogate standard. Dilute to the mark with methylene chloride. Mix by inverting several times.

Surrogate Standard	Volume (ml) of 5,000 ug/ml stock	Control Spike Solution Conc. (ug/ml)
2-Fluorophenol	1.0	100
2-Fluorobiphenyl	0.5	50
2,4,6-Tribromophenol	1.0	100
p-Terphenyl-d_{14}	0.5	50

b. All method blanks and field samples will be spiked with 0.5 ml of this 50/100 ug/ml surrogate spiking solution prior to extraction and analysis, as described in section VII. This produces an extract with 100 ug/ml base/neutral surrogate compounds and 100 ug/ml acid surrogate compounds.

2. Method blanks will be prepared using reagent water spiked with 100 mg/L each of sulfate and chloride (see Section V.A.)

IX. REFERENCES

U.S. EPA Contract Laboratory Program Statement of Work Organics Analysis, Multi-media, Multi-concentration, 10/86, revised 1/87.

X. DATA

A. Off-the-shelf Analytical Reference Material Characterization: Not applicable.

B. Initial Calibration: See attached.

1. Response vs. Concentration Data: See attached.

2. Response vs. Concentration Graphs: N/A.

C. Daily Calibration

1. Response: See attached.

2. Required percentage or two standard deviations: See attached.

XI. INSTRUMENT PARAMETERS/OPERATING CONDITIONS

GC/MS/DS: Hewlett Packard MSD
Electron Energy: 70 volts
Scan Time: 1 sec per scan

Initial Column Temperature Hold	- 50°C for 1 minute
Column Temperature Program	- 50-310°C at 10 degrees/ minute
Final Column Temperature Hold	- 310°C for 10 minutes
Injector Temperature	- 220°C
Transfer Line Temperature	- 290°C
Source Temperature	- 190°C
Injector-Grob type, splitless Sample Volume	- 2 ul
Carrier Gas	- Helium at 1 ml/minute

TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)

4240B

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 268, 261, 262, 264, 265, 266, 270, and 271

[SWH-FRL 3099-6]

Hazardous Waste Management System; Land Disposal Restrictions

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: The Environmental Protection Agency is today promulgating its approach to implementing the congressionally mandated prohibitions on the land disposal of hazardous waste. This action is responsive to amendments to the Resource Conservation and Recovery Act (RCRA), enacted through the Hazardous and Solid Waste Amendments of 1984 (HSWA).

Today's notice establishes procedures for setting treatment standards for hazardous wastes, for granting nationwide variances from statutory effective dates, for granting extensions of effective dates on a case-by-case basis, for evaluating petitions for a variance from the treatment standard, and for evaluating petitions demonstrating that continued land disposal of hazardous wastes is protective of human health and the environment.

In addition, EPA is promulgating specific treatment standards and effective dates for hazardous wastes included in the first phase of the land disposal prohibitions: certain dioxin and solvent-containing hazardous wastes. EPA also is promulgating the Toxicity Characteristic Leaching Procedure (TCLP) for use in determining whether these wastes meet the applicable treatment standards. Extensions of the effective date for certain categories of these wastes are also promulgated in today's rule.

Prohibitions on underground injection of these wastes are on a different schedule and are being addressed in a different rulemaking. The treatment standards, however, will apply when the restrictions are effective.

DATE: This final rule is effective November 8, 1986, except for the provisions in §§ 268.32(b) and 268.41(a), which will become effective on November 8, 1988.

ADDRESSES: The official record for this rulemaking under Docket Number LDR-3 is located in the RCRA Docket (Subbasement), U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460, and is available for viewing from 9:30 a.m. to 3:30 p.m., Monday through Friday, excluding legal holidays. The public must make an appointment to review docket materials by calling Mia Zmud at (202) 475-9327 or Kate Blow at (202) 382-4675 for appointments. The public may copy a maximum of 50 pages of material from any one regulatory docket at no cost. Additional copies cost $0.20/page.

FOR FURTHER INFORMATION CONTACT: For general information about this rulemaking contact the RCRA Hotline, Office of Solid Waste (WH-562), U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, (800) 424-9346 (toll free) or (202) 382-3000 in the Washington, DC metropolitan area.

For information on specific aspects of this rule contact: Stephen R. Weil or Jacqueline W. Sales, Office of Solid Waste (WH-562B), U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460 (202) 382-4770.

SUPPLEMENTARY INFORMATION:

Preamble Outline

I. Background
A. Summary of Hazardous and Solid Waste Amendments of 1984
1. Solvents and Dioxins
2. California List
3. Scheduled Wastes
4. Newly Listed Wastes
B. Summary of the Proposed Rule
1. Determination of Section 3004(m) Treatment Standards
2. Variance Based on Lack of National Capacity
3. Petition Process
4. Storage of Prohibited Wastes
II. Summary of Today's Final Rule
A. Regulatory Framework
B. Applicability
1. Scope of Land Disposal Restrictions
2. CERCLA Response Action and RCRA Corrective Action Wastes
3. Air Emissions
C. Section 3004(m) Treatment Standards
D. Petition Procedures for Demonstrating Land Disposal to be Protective of Human Health and the Environment ("No-migration" Petitions)
E. Variance from the Treatment Standard
F. National Variance from the Effective Date
G. Case-by-Case Extensions
H. Storage of Prohibited Wastes
I. Treatment Standards and Effective Dates for Solvents
J. Treatment Standards and Effective Dates for Dioxins
K. Rationale for Immediate Effective Dates
III. Agency Response to Major Comments on Proposed Rule
A. Applicability
1. Open Burning and Open Detonation
2. Wastes Produced by Small Quantity Generators
B. Treatment Alternatives (BDAT)
1. BDAT Expressed as a Performance Standard
2. Process Variability
3. Criteria for Well Designed and Operated Treatment Systems
C. Capacity
1. Capacity for Waste-as-Fuel
2. Commercial vs. Private Capacity
3. Permitted Facility vs. Interim Status Facility Capacity
4. Existing Facility vs. Planned Facility Capacity
5. National vs. Regional Capacity
D. Petitions Demonstrating Land Disposal of Untreated Waste is Protective
1. Generic Petitions for Sites with Similar Hydrogeologic Properties
2. Conditional Petition Approval Based on *Prima Facie* Evidence
3. Eligibility for Petitions
E. Storage of Prohibited Wastes
F. CERCLA Interface
1. 48-Month Exemption for CERCLA Wastes that are Soil or Debris
2. Capacity Shortfall due to CERCLA Wastes
G. Solvents
1. Definition of Solvent Wastes
2. Impacts on Small-Quantity Generators and Small-Volume Wastes
3. Disposal of Lab Packs Containing Solvents
H. Dioxins
1. Quantity of Dioxin-Containing Wastes Generated
2. Treatment Standard for Dioxin-Containing Wastes
3. Land Disposal Restrictions Effective Date
IV. Detailed Analysis of the Final Regulatory Framework
A. Determination of Best Demonstrated Available Treatment Technologies (BDAT)
1. Waste Treatability Groups
2. Determination of Demonstrated Treatment Technologies
3. Determination of Available Treatment Technologies
4. Collection and Analysis of Performance Data
5. Identification of "Best" Demonstrated Available Treatment Technologies and Determination of Treatment Standards
6. Dilution Prohibition
B. Comparative Risk Assessment and Available Treatment Alternatives
1. Proposed Use of Comparative Risk Assessment
2. Agency Response to Comments
3. Use of Comparative Risk Assessment in the Final Framework
C. Application of Standards
1. Leaching Procedure
2. Testing and Recordkeeping
3. RCRA Facilities Operating Under a Permit or Interim Status
D. Determination of Alternative Capacity and Ban Effective Date
1. Effective Dates
2. Regional and National Capacity
3. The Nationwide Variance and the Case-by-Case Extension
4. Determination of Capacity Requirements by Waste Treatability Group

6. Definition of Available Capacity
6. Definition of Alternative Treatment Capacity
7. Definition of Alternative Recovery and Disposal Capacity
8. Estimation of Capacity
9. Applicability of the Minimum Technological Requirements
E. Exemption for Treatt and in Surface Impoundments
1. Sampling and Removal of Treatment Residuals
2. Applicability of Minimum Technological Requirements
F. Case-by-Case Extensions
1. Demonstrations Included in Applications
2. Where to Send Extension Applications
3. Review of Applications Per an Extension
4. Applicability of Case-by-Case Extensions
5. Length of Case-by-Case Extension and Renewals
6. Consultation With Affected States
G. Evaluation of Petitions Demonstrating Land Disposal To Be Protective of Human Health and the Environment
1. Procedures for Submitting and Reviewing Petitions
H. Treatability Variance
1. Basis for Establishing Treatability Variance
2. Demonstrations Included in a Petition
V. Treatment Standards for Solvents
A. Introduction
B. Treatment Standards For F001–F005 Spent Solvents
1. Industries Affected
2. Demonstrated Technologies for F001–F005 Spent Solvent
3. Determination of Treatment Standards (BDAT) for Spent Solvents
C. Comparative Risk Assessment Determinations for F001–F005 Spent Solvents
D. Treatment and Recycling Capacity for Solvents
1. Quantity of Wastes Land Disposed
2. Reanalysis of Land Disposal Practices Used
3. Comments on EPA's Estimates
4. Summary of Quantities Requiring Capacity
5. Comments on Types of Treatment Required
E. Unused Capacity of Solvent Treatment and Recycling Facilities
1. Capacity for Wastewater Treatment
2. Capacity for Incineration
3. Capacity for Fuel Substitution
4. Capacity for Distillation/
F. Determination of the Effective Date
VI. Treatment Standards for Dioxin Containing Wastes
A. Introduction
B. Summary of Regulations Affecting Land Disposal of Dioxin-Containing Wastes
C. Analysis of Treatment Technologies for Dioxin-Containing Wastes and Determination of BDAT
1. Applicable Treatment Technologies
2. Comparative Risk Assessment Determinations for Dioxin-Containing Wastes
3. Demonstrated Technologies and Determination of BDAT
D. Determination of Alternative Capacity and Effective Dates
1. Required Alternative Treatment Capacity for Dioxin-Containing Wastes
2. Treatment, Disposal, and Recovery Capacity Currently Available
VII. State Authority
A. Applicability of Rules in Authorized States
B. Effect on State Authorizations
C. State Implementation
VIII. Effects of the Land Disposal Restrictions Program on Other Environmental Programs
A. Discharges Regulated Under the Clean Water Act
B. Discharges Regulated Under the Marine Protection, Research, and Sanctuaries Act
C. Air Emissions Regulated Under the Clean Air Act
IX. Implementation of the Part 268 Land Disposal Restrictions Program
X. Regulatory Requirements
A. Regulatory Impact Analysis
1. Cost and Economic Impact Methodology
2. Costs and Economic Impacts
3. Benefits and Cost-Effectiveness of the Restrictions Rule
B. Regulatory Flexibility Analysis
1. Economic Impact on Small Businesses
2. Certification of Finding That No Regulatory Flexibility Analysis Is Required
C. Review of Supporting Documents and Response to Public Comment
1. Review of Supporting Comments
2. Response to Comments
D. Paperwork Reduction Act
XI. References
XII. List of Subjects in 40 CFR Parts 260, 261, 262, 264, 265, 268, 270 and 271

I. Background

A. Summary of Hazardous and Solid Waste Amendments of 1984

The Hazardous and Solid Waste Amendments of 1984 (HSWA), enacted on November 8, 1984, impose substantial new responsibilities on those who handle hazardous waste.

In particular, the amendments prohibit the continued land disposal of untreated hazardous wastes beyond specified dates, "unless the Administrator determines that the prohibition ... is not required in order to protect human health and the environment for as long as the wastes remain hazardous ..." (RCRA sections 3004 (d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)). Congress established a separate schedule in section 3004(j) for making determinations regarding the disposal of dioxins and solvents in injection wells.

Wastes treated in accordance with treatment standards set by EPA under section 3004(m) of RCRA are not subject to the prohibitions and may be land disposed. The statute requires EPA to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924(m)(1)).

Land disposal prohibitions are effective immediately upon promulgation unless the Agency sets another effective date based on the earliest date that adequate alternative treatment, recovery, or disposal capacity which is protective of human health and the environment will be available (RCRA sections 3004(h) (1) and (2), 42 U.S.C. 6924(h) (1) and (2)). However, these effective dates variances may not exceed 2 years beyond the applicable statutory deadlines. In addition, two 1-year case-by-case extensions of the effective date may be granted under certain circumstances.

For the purposes of the land disposal restrictions program, the legislation specifically defines land disposal to include, but not be limited to, any placement of hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome or salt bed formation, or underground mine or cave (RCRA section 3004(k), 42 U.S.C. 6924(k)).

Congress also has prohibited the storage of any hazardous waste that is subject to a prohibition from one or more methods of land disposal unless "such storage is solely for the purpose of the accumulation of such quantities of hazardous waste as are necessary to facilitate proper recovery, treatment or disposal" (RCRA section 3004(j), 42 U.S.C. 6924(j)).

There also is a statutory exemption from the land disposal restrictions for the treatment of wastes in a surface impoundment, provided that the impoundment is meet minimum technological requirements (with limited exceptions) and that treatment residues that do not meet the treatment standard(s) are removed within 1 year of the entry of the waste into the impoundment (RCRA section 3004(j)(11)(A)(B), 42 U.S.C. 6924(j)(11)(A)(B)).

The legislation sets forth a series of deadlines for Agency action. At certain deadlines, further land disposal of a particular group of hazardous wastes is prohibited if the Agency has not set treatment standards under section 3004(m) for such wastes by the deadline, based on a case-specific petition that there will be no migration of hazardous constituents from the unit for so long as the wastes remain hazardous. Other deadlines cause conditional restrictions

on land disposal to take effect if treatment standards have not been promulgated or if a petition has not been granted. In any case, where EPA does not set a treatment standard for a waste by the statutory date, it is not precluded from later promulgating a treatment standard for that waste. Similarly, where EPA has set a treatment standard, it is not precluded from revising that standard after the statutory date through rulemaking procedures. The relevant statutory deadlines are explained in detail in the following units.

1. Solvents and Dioxins

Effective November 8, 1988, the statute prohibits further land disposal (except by deep well injection) of the following wastes: dioxin-containing hazardous wastes numbered F020, F021, F022, and F023,[1] and solvent-containing hazardous wastes numbered F001, F002, F003, F004, and F005. (RCRA sections 3004 (e)(1), (e)(2), 42 U.S.C. 6924 (e)(1), (e)(2)). These wastes are listed in 40 CFR 261.31.

If EPA fails to set treatment standards or grant petitions for solvent- and dioxin-containing wastes by the statutory deadline, such wastes are prohibited from land disposal as of that deadline (other than in injection wells, where the prohibition is effective as of August 8, 1988). If EPA has set treatment standards, wastes that meet the level or are treated by the specified method may be land disposed. Wastes subject to a successful petition may also continue to be land disposed.

2. California List

Effective July 8, 1987 (32 months from November 8, 1984), the statute prohibits disposal (except with respect to deep well injection) for the following wastes, listed or identified under RCRA section 3001:[2]

a. Liquid hazardous wastes, including free liquids associated with any solid or sludge, containing free cyanides at concentrations greater than or equal to 1,000 mg/l.

b. Liquid hazardous wastes, including free liquids associated with any solid or sludge, containing the following metals (or elements) or compounds of these metals (or elements) at concentrations greater than or equal to those specified below:

(1) Arsenic and/or compounds (as As) 500 mg/l;
(2) Cadmium and/or compounds (as Cd) 100 mg/l;
(3) Chromium (VI) and/or compounds (as Cr VI) 500 mg/l;
(4) Lead and/or compounds (as Pb) 500 mg/l;
(5) Mercury and/or compounds (as Hg) 20 mg/l;
(6) Nickel and/or compounds (as Ni) 134 mg/l;
(7) Selenium and/or compounds (as Se) 100 mg/l;
(8) Thallium and/or compounds (as Tl) 130 mg/l.

c. Liquid hazardous wastes having a pH less than or equal to 2.0.

d. Liquid hazardous wastes containing polychlorinated biphenyls (PCBs) at concentrations greater than or equal to 50 ppm.

e. Hazardous wastes containing halogenated organic compounds in total concentrations greater than or equal to 1,000 mg/kg. (RCRA sections 3004(d) (1) and (2), 42 U.S.C. 6924(d) (1) and (2)).

If EPA fails to set treatment standards or grant petitions by July 8, 1987, for wastes appearing on the California List, these wastes will be prohibited from land disposal (other than in injection wells, where the applicable statutory deadline is August 8, 1988).

EPA will propose treatment standards for California List wastes in a future Federal Register notice.

During the period ending November 8, 1988 (48 months from November 8, 1984), disposal of contaminated soil or debris resulting from a response action taken under sections 104 or 106 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (Superfund), or a corrective action required under Subtitle C of RCRA, is not subject to any land disposal prohibition or treatment standard for F001–F005 solvent wastes, dioxin-containing wastes, and wastes covered by the California List. (RCRA sections 3004 (d)(3), (e)(3), 42 U.S.C. 6924 (d)(3), (e)(3)).

3. Scheduled Wastes

Section 3004(g) of RCRA (42 U.S.C. 6924(g)) requires the Agency to set a schedule for making land disposal restriction decisions for all hazardous wastes listed as of November 8, 1984, under RCRA section 3001. This list excludes solvent and dioxin wastes prohibited under section 3004(e) and California List wastes prohibited under section 3004(d). EPA submitted this schedule to Congress on May 28, 1986 (51 FR 19300).

RCRA section 3004(g)(5) (42 U.S.C. 6924(g)(5)) provides that if EPA fails to set treatment standards or grant petitions by the statutory deadline for any hazardous waste according to the schedule, such hazardous waste may be disposed of in landfills or surface impoundments only in facilities in compliance with the minimum technological requirements set forth in RCRA section 3004(o), 42 U.S.C. 6924(o)).[3] If EPA fails to set treatment standards or grant a petition for any of the scheduled listed wastes by May 8, 1990, all such wastes will be prohibited from land disposal.

4. Newly Listed Wastes

The land disposal prohibitions apply to all hazardous wastes under RCRA section 3001 as of November 8, 1984, the date of enactment of HSWA. For any hazardous waste identified or listed under RCRA section 3001 after November 8, 1984, EPA is required to make land disposal restriction determinations within 6 months of the date of identification or listing (RCRA section 3004(g)(4), 42 U.S.C. 6924(g)(4)). However, the statute does not impose an automatic prohibition on land disposal if EPA misses a deadline for any newly listed or identified waste.

B. Summary of the Proposed Rule

On January 14, 1986, EPA proposed to establish a framework by which treatment standards for hazardous wastes restricted from land disposal would be established. EPA also proposed treatment standards and effective dates (dates by which wastes must be treated or be prohibited from land disposal unless subject to a successful petition) for the first class of hazardous wastes—solvents and dioxins—to be evaluated under the proposed framework (51 FR 1602).

1. Determination of Section 3004(m) Treatment Standards

In developing treatment standards under RCRA section 3004(m), the Agency proposed an approach using technology-based levels in conjunction with risk-based standards (screening levels). The technology-based levels were derived from the performance of the best demonstrated available technologies (BDAT). Performance of treatment processes was evaluated based upon the leachability of the residuals of such treatment in the land

[1] The final dioxin rulemaking (50 FR 1978, January 14, 1985) contains three waste codes, F020, F021, and F023, not specified in the statute. The additional waste codes are a result of reorganization and do not represent a substantive departure from the waste codes enumerated in section 3004(e)(1).

[2] This list is based on regulations developed by the California Department of Health Services for hazardous waste land disposal restrictions in the State of California. Thus, it has become known as the "California List."

[3] In this situation, placement of such wastes in other types of land disposal units (e.g., deep injection wells) would not be precluded by section 3004(g)(5). See Vol. 130, Cong. Rec. S9132 (daily ed., July 25, 1984).

disposal environment. The screening levels specified maximum concentration levels of individual hazardous constituents in extracts of hazardous wastes. The Agency also noted that air emissions contamination was not addressed in the proposed framework. However, when work was completed on the air model, more stringent screening levels would be set, if necessary, to protect this media.

To ensure that the total risks to human health and the environment were not increased as a result of implementing the land disposal restrictions, the Agency proposed to compare the risks of managing wastes in land disposal units with the risks of managing wastes in alternative treatment technologies. Treatment technologies found to pose greater risks than those posed by land disposal of the waste would be considered unavailable for purposes of establishing RCRA section 3004(m) treatment standards.

The proposed rule set treatment standards in the following way. If application of BDAT treatment resulted in concentration levels equal to or lower than the screening levels, the Agency proposed to issue the screening level as the treatment standard, capping off required BDAT treatment at these protective levels. If application of BDAT treatment resulted in levels less stringent than the screening levels, but BDAT realized substantial reductions in toxicity or mobility and did not pose greater risks than land disposal, then the technology-based level would become the treatment standard and the screening level would remain as a goal that could be reached as new technologies emerged.

The Agency proposed to apply the framework to the waste codes specified in section 3004(e) (i.e., F020–F023, F026 and F027 [4] for dioxin-containing wastes, and F001–F005 and the corresponding constituents listed in 40 CFR 261.31 (a) and (f) for solvent-containing wastes [5].

The screening levels for dioxin-containing wastes were below established detection limits achievable using standard EPA analytical methods, thus, the Agency proposed treatment standards based on the detection limits. The proposed treatment standards for solvents were derived from screening levels and the potential effects of solvents on synthetic and clay liners.

The Agency requested comments on an alternative approach, that of establishing treatment standards under RCRA section 3004(m) based solely on the performance of the best demonstrated available technology (BDAT).

2. Variance Based on Lack of National Capacity

Because no incinerator or thermal treatment facility has been approved by EPA to treat dioxin-containing wastes, the Agency proposed to grant a 2-year national variance for all dioxin-containing wastes subject to the restrictions. The Agency also proposed to grant a 2-year nationwide variance for F001–F005 solvent wastes containing less than 1 percent (by weight) total organic constituents, and solvent-contaminated soils, because of capacity limitations on alternative treatment, recovery, and disposal technologies.

3. Petition Process

The Administrator is authorized to find that land disposal of a particular waste will be protective of human health and the environment if an interested person demonstrates, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the land disposal unit or injection zone for as long as the wastes remain hazardous (RCRA sections 3004 (d)(1), (e)(1), and (g)(5), 42 U.S.C. (d)(1), (e)(1), and (g)(5)). Under the proposed rule, this demonstration was to be made in the form of a petition to the EPA Regional Administrator or authorized State program director. The applicant would have been required to prove that a specified waste could be contained safely in a particular type of disposal unit. The Agency proposed that the "no migration . . . for as long as the wastes remain hazardous" standard could be met if the petitioner demonstrated that, by the time the constituent reached a point of potential human exposure, or a sensitive environment, it would be at a concentration level that did not threaten human health and the environment.

4. Storage of Prohibited Wastes

Section 3004(j) of RCRA specifies that any waste that is prohibited from one or more methods of land disposal also is prohibited from storage unless the storage is solely to accumulate sufficient quantities of the waste to allow for proper recovery, treatment, or disposal. The Agency interprets the statute to provide that the storage prohibition does not apply to wastes that have been treated in accordance with treatment standards or that have been subject to a successful petition demonstration. EPA proposed that generators and treatment, storage, and disposal facilities be allowed to accumulate prohibited wastes on-site for up to 90 days.

II. Summary of Today's Final Rule

A. Regulatory Framework

The Agency is finalizing the regulatory framework for implementing the land disposal restrictions and promulgating treatment standards and associated effective dates for certain solvent- and dioxin-containing wastes.

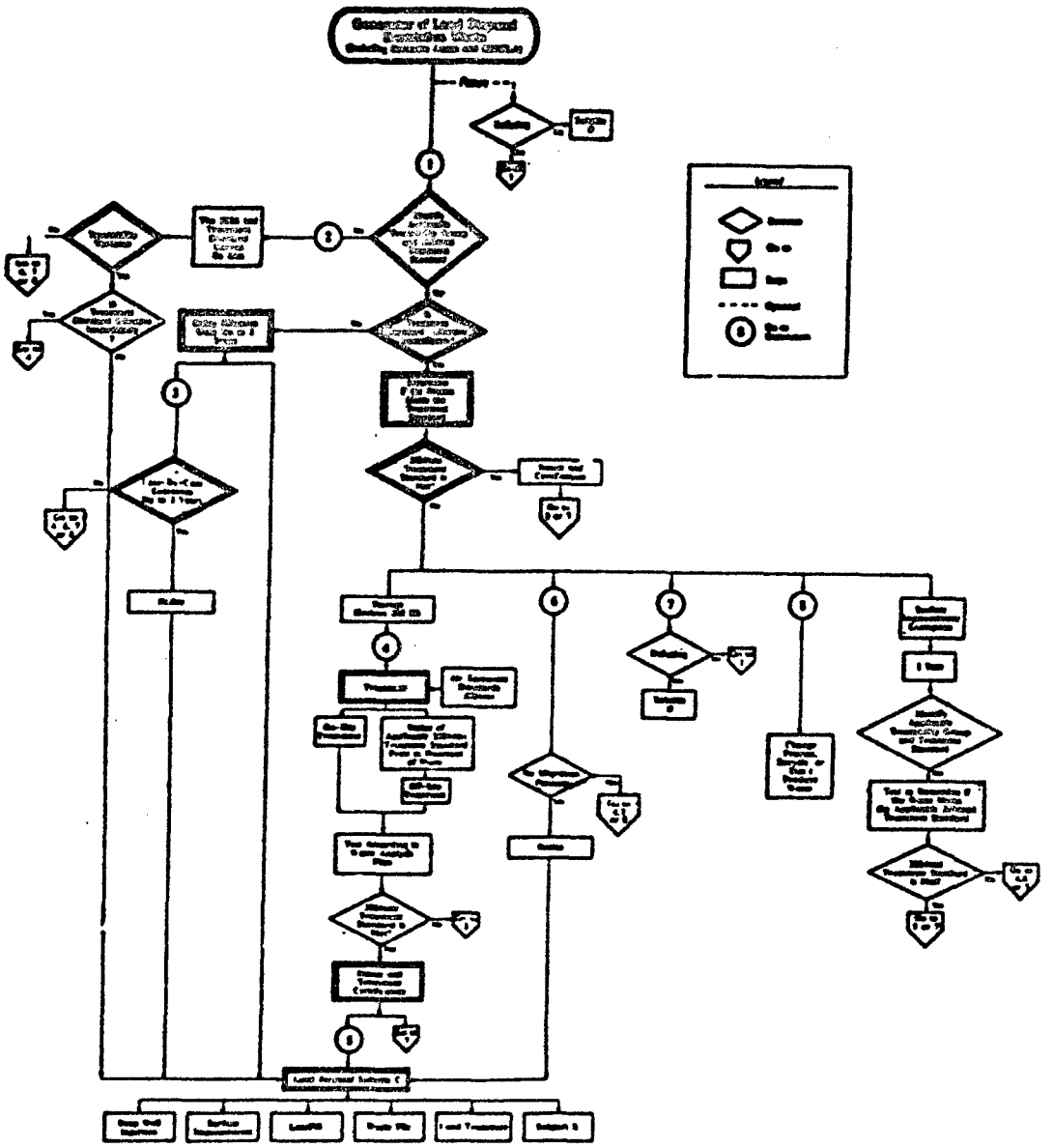
By each statutory deadline, the Agency will promulgate the applicable treatment standards under Part 268 Subpart D for each hazardous waste. After the standards are effective, wastes may be disposed of in a Subtitle C facility if they meet the applicable treatment standard.

After the effective dates of the prohibitions, wastes that do not comply with the applicable treatment standards will be prohibited from continued placement in land disposal units unless a petition has been granted by the Administrator under § 268.6 demonstrating that continued management of specific hazardous wastes in land disposal units is protective of human health and the environment for as long as the waste remains hazardous. EPA may provide an extension of the statutory effective date under § 268.5.

BILLING CODE 6560-50-M

[4] The Agency omitted F026 from the proposed rule because it is the residue from the thermal treatment of soils contaminated with other dioxin-containing wastes. This was an error, as this waste also is required to meet the treatment standard. F026 is included in today's final rule.

[5] The solvent wastes are listed as F001, U002, U031, U037, U044, U057, U070, U080, U112, U117, U121, U140, U151, U154, U161, U165, U169, U170, U171, U220, U226, U228 and U239.



BILLING CODE 6560-50-C

B. Applicability

1. Scope of Land Disposal Restrictions

The definition of land disposal is not being limited to placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave as specifically identified in RCRA section 3004(k). The Agency also considers placement in concrete vaults or bunkers intended for disposal purposes as methods of waste management subject to the land disposal restrictions, as proposed. The Agency, however, is departing from the proposed rule with respect to open detonation. For purposes of clarification, the final rule notes that the Agency interprets any reference to open detonation to include open burning (see Unit III.A.). The Agency has concluded that these methods do not constitute land disposal, except in cases where the residuals from open detonation and open burning of explosives continue to exhibit one or more of the characteristics of hazardous waste.

The Agency interprets the land disposal restriction adopted in today's final rule as applying prospectively to the affected hazardous wastes. In other words, hazardous wastes placed into land disposal units after the effective date are subject to the prohibitions, but wastes land disposed prior to the applicable effective date do not have to be removed or exhumed for treatment. Similarly, the Agency interprets the restrictions on storage of prohibited wastes to apply only to wastes placed in storage after the effective date of an applicable land disposal restriction. If, however, wastes subject to land disposal restrictions are removed from either a storage or land disposal unit after the effective date, subsequent placement of such wastes in or on the land would be subject to the restrictions and treatment provisions.

The provisions of today's final rule also apply to wastes produced by generators of 100 to 1000 kilograms of hazardous waste in a calendar month.

The land disposal restrictions apply to both interim status and permitted facilities. All permitted facilities are subject to the restrictions, regardless of existing permit conditions, because the provisions of RCRA require compliance by all facilities even though the requirements are not specifically referenced in the permit conditions. The land disposal restrictions supersede 40 CFR 270.4(a), which currently provides that compliance with a RCRA permit constitutes compliance with Subtitle C.

2. CERCLA Response Action and RCRA Corrective Action Wastes

Under section 3004(u)(2) Congress provided a 48-month exemption (until November 1988) from the land disposal restriction provisions for disposal of contaminated soil and debris from CERCLA 104 and 106 response actions and RCRA corrective actions. Because of this statutory exemption, today's final rule is not applicable to these wastes. The exemption covers the disposal of any soil and debris wastes under section 3004 (u) and (v). All other CERCLA response action wastes and RCRA corrective actions wastes are subject to this rule.

CERCLA response actions and RCRA corrective actions often address waste matrices different than those associated with industrial waste processes on which this rule is primarily based. These waste matrices are different in terms of chemical/physical composition, concentrations, and media within and among sites. The Agency anticipates that treatability variances may be needed for some soils, debris, and other similar wastes. Therefore, before November 8, 1988, the Agency plans to perform additional characterization of soils and debris and other similar wastes and, where necessary, amend the treatment standards by adding additional standards specifically for these wastes.

Today's final rule provides a 2-year national variance for wastes from CERCLA response actions and RCRA corrective actions that are not soil and debris. These wastes must be disposed of in facilities that are in compliance with the requirements of section 3004(o).

CERCLA and RCRA soil and debris wastes include but are not limited to soils, dirt, and rock as well as materials such as contaminated wood, stumps, clothing, equipment, building materials, storage containers, and liners. In many cases soils and debris will be mixed with liquids or sludges. The Agency will determine on a case-by-case basis whether all or portions of such mixtures should be considered soil or debris.

3. Air Emissions

The framework for restricting wastes from land disposal focuses primarily on the relationship between the land disposal of hazardous waste and ground water quality. However, the Agency also is concerned with air emissions from land disposal of these wastes. The Agency plans to address the issue of releases to the air in a broad context in response to various provisions in RCRA including section 3001 (characterization of waste as hazardous) and section 3004 (restriction of waste from land disposal and standards for air emissions from land disposal).

Historically, the Agency has developed and promulgated rules under section 3001 of RCRA classifying waste as hazardous based on the potential of these wastes to cause harm to human health and the environment if managed improperly. These determinations have included the potential for harm as a result of reactivity, ignitability, corrosivity, and toxicity via the ground water or surface water pathway. While the Agency has consistently maintained that exposure from air emissions is a potential problem for wastes that are treated and disposed improperly, work to develop a characteristic based on potential for air contamination has not as yet been completed. The Agency plans, however, to propose an air toxicity characteristic in the future to provide a more complete definition of hazardous waste, including a list of hazardous constituents that are of concern based on their potential for air contamination.

In conjunction with the development of an air toxicity characteristic, the Agency also plans to propose criteria and performance standards for air emissions in its development of treatment standards for wastes in accordance with section 3004(m). The development of these criteria is tied to the characterization of wastes as hazardous and that portion of the land disposal restrictions framework related to the risks posed by air emissions from best treatment technologies.

Both the air toxicity characteristic and the criteria for treatment standards based on air emissions are related to both the development of air emission standards under section 3004(n) and the petition demonstration for continued land disposal under section 3004(d). With respect to the former, section 3004(n) requires the Administrator to promulgate standards for the control and monitoring of air emissions from treatment, storage and disposal facilities. These standards are currently under development.

In establishing a framework for dealing with air emissions under the RCRA statute, the Agency must also develop criteria under section 3004 (d), (e), and (g) for determining when the statutory standard of "no migration of hazardous constituents from the disposal unit or injection zone for as long as the waste remains hazardous" has been met. As with other portions of the statute dealing with air emissions, the standards and criteria to be applied to the petition demonstration are closely

related to the factors and criteria to be used to determine when a waste should be managed as hazardous under section 3001 of RCRA. EPA expects that the technical analysis of air emissions that will provide a basis for future rulemaking under sections 3001 and 3004(n) will also be used as a guide in making decisions on petitions addressing air emissions concerns.

Implementation of two portions of the regulatory program, nevertheless, must proceed as the air strategy is being developed. These include the issuance of permits to treatment, storage and disposal facilities and the establishment of corrective action requirements as a part of those permits. In these cases, it is expected that air contamination from operating and closed facilities will be addressed on a case-by-case basis as part of the permit process.

C. Section 3004(m) Treatment Standards

As discussed earlier, the Agency proposed two major approaches to setting treatment standards under section 3004(m). The first approach involved development of treatment standards based on either technology- or risk-based screening levels. The second approach was based entirely on technology-based standards expressed as BDAT. The Agency is promulgating the second approach as the framework under which disposal of solvents, dioxins, and the scheduled wastes will be evaluated.

The risk-based methodology proposed by the Agency considered the degree of hazard posed by wastes land disposed in Subtitle C facilities. This led to the development of "maximum acceptable contaminant concentrations" (or screening levels), which were based on the recognition that the potential for harm to human health and the environment will differ depending on the toxicity, mobility, and persistence of the waste stream. This approach also recognized that in some cases, any single technology-based level may provide more protection than is necessary, while in other cases, may provide insufficient safeguards for human health and the environment. Moreover, under the proposed approach, relatively "low hazard" wastes could be considered suitable for land disposal without any treatment at all.

Although a number of comments on the proposed rule favored the first approach; that is, the use of screening levels to "cap" treatment that can be achieved under BDAT, several commenters, including eleven members of Congress, argued strongly that this approach did not fulfill the intent of the law. They asserted that because of the scientific uncertainty inherent in risk-based decisions, Congress expressly directed the Agency to set treatment standards based on the capabilities of existing technology.

The Agency believes that the technology-based approach adopted in today's final rule, although not the only approach allowable under the law, best responds to the above-stated comments. Accordingly, the final rule establishes treatment standards under RCRA section 3004(m) based exclusively on levels achievable by BDAT. The Agency believes that the treatment standards will generally be protective of human health and the environment. Levels less stringent than BDAT may also be protective.

The plain language of the statute does not compel the Agency to set treatment standards based exclusively on the capabilities of existing technology. RCRA section 3004(m) requires EPA to "promulgate regulations specifying those levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (42 U.S.C. 6924(m)). By calling for standards that minimize threats to human health and the environment, the statute clearly allows for the kind of risk-based standard originally proposed by the Agency. However, the plain language of the statute does not preclude a technology-based approach. This is made clear by the legislative history accompanying the introduction of the final section 3004(m) language. The legislative history provides that "[T]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable" and that "[T]he intent here is to require utilization of available technology in lieu of continued land disposal without prior treatment" (Vol. 130, *Cong. Rec.* S1178, (daily ed., July 25, 1984)). Thus, EPA in acting within the authority vested by the statute in selecting to promulgate a final regulation using its proposed alternative approach of setting treatment standards based on BDAT.

The Agency believes that its major purpose in adopting the risk-based approach of the proposal (i.e., to allow different standards for relatively low-risk, low-hazard wastes) may be better addressed through changes to other aspects of its regulatory program. For example, EPA is considering the use of its risk-based methodologies to characterize wastes as hazardous pursuant to section 3001.

D. Petition Procedures for Demonstrating Land Disposal To Be Protective of Human Health and the Environment ("No-migration" Petitions)

In carrying out the directives of RCRA sections 3004 (d)(1), (e)(1), and (g)(5), the Agency proposed to consider petitions to allow land disposal of restricted wastes, provided that petitioners demonstrated that any migration from the disposal site would be at concentrations that did not pose a threat to human health and the environment.

Today's final rule adopts the statutory language requiring petitioners to demonstrate "to a reasonable degree of certainty that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous." The Agency will allow continued land disposal of hazardous wastes without further treatment only where it can be demonstrated, to a reasonable degree of certainty, that the statutory standard will be met.

Since the Agency expects that there will be relatively few cases in which this demonstration can be made, and, therefore, that relatively few petitions might be submitted for review, the Agency is requiring that petitions be submitted to the Administrator rather than to permit writers in authorized States or Regional EPA offices as originally proposed. As noted in the proposed rule, a petition may be submitted at any time prior to or after the effective date of the ban (see Unit IV.G.). However, submission of a petition will not stay the effective date of the prohibitions.

E. Variance From the Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the levels specified as the treatment standard (or, in some cases, by the method specified). In such cases, generators or owners/operators may submit a petition to the Administrator requesting a variance from the treatment standard. Today's final rule includes procedures for obtaining such a variance (see Unit IV.H.). Following a restriction effective date and while the Agency is reviewing the request for a variance, the generator may not land dispose the waste. Alternatively, continued land disposal in surface impoundments meeting the standards of § 268.4(a)(3) may be feasible for some wastes.

F. National Variance From the Effective Date

The Agency has the authority to grant national variances to the effective date based upon a lack of capacity to treat the wastes. The new effective date of the prohibition is to be established based on the earliest date on which treatment capacity that is protective of human health and the environment will be available. In no case can this extension be longer than 2 years. During the period of such a variance, the waste is not subject to the land disposal restrictions or any requirements relating to such restrictions. However, during the period of such an extension, the wastes must be managed in facilities that are in compliance with the requirements of section 3004(o) (42 U.S.C. 6924(o)).

G. Case-by-Case Extensions

The Agency will consider granting up to a 1-year extension (renewable once) of a ban effective date if the applicant demonstrates that a binding contract has been entered into to construct or otherwise provide alternative capacity that cannot reasonably be made available by the applicable effective date due to circumstances beyond the applicant's control. The Agency is departing from the procedures outlined in the proposed rule by deleting the proposed cancellation penalty clause for contracts to construct or provide capacity. The final rule makes it clear that in demonstrating that capacity cannot reasonably be available the applicant may show that it is not feasible to provide such capacity (see Unit IV.F.). During the period that the extension is in place, the waste is not subject to the land disposal restrictions; thus, the successful applicant also is exempt from the prohibition on storage under § 268.50. However, during the period of the extension, the wastes must be disposed of in facilities meeting the requirements of RCRA section 3004(o) (42 U.S.C. 6924(o)).

H. Storage of Prohibited Wastes

The Agency proposed a 90-day storage limit to allow the generator and owner/operator of a hazardous waste treatment, storage, or disposal facility time to accumulate sufficient quantities of wastes to allow for proper recovery, treatment, and disposal. Commenters to the rule stated that 90 days was insufficient and more time should be allowed for storage. In today's final rule the Agency is removing the 90-day storage limit for owners/operators. Owners/operators may store restricted wastes as needed to accumulate sufficient quantities to allow for proper recovery, treatment, and disposal. However, where storage occurs beyond one year, the owner/operator bears the burden of proving that such storage is solely for the purpose of accumulating sufficient quantities to allow for proper recovery, treatment, or disposal. Generators who need to store restricted wastes for periods in excess of the accumulation time limits in 40 CFR 262.34 must obtain interim status and eventually a permit. The Agency is maintaining the proposed 90-day storage limit for restricted waste at transfer facilities. The prohibition on storage applies to restricted wastes, and does not apply to wastes that meet the treatment standard or are the subject of a successful petition under § 268.6 or extension under § 268.5.

I. Treatment Standards and Effective Dates for Solvents

The Agency proposed to establish treatment standards for F001, F002, F003, F004, and F005 solvent wastes and their corresponding P and U wastes (40 CFR 261.3 (e) and (j)) using nondetect levels and a liner protection threshold. Today's rule, however, addresses only the F001 through F005 solvent wastes (including solvent mixtures). The Agency will evaluate the P and U solvent wastes in accordance with the schedule for listed wastes. In today's rule, the Agency is promulgating technology-based treatment standards for the F001–F005 solvents. The Agency also is promulgating the effective dates for F001–F005 solvent wastes essentially as proposed, with modifications to the range of applicable wastes. The land disposal restrictions become effective on November 8, 1986, for all F001–F005 solvent wastes, with the exception of the following wastes which will receive a 2-year variance that extends the effective date for the land disposal restrictions to November 8, 1988:

(1) The generator of the solvent waste is a small quantity generator of 100–1000 kilograms of hazardous waste per month; or

(2) The solvent waste is generated from any response action taken under sections 104 or 106 of CERCLA or any RCRA corrective action, except where the waste is contaminated soil or debris not subject to the provisions of this chapter until November 8, 1988; or

(3) The solvent waste is a solvent-water mixture, a solvent-containing sludge, or a solvent-contaminated soil (non-CERCLA or RCRA corrective action) containing less than 1 percent total F001–F005 solvent constituents listed in Table CCWE of § 268.41.

J. Treatment Standards and Effective Dates for Dioxins

The proposed rule set treatment standards for dioxin-containing wastes (F020, F021, F022, F023, F026, F027) below the current detection limit of 1 ppb for each of the chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) (i.e., all isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxins and dibenzofurans, respectively), and the applicable detection limits for the specified chlorophenols.* The proposed standards required that these constituents be below the 1 ppb limit in the waste extract before being land disposed. Wastes having concentrations that meet or exceed the 1 ppb limit may be treated in accordance with the criteria established for incineration (40 CFR 264.343 and 265.345), and thermal treatment (40 CFR 264.[illegible]). The Agency is promulgating [illegible] treatment standards as proposed (see Unit VI). The Agency also is setting treatment standards for F024, which was not included in the proposed rule.

As proposed, the Agency is establishing a 2-year national variance from the effective date for the dioxin-containing wastes covered under today's final rule. Accordingly, treatment standards for dioxin-containing wastes will not take effect until November 8, 1988.

K. Rationale for Immediate Effective Date

Today's rule provides for an effective date of November 8, 1986. It is clear from the statute that today's rule must go into effect no later than the effective date of the prohibition on solvents and dioxins in section 3004(e). Absent any regulations, the prohibition on solvents and dioxins in section 3004(e) takes effect automatically on November 8, 1986. Therefore, November 8, 1986 is the latest date for EPA to promulgate regulations that will prevent the "hammer" in section 3004(e) from falling. Section 3004(h) of RCRA provides that a prohibition for regulations under section 3004 (d), (e), (f), or (g) takes effect immediately upon promulgation. For section 3004(e), that date is November 8, 1986. Moreover, section 3004(m) provides that regulations setting treatment standards

* In addition to CDDs and CDFs, the compounds of concern for the dioxin-containing wastes include 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 2,3,4,6-tetrachlorophenol, and pentachlorophenol (see Appendix VII to Part 261). The treatment standards for these constituents are 50, 35, 150, and 10 ppb, respectively.

must have the same effective date as the applicable regulation promulgated under subsection (d), (e), (f), and (g). Therefore, since the statute clearly provides that the regulations implementing section 3004(e) go into effect on November 8, 1988, EPA finds that good cause exists under section 2019(b)(2) of RCRA to provide for an effective date of November 8, 1988. For the same reason, EPA finds that there is good cause under section 553(d)(3) of the Administrative Procedure Act, 5 U.S.C. § 553(d)(3), to waive the requirement that regulations be published at least 30 days before they become effective.

III. Agency Response to Major Comments on Proposed Rule

EPA received approximately 200 comments responding to the proposed rule. Comments were submitted by treatment, storage, and disposal (TSDF) facilities, environmental organizations, trade associations, companies, State and Federal regulatory agencies, and private citizens.

The Agency received considerable comment on all aspects of the proposed rule. In today's final rule, major comments on applicability, treatment alternatives (BDAT), capacity, petitions, storage, CERCLA interface, solvents, and dioxins are addressed. Responses to comments not addressed in today's rule are available in the background document to this rulemaking (see Comment Response Background Document For the Land Disposal Restrictions Volume I, November 7, 1986), available in the RCRA docket.

The Agency received numerous comments on the ground water back calculation model used in developing health-based screening levels. However, because the approach promulgated in today's rule does not employ screening levels, the Agency is not addressing these comments in this final rule. The Agency does anticipate using similar models in future regulatory actions. We will address the issues raised by the applicable comments in these future rulemaking activities.

A. Applicability

1. Open Burning and Open Detonation

The majority of the commenters were opposed to the inclusion of open detonation and open burning as forms of land disposal. It was argued that these two methods of waste management are treatment rather than disposal, as supported by the standards in 40 CFR 265.382 for owners and operators who thermally treat explosive wastes using open detonation or open burning. The commenters stated that most wastes handled in this manner are hazardous because they exhibit the characteristic of reactivity (i.e., they are explosive), and when these wastes are open burned or detonated they are rendered nonreactive. The commenters also indicated that no other available technologies provide a safer alternative to handling these wastes.

Although the Agency did not specifically address open burning in the proposed rule, current EPA regulations classify both open detonation and open burning as types of thermal treatment under Subpart D of Part 265. Because open detonation and open burning are similar waste management methods for treatment of explosive wastes, the same regulatory requirements apply to both methods under 40 CFR 265.382. Therefore, we believe that considering open burning in conjunction with open detonation for purposes of this final rule is reasonable and consistent with the current regulatory structure.

Upon reevaluation, the Agency agrees that open burning and open detonation of explosive wastes does not constitute land disposal. EPA does not believe that Congress intended to prohibit these activities because open burning and open detonation are not included in the definition of land disposal in section 3004(k). They are primarily treatment processes that typically result in by-products which are no longer reactive and, therefore, are not considered hazardous. The Agency also agrees with commenters that open detonation and open burning may be the only safe waste management method for handling explosive wastes.

In view of these considerations, the Agency has concluded that the land disposal restrictions program is not applicable to open detonation and open burning.

2. Wastes Produced by Small Quantity Generators

While EPA is authorized to vary standards for small generators under RCRA section 3001(d), this authority is circumscribed by the need to protect human health and the environment. The Agency has carefully considered the risks posed by land disposal of small generator wastes and has weighed these against the impacts of the land disposal restrictions on these generators. Given the smaller aggregate amounts of hazardous waste produced by small generators, it is arguable that the relative risks of land disposal to human health and the environment are lower. However, the major concern with land disposal is the toxicity of the waste rather than the quantity. As EPA explained in a recent rulemaking imposing certain RCRA regulatory requirements on generators of 100 to 1000 kg of hazardous waste per month, data from EPA's National Small Quantity Hazardous Waste Generator Survey indicate that both small and large quantity generators produce many of the same types of waste and use many of the same waste management practices. 50 FR 31289 (Aug. 1, 1985). Therefore, it is appropriate to include wastes produced by small quantity generators in the land disposal prohibitions.

B. Treatment Alternatives (BDAT)

1. BDAT Expressed as a Performance Standard

Generally, commenters supported the Agency's interpretation of section 3004(m) regarding the criteria for the selection of BDAT. The statute specifies that BDAT may be expressed as either a performance standard or a method of treatment. Wherever possible, the Agency prefers to establish BDAT treatment standards as performance standards rather than adopting an approach that would require the use of specific treatment methods. To date, all treatment technologies considered as BDAT can result in a wide range of performance values depending on the operation of the technology. EPA believes performance standards ensure that the technology is properly operated. Additionally, the Agency believes concentration-based performance standards offer the regulated community greater flexibility to develop and implement compliance strategies as well as incentive to develop innovative treatment technologies.

2. Process Variability

One commenter asserted that normal process variability has not been accounted for in the Agency's calculation of treatment standards. The commenter urged the Agency to calculate variability factors which account for variations in influent composition, system performance, sampling and analytical test methods, and site specific conditions. The commenter further stated that the variability factors should be used to develop BDAT treatment standards on a daily maximum basis.

The Agency agrees with the comments that treatment standards need to incorporate a variability analysis. Since variability in performance occurs even at facilities that are well designed and well operated, EPA believes it is appropriate to include such an analysis in the development of BDAT treatment

standards. This analysis is not intended to account for performance differences which occur as a result of treating a waste that is significantly different in composition or for differences which occur from improper or poor treatment of the same waste. Instead, incorporation of a variability factor into the development of a BDAT standard is intended to account for variations which arise from mechanical variations in the equipment used to maintain treatment parameters at the proper setting, small variations in the waste, and variations in analytical test methods.

The variability factor, as outlined in the Notice of Availability of Data (see 51 FR 31703, September 5, 1986), is the ratio of the calculated 99th percentile concentration, C_{99}, to the mean treatment concentration. A detailed discussion of the statistical calculation used to account for process variability is provided in Unit IV.A.

2. Criteria for Well-Designed and Operated Treatment Systems

One commenter asserted that the Agency should document in the record its rationale for evaluating and editing data based on the performance of the treatment system. The commenter stated that the Agency should not simply presume that well designed and operated treatment systems are those that achieve the lowest performance values but should instead consider the effects of the characteristics of the waste on treatment performance. The Agency is aware that the level of treatment achievable is dependent upon the physical and chemical characteristics of the waste. Accordingly, it is necessary for the Agency to assess design and operating parameters in determining whether a system is performing well, in addition to its consideration of the performance value achieved. Because the parameters that comprise a well-designed and operated system will vary for each technology, it is difficult for EPA to generalize the specific parameters that need to be examined. Whenever the Agency has little or no data on the design and operation of the system, the Agency will evaluate the constituent concentrations in the waste before and after treatment and use engineering judgment to determine whether the system is performing well. The Agency also will use a statistical outlier analysis to confirm engineering judgment. The statistical analysis to be used was published in the Federal Register on September 5, 1986 (51 FR 31324). The rationale the Agency used for editing performance data can be found in the technical support documents.

C. Capacity

1. Capacity for Waste-as-Fuel

Several commenters argued that EPA did not consider waste-as-fuel as a treatment alternative in estimating capacity. As one commenter pointed out, this is a potentially large treatment option that cannot be ignored. EPA did not consider this alternative because the data were not available. Since the November 14, 1985 proposed rule the Agency has received waste-as-fuel data from the "Telephone Verification Survey of Commercial Facilities that Manage Solvents" (August 1986). Data from this survey were noticed for public comment on September 5, 1986 (51 FR 31703) and have been included in capacity estimates for today's final rule.

2. Commercial vs. Private Capacity

Several commenters stated that EPA should not consider private capacity as available alternative treatment capacity. They explained that private facilities may not be willing to accept off-site wastes because liability could be considerable, permit conditions may prohibit accepting off-site waste, or on-site capacity may be fully committed to non-hazardous wastes.

EPA recognizes the issues raised by commenters and agrees that private capacity should not automatically be considered as available alternative treatment capacity. However, when there is insufficient available commercial treatment capacity, EPA plans to consider the potential for private facilities to become commercial facilities. EPA will include private capacity if there is sufficient evidence that the private facilities plan to accept off-site wastes. Because limited information exists on the planned public availability of current private capacity, EPA has no basis for including private capacity in total capacity estimates for solvents and dioxins subject to today's final rule.

3. Permitted Facility vs. Interim Status Facility Capacity

Several commenters stated that only existing permitted treatment facilities should be considered in estimating available capacity. They argued that interim status facilities may not receive final permits and consequently may not provide available capacity.

In calculating available capacity for solvents and dioxins, EPA included capacity that is currently available from some interim status facilities and all permitted facilities. The interim status facilities included did not notify the Agency of an intent to close and, therefore, can be expected to provide capacity for the November 8, 1988, effective date. In future capacity determinations, EPA will assess, on a case-by-case basis, the number of interim status facilities expected to accept wastes.

4. Existing Facility vs. Planned Facility Capacity

Several commenters stated that only existing, permitted facilities should be considered in estimating available capacity, because it is uncertain whether "planned" facilities will be on-line by the effective date of the restrictions with approval to operate from Federal, State, and local agencies. EPA will include planned capacity only when there is sufficient evidence that the planned facilities will be fully operational by the effective date of the prohibitions. In the case of solvents and dioxins, such evidence does not exist; therefore, planned facilities have not been included in the capacity estimates for today's rule.

5. National vs. Regional Capacity

Several commenters stated that EPA should determine available capacity under section 3004(h)(2) on a regional basis rather than on a national basis, and variances should be regionalized based on the availability of treatment. These commenters stated that it is realistic to assume that economic and transportation problems affect the availability of alternative capacity for a particular generator. They pointed out that national capacity for some treatment technologies is based on a few high-volume treatment facilities, and emphasized the need for Federal, State, and local efforts to construct more waste treatment facilities.

EPA recognizes these problems. However, the legislative history (S. Rep. No. 284, 98th Cong., 1st Sess. 12(1983)) clearly states that "the available capacity determination is to be done on a national basis" in order to prevent a situation in which regions obtaining variances would become the "dumping ground" for wastes generated in regions implementing the land disposal restrictions. Accordingly, EPA believes that national capacity determinations under section 3004(h)(2) are more in accord with the statutory intent.

D. Petitions Demonstrating Land Disposal of Untreated Waste Is Protective

1. Generic Petitions for Sites With Similar Hydrogeologic Properties

Several commenters suggested that the Agency accept generic petitions that address similar management techniques

for the same or similar wastes in hydrogeologic settings with similar characteristics. Commenters felt that a generic petition, once approved, would allow all such sites where the same or similar wastes were managed with a similar technique to automatically receive approval for land disposal without individual petition demonstrations.

RCRA sections 3004 (d)(1), (e)(1), and (g)(5) do not preclude the submission of generic petitions. However, as a practical matter, the usefulness of the generic petition is limited, since a petition demonstration must include site- and waste-specific data (see § 268.6 (a) and (b)). Accordingly, petitioners must demonstrate that each scenario covered under the generic petition is similar. For example, a demonstration that the hydrogeological characterization of sites is similar would require a detailed assessment of each site addressed in the petition. As a result, the Agency expects few, if any, generic petitions.

2. Conditional Petition Approval Based on Prima Facie Evidence

Several commenters expressed concern over the possibility that land disposal restrictions would become effective prior to Agency rulings on petitions, causing disruption in waste disposal activities. To prevent this situation, the commenters suggested that approval of a petition be granted on the basis of superficial evidence of compliance with the statutory standard. The Agency would perform a brief review of the petition for completeness, and would then grant conditional approval until such time that a full technical review could be completed. Other commenters argued that the statute requires a demonstration that the statutory standard is met, not merely an application for petition approval. It would not be possible, according to these commenters, for the Agency to grant approval for such a demonstration without a full technical review.

Other commenters suggested that the statute provides the Agency with the flexibility of granting a 2-year extension of the effective date, pursuant to section 3004(h)(2) upon receipt of prima facie evidence that the "no migration" standard has been met. Commenters argued that this superficial showing of evidence would satisfy the requirements of the extension to identify the adequate alternative disposal capacity that protects human health and the environment.

The Agency agrees with those commenters who stated that the statute calls for a positive demonstration that the statutory standard is met, which implies that a full review of the petition has been made. Thus, the Agency will not grant a conditional variance for disposal of untreated restricted waste in a Subtitle C unit based on a superficial review of the evidence. The Agency will only make the decision regarding the granting of a variance after an in-depth review of a fully developed no migration demonstration submitted by the petitioner.

Under section 3004(h), the Agency is allowed to set different effective dates for the restrictions based on lack of available capacity for treatment, recovery, or disposal. The Agency does not believe that submission of a petition request is relevant to such a finding.

3. Eligibility for Petitions

The Agency requested comment on an approach limiting eligibility for petitions to those wastes for which no alternative treatment is available. Several commenters objected to this approach, stating that the statute and the legislative history do not limit eligibility for petitions.

Other commenters agreed with this approach for several reasons. They argued that the statute clearly reflects congressional intentions that restricted wastes be treated prior to land disposal. They also argued that rendering ineligible those wastes that can be treated to meet a BDAT standard fulfills the spirit of the law and gives a clear signal to industry to plan for expanded treatment capacity. Additionally, they noted that this approach would reduce the burden on the Agency and the States for petition review, so that resources could be devoted to petitions for untreatable wastes.

The Agency continues to believe that the better reading of the law allows no basis for limiting eligibility for the petition process in the manner discussed. RCRA sections 3004 (d), (e) and (g) set up the petition process as a clear albeit limited alternative treatment prior to land disposal of hazardous wastes. Accordingly, the final regulations do not limit eligibility for petitioners.

E. Storage of Prohibited Wastes

A number of commenters argued that because transporters, recyclers, or treatment facilities often give priority to larger volumes of waste or even refuse to take small quantities, more than 90 days are needed to accumulate sufficient quantities.

All of the comments received regarding the proposed storage limit for waste treatment, storage, and disposal stated that 90 days is inadequate. Some commenters stated that additional time is needed because some waste streams are accumulated more slowly than others. More specifically, one commenter presented the case of a plant that generates a very small amount of spent solvents (e.g., one drum every three months), but is not a small quantity generator due to other nonrestricted waste streams. Because of the small amounts generated, the turnaround time during which waste is accumulated to an amount sufficient for a transporter to pick up consistently takes longer than the 90-day period. Additionally, another commenter stated that because halogenated solvents are often blended with other materials before incineration, the 90-day period will be insufficient due to the evaluations and trial burns that will be required for these new blends of wastes. Other commenters cited the frequent back-ups and delays at treatment facilities that may require storage for more than 90 days; however, these factors are not directly relevant to the statute, which allows storage only for the purpose of accumulating sufficient quantities necessary to facilitate proper recovery, treatment, or disposal.

The alternatives suggested by commenters ranged from setting a storage limit of 180 days to not limiting the storage period. The majority of commenters suggested that the Agency establish a 1-year storage limit. Several of these commenters stated that the provision should be similar to the existing speculative accumulation provision in 40 CFR 261.1(b)(9). This provision allows for a material to be accumulated for recycling provided that during the calendar year (commencing January 1) at least 75 percent of the material accumulated at the beginning of the time period is recycled or is transferred to a different site for recycling.

In the proposed rule, the Agency allowed treatment, storage, and disposal facilities the same time periods for accumulating restricted wastes in tanks and containers as specified under 40 CFR 262.34 for large quantity generators accumulating hazardous waste prior to shipment off-site for treatment or disposal. Effective September 22, 1986, generators of 100–1000 kg/mo can store hazardous waste for 180 or 270 days depending on transportation distances. (See 51 FR 10175 (March 24, 1986).) For hazardous waste storage facilities operating under interim status or a RCRA permit, the Agency proposed a 90-day limit for the storage of restricted wastes.

After considering the length of an appropriate storage limit, the Agency agrees with the commenters that 90 days may not be sufficient time to accumulate quantities necessary to facilitate proper recovery, treatment and disposal of restricted wastes. However, the Agency does not believe that the storage time permissible at a waste management facility should be indefinite but, rather, must have some limit because the legislative history indicates that Congress' concern in enacting this provision was to foreclose the possibility of using long-term storage as a means of avoiding a land disposal prohibition. (S. Rep. No. 284, 98th Cong., 1st Sess. 18 (1983).)

The Agency disagrees with the commenters who felt that a system similar to the speculative accumulation provision (40 CFR 261.1(b)(3)) should be implemented for the storage of restricted wastes. The speculative accumulation provision is designed to determine when a material becomes a waste and relies on assumptions that the materials will be continuously removed from storage. The Agency does not believe that this provision is applicable to the storage of restricted wastes.

The Agency believes that a storage limit of up to one year should generally provide sufficient time for an owner/operator to accumulate sufficient quantities to facilitate proper recovery, treatment, or disposal of restricted hazardous wastes while meeting the intent of Congress to prohibit long-term storage as a means of avoiding the land disposal restrictions. The burden is on the Agency to demonstrate that storage of restricted wastes for periods less than or equal to one year is not in compliance with the storage provisions. The Agency also recognizes that there may be instances where one year does not provide sufficient time to accumulate such quantities. Therefore, the Agency will allow an owner/operator to store restricted wastes beyond one year. Although the owner/operator is not required to submit any data or application to EPA, in the event of an enforcement action, the burden of proving compliance with § 268.50(b) is on the owner/operator. The Agency believes that this is reasonable, because the record for this rulemaking indicates that less than one year should be sufficient. This provision does not apply to situations where back-ups at treatment or recovery facilities, operational difficulties, and repairs and maintenance result in additional delays.

Comments received on the proposed 90-day limit on the length of storage of restricted wastes also indicate that a substantial number of generators without permits or interim status will need to accumulate restricted wastes for more than 90 days to comply with Part 268.

Section 3005(e) allows generators to apply for facility interim status if their accumulation will exceed the time limits of 40 CFR 262.34, as long as the storage is necessary to comply with the land disposal restrictions. 40 CFR 270.70(e) codifies that provision. This section provides that facilities "in existence on the effective date of statutory or regulatory changes . . . that render the facility subject to the requirement to have a permit" may qualify for interim status if they make the appropriate application. A generator who is accumulating hazardous wastes in tanks or containers before the effective date of today's rule, is "in existence" and may qualify for interim status provided that the above stated requirements are met. Section 3005(e)(1) allows interim status only where new regulatory requirements subject an existing facility to permitting requirements. It is not intended to provide an opportunity for a facility to newly engage in hazardous waste management.

Generators who need to obtain interim status should submit a Part A application to the Agency as provided in Part 270. In the Part A application, the generator must demonstrate that the additional accumulation time is necessary as a result of the land disposal restrictions of Part 268.

The Part A must be submitted to the Agency by the deadline specified in § 270.10(e). Note that the § 270.10(e) deadline is the earlier of the following two alternative dates: (1) Six months after publication of regulations which first require the facility to comply with Part 268, or (2) thirty days after the date they first become subject to the standards in Part 268. It is expected that the deadline for most, if not all, of the large quantity generators will be established by the second alternative. By operation of 40 CFR 270.10(e)(1), the generator becomes first subject to the permitting requirements when he exceeds the generator accumulation time limit. For example, the generator would be required to submit the Part A within 30 days after the 90-day accumulation period ends. Therefore, it is critical that any generator who will be newly subject to the interim status requirements becomes familiar with the Part 270 requirements and submit a Part A application on time.

The Agency believes that generators will ship restricted wastes off-site in accordance with the 90-day provision in 40 CFR 262.34 whenever possible in order to remain subject only to the generator standards. Generators applying for interim status must comply with the applicable requirements of Part 265. Furthermore, if requested by the Administrator, the facility will be required to submit to Part B permit application.

The Agency received only one comment addressing the proposed 10-day storage limit for transporters of restricted wastes. The commenter stated that 10 days would be insufficient because it does not allow for unexpected back-ups and delays. Although such situations may occur, the Agency does not have data indicating that such delays occur frequently so as to create a serious problem. Therefore, the rule being promulgated today maintains the 10-day limit for the storage of restricted waste at a transfer facility to allow for activities incidental to normal transporter practices.

To implement the storage provision, the Agency is requiring owners/operators to comply with the same requirements for dating containers as set forth for generators under 40 CFR 262.34(a)(2). The Agency believes that the restrictions on the storage of wastes under § 268.50 are consistent with the intent of Congress to preclude the possibility of using long-term storage as a means of avoiding a land disposal prohibition and are sensitive to the time constraints of the regulated community expressed by the commenters.

F. CERCLA Interface

1. 48-Month Exemption for CERCLA Wastes That Are Soil or Debris

Several commenters requested clarification of § 268.1(c)(3), namely the scope of the 48-month exemption for certain CERCLA wastes (soil or debris) from the solvents and dioxins land disposal restrictions. It was suggested that this exemption should be defined to include all CERCLA bulk wastes. In addition, it was questioned whether State-ordered, State-funded, or private party-funded response action wastes are granted the same exemption.

The Agency does not believe the 48-month exemption can be interpreted to include CERCLA bulk wastes that are clearly not contaminated soil or debris. CERCLA soil and debris have been defined to include, but not be limited to, soil, dirt, and rock of small size mixed and intermingled materials) such as contaminated wood, clothing, equipment, building materials, storage containers, and liners as many times soil or debris will be mixed with liquids

or sludges. The Agency considers liquid- or sludge-containing wastes, including bulk wastes that are not contaminated soil or debris, generated by a CERCLA response action, to be subject to the land disposal restriction requirements. However, a variance from the land disposal restriction requirements, based on insufficient treatment capacity, was granted for these restricted wastes until November 1988. The Agency is preparing guidance that will further define CERCLA soil and debris wastes in order to assist the regulated community in determining which wastes are covered under the exemption. In addition, before November 8, 1988, the Agency will further analyze the solvent and dioxin treatment standards to determine if these standards are applicable to contaminated soil or debris.

Only those wastes that result from CERCLA Fund-financed actions (section 104) and the exercise of CERCLA's enforcement authority (section 106) are included in the exemption. Response action wastes that result from State-ordered, State-funded, or private party-funded responses taken under the authority of CERCLA or exclusive of this authority are not included in the exemption. Relevant sections of the National Contingency Plan (NCP, 50 FR 47912, November 20, 1985) that address these distinctions include Subpart F, § 300.62 (State participation) and § 300.71 (other party responses). Wastes not included in the exemption and prohibited from land disposal are subject to the schedule imposed by the land disposal restriction requirements. Responses generating these wastes may be preauthorized under section 111 of CERCLA (see § 300.25 of the NCP) and, if so, are eligible for the recovery of certain costs under CERCLA section 107. Other party responses under NCP § 300.71(a)(4) are required to comply with all legally applicable or relevant and appropriate requirements. RCRA clearly states that the exemption applies to all CERCLA soil and debris land disposed before November 8, 1988. After this date, these wastes will be managed in accordance with the requirements of the land disposal restrictions applicable to CERCLA wastes.

2. Capacity Shortfall Due to CERCLA Wastes

Several commenters stated that the Agency had not adequately evaluated the effect on treatment capacity of CERCLA wastes. As indicated in Unit V, CERCLA capacity estimates have been revised to incorporate the results of a recently completed EPA analysis of future volumes of wastes resulting from CERCLA responses. A variance has been granted for CERCLA wastes that are not soil or debris until November 8, 1988. The Agency acknowledges that CERCLA demand for treatment capacity may compete with generator demand for the same treatment capacity. However, the Agency's "Off-Site Policy" for disposing CERCLA waste contains stringent criteria that could render some existing capacity unavailable for the management of CERCLA wastes.

G. Solvents

1. Definition of Solvent Wastes

A number of commenters stated that the scope of the land disposal restrictions for solvent-containing wastes extends beyond congressional intent. In particular, the commenters stated that the land disposal restrictions rule should address only F001–F005 hazardous wastes (regulated as of July 1, 1983) specified in section 3004(e). Another specific concern raised by the commenters was that the impacts of including the P and U hazardous wastes as listed in 40 CFR 261.33 (e) and (f), respectively, have not been adequately assessed; therefore, these wastes should not be included in the first class of solvent-containing wastes (i.e., F001–F005) subject to the land disposal restrictions.

In proposing treatment standards for solvent-containing wastes, the Agency included the corresponding commercial chemical products and off-specification species (P and U hazardous wastes) as listed in 40 CFR 261.33 (e) and (f), respectively, and solvent mixtures containing 10 percent or more of the listed solvents (pursuant to the solvent mixtures rule, 50 FR 53315, December 31, 1985). The Agency proposed to exercise its statutory authority under section 3004(g) [7] and include the corresponding P and U wastes with decisions on the F001–F005 wastes because the data indicate that these wastes may pose hazards similar to the spent solvents when disposed in Subtitle C facilities.

However, we are continuing to gather data to better define and characterize the P and U wastes and to assess treatment and recycling capacity for these wastes. Because the Agency agrees with the commenters that we do not have sufficient data to promulgate treatment standards for these wastes by the November 8, 1988, deadline, we will postpone decisions on the P and U wastes until we address the lists of scheduled wastes.

[7] Section 3004(g) requires that the Administrator shall "not later than the date specified in the schedule . . . promulgate final regulations prohibiting one or more methods of land disposal."

With respect to solvent mixtures, the provisions under section 3004(m)(2) require the Agency to make a determination within six months whether to subject newly identified or listed hazardous wastes to the land disposal restrictions (the statute does not impose an automatic prohibition if the Agency misses the deadline). Because six months have already elapsed since the Agency promulgated the final rule to bring certain spent solvent mixtures into the hazardous waste system,[8] the Agency is including solvent mixtures in today's rule.

2. Impacts on Small-Quantity Generators and Small-Volume Wastes

Several comments were received concerning the impacts of the land disposal restrictions on small-quantity generators and small-volume waste types. One commenter was concerned that the economic impacts on small-quantity generators of solvents have not been adequately assessed.

An assessment of the economic impacts on small-quantity generators from land disposal restrictions affecting solvent-containing wastes is included in the "Regulatory Analysis of Proposed Restrictions on Land Disposal of Certain Solvent Wastes." Total small-quantity generator costs attributed to the land disposal restrictions were found to be significant, but the costs and associated economic impacts for individual facilities were found to be small. Overall, based on economic factors that were determined for small-quantity generators that dispose of solvent-containing wastes, the land disposal restrictions appeared not to impose significant economic burdens on these generators.

3. Disposal of Lab Packs Containing Solvents

Several commenters addressed disposal of small quantities of solvent-containing wastes in lab packs.

Commenters requested that solvent-containing lab packs be exempt from the land disposal restrictions. They stated that such an exemption would be consistent with existing exemptions under 40 CFR 264.316 and would allow the disposal of only small quantities of solvent wastes.

Another commenter questioned whether the entire lab pack is banned from land disposal if all the packaged wastes are not solvents. Alternatively, the commenter proposed to remove

[8] The Agency promulgated the solvent mixtures final rule on December 31, 1985. The rule became effective on January 30, 1986 (see 50 FR 53317).

restricted solvents before land disposal of the lab pack.

Neither the legislative history nor the statute indicates that lab packs can be excluded from the land disposal restrictions if they contain solvents designated as F001–F005 or other restricted wastes. Under the approach promulgated in today's rule, listed solvents are subject to the land disposal restrictions. If a lab pack contains these restricted wastes, the entire lab pack is subject to the land disposal restrictions. As a practical matter this means that the lab pack may not be land disposed unless the solvents or other restricted wastes are removed before land disposal, the solvents in the lab pack meet the treatment standard, or a successful petition demonstration has been made under § 268.6.

H. Dioxins

1. Quantity of Dioxin-Containing Wastes Generated

Several commenters argued that the Agency underestimated the actual quantity of dioxin-contaminated soil subject to the proposed rule. Specifically, one commentor argued that EPA did not take into consideration the dioxin-contaminated sites in the States of Arkansas, New Jersey, and New York in developing the estimate for the quantity of dioxin-contaminated soil in the U.S.

In the proposed rule, EPA acknowledges that the estimated quantity of dioxin-contaminated soil present in the U.S. was derived by assessing estimates for such contaminated soil from the State of Missouri. At this time, the Agency does not have data to determine more accurately the total quantity of dioxin-contaminated soil from sites in the U.S. other than the State of Missouri. Thus, EPA decided to estimate the quantity of dioxin-contaminated soil nationwide based solely on the data provided for the State of Missouri. In making this determination, the Agency should have noted that the estimated quantity of 1.1 billion pounds for dioxin-contaminated soil was accurate within a range of ±30 percent. If this quantity is underestimated, then the Agency acknowledges that the national estimate is also underestimated. However, such an underestimation would have no effect on the decisions made in today's rule regarding capacity because there is adequate disposal or treatment capacity even for substantially larger quantities of dioxin-containing wastes.

2. Treatment Standard for Dioxin-Containing Wastes

One commentor argued that as the analytical methodology improves, increasing amounts of materials which might contain insignificant levels of dioxins would be prohibited from land disposal.

The treatment standard for the listed dioxin-containing wastes is based on the current limits of technology available to treat dioxin-containing wastes. The treatment standard for these wastes was proposed at the detection limit afforded by test method 8280 for the CDDs and CDFs in waste extracts because current analytical techniques are not capable of detecting dioxin-containing wastes at the levels achievable by incineration. Research analytical methods indicate that incineration to six 9s destruction removal efficiency (DRE) can achieve reductions in the treatment residuals five to seven orders of magnitude from those concentrations in the starting material. The treatment standard of 1.0 ppb however, represents the routinely achievable detection limit for the CDDs and CDFs using test method 8280. (See 51 FR 1708.)

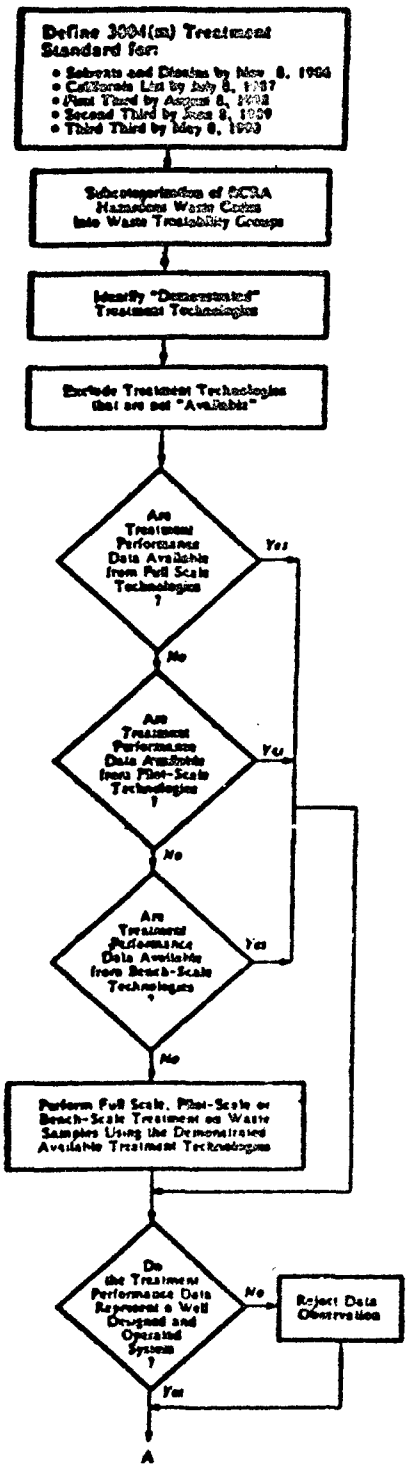
If additional data become available which demonstrate a lower detection limit for these dioxin wastes, the treatment standard may be revised as necessary.

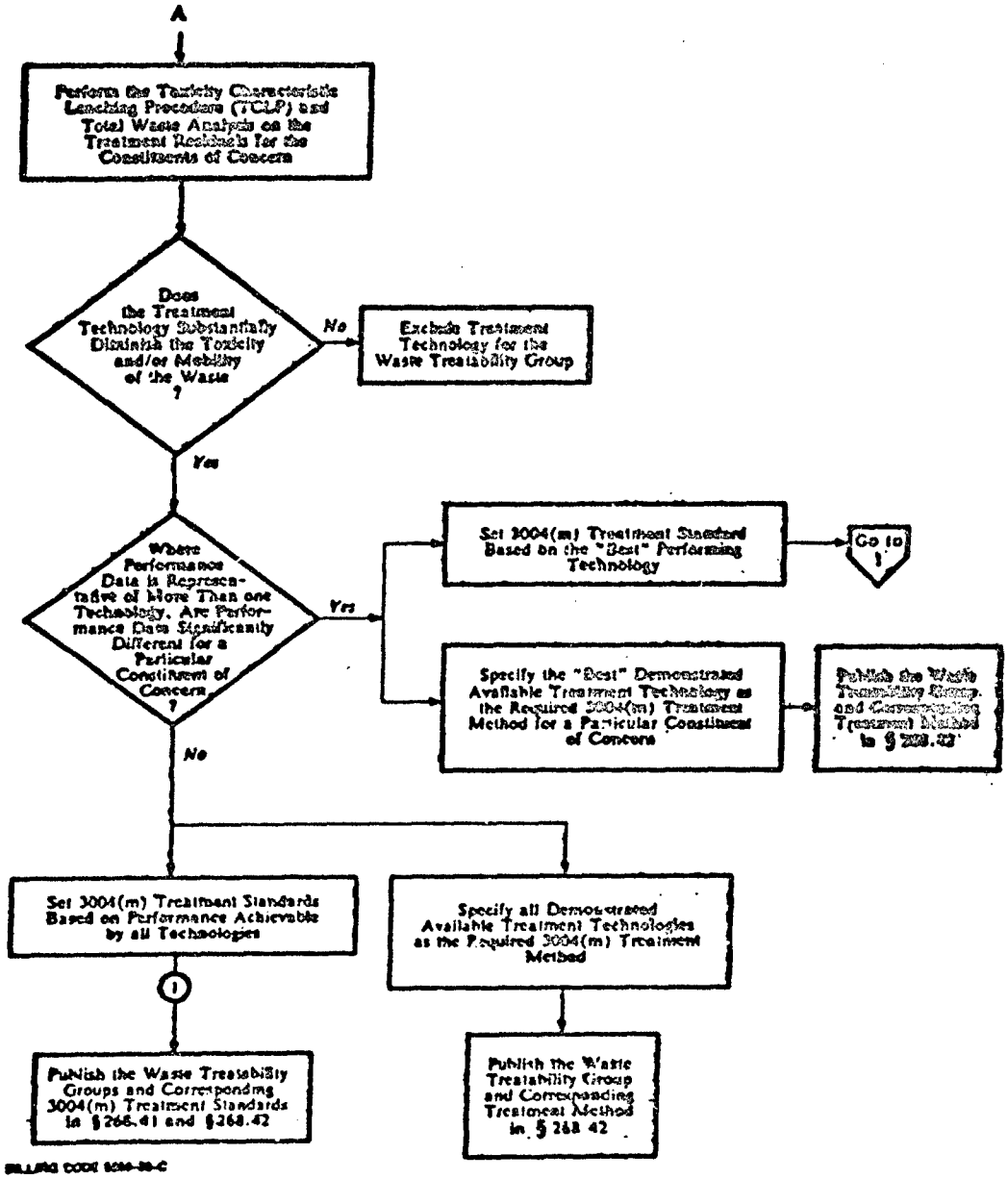
Lowering the detection limit and changing the subsequent treatment standard will not prohibit significantly increased amounts of materials containing low concentrations of dioxins from land disposal. The prescribed toxicity characteristic leaching procedure (TCLP) is designed to determine the leachability of both organic and inorganic contaminants present in liquid, solid, and multiphase wastes. The constituents of concern in the listed dioxin-containing wastes are not mobile, and are present in low concentrations. The treatment standard would have to be significantly lower than 1 ppb in order to significantly increase the amount of material that does not meet the treatment standard before any treatment. In addition, to the extent that incineration achieves 99.999 percent (six 9s) destruction removal efficiency (DRE) as required under the dioxins listing rule, a lowering of the detection limit will only verify that treatment is achieving levels far below the standard method detection limit. As the detection limit approaches the actual treatment level, the Agency will lower the treatment standard to that level.

3. Land Disposal Restrictions Effective Date

Several commenters addressed EPA's proposal to delay the effective date for the land disposal restrictions for dioxin-containing wastes. All commenters agreed that the 2-year extension to the effective date was reasonably justified because of a lack of available treatment capacity. The commenters also argued that unless treatment capacity is available by the effective date, they will be confronted with an unavoidable noncompliance situation due to the limitations on storage of restricted wastes.

The Agency, in today's rule, is granting the maximum 2-year variance allowed under section 3004(h)(2) for the listed dioxin-containing wastes. At the present time, there is no data to show that treatment capacity for dioxin-containing wastes will not be available after the effective date, or after the additional two 1-year extensions which are available to generators on a case-by-case basis.


Define 3004(m) Treatment Standard for:
• Solvents and Dioxins by Nov. 8, 1988
• California List by July 8, 1987
• First Third by August 8, 1988
• Second Third by June 8, 1989
• Third Third by May 8, 1990
Subcategorization of RCRA Hazardous Waste Codes into Waste Treatability Groups
Identify "Demonstrated" Treatment Technologies
Exclude Treatment Technologies that are not "Available"
Are Treatment Performance Data Available from Full Scale Technologies ?
Yes
No
Are Treatment Performance Data Available from Pilot-Scale Technologies ?
Yes
No
Are Treatment Performance Data Available from Bench-Scale Technologies ?
Yes
No
Perform Full Scale, Pilot-Scale or Bench-Scale Treatment on Waste Samples Using the Demonstrated Available Treatment Technologies
Do the Treatment Performance Data Represent a Well Designed and Operated System ?
No
Reject Data Observation
Yes
A



BILLING CODE 6560-50-C

IV. Detailed Analysis of the Final Regulatory Framework

A. Determination of Best Demonstrated Available Treatment Technologies (BDAT)

This section establishes the framework under which treatment standards based on the Best Demonstrated Available Technology will be developed in accordance with 3004(m).

1. Waste Treatability Groups

Fundamental to waste treatment is the concept that the type of treatment technology used and the level of treatment achieved depend on the physical and chemical characteristics of the waste. In the proposed rule, the Agency discussed establishing broad "waste treatability groups" based on similar physical and chemical properties (e.g., metal-bearing sludges or wastes containing cyanides in order to account for differences in types of treatment used and effectiveness of treatment on different wastes. While not directly addressing this approach, commenters stated that the proposed solvent treatment standards did not account for waste matrix effects. These commenters suggested that waste matrix effects could be considered by pooling all available data on the applicable constituents from the plants sampled, presumably without regard to the varying treatability of the specific wastes sampled or the design and operation of the treatment system.

EPA disagrees with this approach because the use of such a pooled data set would result in the establishment of an artificially high treatment standard. This would occur because the broad range of treatment levels associated with numerous waste matrices will yield a high variability factor. The approach of pooling all treatment data would actually result in the masking of different waste matrices as opposed to accounting for matrix effects as suggested by the commenter. While EPA believed, that waste matrix effects were considered in the proposed solvent standards, EPA recognizes, nonetheless, that these effects may not have been fully accounted for in the proposed standards. The Agency anticipates that in future rulemakings, treatment groups could require further subdivision to more fully account for waste matrix effects subject to the availability of sufficient resources. In any event, EPA remains convinced that waste matrix effects are best accounted for by establishing treatability groups and subgroups wherever possible. The legislative history of 3004(m) supports this approach by providing that treatment determinations do not have to be made only by waste code and by authorizing EPA to establish "generic" treatment standards for similar wastes (130 Congressional Record section 31178, daily edition July 25, 1984).

EPA believes that in addition to the types of treatability groups described in the proposed rule, grouping and subgrouping wastes by industry or manufacturing process may be used to account for waste matrix effects on treatment performance (i.e. similar manufacturing operations appear to generate wastes with similar treatability characteristics). For example, in today's rule, EPA has sufficient data to create a separate treatability group for wastewaters containing spent methylene chloride generated by the pharmaceutical industry. However, while the Agency believes that industry-specific analyses will generally account for waste matrix effects, some wastes (e.g., contaminated soils) cannot be categorized by industry. Therefore, EPA may also establish treatability groups for wastes from unknown sources. Finally, as noted in the proposal, EPA intends to focus on the constituents in sections 3004 (d), (e), and (g) and Appendix VIII to Part 261.

2. Determination of "Demonstrated" Treatment Technologies

EPA proposed to determine which technologies are "demonstrated" for a specific waste by studying available data on the types of treatment (including recycling methods) currently used to treat a representative sample of wastes falling within a waste treatability group. To make this determination, EPA proposed first to examine wastes treated by full-scale treatment technologies. A technology may be demonstrated if currently used to treat wastes within the group or wastes judged to be similar. EPA proposed not to consider treatment demonstrated on the basis of insufficient or inadequate full-scale data, for example, if the facility was not designed to remove the constituent or the facility was not well operated. If the treatment of these wastes (or wastes judged to be similar) was not demonstrated by any full scale facility, EPA proposed to study data from pilot-scale and bench-scale treatment operations to determine if a technology was demonstrated. Some commenters were concerned, however, with the use of pilot-scale and bench-scale operations as the basis for determining whether a technology was demonstrated. The Agency agrees with the commenters position that its determinations should not be based on emerging and innovative technologies. This would be in violation of the intent of the statute as indicated in the legislative history, "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable" and not a "best-type process which constitutes technology-forcing standards" (Vol. 130 Cong. Rec. 29178 (daily ed. July 25, 1984)). To the extent that bench- and pilot-scale data represent such emerging and innovative technologies, the Agency believes the proposed approach was too broad. Therefore, today's final rule represents a change in the definition of demonstrated in response to comments. To be considered a "demonstrated" treatment technology for purposes of the final rule, a full scale facility must be known to be in operation for the waste or similar wastes. EPA is amending the proposed approach to the extent that the Agency will not, at this initial stage, examine data to see if the data from the treatment facility represents a well-designed and operated system, because this factor is more appropriately taken into account when evaluating the performance of the treatment operations. EPA believes that this procedure will address the issues raised by commenters who were concerned that the Agency specify the design and operating parameters upon which determinations were made. Accordingly, if no full scale treatment operations are known to exist for a waste or wastes with similar treatability characteristics, the Agency will be unable to identify any "demonstrated" treatment technologies for the waste and, accordingly, the waste will be completely prohibited from continued placement in land disposal units (unless handled in accordance with the exemption and variance provisions promulgated in today's final rule). The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become demonstrated as full-scale operations.

While, the Agency did not consider pilot- and bench-scale operations in identifying "demonstrated" treatment technologies for solvents and dioxins, in certain circumstances, data from these operations may continue to be used by the Agency in evaluating the performance of demonstrated full scale treatment operations for certain wastes. A more detailed discussion of the circumstances that would prompt the use of data from pilot- or bench-scale operations in assessing treatment performance, as well as the manner in

which such data will be used, is presented below.

3. Determination of "Available" Treatment Technologies

EPA proposed the following criteria for "available" treatment technologies: (1) The technology does not present a greater total risk than land disposal; (2) if the technology is a proprietary or patented process it can be purchased from the proprietor; and (3) the technology provides substantial treatment. Today's final rule includes as additional criteria in the determination of "available" treatment technologies. Treatment technologies that are prohibited under section 3004(n) because of air emissions will be excluded as "available" technologies for purposes of establishing treatment standards.

EPA will not set treatment standards based on a technology that does not meet the above criteria. Thus, the decision to classify a technology as "unavailable" may have a direct impact on the treatment standard. If the best technology is unavailable, the treatment standard would have to be based upon the next best treatment technology that was determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There may also be circumstances where EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the treatment standards. Those wastes will be prohibited from continued placement in or on the land unless managed in accordance with the exemption and variance provisions promulgated in today's final rule. The Agency, however, is committed to establishing new treatment standards as soon as new or improved treatment processes become "available".

a. *Treatment technologies that present greater total risks than land disposal methods.* As explained in the proposed rule, EPA will evaluate the risks associated with treatment technologies and land disposal methods. Based on a comparative risk assessment, those technologies that are found to present greater total risks than land disposal of the untreated waste will be excluded (i.e., considered "unavailable") as a basis for establishing treatment standards.

If all demonstrated treatment technologies are determined to present greater risks than land disposal for the waste treatability group, the Agency will not be able to identify any "available" treatment technologies and, accordingly, will not set a treatment standard for that group. As a result of such a determination, the waste will be prohibited from land disposal unless managed in accordance with the exemptions and variance provisions in today's final rule or a new or improved technology emerges that is determined not to pose greater total risks than direct land disposal. Treatment technologies identified as riskier than land disposal and, therefore, classified as unavailable for purposes of establishing standards may still be used by facilities in complying with treatment standards expressed as performance levels. EPA is committed to developing sufficient regulatory controls or prohibitions over the design and operation of these technologies to ensure that their use in complying with the treatment standards do not result in increased risks to human health and the environment.

b. *Proprietary or patented processes.* If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. In the proposed rule, EPA explained that proprietary or patented processes will be considered available if the Agency determines that the treatment method can be purchased from the proprietor or is commercially available treatment. The services of the commercial facility offering this technology can often be purchased, although the technology itself cannot. In these cases, the Agency proposed that the technology should be considered "available" to treat wastes generated by those other than the owner of the proprietary process.

EPA received some comments supporting and others disagreeing with this approach. The comments objecting to this approach stated that EPA should use the best demonstrated treatment regardless of its commercial availability and thereby, provide strong financial incentives for development of new technologies on the grounds that excluding such technologies from the analysis may result in less stringent treatment standards. The Agency believes, however, that its proposal represents a reasonable compromise that is intended to exclude only those technologies that would not be made available even with strong regulatory and economic incentives. Therefore, EPA intends to retain the position expressed in the proposed regulation that proprietary technology that cannot be purchased or is not commercially available treatment cannot be the basis for the treatment standard. The Agency will review the availability of proprietary or patented processes on a case-by-case basis.

Treatment technologies classified as proprietary are unavailable for the purposes of establishing the treatment standards but may still be used by facilities in complying with treatment standards expressed as performance levels.

c. *Substantial treatment.* In order to be considered "available", a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land, and that the Agency does not require a treatment method that provides little or no environmental benefit. As part of the proposed regulation, the Agency stated that treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern in the TCLP extract or if the technology can achieve the prescribed screening concentration levels. Although the screening level approach has been eliminated in today's rule, EPA still intends to evaluate whether or not a treatment technology provides substantial treatment on a case-by-case basis when the treatment technology does not achieve nondetectable constituent concentrations in the residual. This approach is necessary due to the difficulty in establishing a meaningful guideline that can be applied broadly to the many wastes and technologies that will be considered. As stated in the proposed regulation, EPA will consider the following factors in an effort to evaluate whether or not a technology is substantial on a case-by-case basis:

(i) Number and types of constituents treated;

(ii) Performance (concentration of the constituents in the treatment residuals); and

(iii) Percent of constituents removed.

Several commenters objected to this approach. These commenters believed that EPA should have a standard by which to judge whether a technology is simply "treatment for treatment's sake." Although EPA is sympathetic to this concern, no workable and equitable set of standards were provided. The Agency believes that there will be ample opportunity for comment on EPA's

individual EDAT decisions as they are developed. Furthermore, available EPA data show that few, if any, demonstrated technologies will not achieve a high percentage of removal, destruction, or immobilization in the wastes for which they are demonstrated. As a result, the Agency finds no alternative to the approach as proposed (omitting, of course, consideration of the no-longer used screening levels).

If none of the demonstrated treatment technologies achieve substantial treatment of a waste, the Agency cannot establish treatment standards for the constituents of concern in that waste.

4. Collection and Analysis of Performance Data

a. *Collection of performance data.* Once the demonstrated available treatment technologies have been determined for a waste treatability group, the Agency will collect data representing treatment performance and information on the design and operation of the treatment system. In developing technology-based standards for today's final rule, treatment performance is evaluated using the TCLP. The Agency, in future land disposal restrictions rulemakings, may consider using a total waste analysis as the basis for determining treatment standards.

Wherever possible, the Agency will evaluate treatment technologies using full-scale systems. If performance data from properly designed and operated full-scale treatment methods for a particular waste or waste judged to be similar are not available, EPA will use data from pilot-scale operations. Similarly, where pilot-scale data cannot be obtained, EPA will use data from bench-scale treatment operations. Whenever bench- and pilot-scale data are used, EPA may explain the use of such data in the preamble or background documents and will request comments on the use of such data. When data on treatment performance for a particular waste or similar wastes are judged by EPA to be insufficient, EPA will generate data and information through sampling and analysis regarding the operational parameters and performance of the demonstrated available treatment technologies.

The Agency realizes that in some instances all wastes represented by a particular waste code may not be included in the analysis. Therefore, the possibility exists that some unique waste matrices may not be considered in establishing the treatment standard. EPA is providing the opportunity for interested parties to petition the Agency for variances to the treatment standards based on a demonstration that the treatment standards for a particular waste cannot be attained (see Unit IV.H.). The variance process allows the applicant to present information which, if properly considered when the treatment standard was originally developed, would have required EPA to create a separate treatability subgroup for the waste (see the relevant EDAT background document for information regarding the technologies used to develop the standard).

b. *Treatment design and operation.* The Agency will not establish treatment standards using performance data that are determined not to be representative of a well-designed and operated treatment system. The effectiveness of a particular treatment technology will depend, to a significant extent, on how well the system is designed and operated. In the proposed rule, the Agency stated its intention to use only treatment data from well-designed and operated systems. Commenters criticized the Agency for not specifying the parameters on which these determinations were made. Today's rule does not represent a change from the proposed rule with regard to EPA's consideration of the design and operation of treatment in developing treatment standards. Instead, we have revised the EDAT background document to better explain EPA's rationale for data editing with regard to the design and operation of the treatment system. It is difficult for EPA to generalize on the specific parameters that will be examined because parameters that comprise a well designed and operated system will vary for each technology. EPA intends to explain the factors considered in connection with individual regulatory packages. For example, some of the critical design and operating parameters for steam stripping include the number of equilibrium stages in the column, the temperature at which the unit is designed to operate, and how well the design temperature is controlled. In evaluating performance data from a steam stripping operation, the Agency would examine the design specifications (e.g. the basis for selecting the number of stages and design temperature) for the treatment unit in order to determine the extent to which the hazardous constituents could be expected to volatilize. After the design specifications are established, the Agency would collect data (e.g., hourly readings of the column temperature) throughout the operation of the treatment process demonstrating that the unit was operating according to design specifications. If the data collected varies considerably from the design requirements, it could form the basis of a determination that the treatment was improperly operated. If the temperature data show, for example, that for significant periods of time the temperature varied considerably from the design requirements, the Agency would not use this data to determine the levels of performance achievable by EDAT.

Ideally, for all treatment data EPA will have associated design and operating data. However, because treatment performance data are limited, EPA may use treatment performance data for which there are few or no associated design and operating data. In these instances, EPA will use engineering judgement based on a comparison of constituent concentrations before and after treatment to determine whether the data reflect a well-designed and operated treatment system. The Agency will also use a statistical outlier analysis to confirm the engineering analysis. An outlier in a data set is an observation that is significantly different from the trend in the data. The measure of difference is determined by the statistical method known as the Z-score. The Z-score is calculated by dividing the difference between the data point and the average of the data set by the standard deviation. For data that are normally distributed, 95.5 percent (for two standard deviations) of the measurements will have a Z-score between −2.0 and 2.0. A data point outside this range is not considered to be representative of the population from which the data are drawn. The Agency requested comment on this analysis in its September 5, 1986 Notice of Availability (51 FR 31703). A comprehensive discussion of this statistical method can be found in many statistics texts (see, for example, *Statistical Concepts and Methods* by Bhattacharyya and Johnson, 1977, John Wiley Publications, NY). The Agency believes this approach is reasonable in view of statutory time constraints.

5. Identification of "Best" Demonstrated Available Treatment Technologies and Determination of Treatment Standards

In the proposed regulations, EPA based the calculation of the treatment standards on the mean of all data points after rejection of outliers by the specified Commenters criticized this proposed method of setting treatment standards stating that: (1) EPA did not provide for process variability; (2) the Agency did not explain how it would assess whether a treatment system was well designed and operated; and (3) the Agency did not explain how it would

determine treatment standards where more than one technology applied to a waste. In response to these comments, EPA revised its methodology for establishing treatment standards. The revised approach incorporates several statistical methods that were presented in EPA's *Notice of Availability*, September 5, 1986 (51 FR 31705).

a. *Analysis of variance.* EPA is using the statistical method known as *analysis of variance* in the determination of the level of performance that represents BDAT. This method provides a measure of the differences between data sets. If the differences are not statistically different, the data sets are said to be homogeneous.

This method may be used in two cases. The first case is where more than one technology can be used to treat a waste. In this case, the analysis of variance method would be used to determine whether BDAT would represent a level of performance achieved by only one technology or represent a level of performance achievable by more than one or all of the technologies.

If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT would be the level of performance achieved by the best technology multiplied by its variability factor.

The second case where the analysis of variance may be used is where different wastes with common constituents are treated with the same technology. The Agency could use this statistical method to determine whether separate BDAT values should be established for each waste or whether the levels of performance are homogeneous and, therefore, amenable to a single concentration level for a given constituent.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value". These critical values are available in most statistics texts (see for example, *Statistical Concepts and Methods* by Bhattacharyya and Johnson, 1977, John Wiley Publications, NY).

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test would be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data used in the determination.

(ii) The sum of the data points for each data set are computed (T).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \sum_{i=1}^{k} \frac{T_i^2}{n_i} - \frac{T^2}{N}$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T = sum of data points for all technologies

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \sum_{i=1}^{k} \sum_{j=1}^{n_i} x_{i,j}^2 - \sum_{i=1}^{k} \frac{T_i^2}{n_i}$$

where:

x_{ij} = the observations (j) for treatment technology (i)

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degrees of freedom is given by k-1. For SSW, the degrees of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

COMPUTATIONAL TABLE FOR THE F VALUE

Source	Sum of squares	Degrees of freedom	Mean square	F
Between	SSB	k-1	MSB=SSB/(k-1)	MSB/MSW
Within	SSW	N-k	MSW=SSW/(N-k)	

COMPUTATIONAL TABLE FOR THE F VALUE Continued

Source	Sum of squares	Degrees of freedom	Mean square	F
Between	SSB	k-1	MSB=SSB/(k-1)	MSB/MSW
Within	SSW	N-k	MSW=SSW/(N-k)	

b. *Process variability.* Since variability in performance principally arises from inherent mechanical limitations in maintaining control parameters at the optimum setting, calculation of the treatment standard now incorporates a process variability factor. An example of process variability would be an automatic pH control system used to maintain the proper pH range for precipitation of a toxic metal. In this system, a pH sensing device provides a signal to the controller that the pH is out of the set point (i.e., the optimum design point). The controller then changes (either pneumatically or electrically) the position of the valve that supplies the reagent(s) used to adjust pH. The Agency would consider such a system to be well-operated provided that it is properly designed, calibrated, and maintained. However, this system cannot be operated without any variation in the level of pH maintained. Control valves are not designed in such a way that they can precisely add the exact amount of reagent needed to be at the set point. Either too much or too little reagent will be added. Also, there is a lag time between the time when the sensing device detects a problem and the time that the controller adjusts the valve to the correct position. Additionally, there will be process upsets that require greater changes to the system corresponding to greater variations in performance. Another source of variability will occur during the analysis of the treatment residues. Finally, it is acknowledged that EPA approved methods will exhibit some degree of variability in test results for identical samples. All of the above variations can be expected to occur at well designed and operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as "technology based" requirements, but rather as a function of the normal variability of the treatment technology. A technology has to be identified to which the [illegible] achievable treatment [illegible] will in order to be assured [illegible] performance level [illegible] the limits of the treatment standard. The Agency will calculate a variability factor which constitutes a certain

within a waste treatability group using the statistical calculation presented in the Notice of Availability. The equation for calculating the variability factor, as shown below, is the same as has been used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act.

$$VF = \frac{C_{99}}{MEAN}$$

where:

VF = Estimate of daily maximum variability factor determined from a sample population of daily data

C_{99} = Estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = \text{Exp}(y + 2.326y)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data.

mean = average of the individual performance values.

EPA is establishing this figure as a daily maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

6. Dilution Prohibition

In the proposed rule, EPA recognized that successful implementation of the land disposal restrictions program required that dilution be prohibited as a partial or complete substitute for adequate treatment of restricted wastes. The legislative history indicates that such a prohibition "is particularly important where regulations are based on concentrations of hazardous constituents." (H.R. Rep. No. 198, Part I, 98th Cong., 1st Sess. 38 (1983)).

The commenters unanimously support a prohibition on dilution. Their comments indicate a concern with dilution after the waste is generated but before the applicable treatment standard and effective date have been determined, and after the treatment standard has been determined but before the residuals are land disposed. It should be noted that this prohibition does not affect provisions in other EPA regulations which may allow dilution for other purposes.

a. *Dilution before determination of the applicable treatment standard and effective date.* One commenter urged EPA to prohibit dilution to avoid an effective date. Today's rule does not include this provision. EPA's proposed prohibition was limited to dilution for the purpose of substituting for adequate treatment under section 3004(m). A prohibition on dilution for the purpose of avoiding an effective date is outside the scope of this proposal and, therefore, would have to be the subject of a separate proposal. However, as noted in the waste analysis section to today's rule, the applicable treatment standards are to be determined by generators in accordance with § 268.7.

b. *Dilution to meet the treatment standards.* One commenter suggested that EPA reiterate that dilution with non-aqueous agents (e.g., fly ash, sawdust, or other materials) is also prohibited. The Agency agrees and intends that the addition of any other material, either liquids or non-liquids, is prohibited as a substitute for treatment under section 3004(m).

Several commenters expressed concern that some treatment processes (e.g., equalization ponds), which require the addition of other materials to physically or chemically treat the wastes, would be prohibited. As stated in the preamble to the proposed rule (51 FR 1660), the Agency recognizes that many treatment methods require the addition of reagents. These reagents, however, produce physical or chemical changes and do not merely dilute the hazardous constituents into a larger volume of waste so as to lower the constituent concentration. In establishing BDAT, EPA considered dilution which is a normal part of the production process or a necessary part of the process to treat a waste. The legislative history indicates that this is consistent with congressional intent (see S. Rep. No. 284, 98th Cong., 1st Sess. 17 (1983)). In prohibiting dilution as a substitute for adequate treatment, the Agency does not intend to prevent the regulated community from adding materials that are necessary to facilitate proper treatment in meeting treatment standards (e.g., adding lime to neutralize or precipitate a waste prior to further treatment). In addition, EPA does not intend to disrupt or alter the normal and customary practices of properly operated treatment facilities. For example, treatment facilities could mix compatible wastes in order to treat (e.g., incinerate) at capacity levels rather than treating wastes in small batches.

c. *Dilution of residuals.* One commenter recommended that the language of the prohibition should be modified to reflect that the prohibition on dilution also applies after treatment. In particular, wastes meeting Subpart D treatment standards must not be mixed with wastes that do not meet such standards in order to achieve the treatment standard for the mixture. EPA agrees with the commenter and intends that this type of dilution after treatment or at any other time is prohibited under § 268.3. The Agency believes that the language in § 268.3 prohibiting dilution "as a substitute for adequate treatment to achieve compliance with Subpart D" is sufficiently broad enough to cover this scenario.

EPA is adopting the proposed prohibition with the following modifications. First, the prohibition extends to transporters and handlers which were inadvertently excluded from the proposed prohibition. Since the proposal cited legislative history which included the transportation and handling stages within the prohibition as the basis for § 268.3, the Agency believes that the favorable comments indicate support for such a modification which conforms more closely to congressional intent. In addition, support for the prohibition was very broad and did not indicate any intent to treat transporters or handlers differently. EPA believes that this modification is reasonable and necessary in order to implement this provision.

Second, the prohibition extends only to the act of dilution itself. The Agency's proposed language would have prohibited "attempted dilution" but not dilution itself. This is clearly not what was intended by EPA. Overall, the commenters who supported the prohibition expressed concern with the act of dilution.

B. Comparative Risk Assessment and Available Treatment Alternatives

1. Proposed Use of Comparative Risk Assessment

EPA proposed the use of comparative risk analyses as part of its evaluation of treatment technologies in conjunction with establishing treatment standards. As described in the proposed rule, a number of criteria affect the determination of "available" treatment technologies for the purpose of setting treatment standards. Among the criteria considered is whether application of a treatment technology (including land disposal of treatment residuals) poses greater risks to human health and the environment than those posed by direct land disposal of the waste. Comparative risk analyses were proposed to prevent situations in which regulations restricting hazardous wastes from land disposal would encourage treatment technologies posing greater risks to

human health and the environment than risks posed by direct land disposal.

2. Agency Response to Comments

The majority of the comments supported the concept of conducting comparative risk assessments. However, several comments strongly opposed this concept. Both sets of commenters had specific criticisms and suggestions.

The commenters who objected to the use of comparative risk assessment stated that EPA does not have the authority under RCRA to conduct such analyses. The Agency disagrees with the commenters. The Agency interprets the provisions in section 3004(m) to direct EPA to set treatment standards which minimize threats to the "environment" as applying to all media (i.e., air, land, and water). Because there is no language indicating that this term does not include all media, accordingly, EPA does not believe that the section 3004(m) standard can be read to preclude comparative risk analyses. Therefore, EPA believes that Congress did not intend that risks to human health and the environment be increased as a result of implementation of the land disposal prohibitions. The national policy provision in section 1003 supports this approach in stating that hazardous wastes should be treated in order to minimize the present and future threat to human health and the environment. Moreover, this provision, as well as the legislative history (e.g., H.R. Rep. No. 198, Part I, 98th Cong., 1st Sess. 32 (1983)), does not focus merely on the risks of land disposal, but instead demonstrates a concern for the toxicity and mobility of hazardous wastes in all media. EPA believes that it is desirable, reasonable, and consistent with the intent of Congress to include comparative risk assessments in the determination of available technologies for purposes of setting technology-based treatment standards.

One commenter felt that the use of comparative risk assessments are reasonable, but questioned whether it is appropriate to use worst case scenarios in assessing the relative risks. The suggested approach is to utilize a "middle-of-the-road" scenario in evaluating risks at both land disposal and alternative treatment facilities. In response to the comment, the Agency is not using best or worst case scenarios. Instead, EPA has chosen to analyze several land disposal and treatment facilities which represent high, medium, and low exposure sites. Practical, low risk, and representative waste streams were modeled through each of these facilities in order to capture the entire range of waste site scenarios.

Several commenters were critical of EPA's proposal to evaluate population risk in assessing comparative risks. The Agency believes it useful to consider population in comparative risk analyses because it can identify sources of increased risks where a comparison with the Maximum Exposed Individual (MEI) risks may not do so. For example, the MEI risks of incinerating certain wastes may be low in comparison to the MEI risks of land disposal. This could be due to few people living in the immediate path of an incinerator plume. The Agency does, however, want to consider cases where there may be a larger population affected by incinerator emissions.

One commenter was concerned that the treatment methods for a given waste may be riskier in absolute terms than the treatment method for another waste. Their concern was that the riskier technology could be used to define the treatment standard as long as the process poses comparatively less risk than land disposal. In the context of ensuring that the land disposal restrictions do not shift higher risks to other media, the Agency maintains that comparative risk analyses are not the proper vehicle for making absolute risk determinations. The analyses are aimed at assessing whether the land disposal of a given waste or waste stream will pose relatively greater risks than alternative treatment technologies. As stated above, if the alternative treatment method is determined to be less risky than land disposal it will be used in the determination of BDAT. The Agency does, however, have the authority to impose additional controls on the technology if it later determines that the actual risks are unacceptable. Such a determination could lead to either a modification of the BDAT standard or the imposition of additional standards on treatment facilities.

3. Use of Comparative Risk Assessment in the Final Framework

Results of the comparative risk analysis will not be used to allow continued land disposal of untreated hazardous waste. As discussed in section IV of this unit, treatment technologies that are determined to pose greater risks than direct land disposal of a waste will be considered "unavailable" as a basis for establishing the treatment standard for the waste.

C. Application of Standards

1. Leaching Procedure

a. Final decision. The Agency proposed to use the Toxicity Characteristic Leaching Procedure (TCLP) to determine whether applicable treatment standards have been met. Although EPA is changing its overall approach in today's final rule (i.e., from risk-based decisions to technology-based decisions), the Agency will continue to require the use of the TCLP to determine whether a waste requires treatment or when a treated waste meets the applicable treatment standards. Today the Agency is promulgating the TCLP with improvements and modifications based on the comments received on the proposed rule, as well as applicable comments received on the Toxicity Characteristic (TC) proposed rule (51 FR 21648, June 13, 1986). The Agency is promulgating the TCLP in today's final rule specifically for evaluation of the solvent and dioxin-containing wastes. The revised TCLP is promulgated as Appendix I to Part 268.

Because the Agency is continuing to investigate other means of defining BDAT (e.g., a definition based on the concentration of hazardous constituents in the waste, at least in the case where treatment is based on destruction), EPA will make decisions regarding the applicability of the TCLP to other restricted wastes according to the final schedule for land disposal prohibitions which was promulgated on May 28, 1986. In addition, the Extraction Procedure (EP) will continue to be used in determining which nonlisted wastes are hazardous in accordance with the EP toxicity characteristic (40 CFR 261.24). The Agency expects to promulgate the TC by early 1987.

b. Response to comments. The general comments EPA received on the leaching test as it applies to its use in this rulemaking, and EPA's response to these comments are summarized below. Technical and procedural comments on the TCLP, and related issues are summarized and addressed in a background document supporting the use of the TCLP in today's final rule (Ref. 3). The background document also summarizes modifications to the TCLP based on further evaluation of the procedure.

(1) Use of the TCLP is premature. Many of the commenters argued that use of the TCLP was premature. Reasons that were given included: (i) EPA had inadequate amount of time given to evaluate the system prior to its use; (ii) current waste management practices, due to the unavailability of equipment; (iii) the leaching test would impose unnecessary burdens on treatment facilities who perform first the wastes prior to disposal; and (iv) the test had not been properly validated.

EPA does not believe that these concerns are sufficient reasons to prevent the use of the TCLP in today's regulation. In view of the statutory deadlines, EPA was aware that the time available for public review of the leaching test would be relatively short. As a result, during the course of developing and evaluating the TCLP, public presentations were held to familiarize interested parties with the test procedure, in order to facilitate their evaluation of the test.

In addition, most of the equipment needed to conduct the TCLP is the same as that used for the existing EP. The only "new" equipment is the Zero-Headspace Extractor (ZHE) and ancillary equipment (e.g., TEDLAR bags and gas-tight syringes) needed for evaluation of volatile organic compounds.

In addition to the data and information made available to the public in the January 14, 1986 proposal, information on the development and evaluation of the TCLP was provided in the toxicity characteristic proposed rule. Further supporting information on the leaching test was also provided through notices of availability of reports on July 9, 1986 (51 FR 24836) and September 18, 1986 (51 FR 33227). EPA received over 130 comments on the TCLP in response to these proposals and notices. These comments were considered in issuing today's final rule. EPA, therefore, does not agree with the commenter's claim that they have not had adequate opportunity to evaluate the method. The Agency believes that adequate data has been developed and noticed for public comment to allow generators to adequately evaluate the procedure.

Another general concern expressed by commenters related to the belief that the institution of a new test would present unreasonable delays on treatment facilities. Although there may be some delay, EPA does not believe that this would be caused by the introduction of a new testing protocol or a protocol requiring new equipment. Some form of waste analysis is required in order to implement the land disposal restrictions rule. EPA anticipates that the institution of a new protocol will not cause delays beyond those required to perform any waste characterization. The procedures used in conducting the TCLP are very similar to the existing EP. Therefore, the Agency expects that laboratories familiar with the EP protocol should have little problem conducting the TCLP.

Commenters also expressed concern that the TCLP was not ready for application because the method had not been properly tested or validated. The TCLP has been the subject of an extensive evaluation. EPA has completed both intra- and inter-laboratory (collaborative) studies of method reproducibility using a variety of wastes. Industry groups and commercial laboratories participated in EPA's TCLP collaborative evaluation. In addition, the Electric Power Research Institute (EPRI) also evaluated the TCLP in a collaborative study. Finally, six industry associations submitted data to the Agency from a collaborative study of the TCLP. (The results of these studies are detailed in the TCLP Background Document supporting today's rule (Ref. 31). Based on all these efforts, EPA believes that the test has been sufficiently evaluated.

(2) The TCLP is inappropriate for use in the land disposal restriction's rule. Approximately one third of all commenters addressing the leaching test argued that it is inappropriate for such use. Specifically, these commenters argued that the method would be inappropriate as a means to evaluate Subtitle C hazardous wastes because it was developed based on a municipal/industrial waste codisposal scenario.

They specifically pointed out that hazardous waste landfills do not contain municipal wastes and, therefore, that the leaching medium within these landfills was unlikely to contain acetate or acetic acid, common degradation products of decomposing refuse. These commenters further suggested that a water leaching medium would be more representative of a Subtitle C disposal facility.

Several commenters also disagreed with application of the TCLP because of other differences between Subtitle C and Subtitle D land disposal facilities. They asserted that Subtitle C facilities differ in design from municipal facilities in several respects, including minimization of surface and ground water intrusion and containment of accumulated fluids through the 30-year post-closure period beyond the operating life of the facility. They pointed out that well-engineered hazardous waste land disposal units provide a physical-chemical environment that is significantly different from the municipal landfill.

EPA recognizes that RCRA Subtitle C and Subtitle D facilities differ in many respects. However, commenters generally addressed only the fairly narrow example of a well engineered Subtitle C landfill that accepts treated wastes or that is dedicated to a particular waste. Subtitle C facilities include not only these types of landfills but also existing facilities which may be unlined or which may contain a variety of untreated wastes. The current regulations do not prohibit the landfilling of mildly acidic wastes, nor is it uncommon to put liquid acidic wastes in surface impoundments. Thus, a significant number of facilities may not conform to the model suggested by the commenters. In view of these differences, EPA does not believe the commenters have shown that it is unreasonable to assume that wastes in a Subtitle C environment may be subject to mildly acidic conditions. In view of these factors, and considering the time constraints imposed on the Agency's issuance of land disposal regulations, EPA believes it is justified in using the TCLP for the wastes covered by today's rule.

In this regard, it is important to note that the leaching of the organics covered by today's rule is not significantly affected by minor changes to the predominantly aqueous leaching media used in the TCLP (Ref. 34). Thus, the Agency believes it is being prudent in not introducing yet another leaching test for regulatory application.

(3) Effect of the TCLP on constituents other than solvents and dioxins. Because today's final rule addresses only solvents and dioxins, EPA is not responding to those comments dealing with inorganics at this time. EPA has received substantial comment regarding the TCLP's use of a "stronger" leaching fluid for wastes of moderate to high alkalinity, and the need for particle size reduction of all wastes, including monolithic materials. A detailed discussion is available in the TCLP background document.

(4) Potential laboratory capacity shortfall. Several commenters, anticipating that the TCLP may eventually be required as a result of both the land disposal restrictions program and the toxicity characteristic, were concerned over a potential laboratory capacity shortfall. They indicated that commercial laboratories are currently backlogged with work, and that TCLP requirements under both rules would make the situation critical.

We disagree with these commenters. Many commercial laboratories are presently performing TCLP analyses. For example, over 80 laboratories were involved in EPA's TCLP collaborative effort. In addition, EPA is aware that laboratories have been in the process of gearing up to perform TCLP analyses, primarily in anticipation that the TCLP will be required for part of both the land disposal restrictions rule and the toxicity characteristic. In addition, due to the phased approach for the restrictions rule, and the fact that the toxicity characteristic will not be

promulgated until early 1990. EPA believes that the laboratory capacity problem will not be as severe as commenters suggest. By the time the toxicity characteristic becomes effective, EPA believes that sufficient laboratory capacity should exist to conduct the required analyses. Several commenters agreed with EPA, indicating that there are (or would be) a sufficient number of laboratories that will be able to perform the TCLP.

(5) TCLP reproducibility. EPA also received substantial comments regarding the precision or reproducibility of the TCLP, most of which were critical of the method's precision. While specific comments regarding method precision are addressed in the TCLP background document, the outcome of EPA's general evaluation of these comments is presented below.

The relevant question with respect to method precision is: "Is the method sufficiently precise for its intended application?" In other words, given a particular waste, can the same conclusions derived from results of running the TCLP in one laboratory (i.e., are treatment levels exceeded) be reached in other laboratories. EPA believes that the TCLP is sufficiently precise in this application, as indicated below.

A total of three separate multi-laboratory collaborative evaluations of the precision of the TCLP were conducted (Ref. 3). One of these evaluations was sponsored by the Electric Power Research Institute (EPRI), and was limited to investigating the precision of the method for inorganic parameters and dealt specifically with utility industry wastes. This study is unique in that it attempted to determine the relative contribution to total variability due to the three major components of variability: sampling variability, analytical variability, and variability due to the TCLP itself. EPRI also conducted side by side comparisons of the EP to the TCLP. This study was similar to a study EPRI did on the EP in 1979 (Ref. 3).

EPRI's evaluation concluded in general, that the TCLP's reproducibility was equal to or greater than that of the EP (Ref. 3). More significantly, EPRI found that the most frequently encountered source of variability in the TCLP extracts was the analytical variability associated with analysis of duplicate extracts by different laboratories. EPRI, however, also indicated that the interpretation of results may depend on the statistical approach used to analyze the data. Nevertheless, it appears that regardless of how data are interpreted, analytical variability can account for a major source of variability in results.

EPA's collaborative study addressed the conventional bottle extraction (i.e., for metals, semi-volatile organics, and pesticides and herbicides) and the Zero-Headspace Extractor (ZHE) used for volatile organics. The results of this study, noticed in the September 21, 1988 Federal Register, presented the full results of the evaluation for the conventional extraction, and a summary of the results for the ZHE extraction. This report has since been finalized. The general conclusion reached in this study was that "the TCLP could be applied consistently by a diverse group of organizations."

The third collaborative effort was sponsored by six industry trade associations, and dealt with both the conventional bottle extraction and the ZHE. This study also compared the precision of the EP to the TCLP, and, like the EPRI study, concluded that the precision of the TCLP was approximately the same as, or slightly better than, that of the EP. This study further concluded, however, that the TCLP procedure was not a precise test, but attributed the major source of variability to the "lack of homogeneity of wastes and the resulting difficulty in obtaining representative samples . . ." One comment received, however (from one of the participating trade associations), concluded that the association's study seemed to be consistent with the EPA effort in that the data for metals and non-volatile organics showed adequate reproducibility, and that the "preliminary" data for volatile organics also indicated adequate reproducibility.

EPA believes that these three efforts adequately demonstrate the precision of the TCLP, and also support EPA's contention that precision over the existing EP has been improved. Specifically, these studies show that considering the variability contributed by both sampling and analytical variability, the TCLP can be applied consistently among laboratories with reasonable precision.

Nevertheless, EPA agrees with the conclusion in the industry association study that sampling variability is likely to be the most significant contribution to total variability. (EPA is also concerned, to a lesser extent, with the contribution of analytical variability.) Further, EPA believes that sampling variability may actually be more of a problem than indicated in these studies. Whereas extra efforts are usually made to collaborative studies to minimize variability due to the samples, such efforts are not always entirely successful. When sampling for waste analyses or characterizations, it is likely that sample representativeness will not receive the same close attention that it receives during collaborative efforts.

EPA believes that the best way to deal with the variability problem is to take multiple "representative" samples of waste following a well-developed sampling plan, and to subject these samples to the intended analyses. Following fairly simple and fundamental statistical concepts, the results can then be subjected to a statistical evaluation designed to determine whether applicable regulatory levels are exceeded with a certain degree of confidence (e.g., the upper limit of the 90 percent confidence interval). This approach is detailed in Chapter 9 of EPA's 3rd edition of its solid waste testing manual (Test Methods for Evaluating Solid Waste—SW-846), which is complete with several easy ways to follow example (Ref. 3).

(6) Applicability of the TCLP to multiphasic (oily) wastes. EPA has also received substantial comment on the applicability of the TCLP to oily wastes. Commenters were both concerned that the TCLP would not distinguish "liquid" oils from solid materials, resulting in little or no filtration of oil through the TCLP's glass fiber filter (GFF), and that the TCLP's GFF would treat these oils as liquids, resulting in too much oil passing through the filter. These commenters further criticized the TCLP because it treated aqueous liquids and non-aqueous (oily) liquids in an identical manner, when these commenters perceived these liquids to behave differently in the environment.

Materials which filter through the GFF are defined as liquids and are analyzed directly, whereas the "solid" portion of the waste (i.e., that portion which does not pass through the GFF) is extracted with an amount of extraction fluid equal to twenty times its weight. This differentiation is especially critical for oily wastes (which are known to pose filtration problems, especially with the EP's membrane filter), as concordance of the treatment level can depend very heavily on whether the "liquid oil" within the waste is defined as a liquid (passes through the GFF and is analyzed directly) or is defined as a solid (does not filter and is extracted with [illegible] times its weight) of extraction [illegible].

EPA agrees that this is a [illegible] and better so that it is [illegible] TCLP be capable of indicating the movement of oily materials, as these materials have been known to migrate from wastes.

Data is available which suggests that the TCLP's CFF more readily passes oily material than does the EP's membrane filter. In developing the TCLP, EPA investigated eleven wastes in its lysimeter evaluations, three of which were oily wastes (Ref. 24). During this phase of the research, it was demonstrated that oil is capable of migrating from the "solid" matrix of the waste as droplets.

While the CFF was selected mainly for operational reasons, the research also indicated that it was consistently more efficient at detecting contamination due to movement of the oil than was the EP's membrane filter. The CFF is therefore expected to provide a more reasonable differentiation between liquids and solids.

While the CFF then, is an improvement upon the EP's membrane filter, in terms of its ability to pass oils, EPA is continuing to investigate if the TCLP's filtration regime should be altered to better predict movement of the oily phase of a waste. Upon completion of these evaluations, EPA may propose modifications to the TCLP specifically for wastes containing oily or other non-aqueous liquids. In the meantime, given the CFF's ability to better indicate the movement of oil, EPA believes that the TCLP's filtration regime will be sufficiently capable of indicating whether oily wastes meet the treatment levels.

(7) Complexity of TCLP. Several commenters were also concerned that the TCLP is too complex and too dependent on the use of skilled personnel and specialized equipment like the ZHE. Many of these commenters suggested changes to the ZHE protocol. Commenters further asserted that the procedure was overly burdensome, especially for wastes containing solids and multiple liquid phases.

As indicated previously, the TCLP involves two separate procedures with differing equipment. The conventional bottle extraction conducted for "non-volatile" constituents is much simplified over the EP protocol. In fact, one of the conclusions of the EPRI collaborative TCLP study was that "the main advantage of the TCLP appears to be in the ease of use." The TCLP extraction for volatiles, involving the ZHE, is agreeably more complicated than the conventional extraction. The two protocols, however, are very similar, and EPA believes that analysts familiar with the EP method will have little problem successfully conducting the TCLP. As with any new procedure, there will be some learning involved, especially with regard to the ZHE device. Familiarization with the device should be fairly rapid, however.

EPA has also taken steps to simplify the procedure, both on our own further evaluation of the method, and in response to the comments received on the method. EPA is also considering further simplification of the ZHE protocol, as indicated in the background document. Finally, while EPA believes that the protocol can be successfully run by technicians and analysts, as with any waste characterization (including the EP), the oversight of skilled chemists is always essential.

(8) Operational difficulty of the TCLP with some waste types. EPA has received many comments addressing the operational difficulties perceived in performing the TCLP on some waste types. For example, EPA is aware that the TCLP will be more difficult to perform on wastes containing immiscible liquid phases, and on wastes which contain low percent solids (e.g., <5 percent solids). EPA is also aware that the ZHE device may be difficult to clean after extraction of a particularly contaminated waste.

To help generators in dealing with these problems in a consistent manner, EPA is in the process of preparing a guidance section for the TCLP, that will offer suggestions on the best way to deal with these problems. In addition, this guidance will offer suggested reporting forms for recording results, and will also contain helpful suggestions in dealing with minor problems. This guidance section will accompany the method when it is published in SW-846. The background document supporting the TCLP provides more detail regarding the content of the guidance section, along with responses to comments addressing technical and procedural issues (Ref. 3).

(9) Specific wastes and compounds. Many commenters also expressed their concern that application of the TCLP would be inappropriate for their specific wastes. These commenters, however were most concerned with inorganic constituents and the effect of the acetic acid (used in the TCLP) on these constituents. These commenters asserted that their wastes were not managed in municipal landfills (which the acetic acid is designed to simulate) and thus, that the use of acetic acid would be inappropriate. As mentioned earlier, since today's rule applies only to solvents and dioxins, and since the TCLP is only used in the rule as a monitoring technique, EPA is not responding to these comments at this time.

Similar comments were received which assert that reproducibility testing performed on the TCLP should have been done with "their wastes." EPA would like to reemphasize that there were two suitable combinations of the TCLP (Ref. 3). Nonetheless, EPA believes that it would be unnecessary to conduct precision studies on all wastes that may be subject to the TCLP. This would be a waste of resources. Rather, in precision studies, it is more important to test a range of wastes, in terms of physical and chemical characteristics. Between all the investigations conducted on the TCLP, a wide variety of wastes have been tested, including those that would sufficiently challenge the procedure, such as oily (multi-phasic) wastes. This is important, as many of these commenters were specifically referring to oily wastes. EPA believes that the TCLP has been sufficiently tested on a variety of wastes.

Other commenters were concerned that the TCLP would be inefficient at extracting chlorinated (volatile) compounds, as they observed that during the research EPA conducted to develop the TCLP, chlorinated compounds were extracted in the laboratory procedure at levels significantly less than the levels expected (Ref. 26). EPA acknowledged the poor extraction of volatile compounds in general during this research. These results led EPA to the conclusion that volatiles were being lost to the headspace within the conventional (bottle) extraction and as a result of the air pressure filtration. Consequently, the Agency determined that a device which precluded headspace and enabled the use of piston pressure for liquid/solid separation was necessary, and the Zero-Headspace Extractor was developed to minimize the loss of volatiles.

2. Testing and Recordkeeping

Under the framework being finalized today, determination of whether a hazardous waste treatment residue requires further treatment prior to land disposal generally depends on whether the concentration of constituents in an extract from the waste (using the TCLP) exceeds the applicable treatment standards. Because this determination is critical to the scheme, EPA is imposing certain waste testing/analysis requirements.

In the proposed rule, the Agency solicited comments on questions of who should bear responsibility for testing restricted wastes and certifying that the wastes meet the applicable treatment standards. The comments were equally divided on these issues. Some commenters believed that the generator

should be responsible for testing, certification, and recordkeeping. Others agreed with the proposed approach requiring the disposal facility to certify that the wastes meet the treatment standards.

Because the approach promulgated today does not cap RMAT with screening levels, more wastes will require treatment to meet the specified treatment standards. The Agency believes that the shift towards treatment of restricted wastes will place an increased responsibility on treatment facilities to ensure that treated wastes meet the specified treatment standard. Although the provisions in section 3004(m)(2) place the ultimate responsibility on the disposal facility to ensure that only wastes which meet the treatment standards are land disposed, the Agency believes that testing and certification by the treatment facility is critical to implementation of the regulatory program. Thus, the Agency is requiring that the treatment facility provide waste analysis data showing that a waste meets the applicable treatment standard to ensure that only wastes which meet the standards will be transported to disposal facilities. In cases where the generator is shipping a waste directly to the disposal facility (i.e., the waste naturally meets the treatment standard, or has been treated on-site), the generator is responsible for testing and recordkeeping. However, the disposal facility has the ultimate responsibility to ensure that all restricted wastes meet applicable treatment standards before being land disposed. The disposer also is required to maintain all records.

The rules promulgated today are not intended to shift responsibility for improper disposal to the generator. Of course, nothing in these rules prevents the generator and disposer from entering into a private agreement to allocate liability in the event that prohibited wastes are land disposed.

a. *Generator requirements.* For today's final rule, the generator of a restricted waste must notify the treatment facility in writing of the appropriate treatment standard for the waste. The generator may make this determination based on waste analysis data, knowledge of the waste, or both. Where this determination is based solely on the generator's knowledge of the waste, the Agency is requiring that the generator maintain in the facility operating record all supporting data used to make this certification. A waste analysis must be conducted if there is reason to believe that the composition of the waste has changed or if the treatment process has changed. The notification must specify the EPA Hazardous Waste Number, the applicable treatment standard, the manifest number associated with the shipment of waste, and the waste analysis data (if available). The notice must be placed in the operating record of the treatment facility along with a copy of the manifest. Generators who are also treatment, storage, and disposal facilities must place the same information in the operating record, although a formal notification and manifest is not required.

According to the provisions in § 268.7, a generator who determines that a waste can be land disposed without treatment must submit to the disposal facility a certification statement and a notice which contains the EPA Hazardous Waste Number, the manifest number, the applicable treatment standard(s), and the waste analysis data (if available) or cross references to relevant data submitted at an earlier time. The certification is required only in cases where the generator is representing that the waste meets the treatment standard. Generators who dispose on-site must put the same information in the operating record (except for the manifest number).

b. *Treatment facility requirements.* The treatment facility is responsible for treating the restricted waste to the level specified in the applicable treatment standard. An off-site treatment facility must obtain the required data from the generator prior to treatment and place that data in the operating record.

Treatment residues must be tested prior to land disposal according to the requirements of the treatment facility's waste analysis plan to determine if treatment has achieved the required levels.

For instance, if the waste analysis plan calls for testing of each batch of waste from an incineration process, these data must be submitted to the land disposal facility along with the certification statement. If a particular generator's waste does not vary and is consistently treated by the same treatment facility using the same treatment process, the treatment facility's waste analysis plan may require less frequent testing of the treatment residue. It should be emphasized that a waste analysis must be conducted if there is any reason to believe that the composition of the waste has changed or if the treatment process has changed.

Each waste shipment must be accompanied by a certification statement including cross references to any relevant data submitted at an earlier time, and a notice which lacked the EPA Hazardous Waste Number, the manifest number, the applicable treatment standard(s), and waste analysis data (if available). The disposal facility must place the certification notice and accompanying data in the operating record. A treatment facility that disposes on-site must put the same information in the operating record (except for the manifest number).

c. *Land disposal facility requirements.* The disposal facility, which is ultimately responsible for verifying that only wastes meeting the treatment standards are land disposed, must maintain all documentation that the waste has been treated in accordance with the standards. If generation, treatment, and disposal all occur at the same site, all testing records must be placed in the operating record. The Agency believes that this approach will produce the desired result—an assurance that wastes placed in land disposal units have met the applicable treatment standards.

The testing and recordkeeping requirements promulgated in today's rule do not relieve the disposer of his responsibility under 40 CFR 264.13 to designate a facility on the specified which is permitted to accept the waste for off-site management.

d. *Implementation of final rule.* To implement the additional waste testing/analysis standards, the Agency has included a reference in the requirements of 40 CFR Part 268 to the general waste analysis requirements of 40 CFR 264.13 (a)(1) and (b)(3) for permitted facilities, and in 40 CFR 265.13 (a)(1) and (b)(3) for interim status facilities. Consistent with the current approach to waste analysis requirements in Parts 264 and 265, the Agency has added these specific waste analysis requirements to today's final rule that must be incorporated into the general waste analysis as a separate section in Part 268. The Agency has also revised the operating record requirements in 40 CFR 264.73 and 40 CFR 265.73 to indicate that those analyses conducted pursuant to such requirements must be recorded and maintained in the land disposal facility's operating record.

e. *Waste analysis.* Wastes must be tested in accordance with the facility's waste analysis plan, unless land disposal standards are supplied with the waste, requiring that the TCLP be used to determine whether the waste meets the treatment standard (see Part 268). Guidance on methods for waste sampling and analysis is provided

in *Test Methods for Evaluating Solid Wastes*, 2nd Edition, EPA Document SW-846, 1982, as amended. In addition, guidance on the preparation of waste analysis plans is provided in *Waste Analysis Plans, A Guidance Manual*, September 1984. A revised edition of this waste analysis plan (WAP) guidance is forthcoming.

The current WAP guidance describes four basic components of the waste analysis plan. It discusses how the owner or operator of a treatment, storage, or disposal facility should describe:

(1) Specific wastes that will be managed;

(2) Waste-associated properties that are of concern in ensuring safe and effective management;

(3) Specific waste parameters that must be quantified before waste is accepted for treatment, storage and/or disposal;

(4) Methods and frequency of sampling and analysis required to obtain the data on waste characterization and the attendant quality control/quality assurance procedures.

For the purposes of compliance with the land disposal restrictions rule, a waste analysis plan for an off-site disposal facility must address the procedures for screening incoming shipments of waste to ensure that wastes received conform to the certification made by the generator or treatment facility. That is, the waste analysis plan must address the procedures necessary for determining whether an extract of the waste or treated waste meets the treatment standards.

These testing requirements for treatment residuals apply to generators who treat, store, and dispose onsite. Less frequent testing may be appropriate when there are fewer and less variable waste streams at combined facilities, but waste must be tested if the composition or treatment method changes. In developing these waste analysis plans, the Agency recommends that the land disposal facilities follow the general guidelines in the WAP guidance.

For each waste stream, the waste constituents regulated under the land disposal restrictions rule must be comprehensively analyzed. Although the frequency of testing will depend to some extent upon the variability of the waste stream, the Agency recommends that a comprehensive analysis of each waste stream be performed at least annually by the generator or treater. When the comprehensive analysis is performed, however, it must contain data on all the applicable constituents in Subpart D so that the owner/operator will be able to determine whether the waste meets all applicable treatment standards. If the owner/operator of the land disposal facility does not receive this information in writing from the generator or treatment facility, he must perform the analysis to determine whether the waste meets the treatment standards according to the waste analysis plan. The test results of this comprehensive analysis must be placed in the land disposal facility's operating record.

The Agency believes that this approach is consistent with existing industry practice. Off-site land disposal facilities already require extensive waste analysis information from the generator or treatment facility before they initially accept hazardous wastes for disposal.

Finally, by requiring that all waste analyses be placed in the operating record, the owners/operators will be able to demonstrate compliance with the waste analysis requirements in § 268.7.

Where the treatment standard for the applicable waste is a specified method of treatment, the last facility to treat the waste must send a certification to the land disposal facility that the waste has been treated using the specified technology. The certification, which is to be placed in the land disposal facility's operating record, must include the statement required under § 268.7(b)(1).

3. RCRA Facilities Operating Under a Permit or Interim Status

These regulations, when they become effective, will place an increased demand on existing hazardous waste treatment facilities. EPA believes that it is important for these facilities to have the regulatory flexibility to add restricted wastes to their treatment inventories quickly. This flexibility is necessary to permit the prompt treatment of restricted wastes.

Treatment facilities operating under interim status are generally provided with the flexibility to handle new wastes by 40 CFR 270.72, which specifies permissible changes during interim status. Under this section, interim status facilities may add new wastes, increase design capacity (if they can demonstrate a lack of available capacity), or make changes in treatment, storage, or disposal processes (if the changes are necessary to comply with Federal regulations or State or local laws). 40 CFR 270.72(a), however, limits these changes to alterations and expansions of a facility that do not exceed 50 percent of the capital cost of a comparable new facility. In cases where changes exceed 50 percent, the changes cannot be made until the facility receives a RCRA permit.

In the preamble to the proposed rule, the Agency requested comments on whether an amendment to 40 CFR 270.72 is necessary to provide interim status facilities the flexibility to manage restricted wastes. EPA received few comments recommending such a change, however, the commenters did not provide data indicating that this provision would prevent modifications needed in order to comply with today's rule. The Agency is reviewing this issue and will modify 40 CFR 270.72, if needed, by promulgating a rule at a later date. However, at this time, we believe that 40 CFR 270.72 allows sufficient flexibility for interim status facilities to readily manage restricted wastes.

Treatment facilities operating under a permit have significantly less flexibility to make changes than interim status treatment facilities. Under current regulations, these facilities may add new wastes or change treatment, storage, or disposal processes, usually through major permit modifications. Major permit modifications, which are substantially the same as permit issuance procedures, require a draft permit, public notice and comment, and opportunity for a public hearing. In many cases, these procedures can be time-consuming and may discourage facilities from changing permit conditions to treat restricted wastes, thereby limiting available treatment capacity.

To provide greater flexibility to permitted facilities, the Agency proposed to allow treatment facilities to manage restricted wastes not listed in their permit after a minor permit modification (51 FR 1602). The EPA received several comments on this issue. In general, industry supported the increased flexibility provided in the proposed rule. Environmentalists, however, argued that permit modifications which permit management of new wastes should not be granted without the opportunity for at least abbreviated public notice and comment. They stated, however, that certain restrictions should be placed on new wastes that could be added to a permit through minor modification procedures.

After reviewing these comments, the EPA has decided to add a new section [40 CFR 270.42(j)] to allow permit holders greater flexibility in managing restricted wastes. Under this provision, owners and operators of treatment facilities may manage restricted wastes not listed in their permit after [illegible] Federal or State approval of a minor permit modification request. However,

in response to public comments and to ensure that changes made under this provision are in fact minor, the EPA has restricted the scope of 40 CFR 270.42(c) in several important respects.

First, new waste must be treated in accordance with the treatment standards issued under Subpart D of Part 268. This will ensure that the treatment is appropriate for the restricted waste. Second, as suggested by the commenters, minor permit modifications are not allowed under this provision if treatment of the new waste will present substantially different risks from the risks associated with wastes listed in the permit. For example, a facility not already permitted to handle acutely hazardous or reactive wastes would not be allowed to treat such wastes under this provision. Finally, under this provision, treatment of the new waste cannot involve any permit changes other than the addition of waste codes and administrative or technical changes necessary to handle the waste, such as changes in the waste analysis plan. Changes in treatment processes or the addition of new treatment processes will continue to require a major permit modification.

This amendment to the minor modification requirements should provide flexibility to permitted facilities treating restricted wastes. It should be emphasized, that the modifications allowed under this provision are significantly limited and they apply only to restricted wastes as described above. The purpose of the amendment is to allow the prompt treatment of restricted wastes in accordance with the land disposal restrictions standards and to increase available treatment capacity. Without these changes, the EPA believes that the ability of permitted facilities to treat restricted wastes promptly will be significantly reduced.

Because of the conditions limiting the applicability of this provision, any permit modifications made under it will be minor. For this reason the EPA does not believe that public notice and comment procedures are necessary, just as they are not required for other minor permit modifications. Such procedure would eliminate the flexibility provided by the minor modification procedures and could complicate or delay treatment of restricted wastes.

The EPA acknowledges that 40 CFR 270.42(c) only partially addresses the difficulties that will be faced by permitted facilities seeking to treat restricted wastes. In particular, it does not allow the modification of existing treatment processes or the addition of new treatment processes to handle restricted wastes. The Agency believes that such changes raise more complicated issues than does the addition of waste codes. However, the Agency is exploring this issue as part of an overall review of the minor permit modification regulations. The EPA is now conducting regulatory negotiations on minor modifications, announced on July 10, 1986 in the Federal Register, (51 FR 25172), and anticipates issuing a proposed rule revising this regulation in 1987.

D. Determination of Alternative Capacity And Ban Effective Dates

RCRA section 3004(h)(2) states that the Agency may grant a nationwide variance of up to 2 years from the statutory effective date if adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment is not available. EPA will consider several factors when calculating alternative capacity and when determining the length of any variance from the effective dates of the restrictions. These factors are discussed below.

1. Effective Dates

EPA will develop estimates of treatment capacity needed versus capacity available to determine if current capacity for alternative treatment, recovery, and disposal technologies is adequate to manage restricted wastes. These estimates will be developed from currently available data on capacity requirements and technology capacity.

If capacity is available, the prohibition will go into effect immediately. If capacity is not available, the Administrator may set an alternative effective date on the basis of the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment becomes available. Establishment of the effective date will not be affected by the processing of petitions under section 3004 (d), (e), and (g). The relationship between the variance to the effective date and the case-by-case extension under section 3004(h)(3) is discussed later in this unit.

2. Regional and National Capacity

The Agency will determine both the quantity of restricted waste generated and the capacity of alternative treatment, recovery, and disposal technologies on a nationwide basis. If there is a significant shortfall in capacity to treat all of the restricted waste, the Agency will extend the effective date of the prohibitions. If national capacity is only slightly lacking, EPA may grant case-by-case effective date extensions while allowing the nationwide prohibition to go into effect immediately. If national capacity is sufficient, the prohibition will become effective immediately, even if, for instance, the only capacity for a waste generated in California is located in Ohio.

Many commenters urged EPA to make regional instead of national estimates of required and available capacities. However, the national approach is consistent with congressional intent. The Senate legislative history provides that "the available capacity determination is to be done on a national basis" (S. Rep. No. 284, 99th Cong., 1st Sess. 19 (1985)). That is, the effective date of the prohibitions for a given waste should not vary from region to region because one region has sufficient alternative capacity and another does not. If land disposal were prohibited in only a portion of the country, it is possible that waste generated in one region would be transported outside of that region and land disposed elsewhere. As the Senate report points out, those regions of the country in which land disposal is allowed might become the "dumping ground" for wastes generated in regions where land disposal is banned (S. Rep. No. 284, 99th Cong., 1st Sess. 19 (1985)).

3. The Nationwide Variance and the Case-By-Case Extension

In cases where EPA has not granted a nationwide variance, it is not precluded from granting case-by-case effective date extensions. It may be more desirable to grant case-by-case extensions to specific applicants who lack alternative capacity than to allow everyone, even those for whom alternatives are available, to continue to land dispose restricted wastes. This approach is consistent with congressional intent to prohibit land disposal at the earliest possible time.

EPA also may grant variances of less than 2 years, even though not all facilities under construction will be completed. Wastes requiring the capacity from uncompleted facilities also could be handled by case-by-case extensions, without allowing continued land disposal nationwide.

If the Agency promulgates an immediate effective date, it will accept applications for case-by-case extensions before the final rule is promulgated. Such extensions will be granted when the final rule is published in the Federal Register. EPA will consider justification provided by case-by-case extension applicants as well as information submitted during the public comment

period in determining whether to grant a nationwide variance in the final rule.

The Agency will consider the possibility of granting a nationwide variance after the prohibition becomes effective if available data (including data from case-by-case extension applications) indicate that nationwide capacity is inadequate. EPA also will consider whether it should shorten the period of a nationwide variance based on new information showing that nationwide capacity is adequate. However, after EPA promulgates a nationwide effective date, this date is not likely to be amended because it is unlikely that Federal rulemaking activities could be completed in significantly less than 2 years.

4. Determination of Capacity Requirements by Waste Treatability Group

In general, EPA will develop treatment standards for waste groups derived from the physical/chemical characteristics of the restricted wastes. EPA also will determine the quantities of wastes that require specific treatment of recovery methods by waste treatability group. These treatability groups will enable EPA to compare required capacity (capacity demand) with available capacity (capacity supply). In addition, EPA will consider other increases in capacity demand generated by emergency and remedial responses, and to the extent possible, the impact of other final rulemakings that affect availability of or demand for treatment capacity. As necessary, EPA will set different effective dates for different waste groups or subdivisions of waste groups.

In some cases, the same technology will apply to several waste groups that must be regulated in the same or in sequential rulemakings. However, total capacity may not be sufficient to treat all of these groups of wastes. In such cases, the Agency will subdivide the waste groups in order to use all available treatment capacity on specific subgroups so as to implement the restrictions as quickly as possible. Under this approach, as much waste as possible would be prohibited immediately.

5. Definition of Available Capacity

In estimating available capacity, the Agency will consider current on-line facilities, which include permitted facilities and facilities operating under RCRA interim status, and planned facilities and capacity extensions that will be on-line by the effective date of a land disposal prohibition.

Current on-line facilities consist of off-site and on-site facilities, including both stationary and mobile facilities which have been approved by Federal, State, and local agencies to operate and accept certain wastes. Facilities operating under RCRA interim status meet these criteria, and therefore will be included in the capacity determination. Some commenters disagreed with this approach, suggesting that interim status facilities may not receive final permits. However, unless EPA receives notification of intent to close an interim status facility, the Agency will assume continued operation of a facility throughout the permitting process and continued available capacity on the effective date of a prohibition.

Planned facilities are facilities that are under development or under construction. Planned facilities include new off-site and on-site treatment, recovery, and disposal facilities, as well as planned capacity additions or expansions to existing facilities.

Some commenters questioned the validity of including planned facilities in estimates of available capacity. They stated that the Agency could not make accurate predictions about such capacity. The Agency will consider planned capacity only if it is reasonably certain that the facility will be on-line by the effective date of a prohibition. To predict whether a facility will be on-line in time, EPA will consider the time needed to complete the facility, including reasonable estimates of time needed to site the facility, obtain permits, construct, and test. In most cases, EPA will consider the capacity of planned facilities only when all permits required for construction have been approved and sufficient additional evidence of intent to build are available (such as contracts issued for construction). Planned capacity was not included in the estimates of available capacity for solvents and dioxins.

6. Definition of Alternative Treatment Capacity

The Agency believes that treatment technologies that will achieve the standards established under section 3004(m) can be considered available treatment capacity under the provision in section 3004(h)(2).

Section 3004(m) directs EPA to establish standards based on treatment that will minimize long- and short-term threats to human health and the environment. The Agency believes that this provision generally will be satisfied by technologies classified as BDAT. In most cases, treatment levels or methods based on BDAT are expected to fully protect human health and the environment. Accordingly, technologies that form the basis for such standards are candidates for the capacity evaluation under section 3004(h) (2) and (3).

In those cases where standards based on BDAT are not deemed to be fully protective of human health and the environment, the Agency may, as a matter of policy, exercise its discretionary authority not to extend the effective date of a prohibition in cases where the existing capacity of fully protective technologies, coupled with the existing capacity of treatment technologies that meet BDAT, is adequate to address the restricted wastes.

The Agency believes that this approach is consistent with Congressional intent. The section 3004(h) variance is intended to encourage the development of protective alternative treatment, recovery, and disposal capacity. (S. Rep. No. 284, 98th Cong., 1st Sess. 18 (1983); H.R. Rep. No. 198, 98th Cong., 1st Sess. 37 (1983)). However, in cases where BDAT is not fully protective, the regulated community will have little incentive to develop protective alternative treatment methods during the variance period in light of the fact that, at the end of any such variance, hazardous waste may be land disposed if the wastes comply with less protective technology-based standards. In such a case, the effect of the variance would simply be to delay compliance with BDAT, and not, as Congress intended, to provide limited additional time for the development of protective alternative technologies.

Treatment methods that are not identified as the basis for BDAT for the waste group being considered also will be included in the capacity determination, as long as EPA judges that the method can achieve the treatment standards for the wastes in question and will pose less risk than land disposal. EPA believes that this approach is consistent with the congressional intent to ban hazardous wastes from land disposal at the earliest possible date, as discussed earlier.

7. Definition of Alternative Recovery and Disposal Capacity

In assessing available capacity, the Agency will consider the capacity of all on-line recovery and disposal facilities that are protective of human health and the environment. These include disposal facilities for which EPA has granted a site-specific petition demonstrating no migration of hazardous constituents for as long as the wastes remain hazardous (but not facilities where a petition is

pending, but not granted). Planned facilities, including expansion of existing facilities, also will be considered where appropriate.

However, alternative land disposal methods (e.g., deep well injection) will not be considered as available capacity for a restricted waste unless EPA has determined that such methods of disposal are fully protective of human health and the environment. Therefore, EPA will not consider underground injection to be available disposal capacity, until the Agency has determined whether the injection of such wastes is fully protective of human health and the environment. Although EPA is not including underground injection into deep wells in its capacity determinations this does not preclude its use for disposal of these wastes before August 1988.

b. Estimation of Capacity

EPA will estimate the annual unused or surplus capacity of alternative treatment, recovery, and disposal facilities that is available nationwide to manage wastes restricted from land disposal. The Agency will compare nationwide capacity (capacity supply) to the quantities of restricted waste generated annually nationwide (capacity demand).

Surplus capacity will be expressed as throughput capacity. Because data on annual throughput may be difficult to obtain in some instances, EPA may use other available information to calculate capacity, such as the difference between a practical maximum design capacity and capacity currently utilized. As discussed earlier, when information is available, EPA will consider both current surplus capacity and planned capacity when calculating surplus capacity. However, today's final rule considers only current surplus capacity because data on planned capacity were not available.

Current surplus capacity is defined as present capacity which is not being used. Surplus capacity can be any of the following:

(i) Commercially available.

(ii) Private capacity which can be used to process additional waste produced by the facility.

(iii) Private capacity, where the owner is willing and able to accept wastes from other generators, i.e., to provide commercial services.

EPA assumes that commercial facilities are willing to accept wastes that they are capable of treating. In cases where commercial capacity is inadequate, EPA will consider the likelihood that available private capacity not needed to process additional waste produced by the facility will be converted to commercial capacity. However, due to limited information on the availability of private capacity for solvents and dioxins, EPA has considered only commercial capacity for this rulemaking.

In today's final rule, capacity estimates are based on currently available information, including the "National Survey of Hazardous Waste Generators and Treatment facilities regulated under RCRA in 1981" (GSW RIA Mail Survey, RCRA 3001-3 docket for the proposal), a 1985 EPA study on incinerator and cement kiln capacity (Ref. 13), a 1984 survey of the National Association of Solvent Recyclers (Ref. 6), and the 1986 EPA National Screening Survey of Hazardous Waste Facilities (Ref. 21). The Agency is developing a new survey of commercial and private treatment facilities which will address the concerns of commenters who pointed out the need for an updated data base. EPA intends to use data from this survey in making capacity determinations for future rulemakings.

8. Applicability of the Minimum Technological Requirements

Section 3004(h)(4) provides that during the period of a national variance under (h)(3) or a case-by-case extension under (h)(4), the waste may be disposed in a landfill or surface impoundment only if the facility is in compliance with section 3004(o).

a. Exemption for Treatment in Surface Impoundments

The Agency proposed to exempt treatment surface impoundments from the land disposal restrictions under the conditions specified in section 3004. This exemption is authorized by sections 3004(h)(1)(A) and (2). EPA received few comments on the proposed interpretation of sections 3004(h)(1)(A) and (2). Most commenters criticized EPA's general approach as being too restrictive, though some commenters viewed it as too lenient. Some commenters suggested that the Agency not allow treatment of restricted wastes in surface impoundments. After careful review and consideration of the comments, EPA still believes that its proposed approach is the most defensible and logical reading of the statutory language and is consistent with congressional intent. Therefore, the Agency is promulgating exemption for treatment in surface impoundments essentially as proposed.

Under today's final rule, a waste that otherwise would be prohibited from one or more methods of land disposal may be treated in a surface impoundment that meets certain technological requirements as long as treatment residuals that do not meet the applicable treatment standard are removed within 1 year of the entry of the waste into the impoundment.

The provision applies only to restricted wastes and not to wastes that meet the treatment standards established under section 3004(m), or that have been exempted from the effective date of the prohibition by a case-by-case extension or have been exempted through the petition process. Such wastes are not considered "prohibited" wastes and, accordingly, may be given additional treatment in a surface impoundment without complying with the restrictions imposed by section 3004(h)(1)(A). This provision also applies to both permitted and interim status surface impoundments used for the treatment of hazardous wastes. For the purpose of this rulemaking, EPA considers the term "surface impoundment" to include both single units and series of surface impoundments. The Agency believes that Congress did not intend to preclude the use of a series of impoundments.

1. Sampling and Removal of Treatment Residuals

Within 1 year after a restricted waste is placed in an impoundment, representative samples of the treatment residuals must be tested to determine whether they meet the applicable treatment standards. Sampling techniques are detailed in the *Waste Analysis Plans, A Guidance Manual*, September 1984 (ref. 2). The sampling plan must be designed such that the sludge and supernatant (liquid portion) are tested separately, rather than mixed to form a homogeneous sample. If the treatment residuals meet the applicable treatment standard, they remain subject to regulation under Subtitle C of RCRA but are no longer restricted wastes and may remain in the surface impoundment for disposal. Treatment residuals that exceed the treatment standards must be removed at least annually from the time the waste is first placed in the impoundment. These residuals may not be placed in any other surface impoundment for subsequent management.

Treatment impoundments do not necessarily have to be drained in order to remove treatment residuals (See Vol. 130, *Congressional Record*, (daily ed. October 6, 1986)). In the case where the treatment residual is a liquid, that residual may be removed by pumping. If the volume flowing annually through an impoundment (or series of impoundments) is greater than the

volume of the impoundment, this flow-through constitutes removal of the supernatant for purposes of this requirement. However, as stated earlier, any treatment residual that exceeds the applicable treatment standards and, therefore, must be removed annually from the impoundment or series of impoundments, may not be placed in any other surface impoundment for subsequent management.

The two general methods available for removing residuals with a lower water content, such as sludges and solids, are excavation and dredging. The technique used depends upon such variables as surface impoundment design characteristics (e.g., shape, surface area, depth, presence of liner, type of liner), waste characteristics and type, and accessibility of the impoundment.

One commenter argued that the annual removal requirements does not address the potential for damage to the liner. The Agency recognizes that there is a potential for liner damage during the removal process. However, the annual removal requirement is a statutory standard under section 3005(j)(11)(B). The Agency may issue guidance at a later date regarding removal requirements such as testing for liner damage and prohibiting certain types of removal methods.

2. Applicability of Minimum Technological Requirements

Under today's final rule, an owner/operator operating an impoundment under the treatment surface impoundment exemption must certify to the Administrator that the impoundment meets the liner, leachate collection system, and ground water monitoring requirements imposed by section 3004(o)(1), unless the impoundment qualifies for certain exemptions.[9] A surface impoundment is exempted from liner and leachate collection system requirements if the impoundment has at least one liner that is not leaking, is located more than one-quarter mile from an underground source of drinking water, and is in compliance with certain ground water monitoring requirements in section 3005(j)(2), or if it is demonstrated that there will be no migration of any hazardous constituent to ground water or surface water at any future time according to section 3005(j)(4). (See "Interim Status Surface Impoundments Retrofitting Variances Guidance Document," EPA/530-SW-86-017, July 18, 1986, for information concerning the requirements specified in RCRA sections 3005(j)(2) and (j)(4).) An owner or operator of an existing surface impoundment must apply to the Administrator prior to November 8, 1988, to be considered for waivers of the minimum technological requirements.

Several commenters suggested that EPA also should allow an owner/operator to treat restricted wastes in a surface impoundment if they are exempt from the minimum technological requirements under sections 3005(j)(2) or (13). (Paragraph (j)(3) pertains to certain wastewater treatment units; paragraph (j)(13) pertains to certain impoundments subject to corrective action requirements.) However, in specifying the requirements in section 3005(j)(11)(A) for surface impoundments that are used to treat restricted wastes, Congress specifically included only the section 3005(j)(2) and (4) exemptions to the minimum technological requirements. Therefore, only these two exemptions are included in the final rule. Accordingly, an impoundment that was granted an exemption from the minimum technological requirements under sections 3005(j)(3) or (13), nonetheless, would be prohibited from treating restricted wastes.

F. Case-By-Case Extensions

According to section 3004(h)(3), in cases where adequate alternative treatment, recovery, or disposal capacity cannot reasonably be made available by the effective date, any person who generates or manages a restricted hazardous waste may submit an application to the Administrator for an extension of the effective date if such alternative capacity can be provided at a later date. Pursuant to this provision, the Agency proposed to allow a case-by-case extension of the effective date if the applicant can demonstrate that he has entered into a binding contract to construct or otherwise provide such alternative treatment, recovery or disposal capacity. The applicant must also demonstrate that, due to circumstances beyond his control, such alternative capacity reasonably cannot be made available by the applicable effective date. In the event that an extension is granted, an applicant is exempted from the land disposal restrictions, including the conditional prohibition on storage under § 268.50. Any landfill or surface impoundment receiving waste during the extension must comply with the ground water monitoring, liner, and leachate collection system requirements in § 268.5(a)(3).

The majority of the commenters supported the proposed approach for case-by-case extensions. However, the Agency received comments requesting modifications to several aspects of the proposed rule. Section 268.5 of today's final rule incorporates the procedures for case-by-case extensions essentially as proposed, but with modifications based on these comments.

1. Demonstrations Included in Applications

a. *The applicant has made a good-faith effort to locate and contract with alternative technologies nationwide.* EPA proposed to require applicants to make a good-faith effort to locate available capacity before being granted a case-by-case extension. Section 3004(h)(3) requires that the applicant demonstrate a binding contractual commitment to provide capacity and show that "such" capacity (i.e., the capacity contracted for) cannot reasonably be made available by the effective date. Thus, there is no requirement on the face of the statute that the applicant be denied an extension if alternate capacity is currently available. As noted in the proposal, however, the legislative history to the original Senate bill suggests that requiring facilities to investigate available capacity is consistent with congressional intent. Thus, the good-faith showing provided in today's rule, though not statutorily required, is consistent with the legislative history and is within the Agency's authority.

The applicant may provide copies of correspondence with commercial facilities that have rejected the waste on the basis of waste composition or capacity shortages as part of the demonstration for § 268.5(a)(1) and (e)(3).[10] EPA's "1986 Hazardous Waste Treatment Directory" (available at no charge in limited quantities from the RCRA/Superfund Hotline or available for sale through the National Technical Information Service (NTIS) as PB89 #178431/AS) lists commercial treatment and recycling facilities that are identified from the Hazardous Waste Data Management Systems (HWDMS). A more up-to-date list of commercial treatment and recycling facilities is being prepared from data gathered from the 1986 National Screening Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities. The new Treatment Facility Directory

[9] EPA construes section 3005(j)(11)(A) to impose an additional condition on the treatment of hazardous wastes in surface impoundments under section 3005(j)(11)(B).

[10] In cases where a waste cannot be treated by the BDAT method or to the specified level using BDAT, the generator or owner/operator may petition the Agency for a variance from the treatment standard under § 268.44.

prepared from this screening questionnaire is expected to be available in November, 1986.

b. Binding contractual commitment. One commenter argued that the use of the case-by-case extension would be limited to on-site alternative capacity because of the requirement in § 268.5(a)(2) for a binding contractual commitment. EPA disagrees with the commenter. The Agency believes that the regulation is consistent with the statutory provision which requires that the applicant enter into a binding contractual commitment "to construct or *otherwise provide* alternative . . . capacity" (emphasis added). In other words, a generator may enter into a binding contractual commitment with a commercial facility to guarantee that the capacity to manage his waste will be available at the commercial facility. This demonstration requires a commercial facility to agree that alternative capacity under development at the facility is set aside for the applicant's waste. One commenter argued that, in such situations, the generator would not be a party to the contractual commitment to construct the facility. EPA agrees with the comment, but the point is not relevant since the generator would have a contract with a commercial facility which will provide the needed alternative capacity.

One commenter argued that State law defines binding contractual commitments, therefore, the Agency does not need to judge whether the penalties for cancelling the contract are adequate. EPA agrees with the commenter. Accordingly, the Agency is amending the regulatory language by deleting the stipulation for a cancellation penalty clause.

c. Lack of capacity is beyond the applicant's control. For technologies under construction, the applicant may document the completion schedule, including dates already passed, (e.g., date of permit application submission) to demonstrate that the technology cannot be made available by the effective date. This schedule, if available, also will be used by the Agency to identify key target dates that should be discussed in progress reports.

Several commenters stated that the legislative history allows EPA to consider economic factors in evaluating requests for case-by-case extensions. The Agency agrees that the statutory language can be construed to allow an applicant to show that it would not be feasible to use existing capacity. Although the legislation as enacted did not include House of Representatives language expressly providing a variance based on "severe economic hardship," the conference report did add language allowing for a demonstration that adequate alternative capacity cannot "reasonably" be made available by the effective date. Therefore, in making its determinations concerning the availability of such alternative capacity, EPA will consider the feasibility of providing alternative capacity during the period of the requested extension in order to determine whether capacity reasonably is available. The determination of feasibility may involve consideration of the technical and practical difficulties associated with providing alternative capacity.

d. The capacity will be sufficient to manage all of the waste covered by the application. One commenter stated that research and development activities generate variable amounts of waste, so it may be difficult to prove that alternative capacity will be sufficient for all the wastes covered by an extension. EPA recognizes that the amount of waste affected by the land disposal regulations may vary according to economic conditions and unforeseen changes in quantities of waste produced or in constituents present in the waste. However, the Agency expects applicants to plan to provide adequate capacity for all wastes expected to be affected by the restriction decisions. Therefore, EPA expects applicants to make capacity determinations on the basis of the maximum volume of waste expected to be subject to the land disposal restrictions.

The Agency is requiring under § 268.5(a)(4) that the applicant provide information (e.g., waste quantities and operating capacity) to demonstrate that, after the extension, sufficient capacity will exist for the waste covered by the application for extension. EPA will not grant an extension in cases where alternative capacity is not being provided for the entire volume of waste addressed in the application.

The Agency will grant extensions to applicants demonstrating planned changes to a process that eliminate wastes, decrease volume, or render a waste treatable. Any waste not eliminated by process changes instituted as a result of the extension must be sent to other specified capacity.

e. Detailed schedule for providing capacity. The completion schedule, if available, will be used to identify the dates and events that should be addressed in the progress reports. Progress reports should indicate either the existence of alternate capacity that will be available according to the time frame outlined or the circumstances causing delays in the schedule and the efforts required to compensate for the loss of time. If capacity is not available near the end of the first extension, the applicant must request a renewal of the extension, not to exceed one year. In cases where it is obvious that the schedule to provide capacity will exceed one year, the request for a second extension should be straightforward, since the second extension was foreseen from the start.

f. Document locations with adequate capacity to manage waste during an extension. The applicant must demonstrate that sufficient capacity will exist during the extension to store, dispose of, or otherwise manage the waste. This demonstration must include the location of all off-site waste management facilities and a short description of the processes that will be used for waste management during the extension (e.g., storage in on-site tanks). The identification of off-site facilities that will accept the waste during the extension should be part of the demonstration. This information will be shared with the States and will be available for inspection in the event of a public hearing on the extension decision.

g. Any surface impoundment or landfill managing wastes during an extension must meet the requirements of § 268.5(h)(2). During the period of a national variance under section 3004(h)(2) or a case-by-case extension under section 3004(h)(4), the waste may be managed in a landfill or a surface impoundment in compliance with section 3004(o). This section, enacted as part of the 1984 amendments to RCRA, imposes minimum technological requirements on certain new landfill and surface impoundment units, and on replacements and lateral expansions of existing units. The proposed rule would have construed section 3004(h) to require the unit to comply with the requirements set out in section 3004(o). Thus, the proposal would have required existing units to comply with section 3004(o) requirements during the period of a variance, even though the plain language of section 3004(o) exempts such units.

Upon reconsideration, however, EPA believes that the proposed interpretation is not the appropriate reading of the statutory language. On its face, the statute requires [illegible] compliance with section 3004(o) [illegible] facility includes the [illegible] property boundary and encompasses all waste management units (both new and existing). Accordingly, a straightforward reading of the statute would provide that the facility is in compliance with section 3004(o) as long as the new units,

lateral expansions and replacements referred to in section 3004(o) are in compliance with the requirements of that section. Because existing units are excluded from section 3004(o), they would also not be required to comply with the minimum technological requirements under section 3004(h)(4). Section 3004(h)(4) thus makes clear that obtaining a variance from the effective date of the land disposal prohibitions does not relieve the owner or operator of a disposal facility of the obligation to comply with the technical requirements independently imposed by other statutory provisions.

In addition, this interpretation is reasonable in view of the fact that the alternative capacity under consideration in today's rule includes treatment in surface impoundments that meet the requirements of section 3005(j)(11). These requirements include double liners (with limited exceptions). Construing section 3004(h) to require minimum technological requirements for all units would mean that a prohibited waste that was granted a variance from the effective date due, in part, to a lack of double-lined surface impoundment capacity would nonetheless have to be disposed of in an impoundment in compliance with section 3004(o). EPA believes that the statute should not be construed to require such an illogical result. Therefore, today's rule requires that the facility be in compliance with the regulatory provisions that incorporate the requirements of section 3004(o).

2. Where To Send Extension Applications

A petitioner should submit one copy of the application for extension to the applicable land disposal restrictions effective dates to:

The Administrator, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460.

An additional copy marked "Extension" should be submitted to:

Office of Solid Waste (WH-565), U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460.

Applications containing confidential information should be sent with only the inner envelope marked "Extensions" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, as amended by 43 FR 40000).

3. Review of Applications for an Extension

Several commenters recommended that the Agency establish regulatory time constraints for reviewing extension applications under § 268.6(e). One commenter specifically requested deadlines similar to those for evaluation of delisting petitions pursuant to section 3001(f)(2). In particular, they stated that the Agency should impose internal processing deadlines for review of extension applications and set a limit on the period for public comment. Although EPA fully understands the need to grant extensions before the effective date of the land disposal restrictions, EPA will not commit to establishing a set response time for extension applications for several reasons.

First, EPA cannot anticipate the level of resources necessary to process applications. As of August 8, 1988, three months before the statutory restrictions on solvents become effective, EPA had received only one request for an extension, despite one comment predicting extensive use of this provision. Second, experience with the permitting and delisting processes has shown that the review process often includes several requests for clarification or additional information before an application is considered completed. Turnaround time regarding deficiencies can vary depending on the responsiveness of the applicants. Finally, time required for consultation with the affected States is difficult to predict.

While the Agency will not specifically limit its internal review period, EPA has recommended that applicants submit extension requests at least six months before an effective date (when possible) to provide a reasonable opportunity to process applications before the effective date. To further expedite the review process, the Agency will limit the public comment period to 30 days.

Under some circumstances, capacity under development will not become available until after a national variance expires. In these situations, persons requiring an extension should submit an application as soon as the capacity shortage is identified.

4. Applicability of Case-by-Case Extensions

One commenter stated that EPA should grant case-by-case extensions only in cases where a national capacity shortfall exists. The Agency disagrees with the commenter. The case-by-case extension process was intended to cover those rare situations when an individual applicant can demonstrate that capacity will not be reasonably available to him even if national capacity is otherwise sufficient. As stated earlier, the variance is based on the "feasibility" of providing alternative capacity.

5. Length of the Case-by-Case Extension and Renewals

As discussed in the proposed rule, case-by-case extensions cannot extend beyond 48 months from the statutory land disposal restriction dates. Therefore, extensions will not exceed the following dates:

November 8, 1990, for certain listed dioxin-containing and solvent wastes;
July 8, 1991, for wastes identified as California List wastes;
August 8, 1992, for the first third of the listed hazardous wastes;
June 8, 1993, for the second third of the listed hazardous wastes; and
May 8, 1994, for the remaining hazardous wastes, including characteristic hazardous wastes.

On the applicable effective date, a restricted waste is subject to the provisions of Part 268 until a case-by-case extension is granted. For example, if a person requests an extension on January 8, 1987, for a solvent waste restricted from land disposal on November 8, 1988, the waste is restricted from land disposal from November 8, 1988, until the extension is granted. The extension would not exceed the November 8, 1990, deadline.

The effective date for certain newly listed wastes may fall after the May 8, 1990, date for scheduled wastes. Such wastes may require extensions beyond the May 8, 1994, date. EPA expects that the short duration of the extensions (not to exceed two years) will encourage generators of hazardous waste to minimize the quantity of hazardous waste subject to the land disposal restrictions. Generators should explore changes in process substitution, materials recovery, recycling and reuse, and alternative treatment as alternative methods of complying with the land disposal restrictions. EPA has prepared a report to Congress for presentation during November 1986, on waste minimization which identifies some waste minimization practices.

6. Consultation With Affected States

All states will be notified via Federal Register announcement of tentative decisions to grant extensions for restricted wastes. States that anticipate that they may be affected by a specific extension should contact EPA. EPA then will consult with appropriate agencies in the affected States as required by section 3004(h)(3). EPA expects that states most interested in extension decisions will be those in which the waste was generated, those accepting waste during the extension period, and those with capacity under development. Applicants

can expedite the review process by submitting information outlining how the wastes will be managed in each of the affected States as part of the demonstrations under § 268.5 (a)(6), (a)(8), and (a)(7).

C. Evaluation of Petitions Demonstrating Land Disposal To Be Protective of Human Health and the Environment

The statutory standard for evaluation of these petitions requires that the applicable land disposal method be protective of human health and the environment. The statute further specifies that a method of land disposal may not be determined to be protective unless it has been demonstrated, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous. (RCRA section 3004(d), 42 U.S.C. 6924(d)(1)).

In demonstrating "no migration," the petitioner must take into consideration the likely effects of long-term geologic processes and climatic phenomena, such as, but not limited to, earthquakes and floods, and any other events that can be reasonably predicted. The petitioner should not assume that any man-made barriers or engineered systems will satisfy the "no migration" standard, because artificial barriers alone cannot be relied upon to provide the long-term assurances that the statutory standard requires. However, these units may satisfy the standard when the petitioner is requesting temporary storage of restricted waste on the land.

The Agency has identified three scenarios that may satisfy the requirements of the statutory standard of "no migration". The first involves a situation where environmental parameters are such that no detectable migration of hazardous constituents would occur from the disposal unit. For example, this scenario may occur when a waste consisting of relatively immobile hazardous constituents is placed in a monofill located in an arid climate with no ground water recharge. Another example involves placement of a small volume of compatible waste in a massive and stable salt dome formation. The second would rely on an active chemical or physical process, such as the neutralization of a corrosive waste in a surface impoundment, where no hazardous waste remains in the unit. This is especially applicable to characteristic wastes. The third involves the temporary storage of hazardous waste in a land-based unit, such as an in-door waste pile, where engineered containment systems are effective over the period the waste remains in storage.

The "no migration" standard clearly would be violated in a situation where unacceptable concentrations of hazardous constituents are occurring at the waste management boundary, even though the concentration at a potential receptor site some distance from the waste management boundary is below an applicable health-based level.

The Agency, generally, will deny a petition where there is a history of continuing mismanagement of hazardous waste at the disposal unit as evidenced by State or EPA monitoring and on-site inspection reports.

1. Procedures for Submitting and Reviewing Petitions

The Agency proposed that petition review would eventually be the responsibility of either the EPA Regional offices or authorized States. Upon reevaluation, the Agency believes that there will be relatively few petitions submitted. Accordingly, the Agency is requiring that applicants submit petitions to the Administrator.

The five general steps of the petition review process involve the submittal of the petition, Agency review of the petition, notice of the Agency's tentative decision in the Federal Register, a 30-day public comment period, and notice of the Agency's final decision in the Federal Register. (See § 268.6.) Two copies of the petition should be submitted (by registered mail) to the Administrator. The Agency will initially review a petition for completeness. Once a petition is considered complete, it will be reviewed on the basis of the technical information supplied. The Agency will publish in the Federal Register a tentative decision to grant or deny a petition. The Agency will consider public comments and any new data submitted during the comment period. The Agency will then publish its final decision in the Federal Register.

During the petition review period, petition applicants are required to comply with all restrictions on land disposal of the waste. The receipt of a petition by the Agency does not delay the effective date of any restrictions applicable to the waste.

H. Treatability Variance

1. Basis for Establishing a Treatability Variance

Several commenters recognized that there may be particular waste streams that cannot be treated to the level (or by the method) specified by the treatment standard. The Agency agrees with these commenters, and is establishing a procedure to evaluate petitions for a variance from the treatment standard.

The Agency envisions that wastes may be subject to a treatability variance in cases where the treatment standard for a particular waste cannot be met because the waste does not fit into one of the BDAT treatability groups. A particular waste may be significantly different from the wastes considered in establishing treatability groups because the waste contains a more complex matrix which makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard. In such a case, generators or owners/operators may petition the Agency for an alternative treatment standard.

On September 5, 1986, the Agency published a Notice of Availability of Data in the Federal Register (51 FR 31703) outlining its authority under section 7004(a) to act on petitions to amend or repeal any regulation under RCRA and requesting comments on a procedure by which petitions for a variance from the treatment standard would be evaluated. Commenters on the Notice of Availability generally supported the concept of a variance from the treatment standard. Two commenters specifically supported providing variances through a rulemaking procedure, while another commenter, though recognizing EPA's authority to amend the treatment standards by rulemaking, urged the Agency to adopt a more streamlined variance procedure similar to that used in other EPA rules. Commenters also suggested specific criteria to be considered in evaluating variance petitions.

EPA agrees that the Agency has the authority to choose between a rulemaking and a variance procedure when considering the unique aspects of wastes that were not considered in developing the treatment standards. Nothing in the language or legislative history of the statute suggests that Congress intended to preclude EPA from adopting a variance procedure once the Agency has issued treatment regulations under section 3004(m).

The Agency is promulgating procedures for a variance from the treatment standard under § 268.44 of today's rule. Essentially, the new provision will allow applicants to use procedures similar to those now used for rulemaking petitions under 40 CFR

268.30. In light of the comments, however, EPA intends to issue a proposal asking for further comments on the option of using a variance procedure rather than a rulemaking. Because there was insufficient time prior to today's rule to fully consider all issues relating to the establishment of a variance procedure, EPA believes it is more appropriate to request additional comments. Similarly, EPA will consider additional comments on the appropriate criteria by which to evaluate variance requests in the context of the future rulemaking. In the meantime, this preamble outlines some criteria that EPA believes should be considered by applicants for a variance from the treatment standard.

2. Demonstrations Included in a Petition

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful, or through appropriate analyses of the waste which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based on a showing that adequate BDAT treatment capacity is unavailable. Such demonstrations can be made according to the provisions in § 268.5 for case-by-case extensions of the effective date.

The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460.

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch, Office of Solid Waste (WH-565), U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460.

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information," and the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 40000).

The petition should contain the following information:

(1) The petitioner's name and address;

(2) A statement of the petitioner's interest in the proposed action;

(3) name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact;

(4) The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration;

(5) A description of the waste sufficient for comparison with the wastes considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration; (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)

(6) If the waste has been treated, provide a description of the system used for treating the waste, including the process design, operating conditions and an explanation of the reasons the treatment standards are not achievable or are based on inappropriate technology for treating the waste; (Note: The petitioner should refer to the appropriate BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)

(7) A description of the alternative treatment systems examined by the petitioner (if any), a description of the treatment system deemed appropriate by the petitioner for the waste in question, and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (using the TCLP) that can be achieved by applying such treatment to the waste;

(8) The dates of the sampling and testing;

(9) A description of the methodologies and equipment used to obtain representative samples;

(10) A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples; and

(11) A description of the tests performed (including results).

After receiving a petition for a variance, the Administrator may request any additional information or waste samples which he may require to evaluate and process the petition.

Additionally, all petitioners must certify that the information provided to the Agency is accurate under § 268.4(b).

In determining whether a variance would be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such the BDAT properly reflects treatment of the waste.

In cases where more than one technology is applicable to a waste, the petitioner would have to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies is appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in Part 268 Subpart D.

V. Treatment Standards for Solvents

A. Introduction

On May 18, 1980 (45 FR 33119), the Agency listed 27 commonly used organic solvents as hazardous wastes when spent or discarded. The solvents were listed as EPA Hazardous Waste Nos. F001, F002, F003, F004, and F005. The listed solvents include certain spent halogenated and non-halogenated solvents, and still bottoms from the recovery of these solvents. Due to the manner in which the F001–F005 listings were originally structured, a major regulatory loophole was created by the Agency. As written, the listings only covered the pure form or the commercial grades of these solvents. Therefore, the Agency amended the listing to include mixtures containing a total of 10 percent or more (by volume) of one or more of the listed solvents, as published in the Federal Register, December 31, 1985 (50 FR 53315).

In the proposed rule to the land disposal restrictions, several commenters requested that the Agency clarify the scope of the spent solvent listings. The commenters stated that confusion exists regarding specifically what wastes are covered by the solvent listings. The Agency recognizes this problem and has included the following discussion in today's rule to provide further clarification of the F001–F005 solvent listings.

The spent solvent listings cover only those solvents that are used for their solvent properties—that is to solubilize (dissolve) or mobilize other constituents. For example, solvents used in degreasing, cleaning, fabric scouring, as diluents, extractants, reactants and synthesis media; and similar

applications are covered under the listing (when "spent"). A solvent is considered spent when it has been used and is no longer fit for use without being regenerated, reclaimed, or otherwise reprocessed.

Manufacturing process wastes where solvents were used as reactants or ingredients in the formulation of commercial chemical products are not covered by the listings. The products themselves also are not covered. See the original solvent listing background document (November 14, 1980) available in the RCRA docket.

Today's final rule does not include treatment standards for the commercial chemical products, manufacturing chemical intermediates and off-specification commercial chemical products (P and U wastes) that correspond to the F001–F005 spent solvent wastes. These wastes will be addressed according to the schedule promulgated on May 2", 1986 (51 FR 19300). The final rule also does not cover the four newly listed solvents in the F001–F005 listing: benzene, 2-ethoxyethanol, 2-nitropropane, and 1,1,2-trichloroethane (51 FR 6537). The Agency currently is gathering data to fully characterize and evaluate these wastes. We expect to make decisions on these additional solvents when we address the first group of scheduled wastes.

In today's rule, the Agency is promulgating treatment standards for the following F001–F005 solvent constituents listed in Table CCWE:

tetrachloroethylene
trichloroethylene
methylene chloride
1,1,1-trichloroethane
carbon tetrachloride
chlorobenzene
1,1,2-trichloro-1,2,2-trifluoroethane
ortho-dichlorobenzene
trichlorofluoromethane
xylene
acetone
ethyl acetate
ethyl benzene
ethyl ether
methyl isobutyl ketone
n-butyl alcohol
cyclohexanone
methanol
cresols (cresylic acid)
toluene
isobutanol
carbon disulfide
nitrobenzene
pyridine
methyl ethyl ketone

Lab packs containing these solvents also are subject to the treatment standards promulgated in today's final rule.

The treatment standards become effective on November 8, 1988 for all F001 through F005 solvent wastes which do not meet any of the criteria established for a national two-year variance. Solvent wastes that meet at least one of the criteria are subject to the variance and will be restricted from land disposal effective November 8, 1988. The criteria are:

1. The generator of the solvent waste is a small quantity generator of 100–1000 kilograms of hazardous waste per month.

2. The solvent waste is generated from any response action taken under CERCLA or any corrective action taken under RCRA, except where the waste is contaminated soil or debris not subject to the provisions of this chapter until November 8, 1988.

3. The solvent waste is a solvent-water mixture, a solvent-containing sludge, or a solvent-contaminated soil (non-CERCLA or RCRA corrective action) containing less than 1 percent total F001–F005 solvent constituents listed in Table CCWE of § 268.41.

B. Treatment Standards For F001–F005 Spent Solvents

This unit describes the industries affected by the land disposal restrictions for the F001–F005 spent solvents and the demonstrated technologies which the Agency determined to be available. The unit further describes how the Agency developed treatment standards for these wastes.

1. Industries Affected

The Agency has identified a variety of industries which generate waste subject to the land disposal restrictions for F001–F005 spent solvents. Much of the F001–F005 spent solvents, as defined in 40 CFR 261.31, are generated from manufacturing operations where solvents are used as reactant carriers or for surface preparation. Such industries include pharmaceutical plants, semiconductor facilities, printing plants, and plastic and synthetic resin manufacturers. Another large group of spent solvent wastes is generated by paint and ink formulating facilities when tanks containing solvent-based materials are cleaned. Machine shops also generate significant amounts of solvents from degreasing operations. A further description of these industries and the characteristics of the wastes generated is presented in EPA's "EDAT Background Document for F001–F005 Spent Solvents" (Ref. 4).

2. Demonstrated Technologies for F001–F005 Spent Solvents

As presented in the proposed rule, the demonstrated treatment technologies for F001–F005 spent solvents are:

(1) Batch distillation,
(2) Thin film evaporation
(3) Fractionation
(4) Incineration
(5) Steam stripping
(6) Biological treatment
(7) Carbon adsorption
(8) Air stripping
(9) Wet air oxidation

All of these technologies are demonstrated and commercially available. EPA has determined that none have been found to be riskier than land disposal. (See Unit IV.B. for a detailed discussion.)

Below is a brief description of each of these technologies and their general applicability to treatment of spent solvents. The EDAT background document provides a detailed discussion of these technologies.

a. *Batch distillation.* Batch distillation is used to separate various organic compounds from a contaminated spent solvent mixture in order to collect and reuse the individual compounds. The separation is accomplished by the addition of heat which causes the more volatile compounds to vaporize. Batch distillation generally is used in cases where the recovered solvent has sufficient economic value to offset the costs associated with the operation of the distillation system. As a consequence, batch distillation is generally applied to spent solvent wastes that are highly concentrated and yield significant amounts of material upon separation. This technology has been demonstrated for F001–F005 spent solvent wastes as well as those judged to be similar. EPA estimates that at least 400 facilities perform full-scale batch distillation on-site or as commercial treatment.

This technology yields a residue that contains a high amount of suspended solids, is quite viscous, and may require subsequent incineration. The level of performance achieved by this technology will depend on the temperature and duration of the distillation process.

b. *Thin film evaporation.* This technology is also a demonstrated distillation process. Thin film evaporation differs from batch distillation in that the waste stream for thin film evaporation contains considerably less [illegible] solids. Use of this technology results in a recovered stream which almost always can be

reused as a solvent and a bottom stream which often is used as fuel for incinerators. Depending on the suspended solids level of the waste, treatment using thin film evaporation may result in a residue that requires land disposal. EPA has identified several full-scale facilities using thin film evaporation of waste solvents.

c. *Fractionation.* This technology also is a demonstrated distillation process. It differs from batch distillation and thin film evaporation in that it is designed to achieve a finer separation than these other treatment technologies. It would be used when there are recoverable quantities of more than one solvent in a waste. Generally, fractionation will result in multiple product streams while generating minimal amounts of residue to be land disposed. Fractionation is practiced by full scale facilities on spent solvent wastes.

d. *Incineration.* Incineration is a well demonstrated technology commonly used to treat spent solvent wastes. The Agency estimates that there are over 200 full-scale incinerators for hazardous wastes, many of which incinerate F001–F005 spent solvents. This technology destroys the organic fraction of the spent solvents by oxidation to carbon dioxide and water vapor. Chlorinated organics are converted to carbon dioxide, water vapor, and hydrochloric acid vapor.

Incineration generates one or two residual wastes that need to be land disposed depending on whether the incinerator includes air emission controls. The residual wastes are the incinerator ash and the scrubber sludges or air emission control dust. The vast majority of incinerator residue that will require land disposal is generated by rotary kiln incinerators that burn spent solvent wastes containing high concentrations of solids.

e. *Steam stripping.* While steam stripping is a distillation process, the technology is significantly different from the distillation processes previously discussed both from the standpoint of the type of wastes treated and the design and operation of the process. Steam stripping is used by a number of facilities to reduce organic concentration in dilute spent solvent wastes containing mostly water. As such, the stripped solvent is not generally recovered in commercially viable quantities. Data from the Agency's screening questionnaire for capacity showed that 17 full-scale facilities performed steam stripping of spent solvent wastes and that three facilities perform steam stripping specifically on F001–F005 spent solvents.

f. *Biological treatment.* Biological treatment is a demonstrated technology which involves the use of microorganisms to degrade spent solvent compounds. There are a number of different types of biological treatment processes. These processes include aerobic treatment such as activated sludge systems, aerated lagoons, and trickling filters, facultative degradation in waste stabilization ponds, and anaerobic digestion. In aerobic systems, organic compounds are degraded to carbon dioxide and water. Anaerobic processes convert organic wastes into methane and carbon dioxide. Facultative systems alternate between aerobic and anaerobic treatment.

Biological treatment residues include treated water and a biomass sludge. The sludge is a mixture of dead and living microorganisms containing nonbiodegradable inorganic compounds, as well as any organics that are not degraded (i.e. refractory organics) and are adsorbed by the biomass. Depending on the composition of the spent solvent wastewater, the biomass sludge may require treatment prior to land disposal. Treatment could consist of chemical fixation for metals and/or incineration for the organic compounds.

g. *Carbon adsorption.* Carbon adsorption is the use of specially prepared carbon granules (activated carbon) to remove contaminants from wastewaters. Carbon adsorption is applicable to wastewaters containing low concentrations of F001–F005 spent solvent wastes. The spent solvent wastes are removed by adsorption onto the carbon surface. The affinity that a particular spent solvent compound has for carbon will depend on the type of carbon used and the properties of the compound. The residues from carbon adsorption include spent carbon and treated wastewater. Once the quality of the treated wastewater approaches a predetermined level the spent carbon can be regenerated and reused or destroyed in an incinerator. This technology is generally used in combination with steam stripping or biological treatment. This technology is demonstrated for F001–F005 spent solvent wastewaters as well as those judged to be similar.

h. *Air stripping.* Air stripping uses forced air to remove low concentrations of volatile organic compounds, such as solvents, from wastewater. During air stripping, air and wastewater are brought into contact with each other for the purpose of transferring the volatile organic compounds from the wastewater to the air. Transfer is caused by a concentration gradient of the volatile organic compounds, which tends to move these compounds in a direction that will equalize the concentration in the air with that in the water. Air stripping has been used to treat contaminated ground water containing F001–F005 spent solvent constituents. This technology was not chosen as the basis of any BDAT treatment standards for reasons presented in the BDAT background document.

i. *Wet air oxidation.* Wet air oxidation utilizes elevated temperature and pressure to oxidize dissolved or suspended organic contaminants in wastewaters. The wastewater is fed to the wet air oxidation treatment system by a high-pressure pump. It is then mixed with compressed air and passed through a heat exchanger. The heated waste-air mixture exits the exchanger and enters a reactor where oxygen from the compressed air reacts with organic contaminants in the waste to form carbon dioxide and water vapor.

This technology has full scale applications but primarily in areas other than treatment of spent solvent wastes. The Agency is aware of one facility that treats F001–F005 spent solvent wastewater. Unlike the other technologies discussed, this technology was not considered a demonstrated technology at proposal. Subsequent to proposal, we received additional data showing this technology to be demonstrated for F001–F005 spent solvent wastes.

3. Determination of Treatment Standards (BDAT) for Spent Solvents

a. *Data base.* The majority of the data used in developing BDAT for F001–F005 solvents were from full scale treatment. The Agency included some pilot- and bench-scale data from treatment technologies which are also demonstrated on a full scale basis. Below is a description of all available treatment data by technology.

—For biological treatment, the Agency analyzed full scale treatment data from 28 plants in the organic chemicals, plastics, and synthetic fibers industries which manufacture, in total, over 200 different products. These data were from treatment of wastes containing F001–F005 constituents as a result of process contamination. While the waste are not included in EPA's definition of spent solvent wastes, the Agency believes that these wastes are similar to spent solvent wastes. The Agency has biological treatment data on carbon tetrachloride, chlorobenzene, cresols, 1,2-dichlorobenzene,

ethylbenzene, methylene chloride, nitrobenzene, tetrachloroethylene, toluene, trichloroethylene, 1,1,1-trichloroethane, and trichlorofluoromethane.

—For steam stripping, the Agency analyzed full scale data from four plants and pilot scale data on treatment of contaminated ground water. The full scale data represented treatment of F001–F005 spent solvents at one plant the remaining three plants were treating wastes containing F001–F005 constituents generated as process contaminants. The Agency analyzed steam stripping data on ethylbenzene, methylene chloride, methyl isobutyl ketone, nitrobenzene, toluene, 1,1,1-trichloroethane, and trichloroethylene.

—For carbon adsorption, EPA analyzed full scale data from four plants and pilot scale data from two plants. At one of these full scale plants, carbon adsorption is used after biological treatment. The Agency obtained data on chlorobenzene, 1,2-dichlorobenzene, methylene chloride, nitrobenzene, toluene, and trichloroethylene from this facility. At another full scale plant, carbon adsorption follows steam stripping. The Agency obtained data on nitrobenzene and toluene from this facility. In the third case, EPA has full scale data from a plant in the pesticides industry which generates wastewater containing cresols. EPA has full scale data for process wastewater containing cresol at the fourth plant. Pilot scale data for trichloroethylene are available on treatment of contaminated drinking water. Pilot scale data are also available for methylene chloride, toluene, and xylene on treatment of runoff water from a waste disposal site.

—For wet air oxidation, the Agency analyzed pilot-scale data for methylene chloride, methanol, methyl ethyl ketone, tetrachloroethylene, toluene, 1,1,1-trichloroethane, and xylene. These data were submitted as part of a comment on the proposed rule.

—For air stripping, EPA analyzed pilot scale data from treatment of ground water contaminated with 1,1,1-trichloroethane, trichloroethylene, methyl isobutyl ketone, toluene, tetrachloroethylene, and ethylbenzene.

—The Agency also analyzed the extract of incinerator ash for ten incinerators at nine facilities. All incinerators were operating full scale and treating a variety of wastes including spent solvents. The F001–F005 constituents for which data were available are acetone, carbon disulfide, chlorobenzene, 1,2-dichlorobenzene, ethylbenzene, methylene chloride, methyl ethyl ketone, methyl isobutyl ketone, nitrobenzene, tetrachloroethylene, toluene, 1,1,1-trichloroethane, trichloroethylene and xylene.

b. *Analysis of data and establishment of treatability groups.* The Agency reviewed all available treatment data to determine if any data represented treatment from a system that was not well designed or operated. Consistent with the general framework for BDAT, such data were deleted (the BDAT background document provides a detailed analysis of the Agency's rationale for such data editing). The Agency then calculated average performance values for each specific waste treated with a particular technology. In cases where the Agency had data on treatment of the same or similar wastes using more than one technology, we performed an analysis of variance test to determine if one of the technologies performed significantly better. In cases where a particular technology performed better, the treatment standard was based on the best technology. If one of the technologies did not perform significantly better, we averaged the performance values and multiplied this value by the highest variability factor to derive the treatment standard.

In several cases, the Agency analyzed data from the treatment of different wastes containing the same constituent of concern but achieving significantly different levels of performance. The Agency established a separate treatability group in cases where the data and information on the waste were sufficient to do so. Within any treatability group, however, the Agency used the highest treatment value reflecting well designed and operated treatment to establish BDAT. EPA believes that this approach ensures that the treatment standard can be achieved by facilities managing F001–F005 solvents with a wide range of waste matrices.

As proposed, the Agency established a separate treatability group for spent solvent wastewaters. For purposes of defining applicability of the treatment standards for wastewater containing F001–F005 spent solvents, wastewaters are defined as solvent-water mixtures containing total organic carbon of one percent or less. Within the general wastewater category, available data supported a separate treatability group for spent methylene chloride from the pharmaceutical industry. For spent solvents other than wastewaters, the Agency was not able to identify additional treatability groups.

c. *Development of the F001–F005 spent solvent treatment standards.* The Agency determined that available data support the establishment of the final treatment standards as shown for the treatability groups in Table 1. Consistent with the general framework, we believe that each treatment standard ensures substantial treatment of F001–F005 spent solvents. A discussion of our rationale for determining substantial treatment can be found in the BDAT background document.

In cases where data for F001–F005 spent solvents were not available to establish BDAT, the Agency evaluated the wastes to determine if treatment values could be transferred. EPA believes that based on chemical structure BDAT treatment values can be transferred to F001–F005 constituents, except for carbon disulfide, where data are unavailable. Chemical structure, especially as related to functional groups, is used to predict how organic compounds will react with other compounds and under various conditions. The structural groups considered by the Agency for F001–F005 spent solvents are halogenated aliphatics, halogenated alkenes, halogenated aromatics, ketones, alcohols non-halogenated aromatics, ethers, esters, phenols, and organic sulfur compounds. In the case of carbon disulfide, the Agency relied on Henry's Law constants to assess transfer of performance.

The Agency is aware that within similar structure groups compounds can exhibit a range of physical and chemical properties that affect treatability. EPA believes, however, that structure is the best method available at this time for estimating treatability. To take account for the range of physical and chemical properties that affect treatment within a structural group, the Agency will transfer treatment performance from the highest treatment within the structural group.

In some instances, [illegible] standards were based on [illegible] quantification levels that the agency believed may not represent quantification levels over the entire range of F001–F005 plant subcategories subject to today's final rule. In such instances, EPA increased the treatment standard to a level reflective of the quantification level which we believe

can be achieved for all F001–F005 spent solvents. Any changes made to the treatment standards as a result of quantification levels can be found in the BDAT development document.

The Agency proposed treatment standards for each of the F001–F005 constituents listed in Table CCWS of Subpart D in the proposed rule. During the comment period, the Agency obtained additional data which were summarized in the Notice of Availability of Data (51 FR 31703, September 5, 1986). EPA also reevaluated existing data using a number of statistical methods. These methods were also outlined in the Notice of Availability. Finally, the Agency revised the proposed data editing procedure which excluded data when the influent value less than the screening level (generally 2.0 ppm). In today's final rule all data are used provided influent concentrations are above quantification levels.

The departure from the proposed rule which most affected the final treatment standards is the incorporation of a variability factor. The BDAT background document contains all data used to develop the treatment standards and a discussion of procedures used to evaluate these data in determining BDAT for each constituent of concern within a treatability group.

TABLE 1.—TREATMENT STANDARDS (AS CONCENTRATIONS IN THE TREATMENT RESIDUAL EXTRACT)

[Note: The technologies shown are the basis of the treatment standards. They are not required to be used in meeting the treatment standards.]

Constituents of F001–F005 spent solvent wastes	Waste treatability groups for F001–F005 spent solvent wastes (mg/l)			
	Wastewater	Technology basis [1]	Wastewater generated by pharmaceutical plants [2]	All other [3]
Acetone	[4] 0.05	SS		0.59
n-Butyl alcohol	5.00	SS		[4] 5.00
Carbon disulfide	1.05	SS		4.81
Carbon tetrachloride	[4] 0.05	S		0.05
Chlorobenzene	0.15	S/AAC		[4] 0.05
Cresols (cresylic acid)	2.82	AC		0.75
Cyclohexanone	[4] 0.125	SS		0.75
1,2-Dichlorobenzene	0.05	S/AAC		[4] 0.125
Ethyl acetate	[4] 0.05	SS		0.75
Ethylbenzene	[4] 0.05	S		0.053
Ethyl ether	[4] 0.05	SS		0.75
Isobutanol	[4] 5.00	SS		[4] 5.00
Methanol	[4] 0.25	SS		0.75
Methylene chloride	0.20	S	12.7	0.89
Methyl ethyl ketone	[4] 0.05	SS		0.75
Methyl isobutyl ketone	[4] 0.05	SS		0.33
Nitrobenzene	0.66	S/AAC		[4] 0.125
Pyridine	1.12	S/AAC		0.33
Tetrachloroethylene	0.079	S		[4] 0.05
Toluene	1.12	S/AAC		0.33
1,1,1-Trichloroethane	1.05	SS		0.41
1,1,2-Trichloro-1,2,2-trifluoroethane	1.05	SS		0.96
Trichloroethylene	0.062	S/AAC		0.091
Trichlorofluoromethane	[4] 0.05	S		0.35
Xylene	[4] 0.05	AC		0.15

[1] In some treatment cases, concentrations achieved somewhat lower treatment values, but waste characterization data were insufficient to clearly establish treatability groups. Refer to the BDAT background document for a detailed explanation of the determination of the treatment standards.
SS = steam stripping
S = biological treatment
AC = activated carbon
[2] Wastewaters generated by pharmaceutical plants must be treated to the standards given for all other wastewaters except in the case of methylene chloride.
[3] The solvent standards in the treatability group are based on incineration.
[4] These promulgated values represent the lowest level at which EPA can support analytical quantification over the range of wastes that will be subject to this rule. The treatment technology as derived from the data and summarized above (because of the lower quantification levels associated with the wastewater residuals analysis below). The data and the calculation of treatment standards not accounting for quantification limits are shown in the BDAT background document.

C. Comparative Risk Assessment Determinations for F001–F005 Spent Solvents

As discussed in the preamble to the proposed rule, the initial comparative risk studies of solvent wastes using EPA's RCRA Risk-Cost Analysis (WET) Model indicated that the best demonstrated treatment technologies do not pose total risks to human health and the environment greater than those posed by the direct land disposal for most categories of solvent wastes subject to today's rulemaking (i.e., all solvent wastes except metal-bearing solvents). Results of the analysis are summarized in the preamble to the proposed rule (See 51 FR 1720). More detailed information is available in the Background Document for the Comparative Risk Assessment (Ref. 8).

Because results of the WET model analysis indicated that incineration of metal-bearing solvent wastes in some situations may lead to increased risks to human health or the environment, the Agency has conducted a detailed analysis of these risks. Results of the detailed analysis (Ref. 9) indicate that in most cases direct land disposal of metal-bearing wastes is more risky than incineration. These risks, however, are not expected to occur for thousands, and in some cases, millions of years. The detailed analysis also demonstrates that in some cases incineration of these wastes is more risky than land disposal when compared to the performance of a well-operated and engineered unit located in a geographical area that provides optimal containment (e.g., compacted clay).

The Agency stated in the proposed rule that whenever it is uncertain that a technology is riskier than land disposal, the Agency will consider the treatment "available" for determining BDAT and will develop data to support additional regulatory controls. Therefore, because the risk assessment does not indicate that incineration generally is more risky than direct land disposal, the Agency is classifying incineration as available for the purpose of establishing the treatment standard for metal-bearing solvent wastes. It is not possible for the Agency to establish additional regulatory requirements on metals emissions from incineration of metal-bearing solvent wastes within the statutory deadline for solvents waste, because the Agency lacks sufficient data on the feasibility of reducing metals emissions by waste pretreatment or incinerator controls.

However, the Agency has initiated a program under the authority of section 3004(n) (42 U.S.C. 6924(n)) to develop regulatory controls for metal emissions from incineration of hazardous wastes, including solvent wastes. EPA plans to publish a proposed rule by 1987 and a final rule by 1988. The Agency believes that development and implementation of this regulatory program will ensure that incineration of metal-bearing solvent wastes will be protective of human health and the environment.

D. Treatment and Recycling Capacity for Solvents

1. Quantity of Wastes Land Disposed

EPA estimates that 2,650 million gallons per year of solvent wastes are managed in units defined as land disposal under today's rule. This represents a significant increase over the 1,210 million gal/yr estimated in the proposed rule. In the proposed rule, EPA's estimate included all wastes designated as F001, F002, F003, F004, F005, the corresponding commercial

chemical products, off-specification products (P and U wastes), mixtures of these waste codes, and spent solvents from small quantity generators.

For today's rule, EPA has made several modifications to its estimate. First, as explained previously, the Agency decided not to promulgate the land disposal restrictions for those wastes designated as P and U wastes. The estimate of the total quantity of solvent wastes covered under today's rule, therefore, does not include the 11.2 million gal/yr of P and U wastes which previously were included in the proposed rule.

A second modification is more significant. The quantity estimate in the proposed rule included wastes that were mixtures of F001, F002, F003, F004, F005, and P and U wastes, but did not include those wastes that were reported as mixtures of F001–F005 with other nonsolvent waste codes. These waste quantities were not included in the proposed rule because EPA believed that a relatively small solvent portion of these mixtures could be segregated from a much larger component of the nonsolvent wastes. This assumption was based on limited descriptions of these wastes provided by some generators indicating that these wastes primarily were dilute solvent-water mixtures. In the proposal, EPA also determined that the resultant quantity of concentrated segregated solvent wastes could not be estimated properly due to the lack of concentration data for these particular solvent waste mixtures prior to segregation. Although EPA has not changed its position that the quantity of segregable solvent wastes cannot be accurately estimated, it is assuming that the entire quantity of these mixtures would require alternative treatment capacity. This is consistent with several comments indicating that EPA had grossly underestimated the quantity of wastes identified as solvent-water mixtures and generally had underestimated the other types of concentrated solvent wastes. Based on these comments, EPA believes it may have overestimated the ability of generators to separate the concentrated solvents from the nonsolvent components (primarily water) without treatment. This change results in an increase in solvent-water mixtures land disposed of 1,503 million gal/yr and an increase in quantity for all other waste types land disposed of 19 million gal/yr.

A third modification involved correction of invalid data used at proposal. The CSW RIA Mail Survey of Treatment, Storage, and Disposal Facilities regulated in 1981 was the primary source of quantity data for the proposed rule and for today's rule. Because some facilities indicated that they handled very large volumes of waste or were suspect because somewhat large quantities of recyclable organic liquids were being land disposed, EPA decided to verify whether these facilities had made an error in the data submitted. EPA performed follow-up inquiries to these facilities in order to confirm the descriptions of the physical/chemical forms of the wastes disposed. These responses were the subject of a request for comment published September 8, 1986 (51 FR 31703).

Some of the facilities indicated that they no longer handled these wastes. However, EPA does not believe that these reported full or partial closures can be extrapolated accurately to the entire 1981 survey population because of the site-specific nature of these closures. Therefore, updating the survey for closures would require more extensive follow-up by EPA. EPA believes such broad modification to the survey, in order to extrapolate these closures to the universe of facilities, would unreasonably disrupt the statistical reliability of the 1981 survey.

However, EPA does believe that these telephone responses support very limited changes to the descriptions of wastes at five facilities in the data base. The responses from two facilities indicated that a 172.8 million gal/yr waste and a 25.9 million gal/yr waste that had been identified in the survey as organic liquids were actually solvent-water mixtures. Another response from a different facility indicated that a 2.8 million gal/yr waste that had been identified as an organic sludge was actually a solvent-water mixture that had been treated in an impoundment. This waste also had been double-counted as being handled in a landfill. Two additional wastes treated in impoundments also had been double-counted as being disposed in landfills. Therefore, the quantities of these wastes which were subtracted from the total quantity of waste landfilled and subtracted from the total.

A fourth change to EPA's estimate is based on EPA's determination that those wastes from the 1981 RIA Mail Survey that were not described should have been added to the total organic liquids land disposed rather than distributing the wastes to all physical/chemical forms. EPA believes that assuming the undescribed waste quantities are organic liquids is more consistent with the type of wastes identified as the basis for listing these solvent wastes as hazardous. Spent solvents and still bottoms usually are pumpable organic liquids. This modified assumption increases the estimated quantity of organic liquids by approximately 15 million gal/yr, and reduces to solvent-water estimate by an equal amount. This quantity represents a total of six wastes at two facilities.

Two final changes were made to the quantity of waste from small quantity generators and CERCLA actions. The million gal/yr of solvent wastes from small quantity generators increased from the estimate of 7.3 million gal/yr the proposed rule as a result of correcting a calculation error. More importantly, the proposed rule contained no quantity estimates for increases in solvent wastes anticipated to result from removal and/or remedial actions taken by the Agency under CERCLA or RCRA corrective action. For today's rule, this has been estimated to be 21.7 million gal/yr based on a recently completed EPA analysis of future land disposal. These quantities are explained in greater detail in Appendix B of the Background Document to today's rule (Ref. 2). Therefore, the overall total quantity of wastes including small quantity generator and CERCLA wastes is increased to 2,459 million gal/yr for today's rule.

2. Reanalysis of Land Disposal Practices Used

EPA has reanalyzed the 1981 data accounting for each of the streams described in the previous section. Complete analysis of the data is provided in the background document to support today's rule (Ref. 2). The following table indicates how the total quantity of wastes estimated in the previous section is distributed among the various land disposal management technologies covered under today's rule. These figures do not include wastes which may deep well inject.

Land disposal practice	Quantity (million gal/yr)
Treated in surface impoundments	2,155.4
Stored in surface impoundments	209.2
Disposed in surface impoundments	0.09
Waste piles	0.78
Land application	34.26
Landfills	60.0
Total land disposed	2,459.73

3. Comments [illegible]

Several commenters objected to EPA's use of the [illegible] estimate for land disposal [illegible] these data underestimate the quantity of hazardous wastes which [illegible] land

disposed annually. As explained earlier, EPA agrees that the quantity of solvent wastes identified as solvent-water mixtures was underestimated. Inclusion of the additional mixed solvent wastes has increased the total quantity of solvent-water mixtures to 2.681 million gal/yr. Nevertheless, EPA believes that the 1981 data is currently the only readily available source for estimating the quantities based on the physical/chemical characteristics that influences the selection of applicable treatment technologies.

Several commenters suggested that EPA use other data sources such as Part A applications, Part B applications, RCRA Biennial reports, and various state and regional reports. EPA agrees with the commenters that the data contained in these sources are more recent, than the 1981 data. However, none of the sources provide data that readily allow EPA to estimate national quantity of solvent wastes land disposed by individual management units and by physical/chemical forms.

One commenter also contended that EPA's 1981 data grossly underestimated the quantities of hazardous waste which were being land disposed; this statement was based on privately collected data from 725 facilities in standard industrial classification (SIC) code 2800 (Chemicals and Allied Products Manufacturers). The data indicated that this industry treated and disposed of approximately 202 million tons of hazardous waste per year. Since EPA estimated only 240 million tons per year for all hazardous waste facilities, the commenter believes that EPA underestimated the total quantity of hazardous waste. However, the same commenter acknowledged that EPA estimated that this same industry managed 69 percent of the total. These figures, when multiplied together, yield a total quantity of 139 million tons per year for this particular industry (SIC 2800). EPA does not believe that 158 million tons per year is a gross underestimation of 202 million tons per year. EPA's estimate was lower than the commenter's quantity estimate, but by only 22 percent.

However, the commenter did not indicate whether the privately collected quantity figures were for RCRA hazardous wastes or all wastes considered hazardous by state and local authorities. EPA's estimates of waste quantities specifically exclude hazardous wastestream which are exempt from RCRA (such as those treated solely in tanks and subsequently discharged under NPDES permits). It was not clear that the commenter's estimate of 202 million tons per year of wastes treated and disposed includes or excludes these wastewaters. The same commenter provided more recent data, also based on an independent survey of this industry, that indicated the total amount of hazardous waste treated and disposed by responding plants in 1983 was 97.8 million tons per year (97.8 million tons per year of wastewater and 1.7 million tons per year of solid waste). Of the solid wastes treated and disposed, 0.7 million tons per year were landfilled, 0.3 million tons per year were incinerated, 0.48 million tons per year were disposed in surface impoundments, and 0.13 million tons per year were treated by other methods. The corresponding 1981 EPA estimates for all hazardous waste were, 3.0 million tons per year of hazardous waste landfilled, 1.7 million tons per year incinerated, 19 million tons per year disposed in surface impoundments, and 17 million tons per year treated by other means. EPA believes that these data, which represent significantly larger quantities of solid waste being land disposed, further indicate that EPA estimates of quantities of wastes being land disposed are reasonable and are not grossly underestimated.

4. Summary of Quantities Requiring Capacity

Based on the 1981 RIA Mail Survey quantity data presented in the previous section, EPA estimates that a total of 13.9 million gal/yr of pumpable organic solvent wastes will require incineration capacity, 3.4 million gal/yr will require distillation capacity, and 15.3 million gal/yr will require fuel substitution capacity.

EPA also estimates that 21.7 million gal/yr of solvent-containing sludge mixtures will require some form of high solids combustion treatment, such as rotary kiln incineration.

A total quantity of 2.681 million gal/yr of solvent wastes described as solvent-water mixtures also will require some form of wastewater treatment. The following table summarizes this information.

Alternative treatment technology	Quantity requiring treatment (million gal/yr)
Distillation	3.4
Fuel substitution	15.3
Incineration	13.9
Solvent-water solids treatment	21.7
Wastewater treatment	2.681

These quantities do not include the 3.7 million gal/yr of solvent wastes from small quantity generators, nor do they include the 53.1 million gal/yr increase in solvent wastes anticipated to be generated from remedial and removal actions taken under CERCLA and RCRA corrective action. The waste characterization data which would be necessary to analyze treatment technologies for these two waste sources are very limited. Although it is possible that all small quantity generator wastes may have to go to incineration, EPA believes that a more reasonable approach is to extrapolate the waste characterization data from the 1981 survey to the total quantity by applying the ratio of quantities which were directed to each technology. Since the solvent wastes from small quantity generators are not anticipated to include solvent-water mixtures nor any solvent-inorganic sludge mixtures, the ratio developed from the distillation, fuel substitution, and incineration quantities have been applied.

Alternative treatment technology	Quantity requiring treatment (million gal/yr)
Distillation	0.3
Fuel substitution	2.3
Incineration	4.1

All 13.1 million gal/yr of increased capacity needed for RCRA corrective action and the 6.1 million gal/yr for CERCLA responses has been assigned to incineration based on studies of current projects.

5. Comments on Types of Treatment Required

Solvent wastes identified as F001, F002, F003, F004, and F005 typically are described as spent solvents or still bottoms as specifically identified in the listing for these waste codes. However, these waste code descriptions are used to identify wastes which are regulated as F001–F005 wastes as a result of the mixture rule (in 40 CFR 261.3). I.e., a spill residue or combination of solvent wastes with other wastes or materials, such as wastewater, soil, organic or inorganic sludges.

In the preamble to the proposed rule, EPA made clear its conviction that those wastes that are solvent-water mixtures are listed F001–F005 wastes that are derived from the mixture rule in 40 CFR 261.3. The Agency also assumed that these wastes contain less than 1.0 percent total volatile constituents, approximately 1 percent typical. This is consistent with EPA's guidance in defining wastewater as a waste with primarily water and a small amount of contaminants. In addition, several of the large volume, solvent-water mixtures

identified in the TSDF mail survey specifically described their wastes as containing 99 percent water.

Several commenters suggested that defining solvent-water mixtures as those wastes containing less than 1.0 percent total organics would exclude many non-hazardous wastewaters which they indicate typically can contain greater than 1.0 percent total organics. One commenter suggested that the level be raised to 4.0 percent total organics. However, none of these commenters submitted any data substantiating these comments.

Another commenter stated that EPA had overestimated the concentrations of solvents in wastes identified as wastewaters. The commenter supplied data on wastes containing part per million levels of individual solvent constituents. EPA believes that the commenter had misinterpreted EPA's intended use of these data. EPA recognizes that there are many wastewaters that contain only parts per million or even parts per billion levels of individual solvent constituents. However, EPA used a summation of the individual solvent concentrations to arrive at the estimations of total solvent concentrations in wastewaters classified as F001–F005. EPA has established a definition of solvent-water mixtures based on this maximum solvent concentration that it believes is representative of this type of waste. As explained in the proposed rule, the Agency believes this assumption is corroborated by data that indicate that the majority of wastewaters from the organic chemicals manufacturing industry being treated in surface impoundments contains less than 1.0 percent total solvents.

In the proposed rule, the Agency selected the analysis of total organic carbon (TOC) as a surrogate analysis for the total solvent concentration. Several commenters objected to the use of the TOC test because it measures both hazardous and nonhazardous organics, and is not appropriate for nonliquids. While the Agency recognizes that there is no standard method which specifically defines a total solvent concentration in wastewater, there do exist several standard methods for the individual solvent constituents for which the F001–F005 solvent wastes are listed (40 CFR 261 Appendix VII). These individual solvent concentrations then can be summed to yield a total solvent concentration for a particular waste. The Agency never intended to include nonhazardous wastes or wastewaters in this rule, and the Agency agrees with the commenters that there may exist nonhazardous wastes and wastewaters with greater than 1.0 percent total organic carbon. Therefore, the Agency has reevaluated its position on the method for determining that an F001, F002, F003, F004, and F005 waste is considered a solvent-water mixture (wastewater). For the purposes of today's rule, the Agency is defining as aqueous solvent waste as any F001, F002, F003, F004, and F005 solvent waste that is primarily water and contains either (1) less than 1.0 percent total organic carbon or (2) less than 1.0 percent total solvents (defined as the arithmetic summation of the individual solvent concentrations for those constituents for which all of these waste codes are listed in 40 CFR 261 Appendix VII, as determined by GC or GC/MS methods in accordance with the appropriate standard methods for those constituents and waste type). The Agency still believes that the total organic carbon analysis provides an inexpensive screening technique for identifying some F001 through F005 wastes as solvent-water mixtures. However, those facilities that have wastes that exceed a total organic carbon content of 1.0 percent can elect to utilize the more rigorous measurement of less than 1.0 percent total solvent concentration. This choice of methods is intended for use as a screening procedure only to identify those F001, F002, F003, F004, and F005 solvent wastes that are to be designated as a solvent-water mixture. For the purposes of today's rule, the Agency does not intend this definition to be used to classify a wastewater as a hazardous solvent waste. However, this does not preclude the Agency from modifying or clarifying this definition in the future.

In a similar manner, the Agency believes that the 1.0 percent total solvent concentration can be extended to define the solvent wastes that are primarily inorganic sludges or soils. The Agency recognizes that there is no standard method for the analysis of total organic carbon in inorganic solids and thus, is establishing the use of the analysis for the individual solvent constituents in inorganic sludges and soils for the determination of 1.0 percent total solvents. For the purposes of today's rule, the Agency therefore, is defining solvent-inorganic sludge mixtures and solvent-contaminated soil as any F001, F002, F003, F004, and/or F005 solvent waste which is primarily inorganic and contains no greater than 1.0 percent total organic carbon or no greater than 1.0 percent total solvents (defined as the arithmetic summation of the individual solvent concentrations for those constituents for which all of these waste codes are listed in 40 CFR 261 Appendix VII, as determined by GC or GC/MS methods in accordance with the appropriate standard methods for those constituents and waste type). The Agency believes that this is consistent with congressional intent to ban high concentration wastes, whenever capacity shortfalls are demonstrated to exist.

All other F001, F002, F003, F004, and/or F005 solvent wastes by nature of these definitions exceed either 1.0 percent total solvent concentration or exceed 1.0 percent total organic carbon and are, therefore, not considered to be solvent-water mixtures, solvent-inorganic sludges mixtures, or solvent-contaminated soils.

E. Unused Capacity of Solvent Treatment and Recycling Facilities

EPA estimated that solvent wastes restricted from land disposal as a result of today's final rule will be directed to incineration and wastewater treatment methods that can believe the treatment standards. Some solvent wastes will also be directed to recycling methods, including distillation and blending as fuel. In this unit, EPA estimates the unused capacity that is currently available to treat or recycle solvent wastes.

As explained in Unit V, private treatment, recycling, and disposal capacity will be considered in two circumstances: (1) If a private owner operator plans to accept restricted waste commercially on or before the effective date of the restrictions; or (2) when a private owner or operator has excess capacity. At this time, EPA does not have complete information on the extent to which these circumstances will occur. The Agency plans to conduct a treatment, storage, and disposal facility (TSDF) survey in the near future which it hopes will provide comprehensive data on the availability of private capacity to manage hazardous wastes that are prohibited from land disposal. However, for the purposes of this rulemaking the determinations of the capacity to treat and recycle solvent wastes will be based on unused capacity at facilities that are or will be offering commercial services by November 1988.

1. Capacity for Wastewater Treatment

BDAT wastewater treatment methods for solvent-water mixtures are biological degradation, steam stripping, and carbon adsorption. In addition, other technologies such as resin adsorption,

although not BDAT, may be capable of meeting the treatment standards for some wastes. All of the treatment methods are referred to as tank treatment under the RCRA TSDF regulations.

For the proposed rule, the CSW RIA Mail Survey was EPA's only source of information concerning the unused capacity at tank treatment facilities. However, the RIA Mail Survey was not designed to evaluate capacity of specific tank treatment systems. It requested information on total tank treatment capacity, but did not request information for specific tank treatment systems. Thus, within the time constraints for the proposed rule, the Agency was unable to determine available capacity for each treatment system. Accordingly, to prepare the proposed rule, the Agency estimated the total unused treatment tank capacity at commercial facilities that managed solvents. This unused capacity was estimated to be 112 million gallons. In the proposed rule, EPA stated that these commercial facilities managed other hazardous wastes, and that the Agency could not determine the portion of the 112 million gallons of unused treatment capacity that was available to treat solvent wastes.

EPA, however, recently has completed a comprehensive analysis of additional data from the RIA data base for these commercial facilities and has identified the specific types of tank treatment. This new analysis of the RIA Mail Survey data indicates that very little of the tank system capacity at the survey facilities was designed for treatment of solvent wastes. Because of the very limited data on treatment capacity for solvents in the RIA Mail Survey data base, EPA decided to use the 1986 National Screening Survey, which contains data on all facilities, to identify facilities that manage solvents. These facilities were contacted in the August 1986 "Telephone Verification Survey of Commercial Facilities That Manage Solvents" (51 FR 31703). This new data base reveals that there is one extremely large commercial facility that offers biological treatment for solvents, at an available capacity of about 2 billion gallons/yr. In addition, one commercial facility that offers steam stripping for solvents, and two commercial facilities offer carbon adsorption for solvents. These four facilities represent the entire capacity available for wastewater treatment of solvents.

2. Capacity for Incineration

For the proposed rule, EPA estimated that unused commercial incineration capacity is less than 33.6 million gallons per year. This calculation was based on the maximum design capacity of operational commercial incinerators and a utilization rate of 80 percent (Ref. 2). Some commenters stated that incineration capacity was limited to a very few commercial facilities, and that available capacity would not be adequate for the restricted solvent wastes. In response to these concerns, EPA used the results of the 1986 National Screening Survey to verify the commercial status of incinerator facilities and reevaluate the capacity at commercial facilities. Of the 14 commercial incinerators included in the incinerator capacity analysis for the proposed rule, three no longer offer commercial incinerator services. However, one other facility now offers commercial incinerator services. In addition, four of these facilities plan to have a new commercial incinerator operating in 1987, and another company plans to complete a large new incinerator facility in 1987. None of the facilities indicated that they planned to close in 1987. Based on the new data, EPA concludes that there are currently 12 commercial incinerator facilities, and that the number of commercial incinerator facilities will remain fairly constant or increase over the next two years. Even if an existing commercial incinerator facility closes, EPA believes, based on the pattern of construction indicated by the data, that it is reasonable to assume that another facility will begin operation of a new incinerator.

In addition to verifying the status of the commercial incinerator facilities, EPA obtained some additional data on design capacity and utilization. Using the available data for each facility, EPA estimates that the available incineration capacity at these facilities is approximately 28 million gallons per year. This estimate is slightly more than the estimate used for the proposed rule. When information was not available on the utilization rate, the calculation was based on a utilization rate of 80%.

Because there will be an increased demand for incineration capacity for CERCLA wastes that are not covered by this rule (i.e., wastes other than F001–F005), not all of this 28 million gallons per year capacity will be available for the restricted solvent wastes. Data from site analyses conducted by EPA show that the increased demand for off-site commercial incineration of non-solvent CERCLA wastes that will require capacity is 5.4 million gallons per year. Therefore, the available incineration capacity for the restricted solvent wastes is 22.6 million gallons per year.

3. Capacity for Fuel Substitution

Commenters expressed concern that in the proposal rule, EPA did not include capacity estimates for fuel substitution. A commenter stated that fuel substitution is a potentially very large source of alternative capacity and should be included in the capacity estimates for the final rule. EPA recognizes the importance of fuel substitution but did not have a sufficient data base to develop estimates for the proposed rule. Since the proposal, EPA has developed a new data base from the 1986 National Screening Survey. This information was included in the Notice of Availability on September 8, 1986. The new data base shows that at least 20 hazardous waste management facilities use hazardous waste as fuel. The available capacity for fuel substitution at these facilities is approximately 24 million gallons. Because many facilities that are not regulated hazardous waste management facilities recycle hazardous waste as fuel, the available capacity for fuel substitution is greater than 24 million gallons.

4. Capacity for Distillation

In the proposed rule, EPA estimated that the unused capacity for distillation is 213 million gallons per year. Several commenters questioned the applicability of some distillation systems to the restricted solvent wastes. EPA recognizes that not all waste may be acceptable for all systems. However, the additional distillation capacity needed for the restricted solvent wastes is only 4 percent of the available capacity. Therefore, EPA assumes that it is reasonable to expect that there is adequate distillation capacity for the restricted solvents.

F. Determination of the Effective Date

Comparison of the data developed in Sections D and E above results in the demand and capacity estimates in the following table:

ESTIMATES OF DEMAND AND AVAILABLE CAPACITY

Treatment or Recovery Technology	Unused Capacity (Millions of Gallons Per Year)	Capacity Needed (Note)
Wastewater	2,000	2000
Incineration	28	5.4
Fuel Substitution	24	24
Distillation	213	4.6

Analysis of the demand and capacity shows that available wastewater treatment and incineration capacity for solvent wastes will be exhausted by this

regulation but capacity for fuel substitution and distillation will remain. As explained previously, the capacity required for small quantity generator wastes cannot be determined precisely, therefore, the Agency has distributed the capacity demand for these wastes between incineration, distillation and fuel substitution based on the relative demand projected for those technologies. EPA has assigned the entire capacity demand for CERCLA response action and RCRA corrective action wastes to incineration because this technology is currently projected to be the alternative technology used during the next year for the majority of these wastes. As a result of this analysis, EPA has clearly identified the basis for extension of the effective date for at least some wastes requiring incineration and wastewater treatment.

In order to address the shortage of incineration capacity, EPA is granting a two year national variance to CERCLA response action and RCRA corrective action wastes (20.2 million gal/year), solvent-containing sludges and solids (21.7 million gal/year) and small quantity generator wastes (4.4 million gal/year) requiring incineration. This combination of variances should provide full utilization of available incineration capacity. The demand for wastewater treatment capacity cannot be similarly segregated because of EPA's limited data base. Therefore, EPA will grant a variance to all solvent wastewaters because of the significant capacity deficiency identified.

VI. Treatment Standards for Dioxin-Containing Wastes

A. Introduction

Today's final rule for dioxins adopts most of the provisions of the proposed rule and outlines EPA's response to major comments received on the proposal.

Under today's rule, wastes identified by the hazardous waste codes F020, F021, F022, F023, F026, F027, and F028 must be treated to a level below 1 ppb in the waste extract for each of the following specific categories of CDDs and CDFs [44]:

HxCDD—hexachlorodibenzo-p-dioxins
HxCDF—hexachlorodibenzofurans
PeCDD—pentachlorodibenzo-p-dioxins
PeCDF—pentachlorodibenzofurans
TCDD—tetrachlorodibenzo-p-dioxins
TCDF—tetrachlorodibenzofurans

One ppb is the routinely achievable detection limit using method 8290 of SW-846 [45] (40 CFR 261 Appendix IX).

These listed wastes also must be treated below the detection limits for 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 2,3,4,6-tetrachlorophenol, and pentachlorophenol. The detection limits for these constituents are 50, 50, 100, and 10 ppb, respectively in the waste extracts using method 8310/8270 identified in the SW-846.

Wastes that meet the applicable treatment standards may be disposed in a RCRA Subtitle C land disposal facility which has been fully permitted and has an approved waste management plan, in accordance with the dioxin-listing rule (50 FR 1978). Dioxin-containing wastes at or exceeding the detection limit for these constituents of concern in the waste extracts using the TCLP must be treated in accordance with the requirements specified in the dioxin-listing rule, specifically incineration (40 CFR 264.343 and 40 CFR 265.345) or thermal treatment (40 CFR 264.273) to six 9s destruction and removal efficiency (DRE), or tank treatment (40 CFR 264.200) (if such treatment can achieve concentrations of CDDs, CDFs and certain chlorophenols to below detection in the extracts from the treatment residuals).

EPA is also granting the maximum two-year variance to the effective date of the land disposal restrictions for dioxin-containing wastes because of a finding that there is a lack of capacity to treat and dispose of these wastes. Thus, the effective date of this final rule is November 8, 1988. These wastes are subject to all special management requirements specified in the dioxin-listing rule and the minimum technological requirements of section 3004(o).

In the proposed rule, the Agency did not set treatment standards for EPA Hazardous Waste No. F023 (residuals resulting from incineration or thermal treatment of soil contaminated with F020, F021, F022, F026, F027, and F028) was stated in the proposal that F023 is treatment residual from incineration or thermal treatment of dioxin-containing soil to six 9s DRE. Because incineration is the best technology identified to treat dioxin-containing wastes, the Agency concluded, that in most cases, the F023 waste would meet the treatment standard. The Agency recognizes that there may be instances in which this is not the case. Accordingly, EPA now believes that it erred in concluding that all F023 wastes would meet the designated treatment standard of no detection. Instead, it is appropriate to require that F023 wastes, like other dioxin-containing wastes, be tested to determine whether detectable levels of specific categories of CDDs and CDFs and certain chlorophenols are present in the extracts from the waste or treatment residuals. The final rule has been modified to reflect this change.

B. Summary of Regulations Affecting Land Disposal of Dioxin-Containing Wastes

In the dioxin-listing rule, EPA also specified additional management standards relating to land disposal of these wastes. Specifically, the Agency prohibited the management of the listed dioxin-containing wastes at [illegible] status land disposal facilities [illegible] are exceptions for interim status surface impoundments holding wastewater treatment sludges that are created in the impoundments as part of the plant's wastewater treatment system and interim status waste piles that meet the requirements of 40 CFR 264.250(c).

The dioxin-listing rule also establishes special management standards for dioxin-containing wastes in permitted land disposal facilities intending to manage these wastes. These facilities are required to submit a waste management plan to address the additional design and operating measures over and above those in Part 264 which the facility intends to adopt to prevent migration of the waste. The plan is to be submitted by the owner or operator of the disposal facility as part of the Part 264 permit application (see 50 FR 1979 for additional information).

The Agency believes that such a waste management plan will help provide assurance that these wastes are properly managed in a land disposal situation. It should be noted, however, that under today's [illegible] requirements apply only to the land disposal of dioxin-containing [illegible] that meet the treatment [illegible] these standards do not [illegible] the minimum technology requirements

[44] The following acronyms and definitions are used: PCDDs—all isomers of all chlorinated dibenzo-p-dioxins. PCDFs—all isomers of all chlorinated dibenzofurans. CDDs—and CDFs—isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxins and -dibenzofurans, respectively. TCDDs and TCDFs—all isomers of the tetrachlorodibenzo-p-dioxins and -dibenzofurans, respectively. TCDD and TCDF—the respective 2,3,7,8-isomers. The prefixes Tr, T, Pe, and Hx denote the tri-, tetra-, penta-, and hexachlorodioxin and -dibenzofuran congeners, respectively.

[45] In test method 8290, the proposed quantification level for dioxin in water is 10 ppt. However, due to the interferences inherent in leachate samples and the variability of waste matrices, the Agency considers that, generally, dioxin analysis subject to today's rule will have a detection limit of 1 ppb. It should be noted that because the treatment standard for dioxins is set at "no detection" it is important to achieve as the levels specified in 8290.

imposed by section 3004(o). All the prohibitions established under the dioxin-listing rule remain in effect even if the wastes meet the treatment standard.

C. Analysis of Treatment Technologies for Dioxin-Containing Wastes and Determination of BDAT

1. Applicable Treatment Technologies

The dioxin-listing rule established standards for incineration and certain thermal treatment. It states that incinerators burning the listed CDD/CDF-containing wastes must achieve a destruction and removal efficiency of six 9s, in addition to the other standards contained in 40 CFR 264.343 and 265.352.

In the dioxin-listing rule, the Agency acknowledged that there are presently a number of emerging thermal treatment technologies that may be applicable for the treatment of dioxin-containing wastes in order to render them nonhazardous (or at least, less hazardous). However, in the absence of performance standards, such treatment units would not be allowed, and this would stifle and discourage the development of new treatment alternatives for these very toxic wastes. Accordingly, the Agency revised the dioxin-listing rule to allow for interim status thermal treatment units to treat the dioxin-containing wastes if it has been certified that the units meet the applicable performance standards in 40 CFR 264.343 (including six 9s DRE for principal organic hazardous constituents (POHCs)).

The dioxin-listing rule also requires special management practices for the treatment and storage of dioxin-containing wastes in tanks. Secondary containment will be required as a permit condition for all tanks that treat or store CDD- and CDF-containing wastes. Specifically, the dioxin-listing rule requires the owners/operators of tank facilities storing or treating CDD- and CDF-containing wastes to provide EPA with the following information in its permit application specifying the precise design of the secondary containment system and its accompanying leak detection method; the choice of construction material and specifications; and whether additional run-on or precipitation controls are needed to preserve the system's integrity. These technical requirements are specified in 40 CFR 270.14(h) and must be addressed by each individual facility in its RCRA permit application. This information will be evaluated by the EPA before a permit is issued.

As was stated in the proposal, the Agency is aware of much research currently being conducted to develop and evaluate treatment technologies applicable to dioxin-containing wastes. In the proposal, the Agency presented a list of treatment technologies that were in one of three stages of development or consideration. Recently available information and data have allowed the Agency to revise this list. Additional information on the technologies under evaluation for the treatment of these wastes is available in the background docket for today's rule.

The Agency will continue to gather data and information on these and other emerging technologies in order to evaluate their future potential as applicable technologies for the treatment of dioxin-containing wastes. As stated in today's rule however, any technology for the treatment of dioxin-containing wastes must be done in accordance with the dioxin-listing rule. Many of the technologies being analyzed are thermal treatments, or can be conducted in tanks, including infrared heating and chemical detoxification.

2. Comparative Risk Assessment Determinations for Dioxin-Containing Wastes

In support of today's rule, the Agency conducted a more detailed comparative risk analysis on soils contaminated with 2, 3, 7, 8-TCDD, still bottoms contaminated with dioxins and toluene, and unused formulations of pentachlorophenol contaminated with dioxins. A detailed characterization of each waste stream is available in the regulatory impact analysis for dioxin-containing waste [Ref. 8].

The analysis of the comparative risks of land disposal and incineration to six 9s DRE indicates that both technologies potentially result in insignificant risks to human health. Land disposal presents very low risks provided that run-off or wind dispersal of contaminated particles is prevented, and dioxin-containing wastes are not co-disposed with other materials that may mobilize the dioxins (e.g., solvents). Regulations previously established (50 FR 1978) governing the management of dioxin-containing wastes are likely to prevent such releases. Similarly, incineration to six 9s DRE is likely to destroy all of the constituents of concern in these wastes and is also not predicted to present significant risks.

It is possible that, in some cases, incineration may result in greater risks than land disposal. This could occur if incinerator scrubber waters containing undetectable levels of dioxins were discharged untreated to surface waters. However, EPA believes this is unlikely because facilities incinerating dioxin-containing wastes will likely be required under the Clean Water Act to treat the scrubber water prior to discharge, and because treatment of scrubber water by carbon absorption should be effective in preventing releases of dioxin contaminants.

Provided that the discharge of untreated scrubber water is prohibited, restricting land disposal of contaminated soils will likely result in increases in total population risks and decreases in risk to the most exposed individuals (MEI). Under the same conditions (i.e., incineration to six 9s DRE and prohibitions on untreated scrubber water discharge), restricting the land disposal of still bottoms may result in an increase in total population risks, but would significantly reduce the maximum MEI risk. For unused formulations of pentachlorophenol, both the total population and health risk would be significantly reduced by incineration at six 9s DRE.

It should be noted that the greatest risks to human health resulting from the land disposal restrictions are likely to be caused by changes in the extent of transportation and handling of dioxin-containing wastes. The comparative risk analysis shows that risks from transportation and handling of dioxin-containing wastes are typically much greater than the risk posed from land disposal or incineration. The Agency however, is not able to predict whether transportation distances and the extent of handling will increase or decrease as a result of this rule.

Because the risk assessment does not indicate that incineration is clearly more risky than direct land disposal, the Agency is classifying incineration at six 9s DRE as available for the purpose of establishing the treatment standard for dioxin-containing wastes.

3. Demonstrated Technologies and Determination of BDAT

The only sufficiently demonstrated technology for the treatment of dioxin-containing wastes is incineration. Data from the field demonstration of EPA's Mobile Incineration System (MIS) on F020, F021, F022, F023, and F027 wastes at the Denney Farm site in McDowell, Missouri indicate that an incineration unit operating at six 9s DRE is capable of treating dioxin-containing wastes and the constituents of concern subject to this rule to non-detectable levels.

Although the field demonstration at Denney Farm did not include the burning of F021 wastes, the Agency believes that the existing data from the MIS field demonstration and other

available data show that similar non-detectable levels of CDDs, CDFs and pentachlorophenol would occur as the result of incineration at six 9s DRE. As stated in the proposed rule, six 9s DRE for dioxin-containing waste is determined using a POHC with a lower heat of combustion than the CDDs and CDFs contained in the waste. The more difficult a waste is to incinerate, the lower its heat of combustion. Conversely, a constituent with a high heat of combustion is easier to incinerate. In the case of the PCB waste, the Agency believes that six 9s DRE can be achieved for the CDDs and CDFs in these wastes, since PCB wastes and CDDs and CDFs have similar degrees of incinerability (heats of combustion).

The Agency has also determined that incinerators operating in accordance with the performance standards specified in 40 CFR 761.70 for PCB wastes, namely six 9s destruction, also meet the demonstrated component of the BDAT standard. For more information on this determination, the reader is referred to the preamble discussion in the proposed rule (51 FR 1720-1735).

Incineration to six 9s DRE achieves lower concentrations of CDDs, CDFs and certain chlorophenols in the treatment residuals than incineration to four 9s DRE (current standard for all RCRA hazardous waste except dioxin-containing wastes). The efficiency of incineration has been demonstrated by the successful dioxin burn at six 9s DRE in the EPA MIS at the Denney Farm Site in McDowell, Missouri and the incineration of PCB wastes at six 9s destruction at a number of facilities. Data indicate that residuals resulting from the incineration of CDDs and CDFs at six 9s DRE contain these toxicants at concentrations about five to seven orders of magnitude less than those in the starting material. For example, solid residue resulting from the incineration at six 9s DRE of dioxin wastes containing 10 ppm TCDD may be expected to contain less than .1 ppb TCDD. Additional data from the incineration of dioxin-containing wastes at six 9s DRE show no detectable levels of CDDs/CDFs or the chlorophenols in the residuals. Most of the analysis was conducted in accordance with the methods specified in SW-846 (method 8270). (40 CFR 261, Appendix II)

Additional data indicate that incinerators operating at six 9s DRE achieved extremely low concentrations of CDDs, CDFs, and PCBs in the treatment residuals, in most cases, far below these levels measured with standard analytical techniques. Detailed information on the determination of BDAT is available in the preamble discussion in the proposed rule.

D. Determination of Alternative Capacity and Effective Date

1. Required Alternative Treatment Capacity for Dioxin-Containing Wastes

Approximately 147 million pounds (6,650 metric tons) of dioxin-containing wastes are presently covered by the dioxin-listing rule. (Ref. 6). These wastes are primarily associated with the past production and manufacturing use of tri- and tetrachlorophenol and current manufacturing uses of pentachlorophenol. The Agency believes that the quantity of dioxin-containing wastes currently generated and subject to today's land disposal restriction rule amounts to 3 million pounds annually (1,350 metric tons). For the purposes of this rulemaking, the Agency estimates that approximately 1 billion pounds (500,000 metric tons) is dioxin-contaminated soil. This assessment is taken from an estimate that 1.1 billion pounds of dioxin-contaminated soil exist in the State of Missouri. See the background docket for additional information. The Agency is continuing to evaluate the universe of these wastes. As better information becomes available, the Agency will revise its estimate accordingly. Additional information on the quantity estimates of dioxin-containing wastes subject to the land disposal restriction can be found in the regulatory impact analysis for this rule.

2. Treatment, Disposal, and Recovery Capacity Currently Available

Under the dioxin-listing rule, facilities which intend to treat or dispose of dioxin-containing waste must do so in accordance with the special management standard specified in the rule (50 FR 1978). Currently, Agency information on the activities of generators and treatment, storage, and disposal facilities indicate that there is no available disposal or recovery capacity for dioxin-containing wastes. In addition, there are no Agency approved incinerators or other thermal treatment units to treat dioxin-containing wastes. Although several petitions have been received by the Agency, no incineration or thermal treatment units have been certified/permitted as required in the dioxin-listing rule.

Owners/operators of incinerators approved to burn PCBs pursuant to the Toxic Substances Control Act, may wish to apply for certification. As pointed out earlier, PCB incinerators are a logical choice to burn these wastes because they are required to meet the same performance standard (six 9s DRE) required under the dioxin-listing rule. There are currently three commercial incinerators approved under TSCA to burn PCBs. In addition to these units, several other incinerators under development may be available (contingent on certification) for treating CDD- and dioxin-containing wastes. However, the Agency has no indication whether or when any of these or any other facility will be able to treat dioxin-containing wastes.

The Agency has full confidence in the safeguards provided by the required management standards. EPA is committed to move rapidly to assure that approved capacity is available to properly manage the listed dioxin-containing wastes. Again, a priority in this area include identifying facilities that can properly manage dioxin-containing wastes, and encouraging owners and operators to apply for the necessary Federal, State, and local permits. The EPA Regional offices will work closely with these facilities to expedite their permit applications.

VII. State Authority

A. Applicability of Rules in Authorized States

Under section 3006, EPA may authorize qualified States to administer and enforce the RCRA program within the State. Following authorization, EPA retains enforcement authority under sections 3008, 3013, and 7003 although authorized States have primary enforcement responsibility. The standards and requirements for authorization are found in 40 CFR Part 271.

Before the November 8, 1984, RCRA amendments, a State with final authorization administered its hazardous waste program in lieu of EPA administering the Federal program in that State. The Federal requirements no longer applied in the authorized State, and EPA could not issue permits for any facilities that the State was authorized to permit. When new, more stringent Federal requirements were promulgated or enacted, the State was obligated to enact equivalent authority within specified time frames. New Federal requirements did not take effect in authorized States until the States adopted the requirements as State law.

In contrast, under certain statutory [illegible] U.S.C. [illegible]), new requirements and prohibitions imposed by the HSWA take effect in authorized States at the same time that they take effect in

nonauthorized States. EPA is directed to carry out these requirements and prohibitions in authorized States, including the issuance of permits, until the State is granted authorization to do so. While States must still adopt the newly enacted RCRA provisions as State law to retain final authorization, these provisions are effective in authorized States in the interim.

Today's rule is promulgated pursuant to sections 3004 (d) through (k), and (m), of RCRA (42 U.S.C. 6924). Therefore, it is being added to Table 1 in 40 CFR 271.1(j), which identifies the Federal program requirements that are promulgated pursuant to the newly enacted RCRA provisions and take effect in all States, regardless of their authorization status. States may apply for either interim or final authorization for the provisions in Table 1, as discussed in the following section. Table 2 in 40 CFR 271.1(j) is being modified also to indicate that this rule is a self-implementing provision of the RCRA amendments.

B. Effect on State Authorizations

As noted above, EPA will implement today's rule in authorized States until their programs are modified to adopt these rules and the modification is approved by EPA. Because the rule is promulgated pursuant to the RCRA amendments, a State submitting a program modification may apply to receive either interim or final authorization under section 3006(g)(2) or 3006(b), respectively, on the basis of requirements that are substantially equivalent or equivalent to EPA's. The procedures and schedule for State program modifications for either interim or final authorization are described in 40 CFR 271.21. It should be noted that the interim authorization will expire on January 1, 1990 (see 40 CFR 271.24(c)).

40 CFR 271.21(e)(2) requires that States that have final authorization must modify their programs to reflect Federal program changes, and must subsequently submit the modification to EPA for approval. The deadline for State program modifications for today's final rule is July 1, 1988. If regulatory changes are necessary, or July 1, 1990, if statutory changes are necessary. These deadlines can be extended in exceptional cases (see 40 CFR 271.21(e)(3)). Once EPA approves the modification, the State requirements become Subtitle C RCRA requirements.

States with authorized RCRA programs may have requirements similar to those in today's rule. These State regulations have not been assessed against the Federal regulations being promulgated today to determine whether they meet the tests for authorization. Thus, a State is not authorized to implement these requirements in lieu of EPA until the State program modification is approved. Of course, States with existing standards may continue to administer and enforce their standards as a matter of State law. In implementing the Federal program EPA will work with States under agreements to minimize duplication of efforts. In many cases, EPA will be able to defer to the States in their efforts to implement their programs, rather than take separate actions under Federal authority.

States that submit official applications for final authorization less than 12 months after the effective date of these regulations may be approved without including equivalent standards. However, once authorized, a State must modify its program to include standards substantially equivalent or equivalent to EPA's within the time periods discussed above.

C. State Implementation

There are three unique aspects of today's rule which affect State implementation and impact State actions on the regulated community:

1. Under Part 268, Subpart C, EPA is promulgating land disposal restrictions for all generators and disposers of certain types of hazardous waste. In order to retain authorization, States must adopt the regulations under this Subpart since State requirements can be no less stringent than Federal requirements.

2. Also under Part 268, EPA may grant a national variance from the effective date of land disposal prohibitions for up to 2 years if it is found that there is insufficient alternative capacity to land dispose. Under § 268.5, case-by-case extensions of up to 1 year (renewable for an additional year) may be granted for specific applicants lacking adequate capacity.

The Administrator of EPA is solely responsible for granting variances to the effective date because these determinations must be made on a national basis. In addition, it is clear that section 3004(h)(3) intends for the Administrator to grant case-by-case extensions after consulting the affected States, on the basis of national concerns which only the Administrator can evaluate. Therefore, States cannot be authorized for this aspect of the program.

3. EPA may grant petitions of specific duration to allow land disposal of certain hazardous waste where it can be demonstrated that there will be no migration of hazardous constituents for as long as the waste remains hazardous.

States which have the authority to impose prohibitions may be authorized under section 3006 to grant petitions for exemptions from bans. Decisions on site-specific petitions do not require the national perspective required to prohibit waste or grant extensions. In accordance with section 3004(f), EPA will publish notice of the State's final decision on petitions in the Federal Register.

One commenter argued that EPA should publish all petitions submitted by authorized States, as well as publish final decisions. EPA does not believe that section 3004(f) mandates this result. In order to be authorized to administer the petition process, a State will have to adopt notice and comment requirements equivalent to those in today's rules. Publication of the final decision in the Federal Register will satisfy the need to inform the general public by informing the public of which facilities are allowed to receive prohibited waste, and by informing other applicants as to the types of petitions that have been accepted.

States are free to impose their own disposal prohibitions if such actions are more stringent or broader in scope than Federal programs (RCRA section 3009 and 40 CFR 271.1(i)). While States impose bans which circumvent an EPA action, such as granting a case-by-case extension or petition, the more stringent State prohibitions governs and EPA's action is without meaning in the State.

VIII. Effects of the Land Disposal Restrictions Program on Other Environmental Programs

A. Dischargers Regulated Under the Clean Water Act

Compliance with land disposal restriction requirements does not relieve facility owners of the obligation to comply with all other Federal, State, and local environmental requirements, including the requirements of the Clean Water Act. Under the Clean Water Act, facility owners must comply with all applicable pretreatment requirements (for discharges to a publicly owned treatment works) and all requirements of an NPDES permit (for discharges to surface water).

The Agency recognizes that generators and treaters of hazardous wastes may choose to dispose of restricted wastes using non-RCRA disposal options.

Two disposal options facilitated under the Clean Water Act are [illegible] discharge to surface waters and indirect

discharge to publicly owned sewage treatment works (POTWs). Decisions to discharge restricted wastes using these options depend upon a number of factors including the physical form of the waste, the degree of pretreatment required prior to discharge, State and local regulations, and the cost of disposal. The Agency conducted an analysis to determine the impact of the land disposal restrictions on these alternative disposal methods (Ref. 10). The analysis focused primarily on the discharge of solvent wastes to POTWs because the Agency lacked data to analyze the impacts from spent solvent wastes discharged directly to receiving waters. However, inadequate data on these above mentioned factors precluded the Agency from conducting a quantitative assessment of the potential effect of the land disposal restrictions on increased demand for disposal to POTWs.

The results of the analysis indicated that the quantity of F001–F005 solvents discharged to POTWs could potentially increase as much as five times, although it is likely that the actual increase will be much less. The analysis also demonstrated that the discharge of solvent constitutents to POTWs will probably result in some exposure to humans. However, the risks to public health and the environment from these discharges could not be determined.

B. Discharges Regulated Under the Marine Protection, Research, and Sanctuaries Act

Two options regulated under the Marine Protection, Research, and Sanctuaries Act (MPRSA) (33 U.S.C. 1401 et seq.) are ocean dumping and ocean-based incineration. EPA is in the process of revising the MPRSA regulations. If the Agency were to relax the current regulations, there could be increased demand for ocean-based waste management due to the impact of the land disposal restrictions. If, for example, the regulations were revised to allow the issuance of permits to applicants whose wastes fail to comply with one or more of the MPRSA environmental criteria but who successfully demonstrate a need for the permit, the demand for ocean disposal could increase substantially.

The Agency conducted an analysis of the potential shift in demand for ocean disposal (ocean dumping or ocean-based incineration) resulting from the restrictions on land disposal of solvent, dioxins, and California list wastes. The results are described in "Assessment of Impacts of Land Disposal Restrictions on Ocean Dumping and Ocean Incineration of Solvents, Dioxins, and California List Wastes" (Ref. 12). This assessment is based on a methodology to score and rank waste streams for relative acceptability for ocean disposal, supplemented with an analysis of cost factors and capacity constraints.

The scoring/ranking methodology is based on technical requirements (e.g., physical form and heating value) and MPRSA environmental criteria (e.g., constituent concentrations, toxicity, solubility, density, and persistence of the waste) associated with ocean disposal of hazardous waste. The capacity analysis assumes that those wastes least acceptable for ocean disposal will be treated or disposed of by land-based methods. The cost analysis assumes that additional land-based treatment capacity would be built to treat waste streams for which the costs of land-based treatment would be less than the costs of ocean disposal (including on land transportation to a port located on the East Coast).

The results of the cost/capacity analysis indicate that, as a result of the land disposal restrictions, approximately 9.2 million gallons per year of solvent wastes and 1.2 million gallons per year of dioxin wastes potentially could create demand for ocean dumping and ocean-based incineration. Such demands result from capacity short-falls of land-based incineration and the relatively lower cost of ocean dumping and ocean-based incineration, taking into account the costs of transportation on land. These results estimate the demand that may be created if the ocean dumping regulations are revised to allow the issuance of permits for wastes that do not comply with MPRSA environmental criteria, because the analysis did not take into account technical requirements or environmental criteria.

The Agency expanded the cost/capacity analysis to eliminate those wastes that do not meet technical requirements or MPRSA criteria. The results of that analysis indicated that none of the solvent and dioxin waste streams identified as likely to create potential demand for ocean disposal in the cost/capacity analysis would be acceptable for ocean dumping, based on existing ocean dumping regulations. Conversely, all the waste streams identified by the cost/capacity analysis would be acceptable for ocean-based incineration, based on technical requirements and the proposed ocean incineration regulations.

C. Air Emissions Regulated Under the Clean Water Act

Many of the technologies capable of achieving the treatment standard for a restricted waste may result in cross-media transfer of hazardous constituents into the air. Examples would be air-stripping of volatile organics from wastewater and incineration of metal-bearing spent solvents. Unless air controls are added, these technologies may result in transfer of organics and metals, respectively, to the atmosphere.

The Agency has undertaken several efforts to address the potential problem, as discussed in the comparative risk assessment section. The Agency has initiated a program to address metal emissions from incinerators. EPA also has initiated two programs under section 3004(n) to address air emissions from other sources. The first program will address leaks from equipment, such as pumps, valves, and vents from units processing concentrated organics waste streams. Several units identified as BDAT in this rulemaking, batch distillation, thin film evaporation, fractionation, and incineration, would process waste streams with greater than ten percent organics and would be covered by this rulemaking. The Agency expects to propose these standards in November 1986. The second program under section 3004(n) will address all remaining sources of air emissions, such as residual air emissions from land disposal units and non-land disposal sources (e.g., tanks and waste transfer and handling). These standards are scheduled to be proposed in November 1987, and promulgated in November 1988.

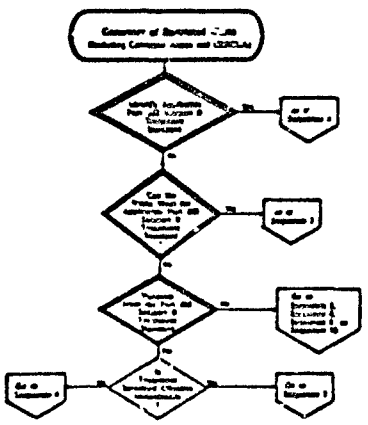
IX. Implementation of the Part 268 Land Disposal Restrictions Program

As a result of the regulations being promulgated today under Part 268, several options will be available to the generator or owner/operator of a treatment, storage, and disposal facility for the management of restricted hazardous wastes. In order to provide direction to those who manage restricted hazardous wastes, the following decision-making sequences are offered for determining appropriate waste management procedures. This unit provides references to applicable 40 CFR Parts 264 and 265 requirements as well as Part 268 requirements for implementation of the various waste management options. The Agency expects to produce an expanded version of this section as guidance to the regulated community.

All of the sequences in this unit's decision-making process must commence with a determination as to whether the hazardous waste is listed in Part 268 Subpart C. If the hazardous

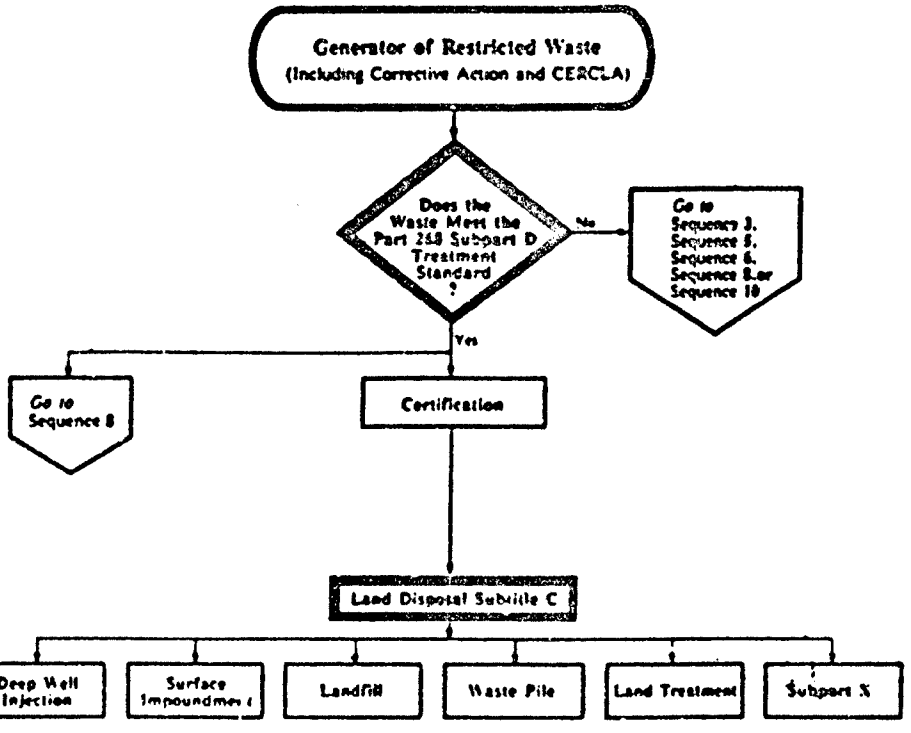
waste is not a restricted waste, it is not subject to land disposal restrictions under Part 268. It must, nevertheless, be managed in accordance Parts 264 and 265.

Sequence 1: Waste Characterization



Sequence 1 in the generator's decision-making process commences with a determination of the appropriate treatability group and corresponding Part 268 Subpart D treatment standard (§§ 268.41, 268.42, or 268.43). The Agency is requiring that applicable Part 268 Subpart D treatment standards for a restricted waste be determined at the point of generation. To require otherwise would allow the generator to dilute waste in order to circumvent an effective date or otherwise alter the applicable treatment standard. The Part 268 Subpart D treatment standards are expressed either as performance standards in the waste extract in § 268.41, as required treatment methods in § 268.42, or as concentrations in the waste in § 268.43. After the generator establishes the applicable Part 268 Subpart D treatment standard, the next step in the sequence is to determine the effective date of the applicable treatment standard. EPA has the discretionary authority to delay the effective dates of the Part 268 treatment standards on the basis of available national treatment capacity. Determinations as to the adequacy of treatment capacity for restricted wastes are based on the quantity of restricted wastes generated and the available capacity of alternative treatment, recovery, and disposal technologies. For those wastes where EPA determines that alternative capacity is adequate, the treatment standards will take effect immediately upon promulgation. When the Part 268 Subpart D treatment standards are expressed as concentrations in the waste extract (§ 268.41), the need for treatment depends upon the nature and concentration of the hazardous constituents. This will be determined either through analysis of constituents in the waste extract specified in § 268.7, using the Toxicity Characteristic Leaching Procedure (Appendix I to Part 268) or through knowledge of the hazardous constituents in the waste extract based on the materials and the manufacturing processes generating the waste. Where the Part 268 Subpart D treatment standards are specified as a required method (§ 268.42), it is not necessary for the generator to determine the concentration of the hazardous constituents in the waste or waste extract. When the Part 268 Subpart D treatment standards are expressed as concentrations in the waste (§ 268.43), the need for treatment is determined either through analysis of the hazardous constituents in the waste, as specified in § 268.7 or through knowledge of the hazardous constituents in the waste based on the materials and the manufacturing processes generating the waste.

Sequence 2: Wastes That Naturally Meet Part 268 Subpart D Treatment Standard

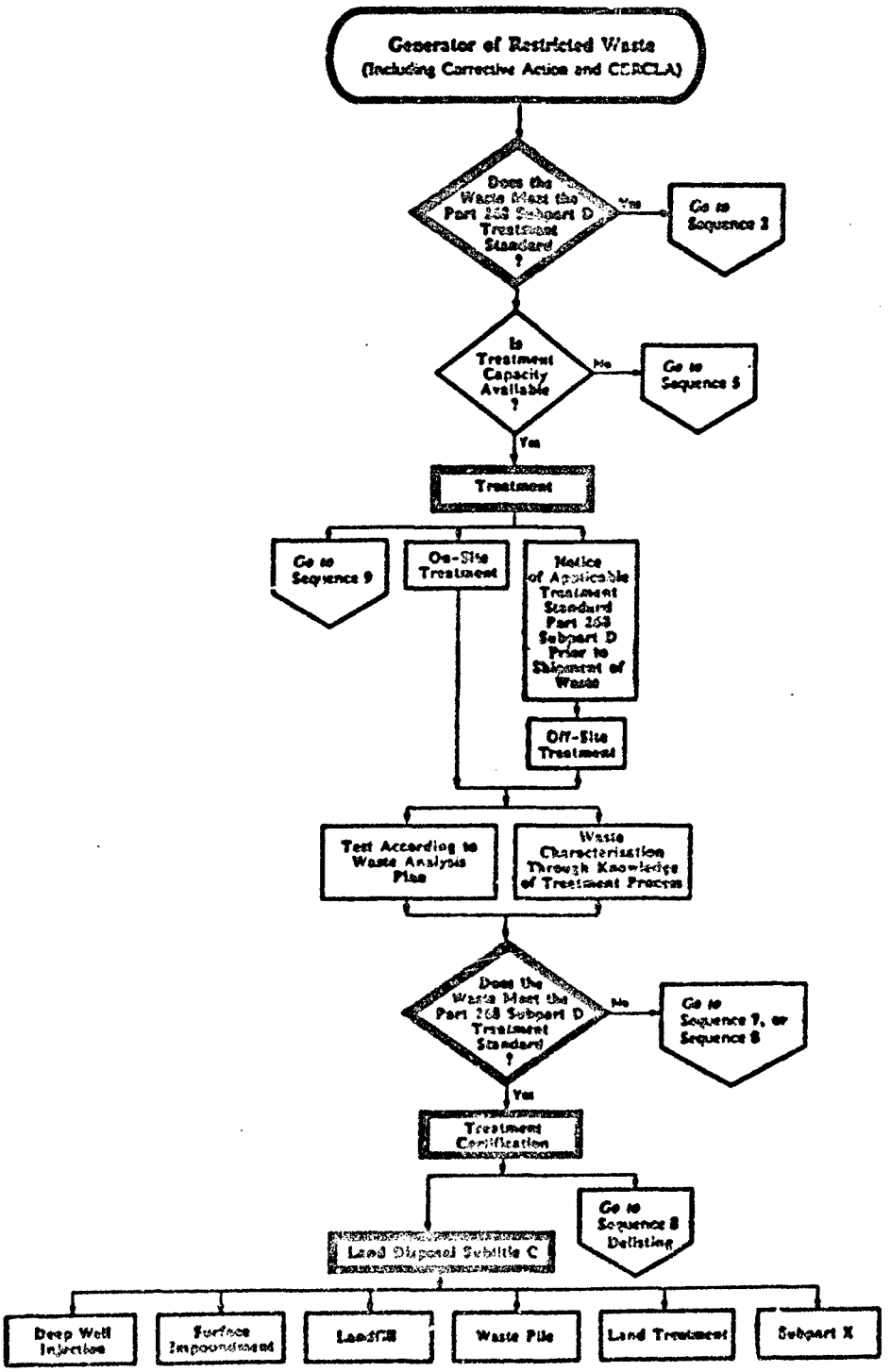


Sequence 2 in the generator's decision-making process commences with the determination that the concentration of hazardous constituents in the waste is lower than the applicable Part 268 Subpart D treatment standard. Therefore, the waste is exempt from the statutory prohibition on land disposal.

The generator must submit a notice (§ 268.7(a)(2)(i)) and include: (1) EPA Hazardous Waste Number; (2) the applicable treatment standard; (3) the manifest number associated with the shipment of waste; and (4) waste analysis data, where available. The generator must also submit a certification statement to the land disposal facility as required under § 268.7(a)(2)(ii). The land disposal facility must verify the records submitted by the generator in accordance with the facility's waste analysis plan. A generator that also operates an on-site land disposal facility must put the same information (except for the manifest number) as would be in the notice (§ 268.7(a)(2)(i)) in the operating record of the land disposal facility.

BILLING CODE 6560-50-M

Sequence 8 Treatment of Restricted Wastes



Sequence 3 in the generator's decision-making process commences with one of the following determinations: (1) The concentration of hazardous constituents in the waste extract exceeds the applicable § 268.41 treatment standard; (2) the waste must be treated in accordance with the treatment method required under § 268.42; or (3) the concentration of hazardous constituents in the waste exceeds the applicable § 268.43 treatment standard. In each case, continued placement of the restricted waste in land disposal units as of the applicable effective date specified in Part 268 Subpart C is prohibited.

Generators may store restricted wastes on site in containers and tanks according to the provisions in section 268.50 prior to treatment. This storage is solely for the purpose of the accumulation of such quantities of hazardous waste as is necessary to facilitate proper, recovery, treatment, or disposal.

The generator must treat the restricted waste in either an on-site or off-site treatment facility with interim status or a RCRA permit that is allowed to accept the restricted waste (as specified in 40 CFR Part 270).

An off-site treatment facility must obtain a notice from the generator specifying the EPA Hazardous Waste Number, the applicable treatment standard, and the manifest number associated with the shipment of waste § 268.7(a)(1)). This notice must be placed in the operating record of the treatment facility along with a copy of the manifest. Generators who are also treatment, storage, or disposal facilities must place the same information in the operating record of the facility, although a formal notice and manifest are not required. The testing and recordkeeping requirements promulgated in today's rule do not relieve the generator of his responsibilities under 40 CFR 264.12 to designate a facility on the manifest which is permitted to accept the waste for off-site management.

The determination that the treatment residue meets the applicable § 268.41 treatment standard can be made through knowledge of the hazardous constituents in the waste extract based on the processes used in the treatment of the waste or by analyzing the treatment residuals according to the waste analysis plan using the Toxicity Characteristic Leaching Procedure (Part 268, Appendix I). The determination that the treatment residue meets the applicable § 268.43 performance standard can be made through knowledge of the hazardous constituents in the waste based on the processes used in the treatment of the water or by analyzing the treatment residuals according to the waste analysis plan. In either case, if the concentration of hazardous constituents in the treatment residual extract exceeds § 268.41 treatment performance standards, or the concentration of hazardous constituents in the residual exceeds § 268.43 treatment standards, additional treatment must be performed before land disposal is permitted. Generators, transporters, handlers, storage facilities, or treatment facilities may not dilute restricted wastes as a substitute for adequate treatment to meet §§ 268.41 or 268.43 treatment standards. Such actions will be considered a violation of the dilution prohibition. In particular, wastes meeting Part 268 Subpart D treatment standards must not be mixed with wastes that do not meet such standards in order to achieve the treatment standard for the mixture (§ 268.3). EPA does not intend to disrupt or alter the normal and customary practices of properly operated treatment facilities. Treatment facilities can mix compatible wastes in order to treat at capacity levels. However, the concentration of a hazardous constituent in the treatment residual must not exceed the concentration of the most stringent applicable §§ 268.41 or 268.43 treatment standard for any given constituent.

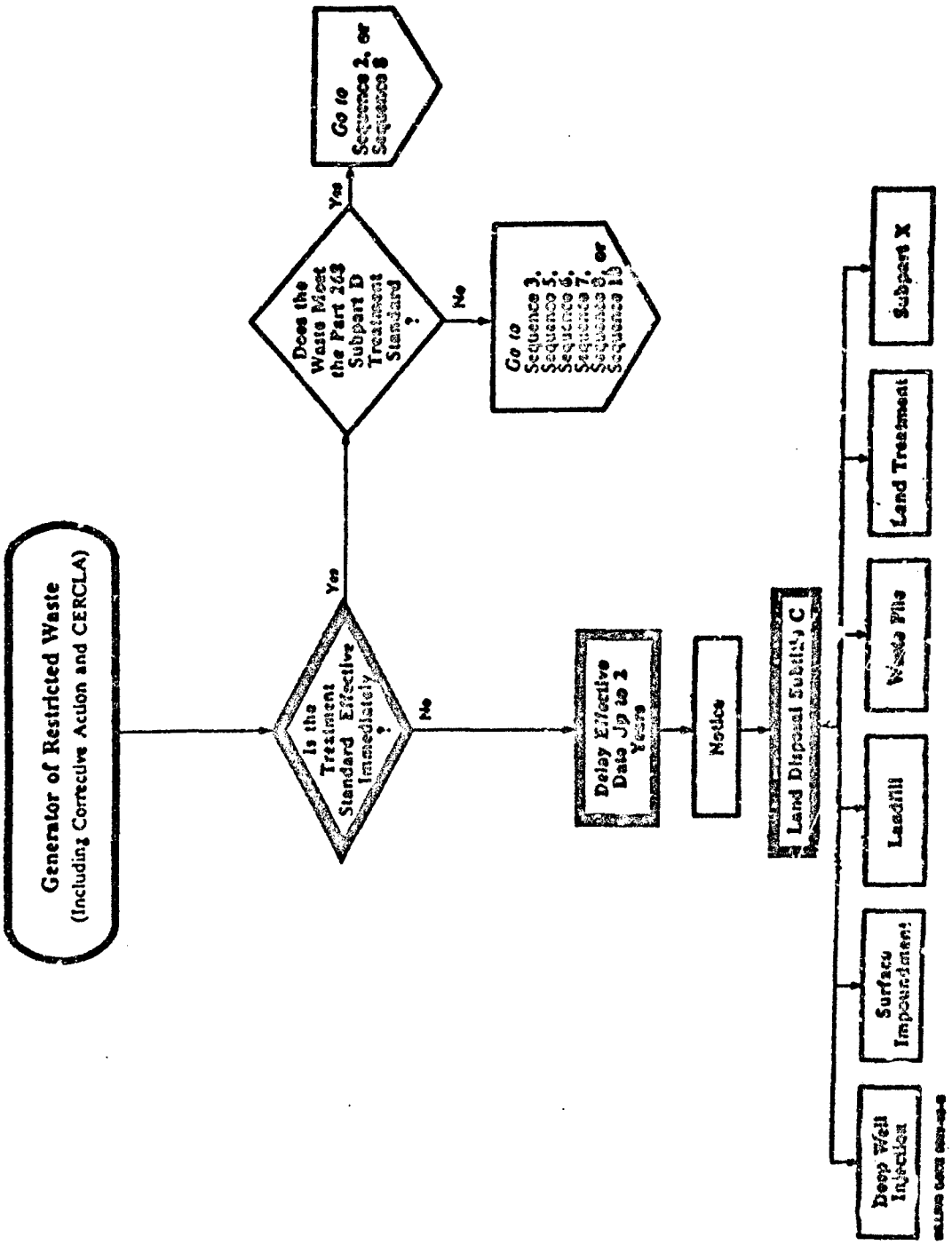
When shipping the treatment residue to an interim status or RCRA permitted land disposal facility, the treatment facility must certify (as specified in § 268.7(b)(2)) that the treatment residue meets the applicable treatment standards in §§ 268.41, or 268.43, or has been treated using the required method in § 268.42 and, therefore, is no longer a restricted waste. The treater must also send a notice to the land disposal facility and include the EPA Hazardous Waste Number, the applicable treatment standard, the manifest number associated with the shipment of waste, and waste analysis data from treatment residues where available as specified in § 268.7(b)(1).

If the treatment residuals meet the delisting criteria, the generator or treatment facility may petition the Agency for a site-specific delisting pursuant to the provisions in 40 CFR 260.22. Delisted residuals can be managed in subtitle D facilities.

In some cases, the generator or treatment facility may consider that it is technically infeasible to meet the §§ 268.41 or 268.43 treatment performance standards established for the waste. If a waste cannot meet the applicable treatment standards, the generator may petition EPA for a treatability variance under § 268.44 (See Sequence 7: Variance From a Treatment Standard, for a detailed discussion.

BILLING CODE 6560-50-M

Sequence 6 National Capacity Variance

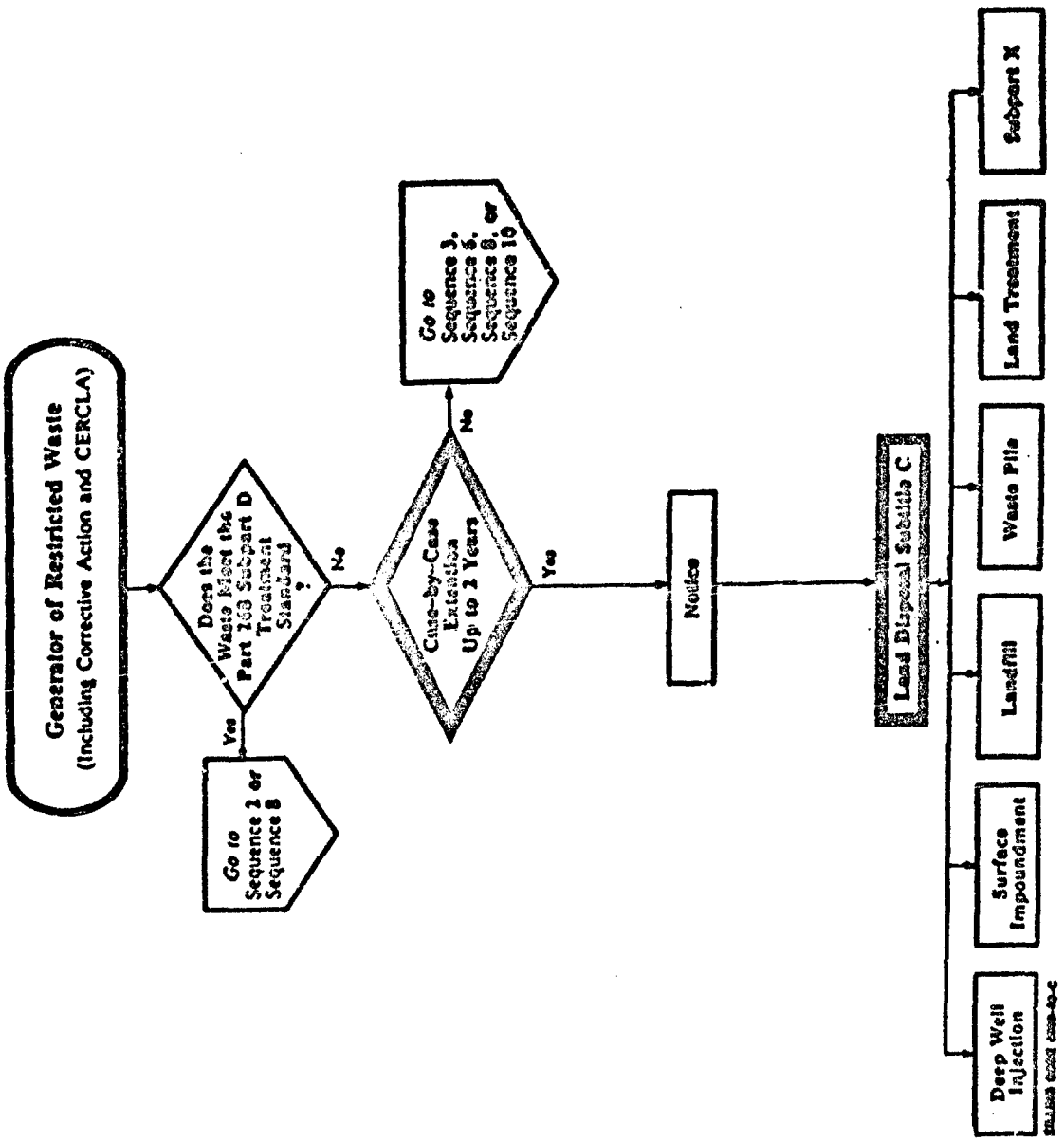


Sequence 4 in the generator's decision-making process commences for those wastes where the Agency has made the determination that capacity is not adequate on a nationwide basis. The Agency will exercise the discretion granted to it under Section 3004(h)(2) and authorize a nationwide variance of up to two years from the statutory effective date. The purpose of granting a national variance is to provide time for development of additional treatment, recovery or disposal capacity. Those wastes that EPA determines are eligible for nationwide variances are specified in Part 268 Subpart C.

During the national variance, the generator must send a notice (as specified in § 268.7(a)(3)) to the land disposal facility indicating that EPA has granted an extension of time in which to comply with the applicable Part 268 Subpart D treatment standard. At the end of the national variance, the Part 268 Subpart D treatment standards take effect and the generator must follow one of the following sequences: Sequence 3: Treatment of a Restricted Waste, Sequence 5: Case-by-Case Extensions, Sequence 6: No Migration Petition, Sequence 8: Delisting, or Sequence 10: Change Production Process, Recycle or Don't Produce Waste.

BILLING CODE 6560-50-M

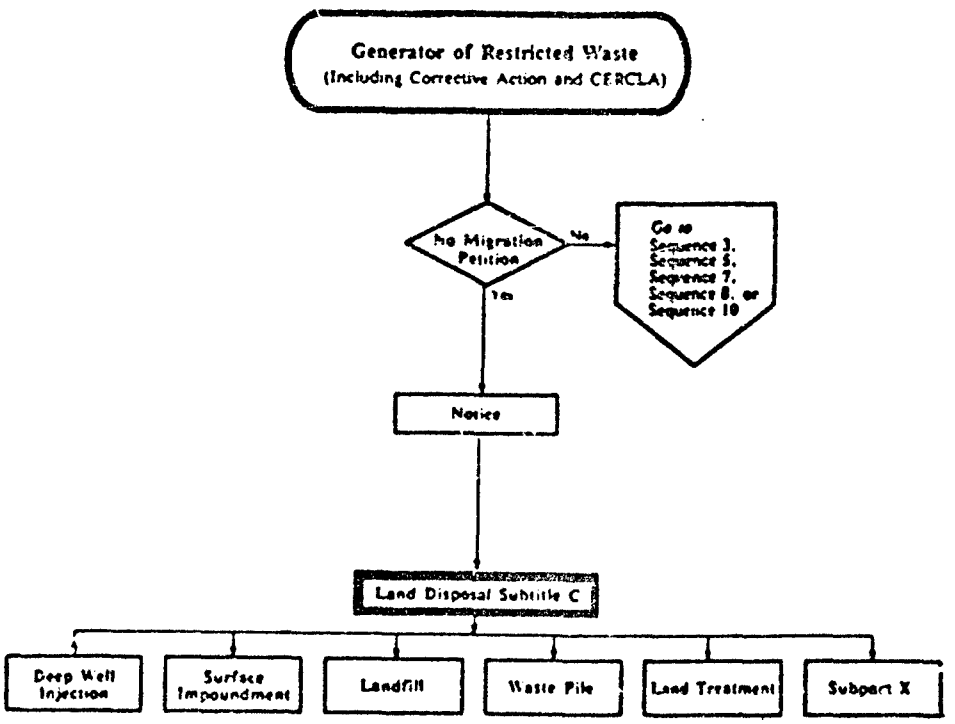
Sequence 9: Case-by-Case Extension



Sequence 5 in the generator's decision-making process commences with a determination that the restricted waste does not comply with the applicable §§ 268.41 or 268.43 treatment standards or that the waste must be treated in accordance with the treatment method required under § 268.42. Continued placement of the restricted waste in land disposal units as of the applicable effective date, as specified in Part 268 Subpart C, is prohibited. The generator may submit an application to EPA, as specified in § 268.5, for an extension of time to comply with the Part 268 Subpart D treatment standards by demonstrating binding contractual commitments to construct or otherwise obtain access to alternative treatment, recovery or disposal capacity and that such capacity is not available by the date that the Subpart D treatment standards take effect due to circumstances beyond his control. Case-by-case extensions may be granted by EPA for two 1-year periods. The extension does not become effective until the notice of approval appears in the Federal Register as specified in § 268.5(g). The generator must forward a notice, as specified in § 268.7(a)(3), stating that the waste is exempt from the land disposal restrictions to the Subtitle C land disposal facility receiving the restricted waste.

If the generator is denied a case-by-case extension, the next step in this sequence is the consideration of the following waste management options: the generator must successfully find available treatment capacity (Sequence 3), submit a no migration petition (Sequence 6), submit a delisting petition (Sequence 8), change his production processes, or recycle so that restricted wastes are no longer generated (Sequence 10).

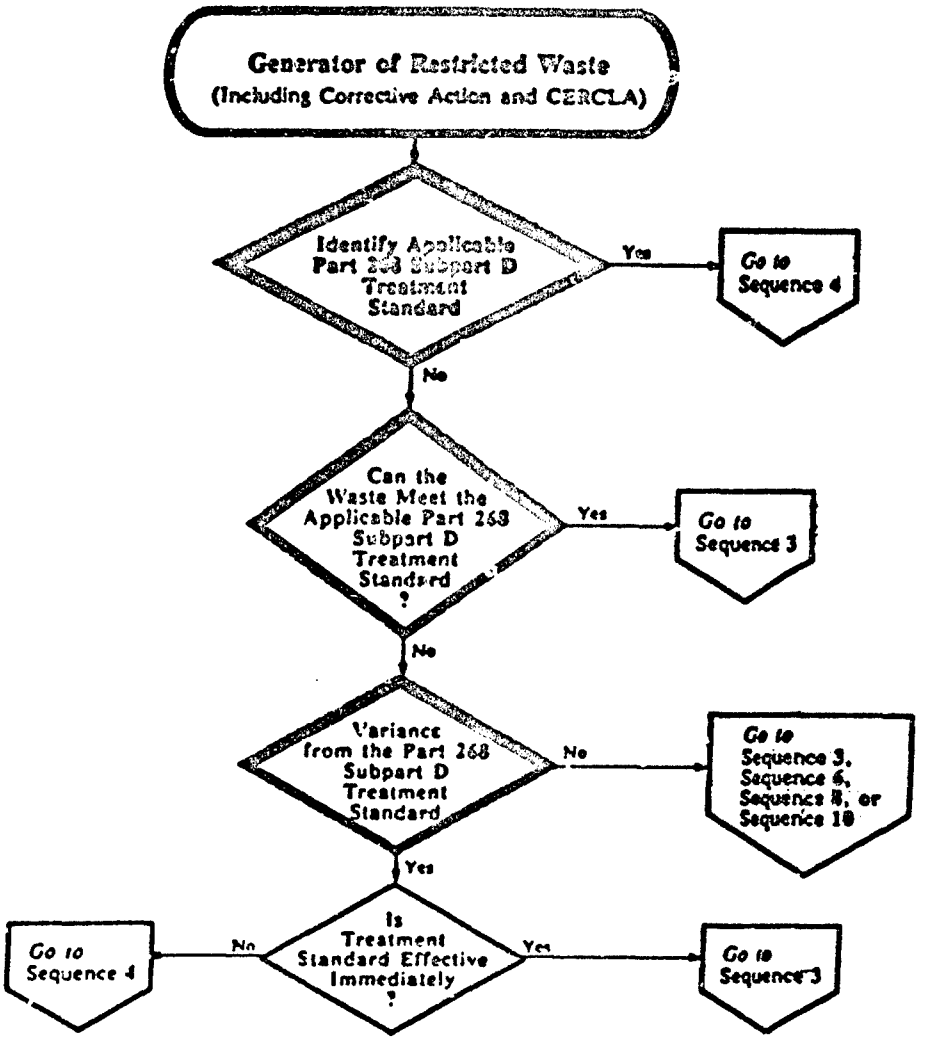
Sequence 6: No Migration Petition



Sequence 6 of the generator's decision-making process commences with a determination that the waste does not meet the §§ 268.41 of 268.43 treatment standards or that the waste must be treated by the method required in § 268.42 Wastes that do not comply with applicable §§ 268.41 or 268.43 treatment standards or are not treated by the method required in § 268.42 will be prohibited from continued placement in land disposal units as of the applicable effective date, unless the generator in conjunction with a Treatment, Storage, and Disposal Facility (TSDF) or a TSDF submits a no migration petition. The petition as specified in § 268.6 must demonstrate that there will be no migration of hazardous constituents from the continued land disposal of particular restricted hazardous wastes at a specific land disposal unit for as long as the waste remains hazardous. The land disposal facility must have either interim status or a RCRA permit, as required in 40 CFR Part 270, to manage the waste. The no migration petition will be a difficult demonstration, but the Agency has identified the following three scenarios that may satisfy the requirements of the statutory standard of "no migration": (1) A situation where environmental parameters are such that no detectable migration of hazardous constituents would occur from the disposal unit; (2) a situation where an active process is taking place rendering the waste non-hazardous; or (3) a situation where hazardous waste is being stored temporarily in a waste pile where engineered controls are sufficient to prevent migration in the short term. Although the Agency is not providing guidance on the no migration petition at this time, it is, however, offering the opportunity for preapplication meetings as assistance in preparing a no migration petition. As a result of such a meeting both the Agency and the petitioner will gain a better understanding of what must be included in the petition and the probability of developing a successful petition. An approved petition allows the land disposal of specific restricted wastes at a specific site. A facility must observe approval in the Federal Register (§ 268.6(g)) before it can land dispose a restricted waste. The generator must forward a notice as specified in § 268.7(a)(3) stating that the waste is exempt from the land disposal restrictions to the Subtitle C facility receiving the restricted waste.

Where a no migration petition is not granted, the generator may follow courses of action in accordance with the following sequences: Sequence 3: Treatment of a Restricted Waste, Sequence 5: Case-By-Case Extensions, Sequence 7: Variance From a Treatment Standard, Sequence 8: Delisting, or Sequence 10: Change Production Process, Recycle, or Don't Produce the Waste.

Sequence 7: Variance From a Treatment Standard

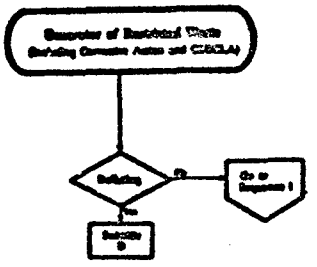


Sequence 7 of the generator's decision-making process begins when a generator determines that he cannot treat the waste to the Part 268 Subpart D treatment standard as specified in §§ 268.41, 268.42, or 268.43. The generator may submit a petition for a variance from the treatment standard as specified under § 268.44. The Agency envisions that wastes may be subject to a treatability variance in cases where a waste is not treatable to the level or by the method specified in the treatment standard. This may occur when a waste is significantly different from the wastes considered in establishing the treatment standard either because the waste matrix is complex and more difficult to treat or the waste contains higher concentrations of the hazardous constituents. The information as specified in §§ 268.44 must be included in the petition for a variance from a Part 268 Subpart D treatment standard.

When the Agency grants a variance from a treatment standard, it must subsequently make a national capacity determination regarding the availability of appropriate treatment capacity for that waste. For those wastes where EPA determines that capacity for the appropriate treatment technology is adequate, the performance standard set as a result of the variance from the treatment standard will take effect immediately upon promulgation. Otherwise, the Agency will grant a national capacity variance (Sequence 4) of up to two years during which time the continued placement of untreated waste in land disposal facilities regulated under Subtitle C of RCRA will be allowed.

Where a variance from a treatment standard is not granted, the waste may be managed in accordance with Sequence 3: Treatment of Restricted Wastes, Sequence 6: Case-By-Case Extension, Sequence 8: No Migration Petition, Sequence 9: Delisting, and Sequence 10: Change Production Process, Recycle, or Don't Produce the Waste.

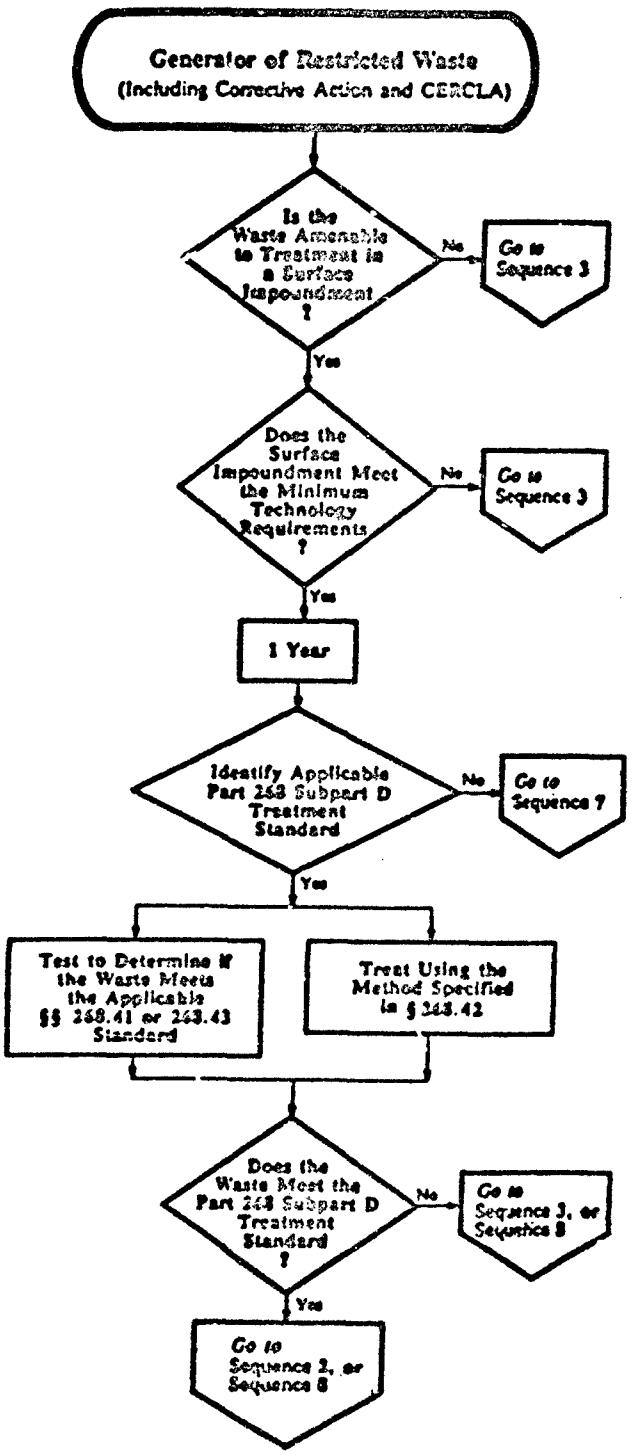
Sequence 8 Delisting



Sequence 8 commences with the generator's determination that the waste is restricted (40 CFR Part 268 Subpart C). Upon evaluation of the available waste management options, and possibly after treatment (including treatment not meeting the treatment standards of §§ 268.41–268.43) the generator may decide to submit a petition to EPA for a site-specific delisting, pursuant to the provisions in 40 CFR 260.22. Delisted wastes are no longer considered hazardous and may be disposed in a Subtitle D facility.

The generator may choose to submit a delisting petition to the Agency after the restricted waste has been treated to the Part 268 Subpart D treatment standard as well as after the denial of any of the exceptions to achieving the Part 268 Subpart D treatment standard.

Sequence 2: Surface Impoundment Exemption



BILLING CODE 6560-50-C

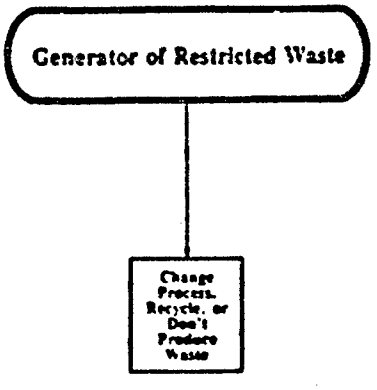
Sequence 9 in the generator's decision-making process commences with a determination by the generator that the restricted waste does not comply with the applicable Part 268 Subpart D treatment standard and will be prohibited from continued placement in land disposal units as of the applicable effective date. The generator may treat in an interim status or RCRA permitted surface impoundment meeting the minimum technology requirements in accordance with 40 CFR 264.221(c) and 265.221(c) and that is in compliance with 40 CFR Part 264 or 265 Subpart F as applicable (i.e., it has been constructed with two or more liners, and a leachate collection system, and is in compliance with ground water monitoring requirements). On an annual basis, the facility must identify the treatability group and Part 268 Subpart D treatment standard applicable to the contents of the surface impoundment. If the applicable Part 268 Subpart D treatment standard is specified in § 268.42, the contents of the surface impoundment must be treated using the required method.

A request for a variance from the treatment standards, (as specified in § 268.44), set under Part 268 Subpart D may be submitted if in the identification of an applicable Part 268 Subpart D treatability group the response is negative.

The need for treatment depends on the concentration of the hazardous constituents in the waste extract as specified in § 268.41 or on the concentration of the hazardous constituents in the waste itself as specified in § 268.43. Therefore, the facility must analyze the contents of the surface impoundment annually in accordance with § 268.4(a)(2). Impoundment residues that do not meet the applicable Part 268 Subpart D treatment standards (§§ 268.41 or 268.43) must be removed and managed as a restricted waste, and cannot be further treated in a surface impoundment. The options available for management of the restricted waste are as discussed in Sequence 3: Treatment of Restricted Wastes, Sequence 8: No Migration Petition, and Sequence 8: Delisting.

Surface impoundment residues that meet the applicable Part 268 Subpart D treatment standard are exempt from the statutory prohibitions on land disposal. The residue may remain in the impoundment or may be otherwise land disposed in a Subtitle C facility. If the residue remains in the surface impoundment, certification that the hazardous waste complies with the treatment standard must be put in the operating record of the land disposal unit. Residues that are removed and land disposed off-site must be accompanied with the notice and certification as specified in § 268.7(a)(2).

Sequence 10: Change Production Process, Recycle or Don't Produce the Waste



Sequence 10 of the generator's decision-making process represents an opportunity that always presents itself to any generator of hazardous wastes: the decision to change production processes or to recycle wastes so that restricted hazardous wastes are no longer produced. Waste minimization is strongly encouraged.

X. Regulatory Requirements

A. Regulatory Impact Analysis

Executive Order 12291 requires EPA to assess the effect of contemplated Agency actions during the development of regulations. Such an assessment consists of a quantification of the potential benefits and costs of the rule, as well as a description of any beneficial or adverse effects that cannot be quantified in monetary terms.

In addition, Executive Order 12291 requires that regulatory agencies prepare an analysis of the regulatory impact of major rules. Major rules are defined as those likely to result in:

1. An annual cost to the economy of $100 million or more; or

2. A major increase in costs or prices for consumers or individual industries; or

3. Significant adverse effects on competition, employment, investment, productivity, innovation, or international trade.

The Agency has performed an analysis of the rule to assess the economic effect of associated compliance costs. Based on this analysis, EPA has determined that restricting the land disposal of solvent and dioxin wastes will constitute a major rule as defined by Executive Order 12291, because the total annualized cost of this rule is $152.4 million. In consequence, EPA has prepared a regulatory impact analysis of this rule.

The remainder of Unit X describes the economic analysis performed by EPA in support of today's final rule.

1. Cost and Economic Impact Methodology

EPA has assessed the cost and potential economic effects of today's rule and of the major regulatory alternatives. For its analysis of solvent wastes, EPA has examined two alternatives to today's final rule. The first alternative is to codify the statutory prohibition on land disposal of affected wastes. This approach would prohibit the land disposal of all solvent wastes at any concentration. The second approach is to use risk-based screening levels in the development of treatment standards. Costs and benefits of both these alternatives are described in more detail in the regulatory impact analysis of restricting solvents from land disposal.

For dioxin wastes, no less stringent alternative could be examined, because the dioxin listing requires incineration to six 9s DRE or the application of a thermal technology of equivalent performance.

The methodology for establishing total costs and impacts involves three steps. First, EPA estimates the population of facilities and waste management practices which will be affected. Next, total social costs of the regulation are derived by adding costs for individual facilities. Finally, economic impacts on affected facilities are assessed.

a. Affected population and practices. The affected population is the total number of hazardous waste treatment, storage and disposal facilities (TSDFs) and generators land disposing of affected wastes either directly at the generation site or indirectly through the purchase of commercial land disposal services. This group's waste management practices are assessed to identify costs of managing wastes and incremental cost increases attributable to today's rule.

The number of facilities that land dispose of affected wastes was determined using the EPA's 1981 RIA

Mail Survey.[19] Waste quantities and management practices for facilities responding to the Mail Survey are scaled up to represent the national population by means of weighting factors developed for the Survey. EPA estimates that 74 facilities comprise the total national population of commercial and noncommercial facilities land disposing of affected wastes on-site.

EPA estimates that generators sending more than 1,000 kilograms per month of waste off-site for management add an additional 5,511 plants. Generators of less than 1,000 kilograms per month were not included in the 1981 Survey because they were considered exempt at that time.

Because the 1984 RCRA amendments direct EPA to lower the exemption for small quantity generators (SQGs) from 1,000 to 100 kilograms per month by March 31, 1988, SQGs generating between 100 and 1,000 kilograms of waste per month for off-site disposal are also included in the affected population. The Agency estimates that SQGs add 14,400 plants to the affected population. Plant and waste specific data on this group are derived from EPA's Small Quantity Generator Survey.

Current management practices for these groups include the cost of compliance with regulations which have taken effect since 1981. In particular, EPA adjusted waste management practices as reported in 1981 to reflect compliance with the provisions of 40 CFR Part 264 of RCRA. In making this adjustment, the Agency assumes facilities elect the least costly legal methods of compliance.

b. Development of costs. Once waste quantity, type and method of treatment are known for the affected population, EPA estimates costs of compliance for individual facilities. The Agency developed facility-specific costs in two components, which are weighted and then summed to estimate total national costs of the rule. The first component of the total compliance cost is incurred annually for operation and maintenance (O&M) of alternative modes of waste treatment and disposal. The second component of the compliance cost is a capital cost, which is an initial outlay incurred for construction and depreciable assets. Capital costs are restated as annual values using a capital recovery factor based on a real cost of capital of 7 percent. These annualized costs are then added to yearly O&M costs to derive an annual equivalent cost. This is EPA's estimate of the impact of the regulation on annual firm cashflow.

c. Economic Impact Analysis. (1) Non-Commercial TSDFs and SQGs. Economic impacts on non-commercial facilities and SQGs are assessed in several steps. First, a general screening analysis compares facility-specific incremental costs to financial information about firms, disaggregated by Standard Industrial Classification (SIC) and number of employees per facility. This comparison generates two ratios, which are used to identify facilities likely to experience adverse economic effects. The first is a ratio of individual facility compliance costs to costs of production. A change exceeding five percent is considered to imply a substantial adverse economic effect on a facility. The second is a "coverage" ratio, relating cash flow from operations to cost of compliance. For this ratio, a value of less than 20 is considered to represent a significant adverse impact.

Once facilities experiencing adverse impacts are identified using the two screening ratios, more detailed financial analysis is performed to verify the results and focus more closely on affected firms. For this subset of facilities, the coverage ratio is adjusted to allow a portion of costs to be passed through. Economic effects on facilities are examined assuming product price increases of one and five percent are possible. Those facilities for which the coverage ratio is less than two are considered likely to close.

(2) Commercial TSDFs. Commercial TSDFs are defined here as those facilities which accept fees in exchange for managing wastes generated elsewhere. For this group of facilities, there exists no Census SIC from which to draw financial information. Two SICs which we might use as proxies, 4953 and 4959, do not distinguish between financial data for hazardous waste treatment firms and for firms managing municipal wastes. Consequently, our analysis of economic effects on commercial facilities is qualitative.

(3) Generators of large quantities of wastes. EPA's analysis of the effects of this rule on generating plants disposing of large quantities of affected wastes off-site assumes that commercial facilities can entirely pass on to them the costs of compliance with this regulation in the form of higher prices for waste management services. Because of data limitations in the Mail Survey, EPA has not developed plant-specific waste characterizations, treatment methods, and compliance costs for generators, as it has for TSDFs. Our analysis of the economic effects of the rule on this group uses Survey data to develop model plants generating average, maximum and minimum waste quantities. This allows EPA to assess the range of possible effects on generating plants.

2. Costs and Economic Impacts

a. Total costs and economic impacts for solvent wastes. Total annualized compliance costs for facilities currently land disposing of solvent wastes are $147 million. Commercial TSDFs account for 82 percent of this total, while non-commercial TSDFs account for the balance. Although SQGs constitute 72 percent of the total population of TSDFs and generators of solvent waste, they account for only 12 percent of the total costs. These costs are not adjusted for the effect of taxation, which is merely a transfer from one sector of the economy to another. Costs are stated in 1985 dollars.

Economic effects have been assessed for both non-commercial and commercial facilities. Non-commercial facilities are those which do not accept fees in exchange for management and disposal of wastes generated by other plants. Among the 68 non-commercial facilities, twelve appear likely to be significantly affected because of compliance costs imposed by this rule. Based on further analysis, three of these twelve facilities seem likely to close. Employment effects associated with these potential closures amount to 224 jobs lost.

Among commercial facilities (i.e., those which manage the wastes of other firms for a fee) direct effects were impossible to assess due to the lack of any appropriate Standard Industrial Classification code (SIC) from which to draw Census financial data. Therefore, EPA's analysis has assumed that commercial facilities will be able to pass the increased costs of regulatory compliance on to their customers in the form of higher prices. The cost of compliance with today's rule is thus assumed to fall on consumers of commercial hazardous waste management services, and a qualitative assessment of economic effects on commercial facilities is performed.

We estimate that 73 commercial facilities will incur incremental costs as a result of today's final rule. Forty percent of these commercial facilities

[19] EPA conducted the RIA Mail Survey of hazardous waste generators and TSDFs to determine waste management practices in 1981. The survey included both generators of hazardous wastes and facilities treating, storing, or disposing of wastes. Facilities that handled less than 1000 kilograms of waste per month were not regulated in 1981 and thus, are not included in the data. For more information see the "National Survey of Hazardous Waste Generators and Treatment, Storage and Disposal Facilities Regulated under RCRA in 1981," (April 1984).

offer a range of hazardous waste management services, including land-based disposal, storage and treatment. For these facilities, the increased demand this rule will create for more highly-price treatment services may actually increase firm financial viability. For the 27 percent of commercial facilities which offer solely land-based management of restricted wastes, on the other hand, the increased emphasis on treatment prior to land disposal may reduce demand for these services. It was not possible to characterize the remaining 33 percent of commercial facilities based on services offered.

Based on RIA Mail Survey data, the five industrial sectors which send the majority of the solvent waste to each commercial facility have been identified. Actual plants generating these wastes cannot be identified using Mail Survey data. Therefore, EPA examines economic effects on generating plants using model plants generating minimum, maximum and average quantities for each sector identified in the RIA Mail Survey. Ratios of the compliance costs to costs of production, and gross margin to compliance costs are examined for each of the five sectors which sends affected waste to each of these 28 facilities. This procedure is intended to bound the range of economic effects likely to occur among generating plants. Economic effects presented in this unit are based on average waste quantities.

This analysis identifies 93 industrial sectors, representing 5,511 plants, generating solvent waste for off-site commercial management. Of these 5,511 plants, 1,004 may experience significant economic impacts. Among the most adversely affected plants are manufacturers of fabricated metals products (SIC 34). This sector includes 718 significantly affected facilities. Other affected sectors include SIC 33, primary metals products, in which 197 plants may close, and SIC 28, the chemical industry, in which 42 plants may close. Based on further analysis, 79 of these facilities appear likely to close. Job loss associated with these closures amounts to 5,240 jobs in the plating and polishing industry and 167 in the industrial inorganic chemicals industry. Total annualized costs for the 14,400 small quantity generators of solvent wastes are $18 million. Based on the estimated cost for off-site incineration, maximum incremental compliance charges for any individual SQG will not exceed $13,200 annually. Economic ratios were examined for all SQGs in each sector identified in the EPA survey as generating solvent wastes. Based on this examination, EPA identified 973 facilities which may be significantly affected by compliance costs of this rule. On closer examination, no SQGs appeared likely to close as a result of costs imposed by this rule.

b. Total costs and economic impacts for dioxin wastes. Total annualized compliance costs for the approximately 47 non-soil sources of dioxin wastes are $3.2 million. Costs for managing that portion of the estimated 1.1 billion pounds of existing dioxin-contaminated soil for which this regulation will require BDAT treatment are $2.2 million. A preliminary study of dioxin-contaminated soils suggests that only 5 percent of the total quantity will require incineration, and the costs reflect this finding. Ninety-five percent of these soils, EPA estimates, will not be subject to restrictions on land disposal because they will meet the treatment standard.

Economic effects appear most significant for plants in SIC 2899 as a result of the restriction of dioxin wastes. This sector manufactures industrial organic chemicals, with major products such as solvents, noncyclic organics, and polyhydric alcohols. One plant may close as a result of restrictions in this group. Other affected SIC sectors include 2879, in which one plant may close. SIC 2879 includes plants manufacturing pesticides and agricultural chemicals for household and farm use.

3. Benefits and Cost-Effectiveness of the Restrictions Rule

a. Benefits and cost-effectiveness of restricting land disposal of solvent-containing wastes. The Agency performed a benefits analysis that assessed the incremental reductions in human health effects taking into account net changes in risk resulting from the use of alternative solvent waste management practices. Based on this analysis of relative risks, it was determined that substantial reductions in both average and maximum health risks are possible when alternative technologies to land disposing solvent wastes are used. Incineration and distillation of halogenated (F001 and F002) solvent wastes result in substantial reductions in human health risk when compared to disposal of such wastes in land disposal units. Incineration reduces average risks by a minimum of four orders of magnitude from the levels for landfills, a factor that is similarly reflected by the reductions in risk to the most exposed individual (MEI). Risk reductions for halogenated solvent wastes disposed in surface impoundments are also substantial. For the non-halogenated wastes, although risk levels were substantially reduced, the reduction in human health risk were less significant, since initial levels were often below the Acceptable Daily Intake (ADI).

Benefits attributable to the restrictions on solvent wastes have also been assessed by the Agency in another regulatory impact analysis prepared in support of the overall land disposal restrictions program (see "Draft Regulatory Analysis of Proposed Restrictions on Land Disposal of Hazardous Wastes" in the RCRA docket entitled LDR-2). Relevant data on the restricted F001–F005 wastes provided in this analysis may be summed to obtain a total incremental benefit (number of cases of cancer or cancer-equivalence avoided) of 118 cases avoided or annualized benefits for solvents equal to 1.65 cases avoided. Division of the total annualized cost of the solvents land disposal restrictions, $147 million, by the annualized cases avoided, 1.65, determines that the cost of the regulation is $89.7 million per cancer case avoided.

The benefits in both RIA documents discussed above may be underestimated in this analysis because the estimates are based solely on the adverse human health effects resulting from exposure to the solvent constituents in these wastes. Other benefit considerations, specifically environmental benefits, risks from mobilization of liner degradation, and risks attributable to mobilization of other toxic constituents land disposed with solvents, were not evaluated. Since the benefits analysis is based only on the toxicity of the solvents themselves, the benefits of the land disposal restrictions for spent solvent wastes may be significantly underestimated.

b. Benefits and cost-effectiveness of restricting land disposal of dioxin-containing wastes. The assessment of risk associated with today's rule depends to a significant degree on assumptions regarding baseline disposal practices and on the population exposed to releases from land disposal. These assumptions and their effect on the benefit estimates are discussed in detail in the supporting RIA (Ref. 2).

Based on the assumptions regarding incineration performances and baseline practices that effectively minimize risks, it appears that reductions in expected health effects would be insignificant for many of the affected dioxin wastes. Baseline MEI risks for some dioxin wastes were high and would be reduced significantly by incineration. The benefits of the rule depend directly on whether discharge of contaminated water (with undetectable levels of

dioxin) from incinerators are likely to occur and whether spills and run-off from landfill or incineration facilities are likely to result in contamination of surface waters. Such surface water contamination, however, is not expected to occur. Although the rule may not reduce expected levels of health effects for many types of dioxin wastes, it may reduce the uncertainty about potential risks associated with the current regulatory status for dioxins.

Quantification of the incremental benefits for restricting land disposal of dioxin wastes results in a calculated annualized dioxin benefit value of zero cases avoided, though as noted above, this risk estimate is very dependent on assumptions about population exposed and treatment of scrubber waters from incinerators (of which there are currently none), and may significantly underestimate actual risk reductions.

B. Regulatory Flexibility Analysis

Pursuant to the Regulatory Flexibility Act, 5 U.S.C. 601 *et seq.*, whenever an agency is required to publish a notice of rulemaking for any proposed or final rule, it must prepare and make available for public comment a regulatory flexibility analysis which describes the effect of the rule on small entities (i.e., small businesses, small organizations, and small governmental jurisdictions). This analysis is unnecessary, however, if the Administrator certifies that the rule will not have a significant economic effect on a substantial number of small entities.

EPA has examined the rule's potential effect on small business as required by the Regulatory Flexibility Act, and has concluded that this regulation will not have a significant effect on a substantial number of small entities. As a result of this finding, EPA has not prepared a formal Regulatory Flexibility Analysis in support of this rule. The following discussion summarizes the methodology used in the small business analysis and the findings on which the conclusions above are based. More detailed information is available in the documents assembled in the record prepared in support of this rulemaking.

1. Economic Impact on Small Businesses

EPA evaluated the economic effect of today's rule on small businesses, which are defined as those facilities employing fewer than 50 persons. Because of data limitations, this small business analysis excludes generators of large quantities of affected wastes. The universe of small businesses that were examined in the analysis here includes two groups: all TSDFs employing fewer than 50 people, and all SQGs which are also small businesses. Eleven TSDFs are small businesses. None of these exceed threshold values on the cost of production ratio. Twenty-five percent (twelve out of 48) of all non-commercial facilities are expected to experience adverse economic effects.

Of the total of 14,400 small quantity generators examined in this analysis, the vast majority (10,800 or 75 percent) are also small businesses. A total of 83 SQGs (or .8 percent of small businesses SQGs) exceeded threshold values on the cost of production ratio. For the population of small businesses as a whole, less than one percent are likely to be affected.

The small business analysis performed for sources of dioxin wastes revealed that no plants employing fewer than 50 persons experience significant economic effects as a result of costs imposed by this regulation.

2. Certification of Finding That No Regulatory Flexibility Analysis Is Required

This rule was submitted to the Office of Management and Budget (OMB) for review, as required by Executive Order 12291. EPA performed an analysis, described above, to determine whether this rule would impose significant costs on small entities (see U.S. EPA, 1985). Results of the analysis indicate that this rule will not have a significant economic impact on a substantial number of small entities.

Accordingly, I hereby certify that this regulation will not have a significant impact on a substantial number of small entities. Therefore, this regulation does not require a Regulatory Flexibility Analysis.

C. Review of Supporting Documents and Response to Public Comment

1. Review of Supporting Documents

The primary source of information on current land disposal practices and industries affected by restrictions on solvent waste is EPA's 1981 *National Survey of Hazardous Waste Generators and Treatment, Storage and Disposal Facilities* (referred to in this preamble as the "RIA Mail Survey"). Waste stream characterization data and engineering costs of waste management are based on the Mail Survey and on reports by the Mitre Corporation "Composition of Hazardous Waste Streams Currently Incinerated," (April 1985), and U.S. EPA, "The RCRA Risk-Cost Analysis Model," (March 1984). The survey of Small Quantity Generators has been the major source of data on this group. EPA's Office of Research and Development developed estimates of the type and quantity of wastes containing dioxins and meeting the listing definitions for these wastes.

For financial and value of shipment information for the general screening analysis, 1982 Census data was used, adjusted by 1983 Annual Census of Manufactures data. Producer price indices were also used to restate 1983 dollars in 1985 terms.

2. Response to Comments

Several commenters contend that EPA has grossly understated the total costs of this rule because the Agency failed to consider product substitution. In particular, commenters were concerned that some producers of certain inputs to other end products may suffer as downstream manufacturers switch to inputs which generate less hazardous waste.

EPA disagrees with the commenters' statement that the total cost of the rule is understated. In fact, because EPA's analysis does not allow for longer term market adjustments such as product-substitution, it overstates total costs. The switch to products and inputs which generate less hazardous waste will undoubtedly cause short-term dislocation and economic hardships, both to the suppliers of highly polluting inputs and to the manufacturers forced by higher waste treatment costs to switch to higher cost inputs.

Other commenters argue that the Agency has not sufficiently balanced cost and risk in designing regulations restricting land disposal. EPA believes that its consideration of costs and benefits has been comprehensive and consistent with Executive Order 12291.

One commenter stated the EPA's assessment that land disposal restrictions on solvent wastes did not constitute a major rule was incorrect. EPA agrees with the commenter. Based on the Agency's reassessment of treatment costs, EPA now considers this final rule to be major by the criteria given in Executive Order 12291.

Another commenter expressed concern that restricted wastes will compete with non-restrictive wastes for alternative capacity. Given the cost differential between direct land disposal, which EPA is prohibiting for regulated waste, and treatment through incineration or other treatment technology, it is likely that restricted wastes will use what limited incineration capacity exists.

The commenter contends petitioners that the increased demand for waste treatment services may have the effect of driving up the price of these services, thus making it uneconomic for non-

restricted wastes to be treated to RDAT treatments. EPA also believes it likely that alternative capacity will be rationed through the medium of price, and that producers of non-restricted wastes may find the new price prohibitive. This effect of establishing treatment priorities is expected to prevent the use of limited incineration capacity on non-restricted wastes which do not present the environmental dangers associated with restricted wastes.

Finally, some commenters objected that EPA did not consider economic achievability in setting treatment standards. Economic achievability is not a consideration for rulemaking under RCRA.

D. Paperwork Reduction Act

The Paperwork Reduction Act of 1980, 44 U.S.C. 3501 et seq., requires that the information collection requirements of proposed and final rules be submitted to the Office of Management and Budget (OMB) for approval. OMB has approved the information collection requirements contained in this rule and assigned the OMB Control Number 2050-0085.

This rule modifies another information collection requirement that has been approved by OMB under the Paperwork Reduction Act and given the number 2050-0012. The appropriate changes to these requirements have been approved by OMB.

XI. References

Background Documents

(1) U.S. EPA. "Background Document for Solvents, to Support Land Disposal Restrictions, Vol. 1." U.S. EPA, OSW, Washington, DC, 1986.

(2) U.S. EPA. "Background Document for Solvents, to Support Land Disposal Restrictions, Vol. 2." U.S. EPA, OSW, Washington, DC, 1986.

(3) U.S. EPA. "Background Document for Toxicity Characteristic Leaching Procedure: Final TCLP Response to Technical and Procedural Comments Received to the Final Land Disposal Restrictions Rule for Solvents and Dioxins." U.S. EPA, OSW, Washington, DC, 1986.

(4) U.S. EPA. "RDAT Background Document for F001–F005 Spent Solvents." U.S. EPA, OSW, Washington, DC, 1986.

(5) U.S. EPA. "Comparative Risk Case Study for Metal-Bearing Solvent Wastes." U.S. EPA, OSW, Washington, DC, 1986.

(6) U.S. EPA. "Thermal Treatment Background Information, to Support Land Disposal Restrictions." U.S. EPA, OSW, Washington, DC, 1986.

Guidance Documents

(7) U.S. EPA. "Interim Status Surface Impoundments Retrofitting Variances Guidance Document." U.S. EPA, OSW, Washington, DC, EPA/530-SW-86-017, 1986.

(8) U.S. EPA. "Waste Analysis Plans, A Guidance Manual." U.S. EPA, OSW, Washington, DC, 1986.

Regulatory Impact Analysis

(9) U.S. EPA. "Regulatory Analysis of Restrictions on Land Disposal of Certain Dioxin-Containing Wastes." U.S. EPA, OSW, Washington, DC, 1986.

(10) U.S. EPA. "Regulatory Analysis of Restrictions on Land Disposal of Certain Solvent Wastes." U.S. EPA, OSW, Washington, DC, 1986.

Other References

(11) Acurex Corp. "Characterization of Hazardous Waste Incineration Residuals." U.S. EPA, Contract No. 68-02-3991, 1986.

(12) ICF, Inc. "Assessment of Impacts of LDR on Ocean Disposal of Solvents, Dioxins, and California List Wastes." U.S. EPA, OSW, EPA Contract No. 68-01-7038, 1986.

(13) ICF, Inc. "Scoping Analysis for RCRA Section 3004(j)(11)." U.S. EPA, OSW, EPA Contract No. 68-01-6621, 1986.

(14) Industrial Economics. "Regulatory Analysis of Waste-As-Fuel Technical Standards." Prepared for U.S. EPA, OSW, Washington, DC, 1986.

(15) Mitre Corp. "Incineration and Cement Kiln Capacity for Hazardous Waste Treatment." U.S. EPA, OSW, Washington, DC, 1986.

(16) NATO Committee. "NATO–CCMS Pilot Study on Disposal of Hazardous Wastes." Annex V. NATO Committee on the Challenges of Modern Society, Brussels, Belgium, 1979.

(17) Radian Corp. "Follow-Up Survey of Selected Facilities." U.S. EPA, Washington, DC, 1986.

(18) Reed, R.J. *North American Combustion Handbook*. 1978.

(19) U.S. EPA. "Analysis of the Quantity of Waste from CERCLA Actions." Raw Data. U.S. EPA, OSW, Washington, DC, 1986.

(20) U.S. EPA. "Development Document for Effluent Limitations Guidelines and Standards for the Pharmaceutical Manufacturing Point Source Category." U.S. EPA, OW, Washington, DC, EPA/440–1–83/084, pp. 120–129, 1983.

(21) U.S. EPA. "Telephone Verification Survey of Commercial Facilities That Manage Solvents." Compiled by Pope-Reid Assoc. and Radian Corp., U.S. EPA, OSW, Washington, DC, 1986.

(22) U.S. EPA. "RCRA Method 8280 for the Analysis of Polychlorinated Dibenzo-A-Dioxins and Polychlorinated Dibenzofurans." U.S. EPA, OSW, Washington, DC, September 15, 1986.

(23) Friedman, Paul (U.S. EPA, Office of Solid Waste), Memorandum entitled "Detection Limit of 8280 in TCLP Leachate." September 12, 1986.

(24) U.S. EPA. "Background Document for Proposed Toxicity Characteristic Leaching Procedure." U.S. EPA, OSW, Washington, DC, March 29, 1986.

List of Subjects in 40 CFR Parts 260, 261, 262, 264, 265, 268, 270, and 271

Administrative practice and procedure, Confidential business information, Environmental protection, Hazardous materials, Hazardous materials transportation, Hazardous waste, Imports, Indian lands, Insurance, Intergovernmental relations, Labeling, Packaging and containers, Penalties, Recycling, Reporting and recordkeeping requirements, Security measures, Surety bonds, Waste treatment and disposal, Water pollution control, Water supply.

Lee M. Thomas,
Administrator.

For reasons set out in the preamble, Chapter I of Title 40 is amended as follows:

PART 260—HAZARDOUS WASTE MANAGEMENT SYSTEM: GENERAL

I. In Part 260:

1. The authority citation for Part 260 continues to read as follows:

Authority: Secs. 1008, 2002(a), 3001 through 3007, 3010, 3014, 3015, 3017, 3018, and 7004, Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6908, 6912(a), 6921 through 6927, 6930, 6934, 6935, 6937, 6938, and 6974).

§§ 260.1, 260.2, 260.3, 260.10, 260.20 [Amended]

2. By inserting in the first sentence "and 268" after the phrase "Parts 262 through 265" in the following places:

a. 40 CFR 260.1 (a) and (b)(1) through (4).

b. 40 CFR 260.3(a).

c. 40 CFR 260.3 introductory text.

d. 40 CFR 260.10 introductory text.

e. 40 CFR 260.20(a).

§ 260.2 [Amended]

3. In § 260.2, paragraph (b) is amended by inserting "and 268" after the phrase "Parts 262 through 265"

PART 261—IDENTIFICATION AND LISTING OF HAZARDOUS WASTE

II. In Part 261:

1. The authority citation for Part 261 continues to read as follows:

Authority: Secs. 1006, 2002(a), 3001, and 3002 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6905, 6912(a), 6921, and 6922).

§§ 261.1, 261.4, 261.20, 261.30 [Amended]

2. By adding the Part number "268," after the phrase "Parts 262 through 265" in the following places:

a. 40 CFR 261.1(a) introductory text;

b. 40 CFR 261.4(e);

c. 40 CFR 261.20(b); and

d. 40 CFR 261.30(d).

§ 261.1 [Amended]

3. In § 261.1, paragraph (a)(1) is amended by inserting ", 267" after the phrase "Parts 264 through 265".

§ 261.4 [Amended]

4. By removing from paragraph (d)(1) introductory text of § 261.4 the Part number "265" and inserting the Part number "266" in its place.

§ 261.5 [Amended]

5. In § 261.5 paragraphs (b), (c), (e) introductory text, and (f)(1) are amended by inserting ", 266," after the phrase "Parts 262 through 265".

6. In § 261.5 paragraph (e)(2) is amended by inserting ", 266," after the phrase "Parts 262 through 265".

§ 261.6 [Amended]

7. In § 261.6 paragraph (a)(2) introductory text is amended by inserting Part number "266," after the phrase "Part 262 through 265 or Parts".

8. By revising paragraph (c)(3) of § 261.6 to read as follows:

§ 261.6 Requirements for recyclable materials.

* * * * *

(c)(1) Owners or operators of facilities that store recyclable materials before they are recycled are regulated under all applicable provisions of Subparts A through L of Parts 264 and 265, and under Parts 124, 228, 270, and 270 of this Chapter and the notification requirements under section 3010 of RCRA, except as provided in paragraph (a) of this section. (The recycling process itself is exempt from regulation.)

* * * * *

§ 261.7 [Amended]

9. In § 261.7 paragraphs (a)(1)(ii) and (2)(iii) are amended by adding the Part number "266," after the phrase "Parts 261 through 265, or Part".

PART 262—STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE

III. In Part 262:

1. The authority citation for Part 262 continues to read as follows:

Authority: Secs. 1006, 2002, 3002, 3003, 3005, 3006, 3008, and 3017 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6918, 6912, 6922 through 6924, and 6937)

Subpart A—General

2. In § 262.11, paragraph (d) is added to read as follows:

§ 262.11 Hazardous waste determination.

* * * * *

(d) If the waste is determined to be hazardous, the generator must refer to Parts 264, 265, 266 of this chapter for possible exclusions or restrictions pertaining to management of the specific waste.

PART 263—STANDARDS APPLICABLE TO TRANSPORTERS OF HAZARDOUS WASTE

IV. In Part 263:

1. The authority citation for Part 263 is revised to read as follows:

Authority: Secs. 2002(a), 3002, 3003, 3017, 3018, and 3020 of the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 and as amended by the Quiet Communities Act of 1978 (42 U.S.C. 6912a, 6922, 6923, 6937, 6938).

Subpart A—General

§ 263.12 [Amended]

2. By inserting ", 266" after the phrase "Parts 270, 124, and 22".

PART 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE AND DISPOSAL FACILITIES

V. In Part 264:

1. The authority citation for Part 264 continues to read as follows:

Authority: Secs. 1006, 2002, 3004, and 3005 of the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6912, 6912a, 6924, and 6925).

Subpart B—General Facility Standards

2. In § 264.13, by revising paragraphs (a)(1) and (b)(2) and adding paragraph (b)(7) to read as follows:

§ 264.13 General waste analysis.

(a)(1) Before an owner or operator treats, stores, or disposes of any hazardous waste, he must obtain a detailed chemical and physical analysis of a representative sample of the waste. At a minimum, this analysis must contain all the information which must be known to treat, store or dispose of the waste in accordance with the requirements of this part of Part 265 of this chapter or with the conditions of a permit issued under Part 270 and Part 124 of this chapter.

* * * * *

(b) * * *

(2) Where applicable, the methods which will be used to meet the additional waste analysis requirements for specific waste management methods as specified in §§ 264.17, 264.314, 264.347, and 264.7 of this chapter;

(7) For facilities that conduct boards exempted from land disposal restrictions under § 268.6(a), the procedures and schedules for:

(i) The sampling of impoundment contents;

(ii) The analysis or test data; and,

(iii) The annual removal of residues which are not restricted wastes under Part 268 Subpart D of this chapter.

* * * * *

Subpart C—Preparedness, Prevention, and Contingency Plan

3. In § 264.73, by revising paragraph (b)(2) and adding paragraphs (b)(14) through (b)(16) to read as follows:

§ 264.73 Operating record.

* * * * *

(b) * * *

(2) Records and results of waste analyses performed as specified in §§ 264.13, 264.17, 264.314, 264.347, 264.6(a), and 268.7 of this chapter.

* * * * *

(10) Records of the quantities (and date of placement) for each shipment of hazardous waste placed in land disposal units under an extension to the effective date of any land disposal restriction granted pursuant to § 268.5 of this chapter, a petition pursuant to § 268.6, and the certification required by a generator under § 268.7(a)(2).

(11) For an off-site land disposal facility, a copy of the notice required by a generator under § 268.7(a)(2).

(12) For an on-site land disposal facility, the information contained in the notice required by a generator under § 268.7(a)(1), except for the manifest number.

(13) For an off-site land disposal facility, a copy of the notice and certification required by the owner or operator of a treatment facility under § 268.7(b)(3) and (4), or a copy of the notice and certification required by the generator under § 268.7(a)(2), whichever is applicable; and

(14) For an on-site land disposal facility, the information contained in the notice required under § 268.7(a)(1), except for the manifest number, the information contained in the notice required by a generator under § 268.7(b)(3) except for the [illegible] whichever is applicable.

(Approved by Office of Management and Budget under control number [illegible])

PART 265—INTERIM STATUS STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

VI. In Part 265:

1. The authority citation for Part 265 continues to read as follows:

Authority: Secs. 1006, 2002(a), 3004, 3005 and 3015 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6905, 6912(a), 6924, 6925, and 6935).

Subpart C—General Facility Standards

2. In § 265.13, paragraphs (a)(1) and (b)(6) are revised and paragraph (b)(7) is added to read as follows:

§ 265.13 General waste analysis.

(a)(1) Before an owner or operator treats, stores, or disposes of any hazardous waste, he must obtain a detailed chemical and physical analysis of a representative sample of the waste. At a minimum, this analysis must contain all the information which must be known to treat, store, or dispose of the waste in accordance with the requirements of this part and Part 268 of this chapter.

* * * * *

(b) * * *

(6) Where applicable, the methods which will be used to meet the additional waste analysis requirements for specific waste management methods as specified in §§ 265.120, 265.225, 265.252, 265.273, 265.314, 265.341, 265.375, 265.402 and 268.7 of this chapter.

(7) For surface impoundments exempted from land disposal restrictions under § 268.4(a) of this chapter, the procedures and schedule for:

(i) The sampling of impoundment contents;

(ii) The analysis of test data; and,

(iii) The annual removal of residue which does not meet the standards of Part 268 Subpart D of this chapter.

Subpart E—Manifest System, Recordkeeping, and Reporting

3. In § 265.73, by revising paragraph (b)(3) and adding paragraphs (b)(4) through (b)(12) to read as follows:

§ 265.73 Operating record.

* * * * *

(b) * * *

(3) Records and results of waste analysis and trial tests performed as specified in §§ 265.13, 265.120, 265.225, 265.252, 265.273, 265.314, 265.341, 265.375, 265.402, 268.4(a) and 268.7 of this chapter.

* * * * *

(8) Records of the quantities (and date of placement) for each shipment of hazardous waste placed in land disposal units under an extension to the effective date of any land disposal restriction granted pursuant to § 268.5, or a petition pursuant to § 268.6 and the notice required by a generator under § 268.7(a)(3).

(9) For an off-site treatment facility, the notice required by a generator under § 268.7(a)(1);

(10) For an on-site treatment facility the information contained in the notice required by a generator under § 268.7(a)(1), except for the manifest number.

(11) For an off-site land disposal facility, the notice and certification required by the owner or operator of a treatment facility under § 268.7(b) or the certification required by the generator under § 268.7(a)(2), whichever is applicable;

(12) For an on-site land disposal facility, the information contained in the notice required by a generator under § 268.7(a)(2), except for the manifest number, or the information contained in the notice required by the treatment facility under § 268.7(b)(2), except for the manifest number, whichever is applicable.

(Approved by Office of Management and Budget under control number 2050-0012)

PART 268—LAND DISPOSAL RESTRICTIONS

VII. In Part 268:

1. The authority citation for Part 268 continues to read as follows:

Authority: Secs. 1006, 2002(a), 3001, and 3004 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6905, 6912(a), 6921, and 6924).

2. By adding Subparts A, C, D, and E to Part 268 to read as follows:

Subpart A—General

268.1 Purpose, scope, and applicability.
268.2 Definitions applicable to this part.
268.3 Dilution prohibited as a substitute for treatment.
268.4 Treatment surface impoundment exemption.
268.5 Procedures for case-by-case extensions to an effective date.
268.6 Petitions to allow land disposal of a waste prohibited under Subpart C of Part 268.
268.7 Waste analysis.

* * * * *

Subpart C—Prohibitions on Land Disposal

268.30 Waste specific prohibitions—Solvent wastes.
268.31 Waste specific prohibitions—Dioxin-containing wastes.

Subpart D—Treatment Standards

268.40 Applicability of treatment standards.
268.41 Treatment standards expressed as concentrations in waste extract.
268.42 Treatment standards expressed as specified technologies.
268.43 Treatment standards expressed as waste concentrations. [Reserved]
268.44 Variance from a treatment standard.

Subpart E—Prohibitions on Storage

268.50 Prohibitions on storage of restricted wastes.
Appendix I to Part 268—Toxicity Characteristic Leaching Procedure (TCLP)
Appendix II to Part 268—Treatment Standards (As Concentrations in the Treatment Residual Extract)

Subpart A—General

§ 268.1 Purpose, scope and applicability.

(a) This part identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed.

(b) Except as specifically provided otherwise in this part or Part 261 of this chapter, the requirements of this part apply to persons who generate or transport hazardous waste and owners and operators of hazardous waste treatment, storage, and disposal facilities.

(c) Prohibited wastes may continue to be land disposed as follows:

(1) Persons have been granted an extension to the effective date of a prohibition pursuant to § 268.5, with respect to those wastes covered by the extension;

(2) Persons have been granted an exemption from a prohibition pursuant to a petition under § 268.6, with respect to those wastes and units covered by the petition; or

(3) Until November 8, 1988, land disposal of contaminated soil or debris resulting from a response action taken under section 104 or 106 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 or a corrective action required under the Resource Conservation and Recovery Act.

(4) Small quantity generators of less than 100 kilograms of hazardous waste per month, as defined in § 261.5 of this chapter.

§ 268.2 Definitions applicable to this part.

(a) When used in this part the following terms have the meanings given below:

"Hazardous constituent or constituents" means those constituents listed in Appendix VIII to Part 261 of this chapter.

"Land disposal" means placement in or on the land including, but is not limited to, placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility,

salt dome formation, salt bed formation, underground mine or cave, concrete vault or bunker intended for disposal purposes, and placement in or on the land by means of open detonation and open burning where the residues continue to exhibit one or more of the characteristics of hazardous waste. The term "land disposal" does not encompass ocean disposal.

(b) All other terms have the meanings given under §§ 260.10, 261.2, 261.3, or 270.2 of this chapter.

§ 268.3 Dilution prohibited as a substitute for treatment.

No generator, transporter, handler, or owner or operator of a treatment, storage, or disposal facility shall in any way dilute a restricted waste or the residual from treatment of a restricted waste as a substitute for adequate treatment to achieve compliance with Subpart D of this part.

§ 268.4 Treatment surface impoundment exemption.

(a) The requirements of this part do not apply to persons treating hazardous wastes in a surface impoundment or series of impoundments provided that:

(1) Treatment of such wastes occurs in the impoundment;

(2) The residues of the treatment are analyzed, as specified in § 268.7, to determine if they meet the applicable treatment standards in § 268.41. The sampling method specified in the waste analysis plan under § 264.13 or § 265.13, must be designed such that representative samples of the sludge and the supernatant are tested separately rather than mixed to form homogeneous samples. The treatment residues (including any liquid waste) that do not meet the treatment standards promulgated under Subpart D of this part, or are not delisted under § 260.22 of this chapter, must be removed at least annually. These residues may not be placed in any other surface impoundment for subsequent management. If the volume of liquid flowing through the impoundment or series of impoundments annually is greater than the volume of the impoundment or impoundments, this flow-through constitutes removal of the supernatant for the purpose of this requirement. The procedures and schedule for the sampling of impoundment contents, the analysis of test data, and the annual removal of residue which does not meet the Subpart D treatment standards must be specified in the facility's waste analysis plan as required under §§ 264.13 or 265.13 of this chapter;

(3) The impoundment must meet the design requirements of § 264.221(b) or § 265.221(a) of this chapter, regardless that the unit may not be new, expanded, or a replacement, and be in compliance with applicable ground water monitoring requirements of Subpart F of Part 264 or Part 265 of this chapter unless:

(i) Exempted pursuant to § 264.221 (d) or (e) of this chapter, or to § 265.221 (c) or (d) of this chapter; or,

(ii) Upon application by the owner or operator, the Administrator has granted a waiver of the requirements on the basis that the surface impoundment:

(A) Has at least one liner, for which there is no evidence that such liner is leaking;

(B) Is located more than one-quarter mile from an underground source of drinking water; and

(C) Is in compliance with generally applicable ground water monitoring requirements for facilities with permits; or,

(iii) Upon application by the owner or operator, the Administrator has granted a modification to the requirements on the basis of a demonstration that the surface impoundment is located, designed, and operated so as to assure that there will be no migration of any hazardous constituent into ground water or surface water at any future time.

(4) The owner or operator must submit to the Regional Administrator a written certification that the requirements of § 268.4(a)(2) have been met and submits a copy of the waste analysis plan required under § 268.4(a)(2). The following certification is required:

I certify under penalty of law that the requirements of 40 CFR 268.4(a)(2) have been met for all surface impoundments being used to treat restricted wastes. I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

§ 268.5 Procedures for case-by-case extensions to an effective date.

(a) Any person who generates, treats, stores, or disposes of a hazardous waste may submit an application to the Administrator for an extension to the effective date of any applicable restriction established under Subpart C of this Part. The applicant must demonstrate the following:

(1) He has made a good-faith effort to locate and contract with treatment, recovery, or disposal facilities nationwide to manage his waste in accordance with the effective date of the applicable restriction established under Subpart C of this Part;

(2) He has entered into a binding contractual commitment to construct or otherwise provide alternative treatment, recovery (e.g., recycling), or disposal capacity that meets the treatment standards specified in Subpart D;

(3) Due to circumstances beyond the applicant's control, such alternative capacity cannot reasonably be made available by the applicable effective date. This demonstration may include a showing that the technical and practical difficulties associated with providing the alternative capacity will result in the capacity not being available by the applicable effective date;

(4) The capacity being constructed or otherwise provided by the applicant will be sufficient to manage the entire quantity of waste that is the subject of the application;

(5) He provides a detailed schedule for obtaining required operating and construction permits on an outline of how and when alternative capacity will be available;

(6) He has arranged for adequate capacity to manage his waste during an extension and has documented in the application the locations at which the waste will be managed; and

(7) Any waste managed in a surface impoundment or landfill during the extension period will meet the requirements of paragraph (a)(2) of this section.

(b) An authorized representative signing an application described under paragraph (a) of this section shall make the following certification:

I certify under penalty of law that I have personally examined and that I am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

(c) After receiving an application for an extension, the Administrator may request any additional information which he deems as necessary to evaluate the application.

(d) An extension will apply only to the wastes generated at the individual facility covered by the application and will not apply to restricted wastes from any other facility.

(e) On the basis of the information referred to in paragraph (a) of this section after notice and opportunity for comment and after consultation with the appropriate State agencies in the affected States, the Administrator may grant an extension of up to 1 year from

the effective date. The Administrator may review this extension for up to 1 additional year upon the request of the applicant if the demonstration required in paragraph (a) of this section can still be made. In no event will an extension extend beyond 24 months from the applicable effective date specified in Subpart C of Part 268. The length of any extension authorized will be determined by the Administrator based on the time required to construct or obtain the type of capacity needed by the applicant as described in the compliance schedule discussed in paragraph (a)(3) of this section. The Administrator will give public notice of the intent to approve or deny a petition and provide an opportunity for public comment. The final decision on a petition will be published in the Federal Register.

(f) Any person granted an extension under this section must immediately notify the Administrator as soon as he has knowledge of any change in the conditions certified to in the application.

(g) Any person granted an extension under this section shall submit written progress reports at intervals designated by the Administrator. Such reports must describe the overall progress made toward constructing or otherwise providing alternative treatment, recovery or disposal capacity; must identify any event which may cause or has caused a delay in the development of the capacity; and must summarize the steps taken to mitigate the delay. The Administrator can revoke the extension at any time if the applicant does not demonstrate a good-faith effort to meet the schedule for completion. If the Agency denies or revokes any required permit, if conditions certified in the application change, or for any violation of this chapter.

(h) Whenever the Administrator establishes an extension to an effective date under this section, during the period for which such extension is in effect:

(1) The storage restrictions under § 268.50(a)(2) do not apply; and

(2) Such hazardous waste may be disposed of at a facility only if such new landfill or surface impoundment unit, each replacement of an existing landfill or surface impoundment unit, and each lateral expansion of an existing landfill or surface impoundment unit at the facility is in compliance with the following requirements:

(i) The landfill, if the interim status is in compliance with the requirements of Subpart F of Part 264 and § 264.301 (a), (c), and (d) of this chapter; or

(ii) The landfill, if operating in compliance with the requirements of Subpart F of Part 264 and § 264.301 (c), (d) and (e) of this chapter.

(iii) The surface impoundment, if in interim status, is in compliance with the requirements of Subpart F of Part 265 and § 265.221 (a), (c), and (d) of this chapter regardless that the unit is not new, expanded or a replacement; or,

(iv) The surface impoundment, if permitted, is in compliance with the requirements of Subpart F of Part 264 and § 264.221 (c), (d) and (e) of this chapter.

(i) Pending a decision on the application the applicant is required to comply with all restrictions on land disposal under this part once the effective date for the waste has been reached.

(Approved by the Office of Management and Budget under control number 2050-0052)

§ 268.6 Petitions to allow land disposal of a waste prohibited under Subpart C of Part 268.

(a) Any person seeking an exemption from a prohibition under Subpart C of this part for the disposal of a restricted hazardous waste in a particular unit or units must submit a petition to the Administrator demonstrating, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the waste remains hazardous. The demonstration must include the following components:

(1) An identification of the specific waste and the specific unit for which the demonstration will be made;

(2) A waste analysis to describe fully the chemical and physical characteristics of the subject waste;

(3) A comprehensive characterization of the disposal unit site including an analysis of background air, soil, and water quality.

(b) The demonstration referred to in paragraph (a) of this section must meet the following criteria:

(1) All waste and environmental sampling, test, and analysis data must be accurate and reproducible to the extent that state-of-the-art techniques allow;

(2) All sampling, testing, and extraction techniques for chemical and physical properties of the waste and all environmental parameters must have been approved by the Administrator;

(3) Simulation models must be calibrated for the specific waste and site conditions, and validated for accuracy by comparison with actual measurements;

(4) A quality assurance and quality control plan that addresses all aspects of the demonstration must be approved by the Administrator; and,

(5) An analysis must be performed to identify and quantify any aspects of the demonstration that contribute significantly to uncertainty. This analysis must include an evaluation of the consequences of predictable future events, including, but not limited to, earthquakes, floods, severe storm events, droughts, or other natural phenomena.

(c) Each petition must be submitted to the Administrator.

(d) Each petition must include the following statement signed by the petitioner or an authorized representative:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this petition and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

(e) After receiving a petition, the Administrator may request any additional information that reasonably may be required to evaluate the demonstration.

(f) If approved, the petition will apply to land disposal of the specific restricted waste at the individual disposal unit described in the demonstration and will not apply to any other restricted waste at that disposal unit, or to that specific restricted waste at any other disposal unit.

(g) The Administrator will give public notice in the Federal Register of the intent to approve or deny a petition and provide an opportunity for public comment. The final decision on a petition will be published in the Federal Register.

(h) The term of a petition granted under this section shall be no longer than the term of the RCRA permit if the disposal unit is operating under a RCRA permit, or up to a maximum of 10 years from the date of approval provided under paragraph (g) of this section if the unit is operating under interim status. In either case, the term of the granted petition shall expire upon the termination or denial of a RCRA permit, or upon the termination of interim status or when the volume limit of waste that land disposal during the term of petition is reached.

(i) After the Administrator approves a petition, the applicant is required to comply with all restrictions on land disposal under this part once the effective date for the waste has been reached.

(j) The petition granted by the Administrator does not relieve the petitioner of its responsibilities in the management of hazardous waste under 40 CFR Part 260 through Part 271.

(Approved by the Office of Management and Budget under control number 2050-0053)

§ 268.7 Waste analysis.

(a) The generator must test his waste or an extract developed using the test method described in Appendix I of this part, or using knowledge of the waste to determine if the waste is restricted from land disposal under this part.

(1) If a generator determines that he is managing a restricted waste under this part and the waste requires treatment prior to land disposal, for each shipment of waste the generator must notify the treatment facility in writing of the appropriate treatment standard set forth in Subpart D of this part. The notice must include the following information:

(i) EPA Hazardous Waste Number;

(ii) The corresponding treatment standard;

(iii) The manifest number associated with the shipment of waste; and

(iv) Waste analysis data, where available.

(2) If a generator determines that he is managing a restricted waste under this part, and determines that the waste can be land disposed without further treatment, for each shipment of waste he must submit, to the land disposal facility, a notice and a certification stating that the waste meets applicable treatment standards.

(i) The notice must include the following information:

(A) EPA Hazardous Waste Number;

(B) The corresponding treatment standard;

(C) The manifest number associated with the shipment of waste;

(D) Waste analysis data, where available.

(ii) The certification must be signed by an authorized representative and must state the following:

I certify under penalty of law that I personally have examined and am familiar with the waste through analysis and testing or through knowledge of the waste to support this certification that the waste complies with the treatment standards specified in 40 CFR Part 268 Subpart D. I believe that the information I submitted is true, accurate and complete. I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment.

(3) If a generator's waste is subject to a case-by-case extension under § 268.5, a petition under § 268.6, or a nationwide variance under Subpart C, he must forward a notice to the land disposal facility receiving his waste, stating that the waste is exempt from the land disposal restrictions.

(b) For wastes with treatment standards expressed as concentrations in the waste extract (§ 268.41), the owner or operator of the treatment facility must test the treatment residues according to the waste analysis plans under §§ 264.13 or 265.13, or an extract development using the test method described in Appendix I of this part to assure that the treatment residues extract meet the applicable treatment standards.

(1) A notice must be sent to the land disposal facility which includes the following information:

(i) EPA Hazardous Waste Number;

(ii) The corresponding treatment standard;

(iii) The manifest number associated with the shipment of waste; and

(iv) Waste analysis data, where available.

(2) The treatment facility must submit a certification for each shipment of waste or treatment residue of a restricted waste to the land disposal facility stating that the waste or treatment residue has been treated to the performance standards specified in Subpart D.

(i) For wastes with treatment standards expressed as concentrations in the waste extract or in the waste (§§ 268.41 or 268.43), the certification must be signed by an authorized representative and must state the following:

I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification and that, based on my inquiry of those individuals immediately responsible for obtaining this information, I believe that the treatment process has been operated and maintained properly so as to achieve the performance levels specified in 40 CFR Part 268 Subpart D without dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possibility of fine and imprisonment.

(ii) For wastes with treatment standards expressed as technologies (§ 268.42), the certification must be signed by an authorized representative and must state the following:

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.42. I am aware that there are significant penalties for submitting a false certification, including the possibility of fine and imprisonment.

(c) The owner or operator of any land disposal facility accepting any waste subject to restrictions under this part must have records of the notice and certification specified in either paragraph (c) or (b) of this section and shall do waste analysis data through testing of the waste to determine that the wastes are in compliance with the applicable treatment standards in § 268.41.

(Approved by the Office of Management and Budget under control number 2050-0085)

* * * * *

Subpart C—Prohibitions on Land Disposal

§ 268.30 Waste specific prohibitions—Solvent wastes.

(a) Effective November 8, 1986, the spent solvent wastes specified in 40 CFR 261.31 as EPA Hazardous Waste Nos. F001, F002, F003, F004, and F005, are prohibited from land disposal (except in an injection well) unless one or more of the following conditions applies.

(1) The generator of the solvent waste is a small quantity generator of 100–1000 kilograms of hazardous waste per month; or

(2) The solvent waste is generated from any response action taken under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) or any corrective action taken under the Resource Conservation and Recovery Act (RCRA), except where the waste's contaminated soil or debris not subject to the provisions of this chapter until November 8, 1988; or

(3) The solvent waste is a solvent-water mixture, solvent-containing sludge, or solvent-contaminated soil (non-CERCLA or non-RCRA corrective action) containing less than 1 per cent total F001–F005 solvent constituents listed in Table CCWE of § 268.41 of this part.

(b) Effective November 8, 1988, the F001–F005 solvent wastes listed in paragraphs (a) (1), (2), and (3) of this section are prohibited from land disposal. Between November 8, 1986 and November 8, 1988, wastes included in paragraphs (a) (1), (2), and (3) of this section may be disposed of in a landfill or surface impoundment unless the facility is in noncompliance with any requirements specified in [illegible] requirements.

(c) The requirements of paragraphs (a) and (b) of this section do not apply if:

(1) The wastes meet the applicable standards of Subpart D of this part; or

(2) The wastes are disposed in a waste facility that has been granted a petition under § 268.6; or

(3) An extension has been granted under § 268.5.

§ 268.31 Waste specific prohibitions—Dioxin-containing wastes.

(a) Effective November 8, 1988, the dioxin-containing wastes specified in 40 CFR 261.31 as EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F028, are prohibited from land disposal.

(b) The requirements of paragraph (a) of this section do not apply if:

(1) The wastes are treated to meet the standards of Subpart D of this part; or,

(2) The wastes are disposed at a facility that has been granted a petition under § 268.6; or

(3) An extension has been granted under § 268.5.

(c) Between November 8, 1988, and November 8, 1989, wastes included in paragraph (a) of this section may be disposed of in a landfill or surface impoundment only if the facility is in compliance with the requirements specified in § 268.5(h)(2).

Subpart D—Treatment Standards

§ 268.40 Applicability of treatment standards.

A restricted waste identified in this subpart may be land disposed without further treatment only if an extract of the waste or of the treatment residual of the waste developed using the test method of Appendix I of this part does not exceed the value shown in Table CCWE of § 268.41 for any hazardous constituent listed in Table CCWE for that waste. A restricted waste for which a treatment technology is specified under § 268.42(a) may be land disposed after it is treated using that specified technology or an equivalent treatment method approved by the Administrator under the procedures set forth in § 268.42(b).

§ 268.41 Treatment Standards expressed as concentrations in waste extract.

(a) Table CCWE identifies the restricted wastes and the concentrations of their associated hazardous constituents which may not be exceeded by the extract of a waste treatment residual developed using the test method in Appendix I of this part for the allowable land disposal of such waste. (Appendix II of this part provides Agency guidance on treatment methods that have been shown to achieve the Table CCWE levels for the respective wastes. Appendix II is not a regulatory requirement but is provided to assist generators and owners/operators in their selection of appropriate treatment methods.)

TABLE CCWE—CONSTITUENT IN WASTE EXTRACT

F001—F005 spent solvents	Concentration (in mg/l)	
	Wastewaters containing spent solvents	All other spent solvent wastes
Acetone	0.05	0.59
n-Butyl alcohol	5.0	5.0
Carbon disulfide	1.05	4.81
Carbon tetrachloride	.05	.05
Chlorobenzene	.10	.05
Cresols and cresylic acid	5.01	.75
Cyclohexanone	.125	.75
1,2-Dichloroethane	.05	.205
Ethyl acetate	.05	.75
Ethyl benzene	.05	.053
Ethyl ether	.05	.75
Isobutanol	5.0	5.0
Methanol	.05	.75
Methylene chloride	.05	.05
Methyl ethyl ketone	5.0	5.0
Nitrobenzene	.05	.05
Pyridine	1.12	5.25
Tetrachloroethylene	0.079	0.05
Toluene	5.07	5.05
1,1,1-Trichloroethane	1.05	5.01
1,1,2-Trichloro-1,2,2-trifluoroethane	1.05	0.05
Trichloroethylene	0.062	0.081
Trichlorofluoromethane	0.05	0.05
Xylene	0.05	0.15

F020—F023 and F026—F028 waste containing wastes	Concentration
Hexachlorodibenzo-p-dioxins	< 1 ppb
Hexachlorodibenzofurans	< 1 ppb
Pentachlorodibenzo-p-dioxins	< 1 ppb
Pentachlorodibenzofurans	< 1 ppb
Tetrachlorodibenzo-p-dioxins	< 1 ppb
Tetrachlorodibenzofurans	< 1 ppb
2,4,5-Trichlorophenol	< 0.05 mg/l
2,4,6-Trichlorophenol	< 0.05 mg/l
2,3,4,6-Tetrachlorophenol	< 0.05 mg/l
Pentachlorophenol	< 0.01 mg/l

(b) When wastes with differing treatment standards for a constituent of concern are combined for purposes of treatment, the treatment residue must meet the lowest treatment standard for the constituent of concern.

§ 268.42 Treatment standards expressed as specified technologies.

(a) The following wastes must be treated using the identified technology or technologies, or an equivalent method approved by the Administrator.

(1) [Reserved]

(b) Any person may submit an application to the Administrator demonstrating that an alternative treatment method can achieve a level of performance equivalent to that achieved by methods specified in paragraph (a) of this section. The applicant must submit information demonstrating that his treatment method will not present an unreasonable risk to human health or the environment. On the basis of such information and any other available information, the Administrator may approve the use of the alternative treatment method if he finds that the alternative treatment method provides a level of performance equivalent to that achieved by methods specified in paragraph (a) of this section. Any approval must be stated in writing and may contain such provisions and conditions as the Administrator deems appropriate. The person to whom such certification is issued must comply with all limitations contained in such determination.

§ 268.43 Treatment standards expressed as waste concentrations. [Reserved]

§ 268.44 Variance from a treatment standard.

(a) Where the treatment standard is expressed as a concentration in a waste or waste extract and a waste cannot be treated to the specified level, or where the treatment technology is not appropriate to the waste, the generator or treatment facility may petition the Administrator for a variance from the treatment standard. The petitioner must demonstrate that because the physical or chemical properties of the waste differ significantly from wastes analyzed in developing the treatment standard, the waste cannot be treated to specified levels or by the specified methods.

(b) Each petition must be submitted in accordance with the procedures in § 268.7(b).

(c) After receiving a petition for variance from a treatment standard, the Administrator may request any additional information or samples which he may require to evaluate the petition. Additional copies of the complete petition may be requested as needed to send to affected states and Regional Offices.

(d) The Administrator will give public notice in the Federal Register of the intent to approve or deny a petition and provide an opportunity for public comment. The final decision on a variance from a treatment standard will be published in the Federal Register.

(f) A generator, treatment facility, or disposal facility that is managing a waste covered by a variance from the treatment standards must comply with the waste analysis requirements for restricted wastes found under § 268.7.

(g) During the petition review process, the applicant is required to comply with all restrictions on land disposal under this part once the effective date for the waste has been reached.

Subpart E—Prohibitions on Storage

§ 268.50 Prohibitions on storage of restricted wastes.

(a) Except as provided in paragraph (b) of this section, the storage

of hazardous wastes restricted from land disposal under Subpart C of this Part is prohibited, unless the following conditions are met:

(1) A generator stores such wastes on-site solely for the purpose of the accumulation of such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal and the generator complies with the requirements in § 262.34 of this chapter. (A generator who is in existence on the effective date of a regulation under this part and who must store hazardous wastes for longer than 90 days due to the regulations under this Part becomes an owner/operator of a storage facility and must obtain a RCRA permit. Such a facility may qualify for interim status upon compliance with the regulations governing interim status under 40 CFR 270.70).

(2) An owner/operator of a hazardous waste treatment, storage, or disposal facility stores such wastes solely for the purpose of the accumulation of such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal provided that each container or tank is clearly marked to identify its contents and the date it entered storage.

(3) A transporter may store manifested shipments of such wastes at a transfer facility for 10 days or less.

(b) An owner/operator of a treatment, storage or disposal facility may store such wastes for up to one year unless the Agency can demonstrate that such storage was not solely for the purpose of accumulation of such quantities of hazardous waste as are necessary to facilitate proper recovery, treatment, or disposal.

(c) A owner/operator of a treatment, storage or disposal facility may store such wastes beyond one year, however, the owner/operator bears the burden of proving that such storage was solely for the purpose of accumulation of such quantities of hazardous waste as are necessary to facilitate proper recovery, treatment, or disposal.

(d) The prohibition in paragraph (a) of this section does not apply to the wastes which are the subject of an approved petition under § 268.6 or an approved case-by-case extension under § 268.5.

(e) The prohibition in paragraph (c) of this section does not apply to hazardous wastes that meet the treatment standards specified under §§ 268.41, 268.42 and 268.43 or the treatment standards specified under the variance in § 268.44.

Appendix I to Part 268—Toxicity Characteristic Leaching Procedure (TCLP)

1.0 SCOPE AND APPLICATION

1.1 The TCLP is designed to determine the mobility of both organic and inorganic contaminants present in liquid, solid, and multiphasic wastes.

1.2 If a total analysis of the waste demonstrates that individual contaminants are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory thresholds would not possibly be exceeded, the TCLP need not be run.

2.0 SUMMARY OF METHOD (see Figure 1)

2.1 For liquid wastes (i.e., those containing insignificant solid material), the waste, after filtration through a 0.6- to 0.8-um glass fiber filter, is defined as the TCLP extract.

2.2 For wastes comprised of solids or for wastes containing significant amounts of solid material, the particle size of the waste is reduced (if necessary), the liquid phase, if any, is separated from the solid phase and stored for later analysis. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A special extractor vessel is used when testing for volatiles (see Table 1). Following extraction, the liquid extract is separated from the solid phase by 0.6- to 0.8-um glass fiber filtration.

2.3 If compatible (i.e., multiple phases will not form on combination), the initial liquid phase of the waste is added to the liquid extract, and these liquids are analyzed together. If incompatible, the liquids are analyzed separately and the results are mathematically combined to yield a volume-weighted average concentration.

3.0 INTERFERENCES

3.1 Potential interferences that may be encountered during analysis are discussed in the individual analytical methods.

4.0 APPARATUS AND MATERIALS

4.1 *Agitation apparatus:* An acceptable agitation apparatus is one which is capable of rotating the extraction vessel in an end-over-end fashion (See Figure 2) at 30 ± 2 rpm. Suitable devices known to EPA are identified in Table 2.

4.2 *Extraction Vessel*

4.2.1 Zero-Headspace Extraction Vessel (ZHE): This device is for use only when the waste is being tested for the mobility of volatile contaminants (see Table 1). The ZHE is an extraction vessel that allows for liquid/solid separation within the device, and which effectively precludes headspace (as defined in Figure 3). This type of vessel allows for the initial liquid/solid separation, maintenance, and final extract filtration without having to open the vessel (see Step 6.5.2). These vessels shall have an internal volume of 500 to 600 mL and be equipped to accommodate a 90-mm filter. Suitable ZHE devices known to EPA are identified in Table 2. These devices contain valves which allow pressurization of the vessel with an inert gas after the test material has been introduced. This pressurization will force the liquid extract through the filter for collection, while maintaining a zero headspace environment in the vessel. The pressure applied is determined by the depth of the material to be filtered (see Step 6.5.2). For the ZHE to be acceptable for use, the piston within the ZHE should be able to be moved with approximately 15 psi or less. If it takes more pressure to move the piston, the O-rings in the device should be replaced. If this does not solve the problem, the ZHE is unacceptable for TCLP analyses and the manufacturer should be contacted.

The ZHE should be checked after every extraction. If the device contains a built-in pressure gauge, pressurize the device to 50 psi, allow it to stand unattended for 1 hour, and recheck the pressure. If the device does not have a built-in pressure gauge, pressurize the device to 50 psi, submerge it in water, and check for the presence of air bubbles escaping from any of the fittings. If pressure is lost, check all fittings and inspect and replace O-rings, if necessary. Retest the device. If leakage problems cannot be solved, the manufacturer should be contacted.

4.2.2 When the waste is being evaluated for other than volatile contaminants, an extraction vessel that does not contain headspace (e.g., a 2-liter bottle) is used. Suitable extraction vessels could be bottles made from various materials, depending on the contaminants to be analyzed and the nature of the waste (see Step 6.2.3). It is recommended that borosilicate glass bottles be used over other types of bottles (especially when inorganics are of concern). Plastic bottles may be used if inorganics are to be investigated. Teflon containers often are a source of laboratory contamination. The best type of extraction vessel is one that allows the filtration device discussed in Step 4.2.3 to be used for initial liquid/solid separation and final extract filtration.

4.2.3 Some of the one-gram aliquots to undergo volatiles procedures (see Section 7) will require mechanical pressure (see Table 2). Whereas the volatiles procedure does not require the addition of headspace (see Section 7), for the mechanically extracted aliquot, the pressure applied is measured in pounds-per-square-inch. Refer to the manufacturer's instructions as to the proper conversion.

4.3 *Filtration Devices:* It is recommended that all filtrations be performed in a hood.

4.3.1 Zero-Headspace Extractor Vessel (see Figure 3): When the waste is being evaluated for volatiles, the zero-headspace extraction vessel is used for filtration. The device shall be capable of supporting and keeping in place the glass fiber filter, and be able to withstand the pressure needed to accomplish separation (50 psi).

Note—When a ZHE is unavailable, a glass fiber filter may be used in the glass fiber filter may be used to filter the material within the ZHE.

4.3.2 Filter Holder: When the waste is being evaluated for [illegible] contaminants, a filter holder capable of supporting a glass fiber filter [illegible] withstand the pressure needed to accomplish separation (if these filters are used) ranges from [illegible] pressurized (if ZHE is not used) [illegible] filter holder used depends on the [illegible] of the material to be filtered [illegible].

These devices shall have a minimum internal volume of 300 mL and be equipped to accommodate a minimum filter size of 47 mm (Filter holders having an internal capacity of 1.5 L or greater and equipped to accommodate a 142 mm diameter filter are recommended). Vacuum filtration is only recommended for wastes with low solids content (<10%) and for highly granular (liquid-containing) wastes. All other types of wastes should be filtered using positive pressure filtration. Filter holders known to EPA to be suitable for use are shown in Table 4.

4.3.3 *Materials of Construction:* Extraction vessels and filtration devices shall be made of inert materials which will not leach or absorb waste components. Glass, polytetrafluoroethylene (PTFE), or type 316 stainless steel equipment may be used when evaluating the mobility of both organic and inorganic components. Devices made of high-density polyethylene (HDPE), polypropylene, or polyvinyl chloride may be used only when evaluating the mobility of metals. Borosilicate glass bottles are recommended for use over other types of glass bottles, especially when inorganics are constituents of concern.

4.4 *Filters:* Filters shall be made of borosilicate glass fiber, shall contain no binder materials, and shall have an effective pore size of 0.6– to 0.8–um, or equivalent. Filters known to EPA to meet these specifications are identified in Table 3. Pre-filters must not be used. When evaluating the mobility of metals, filters shall be acid-washed prior to use by rinsing with 1.0 N nitric acid followed by three consecutive rinses with deionized distilled water (a minimum of 1–L per rinse is recommended). Glass fiber filters are fragile and should be handled with care.

4.5 *pH meters:* Any of the commonly available pH meters are acceptable.

4.6 *ZHE extract collection devices:* TEDLAR® bags or glass, stainless steel or PTFE gas tight syringes are used to collect the initial liquid phase and the final extract of the waste when using the ZHE device. The devices listed are recommended for use under the following conditions.

4.6.1 If a waste contains an aqueous liquid phase or if a waste does not contain a significant amount of non-aqueous liquid (i.e., <1% of total waste), the TEDLAR® bag should be used to collect and combine the initial liquid and solid extract. The syringe is not recommended in these cases.

4.6.2 If a waste contains a significant amount of non-aqueous initial liquid phase (i.e., >1% of total waste), the syringe or the TEDLAR® bag may be used for both the initial solid/liquid separation and the final extract filtration. However, analysts should use one or the other, not both.

4.6.3 If the waste contains no initial liquid phase (is 100% solid) or has no significant solid phase (is 100% liquid), either the TEDLAR® bag or the syringe may be used. If the syringe is used, discard the first 5 mL of liquid expressed from the device. The remaining aliquots are used for analysis.

4.7 *ZHE extraction fluid transfer devices:* Any device capable of transferring the extraction fluid into the ZHE without changing the nature of the extraction fluid is acceptable (e.g., a constant displacement pump, a gas tight syringe, pressure filtration unit (See Step 4.3.2), or another ZHE device).

4.8 *Laboratory balances:* Any laboratory balance accurate to within ±0.01 grams may be used (all weight measurements are to be within ±0.1 grams).

5.0 REAGENTS

5.1 *Reagent water:* Reagent water is defined as water in which an interferent is not observed at or above the method detection limit of the analyte(s) of interest. For non-volatile extractions, ASTM Type II water, or equivalent meets the definition of reagent water. For volatile extractions, it is recommended that reagent water be generated by any of the following methods. Reagent water should be monitored periodically for impurities.

5.1.1 Reagent water for volatile extractions may be generated by passing tap water through a carbon filter bed containing about 500 grams of activated carbon (Calgon Corp., Filtrasorb-300 or equivalent).

5.1.2 A water purification system (Millipore Super-Q or equivalent) may also be used to generate reagent water for volatile extractions.

5.1.3 Reagent water for volatile extractions may also be prepared by boiling water for 15 minutes. Subsequently, while maintaining the water temperature at 90 ± 5°C, bubble a contaminant-free inert gas (e.g., nitrogen) through the water for 1 hour. While still hot, transfer the water to a narrow-mouth screw-cap bottle under zero-headspace and seal with a Teflon-lined septum and cap.

5.2 1.0 N Hydrochloric acid (HCl) made from ACS reagent grade.

5.3 1.0 N Nitric acid (HNO_3) made from ACS reagent grade.

5.4 1.0 N Sodium hydroxide (NaOH) made from ACS reagent grade.

5.5 Glacial acetic acid (HOAc) ACS reagent grade.

5.6 *Extraction fluid:*

5.6.1 Extraction fluid #1: This fluid is made by adding 5.7 mL glacial HOAc to 500 mL of the appropriate water (see Step 5.1), adding 64.3 mL of 1.0 N NaOH, and diluting to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 4.93 ± 0.05.

5.6.2 Extraction fluid #2: This fluid is made by diluting 5.7 mL glacial HOAc with ASTM Type II water (see Step 5.1) to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 2.88 ± 0.05.

Note—It is suggested that these extraction fluids be monitored frequently for impurities. The pH should be checked prior to use to ensure that these fluids are made up accurately.

5.7 Analytical standards shall be prepared according to the appropriate analytical method.

6.0 SAMPLE COLLECTION, PRESERVATION AND HANDLING

6.1 All samples shall be collected using an appropriate sampling plan.

6.2 At least two separate representative samples of a waste should be collected. If volatile organics are of concern, a third sample should be collected. The first sample is used in several preliminary TCLP evaluations (e.g., to determine the percent solids of the waste; to determine if the waste contains insignificant solids (i.e., the waste is its own extract after filtration); to determine if the solid portion of the waste requires particle-size reduction; and to determine which of the two extraction fluids are to be used for the non-volatile TCLP extraction of the waste). These preliminary evaluations are identified in Section 7.0. The second and, if required, third samples are extracted using the TCLP non-volatile procedure (Section 8.0) and volatile procedure (Section 8.2), respectively.

6.3 Preservatives shall not be added to samples.

6.4 Samples can be refrigerated unless refrigeration results in irreversible physical change to the waste (e.g., precipitation).

6.5 When the waste is to be evaluated for volatile contaminants, care should be taken to minimize the loss of volatiles. Samples shall be taken and stored in a manner to prevent the loss of volatile contaminants. If possible, it is recommended that any necessary particle-size reduction should be conducted as the sample is being taken (See Step 8.5).

6.6 TCLP extracts should be prepared for analysis and analyzed as soon as possible following extraction. If they need to be stored, even for a short period of time, storage shall be at 4° C, and samples for volatiles analysis shall not be allowed to come into contact with the atmosphere (i.e., no headspace). See Section 10.0 (QA requirements) for acceptable sample and extract holding times.

7.0 PRELIMINARY TCLP EVALUATIONS

The preliminary TCLP evaluations are performed on a minimum 100 gram representative sample of waste that will not actually undergo TCLP extraction (designated as the first sample in Step 6.2). These evaluations include preliminary determination of the percent solids of the waste; determination of whether the waste contains insignificant solids, and is therefore, its own extract after filtration; determination of whether the solid portion of the waste requires particle-size reduction; and determination of which of the two extraction fluids are to be used for the non-volatile TCLP extraction of the waste.

7.1 *Preliminary determination of percent solids:* Percent solids is defined as that fraction of a waste sample (as a percentage of the total sample) from which no liquid may be forced out by an applied pressure, as described below.

7.1.1 If the waste will obviously yield no free liquid when subjected to pressure filtration (i.e., is 100% solids) proceed to Step 7.4.

7.1.2 If the sample is liquid or multiphasic, liquid/solid separation to make a preliminary determination of percent solids is required. This involves the filtration device described in Step 4.3.2 and is outlined in Steps 7.1.3 through 7.1.8.

7.1.3 Pre-weigh the filter and the container that will receive the filtrate.

7.1.4 Assemble the filter holder and filter following the manufacturer's instructions.

Place the filter on the support screen and secure.

7.1.5 Weigh out a representative subsample of the waste (100 grams minimum) and record the weight.

7.1.6 Allow the waste to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Centrifugation is to be used only as an aid to filtration. If used, the liquid should be decanted and filtered followed by filtration of the solid portion of the waste through the same filtration system.

7.1.7 Quantitatively transfer the waste sample to the filter holder (liquid and solid phases). If filtration of the waste at 4° C reduces the amount of expressed liquid over what would be expressed at room temperature then allow the sample to warm up to room temperature in the device before filtering.

Note.—If waste material (>1% of original sample weight) has obviously adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Step 7.1.5 to determine the weight of the waste sample that will be filtered.

Gradually apply vacuum or gentle pressure of 1–10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2-minute interval, slowly increase the pressure in 10-psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not moved through the filter, and if no additional liquid has passed through the filter in any 2-minute interval, proceed to the next 10-psi increment. When the pressurizing gas begins to move through the filter, or when liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within any 2-minute period), filtration is stopped.

Note.—Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

7.1.8 The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase.

Note.—Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. But even after applying vacuum or pressure filtration, as outlined in Step 7.1.7, this material may not filter. If this is the case, the material within the filtration device is defined as a solid. The original filter is not to be replaced with a fresh filter under any circumstances. Only one filter is used.

7.1.9 Determine the weight of the liquid phase by subtracting the weight of the filtrate container (from Step 7.1.2) from the total weight of the filtrate-filled container. The weight of the solid phase of the waste sample is determined by subtracting the weight of the liquid phase from the weight of the total waste sample, as determined in Step 7.1.5 or 7.1.7. Record the weight of the liquid and solid phases. Calculate the percent solids as follows:

$$\text{Percent solids} = \frac{\text{Weight of solid (Step 7.1.9)}}{\text{Total weight of waste (Step 7.1.5 or 7.1.7)}} \times 100$$

7.2 *Determination of whether waste is liquid or has insignificant amounts of solid material.* If the sample obviously has a significant amount of solid material, the solid phase must be analyzed to determine the percent in Step 7.3 to determine if the waste requires particle-size reduction (and to volume production, if necessary). Determine whether the waste is liquid or has insignificant amounts of solid material (which need not undergo extraction) as follows:

7.2.1 Remove the solid phase and filter from the filtering apparatus.

7.2.2 Dry the filter and solid phase at 100 ± 20° C until two consecutive weighings yield the same value within ±1%. Record final weight.

Note.—Caution should be taken to insure that the subject solid will not flash upon heating. It is recommended that the drying oven be vented to a hood or appropriate device.

7.2.3 Calculate the percent dry solids as follows:

$$\text{Percent dry solids} = \frac{\text{Weight of dry waste and filter} - \text{tared weight of filter}}{\text{Initial weight of waste (Step 7.1.5 or 7.1.7)}} \times 100$$

7.2.4 If the percent dry solids is less than 0.5%, proceed to Step 8.2 and proceed to Section 8.0 if non-volatiles in the waste are of concern, and to Section 9.0 if volatiles are of interest. In this case, the waste, after filtration is defined as the TCLP extract. If the percent dry solids is greater than or equal to 0.5%, and if the non-volatile TCLP is to be performed, proceed to the particle-size reduction of this Section (7.3) with a new representative waste sample so that it can be determined if particle-size reduction is necessary (Step 7.3), and so that the appropriate extraction fluid may be determined (Step 7.4) on a fresh portion of the solid phase of the waste. If only the volatile TCLP is to be performed, see the Note in Step 7.4.

7.3 *Determination of whether the waste requires particle-size reduction (particle size is reduced during this Step).* Using the solid portion of the waste, evaluate the solid for particle-size. If the solid has a surface area per gram of material equal to or greater than 3.1 cm², or is smaller than 1 cm in its narrowest dimension (e.g., is capable of passing through a 9.5-mm (0.375-inch) standard sieve), particle-size reduction is not required (proceed to Step 7.4). If the surface area is smaller or the particle-size larger than described above, the solid portion of the waste is prepared for extraction by crushing, cutting, or grinding the waste to a surface area or particle-size as described above.

Note.—Surface area requirements are meant for flexible wastes (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not required, nor is it recommended.

7.4 *Determination of appropriate extraction fluid.* If the solid content is greater than or equal to 0.5% of the sample (Step 7.2.4), TCLP extraction fluid non-volatile constituents will be used (Section 8.0). Determination of the appropriate extraction fluid (Step 8.2) to be used for the non-volatiles extraction is performed as follows:

Note.—TCLP extraction for volatile constituents entails using only extraction fluid #1 (Step 8.2.1). Therefore, if TCLP extraction for non-volatiles extraction is not required, proceed to section 9.0.

7.4.1 Weigh out a small subsample of the solid phase of the waste, reduce the solid (if necessary) to a particle size of approximately 1mm in diameter or less, and transfer 5.0 grams of the solid phase of the waste to a 500-mL beaker of Erlenmeyer flask.

7.4.2 Add 96.5 mL of reagent water (ASTM Type II) to the beaker, cover with a watchglass, and stir vigorously for 5 minutes using a magnetic stirrer. Measure and record the pH. If the pH is <5.0, extraction fluid #1 is used. Proceed to Section 8.0.

7.4.3 If the pH from Step 7.4.2 is >5.0, add 3.5 mL 1.0 N HCl, cover briefly, stir vigorously, heat to 50 °C, and hold at 50 °C for 10 minutes.

7.4.4 Let the solution cool to room temperature and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2. Proceed to Section 8.0.

7.5 The sample of waste used for performance of this Section shall not be used any further. Other samples of the waste (see Step 8.2) should be employed for the Section 8.0 and 9.0 extractions.

8.0 PROCEDURE WHEN VOLATILES ARE NOT INVOLVED

Although a multi-phase sample (i.e., grabs (solid and liquid phases) is ... large sample size, may be ... depending on the ... sample (enough ... the initial liquid ... mixture with the ... solid, and ... organics, perform ... analysis of ... generated for extraction must then ...

of TCLP extract will be sufficient to support all of the analyses required. If the amount of extract generated by the performance of a single TCLP extraction will not be sufficient to perform all of the analyses to be conducted, it is recommended that more than one extraction be performed and that the extracts from each extraction be combined and then aliquoted for analysis.

8.1 If the waste will obviously yield no liquid when subjected to pressure filtration (i.e., is 100% solid, see Step 7.1), weigh out a representative subsample of the waste (100 gram minimum) and proceed to Step 8.8.

8.2 If the sample is liquid or multiphasic, liquid/solid separation is required. This involves the filtration device described in Step 4.3.2 and is outlined in Steps 8.3 to 8.6.

8.3 Pre-weigh the container that will receive the filtrate.

8.4 Assemble the filter holder and filter following the manufacturer's instructions. Place the filter on the support screen and secure. Acid wash the filter if evaluating the mobility of metals (See Step 4.4).

Note.—Acid washed filters may be used for all non-volatile extractions even when metals are not of concern.

8.5 Weigh out a representative subsample of the waste (100 gram minimum) and record the weight. If the waste was shown to contain <0.5% dry solids (Step 7.2), the waste, after filtration is defined as the TCLP extract. Therefore, enough of the sample should be filtered so that the amount of filtered liquid will support all of the analyses required of the TCLP extract. For wastes containing >0.5% dry solids (Steps 7.1 or 7.3), use the percent solids information obtained in Step 7.1 to determine the optimum sample size (100 gram minimum) for filtration. Enough solids should be generated after filtration to support the analyses to be performed on the TCLP extract.

8.6 Allow slurries to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Centrifugation is to be used only as an aid to filtration. If used, the liquid should be decanted and filtered followed by filtration of the solid portion of the waste through the same filtration system.

8.7 Quantitatively transfer the waste sample (liquid and solid phases) to the filter holder (see Step 4.3.2). If filtration of the waste at 4° C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm up to room temperature in the device before filtering.

Note.—If waste material (>1% of the original sample weight) has obviously adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Step 8.5, to determine the weight of the waste sample that will be filtered.

Gradually apply vacuum or gentle pressure of 2–10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2-minute interval, slowly increase the pressure in 10-psi increments to maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not moved through the filter, and if no additional liquid has passed through the filter in any 2-minute interval, proceed to the next 10-psi increment. When the pressurizing gas begins to move through the filter, or when the liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within a 2-minute period), filtration is stopped.

Note.—Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

8.8 The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase. Weigh the filtrate. The liquid phase may now be either analyzed (see Step 8.12) or stored at 4 °C until time of analysis.

Note.—Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. But even after applying vacuum or pressure filtration, as outlined in Step 8.7, this material may not filter. If this is the case, the material within the filtration device defined as a solid and is carried through the extraction as a solid. The original filter is not to be replaced with a fresh filter under any circumstances. Only one filter is used.

8.9 If the waste contains <0.5% dry solids (see Step 7.2), proceed to Step 8.12. If the waste contains >0.5% dry solids (see Step 7.1 or 7.3), and if particle-size reduction of the solid was needed in Step 7.3, proceed to Step 8.10. If particle-size reduction was not required in Step 7.3, quantitatively transfer the solid material into the extractor vessel, including the filter used to separate the initial liquid from the solid phase. Proceed to Step 8.11.

8.10 The solid portion of the waste is prepared for extraction by crushing, cutting, or grinding the waste to a surface area of particle-size as described in Step 7.3. When the surface area of particle-size has been appropriately altered, quantitatively transfer the solid material into the extractor vessel, including the filter used to separate the initial liquid from the solid phase.

Note.—Sieving of the waste through a sieve that is not Teflon coated should not be done due to avoid possible contamination of the sample. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended.

8.11 Determine the amount of extraction fluid to add to the extractor vessel as follows:

$$\text{Weight of extraction fluid} = \frac{20 \times \%\ \text{solids (Step 7.1)} \times \text{weight of waste filtered (Step 8.5 or 8.7)}}{100}$$

Slowly add this amount of appropriate extraction fluid (see Step 7.4) to the extractor vessel. Close the extractor bottle tightly (it is recommended that Teflon tape be used to ensure a tight seal), secure in rotary extractor device, and rotate at 30±2 rpm for 18±2 hours. Ambient temperature (i.e., temperature of room in which extraction is to take place) shall be maintained at 22±3 °C during the extraction period.

Note.—As agitation continues, pressure may build up within the extractor bottle for some types of wastes (e.g., limed or calcium carbonate containing waste may evolve gases such as carbon dioxide). To relieve excess pressure, the extractor bottle may be periodically opened (e.g., after 15 minutes, 30 minutes, and 1 hour) and vented into a hood.

8.12 Following the 18±2 hour extraction, the material in the extractor vessel is separated into its component liquid and solid phases by filtering through a new glass fiber filter, as outlined in Step 8.7. For final filtration of the TCLP extract, the glass fiber filter may be changed, if necessary, to facilitate filtration. Filter(s) shall be acid-washed (see Step 4.4) if evaluating the mobility of metals.

8.13 The TCLP extract is now prepared as follows:

8.13.1 If the waste contained no initial liquid phase, the filtered liquid material obtained from Step 8.12 is defined as the TCLP extract. Proceed to Step 8.14.

8.13.2 If compatible (e.g., multiple phases will not result on combination), the filtered liquid resulting from Step 8.12 is combined with the initial liquid phase of the waste as obtained in Step 8.7. This combined liquid is defined as the TCLP extract. Proceed to Step 8.14.

8.13.3 If the initial liquid phase of the waste, as obtained from Step 8.7, is not or may not be compatible with the filtered liquid resulting from Step 8.12, these liquids are not combined. These liquids, collectively defined as the TCLP extract, are analyzed separately, and the results are combined mathematically. Proceed to Step 8.14.

8.14 Following collection of the TCLP extract, it is recommended that the pH of the extract be recorded. The extract should be immediately aliquoted for analysis and properly preserved (metals aliquots must be acidified with nitric acid to pH <2; all other aliquots must be stored under refrigeration (4 °C) until analyzed). The TCLP extract shall be prepared and analyzed according to appropriate analytical methods. TCLP extracts to be analyzed for metals, other than mercury, shall be acid digested. If the individual phases are to be analyzed separately, determine the volume of the individual phases (to ±0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average.

$$\text{Final Analyte Concentration} = \frac{(V_1)(C_1)+(V_2)(C_2)}{V_1+V_2}$$

where:

V_1 = The volume of the first phase (L).
C_1 = The concentration of the contaminant of concern in the first phase (mg/L).
V_2 = The volume of the second phase (L).
C_2 = The concentration of the contaminant of concern in the second phase (mg/L).

8.18 The contaminant concentrations in the TCLP extract are compared with the thresholds identified in the appropriate regulations. Refer to Section 10.0 for quality assurance requirements.

9.0 PROCEDURE WHEN VOLATILES ARE INVOLVED

The ZHE device is used to obtain TCLP extracts for volatile analytes only. Extract resulting from the use of the ZHE shall not be used to evaluate the mobility of non-volatile analytes (e.g., metals, pesticides, etc.).

The ZHE device has approximately a 500-mL internal capacity. Although a minimum sample size of 100 grams was required in the Section 8.0 procedure, the ZHE can only accommodate a *maximum* of 25 grams of solid (defined as that fraction of a sample from which no liquid (additional) may be forced out by an applied pressure of 50 psi), due to the need to add an amount of extraction fluid equal to 20 times the weight of the solid phase.

The ZHE is charged with sample only once and the device is not opened until the final extract (of the solid) has been collected. Repeated filling of the ZHE to obtain 25 grams of solid is not permitted. The initial filtrate should be weighed and then stored at 4 °C until either analyzed or recombined with the final extract of the solid.

Although the following procedure allows for particle-size reduction during the conduct of the procedure, this could result in the loss of volatile compounds. If possible (e.g., particle-size may be reduced easily by crumbling), particle-size reduction (See Step 9.7) should be conducted on the sample as it is being taken. If necessary, particle-size reduction may be conducted during the procedure.

In carrying out the following steps, do not allow the waste, the initial liquid phase, or the extract to be exposed to the atmosphere for any more time than is absolutely necessary. Any manipulation of these materials should be done when cold (4° C) to minimize loss of volatiles.

9.1 Pre-weigh the (evacuated) container which will receive the filtrate (See Step 9.9), and set aside. If using a TEDLAR® bag, all liquid must be expressed from the device, whether it be for the initial or final liquid/solid separation, and an aliquot taken from the liquid in the bag, for analysis. The containers listed in Step 4.4 are recommended for use under the following conditions:

9.1.1 If a waste contains an aqueous liquid phase or if the waste does not contain a significant amount of non-aqueous liquid (i.e., < 1% of total waste), the TEDLAR® bag should be used to collect and combine the initial liquid and solid extract. The syringe is not recommended in these cases.

9.1.2 If a waste contains a significant amount of non-aqueous initial liquid phase (i.e., > 1% of total waste), the syringe or the TEDLAR® bag may be used for both the initial solid/liquid separation and the final extract filtration. However, analysts should use one or the other, not both.

9.1.3 If the waste contains no initial liquid phase (i.e. 100% solid) or has no significant solid phase (i.e. 100% liquid), either the TEDLAR® bag or the syringe may be used. If the syringe is used, discard the first 5 mL liquid expressed from the device. The remaining aliquots are used for analysis.

9.2 Place the ZHE piston within the body of the ZHE (it may be helpful first to moisten the piston O-rings slightly with extraction fluid). Adjust the piston within the ZHE body to a height that will minimize the distance the piston will have to move once the ZHE is charged with sample (based upon sample size requirements determined from Section 9.A Step 7.1 and/or 7.2). Secure the gas inlet/outlet flange (bottom flange) onto the ZHE body in accordance with the manufacturer's instructions. Secure the glass fiber filter between the support screens and set aside. Set liquid inlet/outlet flange (top flange) aside.

9.3 If the waste is 100% solid (see Step 7.1), weigh out a representative subsample (25 gram maximum) of the waste, record weight, and proceed to Step 9.8.

9.4 If the waste was shown to contain < 0.5% dry solids (Step 7.2), the waste, after filtration is defined as the TCLP extract. Enough of the sample should be filtered so that the amount of filtered liquid will support all of the volatile analyses required. For wastes containing > 0.5% dry solids (Steps 7.1 and/or 7.2), use the percent solids information obtained in Step 7.1 to determine the optimum sample size to charge into the ZHE. The appropriate sample size recommended is as follows:

9.4.1 For wastes containing < 5% solids (see Step 7.1), weigh out a representative 100 gram sample or waste and record the weight.

9.4.2 For wastes containing > 5% solids (see Step 7.1), the amount of waste to charge into the ZHE is determined as follows:

$$\text{Weight of waste to charge ZHE} = \frac{25}{\text{\% solids (Step 7.1)}} \times 100$$

Weigh out a representative subsample of the waste of the appropriate size and record the weight.

9.5 If particle-size reduction of the solid portion of the waste was required in Step 7.2, proceed to Step 9.8. If particle-size reduction was not required in Step 7.2, proceed to Step 9.7.

9.6 The waste is prepared for extraction by crushing, cutting, or grinding the solid portion of the waste to a surface area or particle-size as described in Step 7.2. Wastes and appropriate reduction equipment should be refrigerated, if possible, to 4 °C prior to particle-size reduction. The *maximum* used to effect particle-size reduction must not generate heat in and of itself. If reduction of the solid phase of the waste is necessary, exposure of the waste to the atmosphere should be avoided to the extent possible.

Note.—Sieving of the waste is not recommended due to the possibility that volatiles may be lost. The use of an appropriately graduated ruler is recommended as an acceptable alternative. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended.

When the surface area or particle-size has been appropriately altered, proceed to Step 9.7.

9.7 Waste slurries need not be allowed to stand to permit the solid phase to settle. Wastes that settle slowly shall not be centrifuged prior to filtration.

9.8 Quantitatively transfer the entire sample (liquid and solid phases) quickly to the ZHE. Secure the filter and support screens into the top flange of the device and secure the top flange to the ZHE body in accordance with the manufacturer's instructions. Tighten all ZHE fittings and place the device in the vertical position (gas inlet/outlet flange on the bottom). *Do not* attach the extraction collection device to the top plate.

Note.—If waste material (> 1% of original sample weight) has obviously adhered to the container used to transfer the sample to the ZHE, determine the weight of this residue and subtract it from the sample weight determined in Step 9.4, to determine the weight of the waste sample that will be filtered.

Attach a gas line to the gas inlet/outlet valve (bottom flange) and, with the liquid inlet/outlet valve (top flange) closed, apply gentle pressure of 1–10 psi (if necessary) to force all headspace (into a hood) slowly out of the ZHE device. At the first appearance of liquid from the liquid inlet/outlet valve, quickly close the valve and discontinue pressure. If filtration of the waste at 4°C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm up to room temperature in the device before filtering. If the waste is 100% solid (see Step 7.1), slowly increase the pressure to a maximum of 50 psi to force most of the headspace out of the device as I proceed to Step 9.12.

9.9 Attach the evacuated pre-weighed filtrate collection container to the liquid inlet/outlet valve and open the valve. Begin applying gentle pressure of 1–10 psi to force the liquid phase into the filtrate collection container. If no additional liquid has passed through the filter in any 2-minute interval, slowly increase the pressure in 10-psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if no additional liquid has passed through the filter in any 2-minute interval, proceed to the next 10-psi increment. When liquid flow has ceased such that continued pressurization at 50 psi does not result in any additional filtrate within any 2-minute period, filtration is stopped. Close the liquid inlet/outlet valve, disconnect pressure line to the gas inlet/outlet valve, and disconnect the filtrate collection container.

Note.—Using pressure in excess of 50 psi to speed up filtration may cause premature clogging.

6.10 The material in the ZHE is defined as the solid phase of the waste and the filtrate is defined as the liquid phase.

Note.—Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. But even after applying pressure filtration, this material will not filter. If this is the case, the material within the filtration device is defined as a solid and is carried through the TCLP extraction as a solid.

If the original waste contained <0.5% dry solids (see Step 7.3), this filtrate is defined as the TCLP extract and is analyzed directly. Proceed to Step 8.18.

6.11 The liquid phase may now be either analyzed immediately (see Steps 8.13 through 8.15) or stored at 4 °C under minimal headspace conditions until time of analysis. The weight of extraction fluid #1 to add to the ZHE is determined as follows:

$$\text{Weight of extraction fluid} = \frac{20 \times \text{solids (Step 7.1)} \times \text{weight of waste filtered (Step 6.4 or 6.8)}}{100}$$

6.12 The following steps detail how to add the appropriate amount of extraction fluid to the solid material within the ZHE and agitation of the ZHE vessel. Extraction fluid #1 is used in all cases (see Step 5.6).

6.12.1 With the ZHE in the vertical position, attach a line from the extraction fluid reservior to the liquid inlet/outlet valve. The line used shall contain fresh extraction fluid and should be prefluched with fluid to eliminate any air pockets in the line. Release gas pressure on the ZHE piston (from the gas inlet/outlet valve), open the liquid inlet/outlet valve, and begin transferring extraction fluid (by pumping or similar means) into the ZHE. Continue pumping extraction fluid into the ZHE until the appropriate amount of fluid has been introduced into the device.

6.12.2 After the extraction fluid has been added, immediately close the liquid inlet/outlet valve and disconnect the extraction fluid line. Check the ZHE to ensure that all valves are in their closed positions. Physically rotate the device in an end-over-end fashion 2 or 3 times. Reposition the ZHE in the vertical position with the liquid inlet/outlet valve on top. Put 5–10 psi behind the piston (if necessary) and slowly open the liquid inlet/outlet valve to bleed out any headspace (into a hood) that may have been introduced due to the addition of extraction fluid. This bleeding shall be done quickly and shall be stopped at the first appearance of liquid from the valve. Re-pressurize the ZHE with 5–10 psi and check all ZHE fittings to ensure that they are closed.

6.12.3 Place the ZHE in the rotary extractor apparatus (if it is not already there) and rotate the ZHE at 30 ± 2 rpm for 18 ± 2 hours. Ambient temperature (i.e., temperature of room in which extraction is to occur) shall be maintained at 22 ± 3 °C during agitation.

6.13 Following the 18 ± 2 hour agitation period, check the pressure behind the ZHE piston by quickly opening and closing the gas inlet/outlet valve and noting the escape of gas. If the pressure has not been maintained (i.e., no gas release observed), the device is leaking. Check the ZHE for leaking as specified in Step 4.2.1, and redo the extraction with a new sample of waste. If the pressure within the device has been maintained, the material in the extractor vessel is once again separated into its component liquid and solid phases. If the waste contained an initial liquid phase, the liquid may be filtered directly into the same filtrate collection container (i.e., TEDLAR® bag) holding the initial liquid phase of the waste, unless doing so would create multiple phases, or unless there is not enough volume left within the filtrate collection container. A separate filtrate collection container must be used in these cases. Filter through the glass fiber filter, using the ZHE device as discussed in Step 6.8. All extract shall be filtered and collected in the TEDLAR® bag is used, if the extract is multiphasic, or if the waste contained an initial liquid phase (see Steps 4.8 and 6.1).

Note.—An in-line glass fiber filter may be used to filter the material within the ZHE when it is suspected that the glass fiber filter has been ruptured.

6.14 If the original waste contained no initial liquid phase, the filtered liquid material obtained from Step 6.13 is defined as the TCLP extract. If the waste contained an initial liquid phase, the filtered liquid material obtained from Step 6.13 and the initial liquid phase (Step 6.9) are collectively defined as the TCLP extract.

6.15 Following collection of the TCLP extract, the extract should be immediately aliquoted for analysis and stored with minimal headspace at 4 °C until analyzed. The TCLP extract will be prepared and analyzed according to the appropriate analytical methods. If the individual phases are to be analyzed separately (i.e., are not miscible), determine the volume of the individual phases (to ±0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final Analyte Concentration} = \frac{(V_1)(C_1) + (V_2)(C_2)}{V_1 + V_2}$$

where:

V_1 = The volume of the first phase (L).

C_1 = The concentration of the contaminant of concern in the first phase (mg/L).

V_2 = The volume of the second phase (L).

C_2 = The concentration of the contaminant of concern in the second phase (mg/L).

6.16 The contaminant concentrations in the TCLP extract are compared with the thresholds identified in the appropriate regulations. Refer to Section 10.0 for quality assurance requirements.

10.0 QUALITY ASSURANCE REQUIREMENTS

10.1 All data, including quality assurance data, should be maintained and available for reference or inspection.

10.2 A minimum of one blank (extraction fluid #1) for every 20 extractions that have been conducted in an extraction vessel shall be employed as a check to determine if any memory effects from the extraction equipment are occurring.

10.3 For each analytical batch (up to twenty samples), it is recommended that a matrix spike be performed. Addition of matrix spikes should occur once the TCLP extract has been generated (i.e., should not occur prior to performance of the TCLP procedure). The purpose of the matrix spike is to monitor the adequacy of the analytical methods used on the TCLP extract and for determining if matrix interferences exist in analyte detection.

10.4 All quality control measures described in the appropriate analytical methods shall be followed.

10.5 The method of standard addition shall be employed for each analyte if: 1) recovery of the compound from the TCLP extract is not between 50 and 120%, or 2) if the concentration of the constituent measured in the extract is within 20% of the appropriate regulatory threshold. If more than one extraction is being run on samples of the same waste (up to twenty samples), the method of standard addition need be applied only once and the percent recoveries applied to the remainder of the extractions.

10.6 Samples must undergo TCLP extraction within the following time period after sample receipt: Volatiles, 14 days; Semi-Volatiles, 40 days; Mercury, 28 days; and other Metals, 180 days. Extraction of the solid portion of the waste should be initiated as soon as possible following initial solid/liquid separation. TCLP extracts shall be analyzed after generation and preservation within the following periods: Volatiles, 14 days; Semi-Volatiles, 40 days; Mercury, 28 days; and other Metals, 180 days.

TABLE 1.—VOLATILE CONTAMINANTS [1]

Compound	CAS No.
Acetone	67-64-1
Acrylonitrile	71-43-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Methylene chloride	75-09-2
Methyl ethyl ketone	78-93-3
Methyl isobutyl ketone	108-10-1
Tetrachloroethylene	127-18-4
Toluene	108-88-3
1,1,1-Trichloroethane	71-55-6
Trichloroethylene	79-01-6
Trichlorofluoromethane	75-69-4
Xylene	1330-20-7

[1] Includes compounds identified in the Land Disposal Restrictions Rule. If any of the compounds are of concern, the semi-volatile fraction should be used. If other (non-volatile) compounds are of concern, the extraction fluids extractor must be used.

TABLE 2.—SUITABLE ROTARY AGITATION APPARATUS [1]

Company	Location	Model
Associated Design and Manufacturing Company	Alexandria, VA (703) 549-5999	4-vessel station, 6-vessel station
Lars Landa Manufacturing	Wellington, CO (303) 447-2813	10-vessel station, 6-vessel station
RIA Machine Shop and Laboratory	Bellevue, KS (913) 734-1854	16-vessel station
Rittle Instrument		6-vessel station [2]
RECMIXER	Wilmington, DE (414) 649-9503	6-vessel station

TABLE 2.—SUITABLE ROTARY AGITATION APPARATUS [1]—Continued

Company	Location	Model
Analytical Testing and Consulting Services, Inc.	Warrington, PA (215) 343-4028	4-vessel station

[1] Any device that rotates the extraction vessel in an end-over-end fashion at 30 ± 2 rpm is acceptable.
[2] Although this device is suitable, it is not commercially available. It may also require fabrication of accessories and devices.

TABLE 3.—SUITABLE ZERO-HEADSPACE EXTRACTOR VESSELS

Company	Location	Model No.
[redacted] Manufacturing Co.	Alexandria, VA (703) 549-5999	3745-2HB, Gas Pressure Control
[redacted]	Bedford, MA (617) 275-1234	201 PSI CS, Gas Pressure Control
[redacted] Laboratory Services, Inc.	Warrington, PA (215) 343-4028	CSE, Mechanical Pressure Control

TABLE 4.—SUITABLE FILTER HOLDERS [1]

Company	Location	Model	Size
[redacted]	Pleasanton, CA (800) 882-7711	420410	142 mm
[redacted]	Dublin, CA (415) 833-8710	410420	47 mm
[redacted]	Bedford, MA (800) 225-2304	300420	142 mm
[redacted]		YT30142HW	142 mm
[redacted]		XX1004700	47 mm

[1] [redacted] of supporting the fritted glass of the vessel is suitable, provided that it is chemically compatible with the waste and the constituents to be analyzed for. [redacted] listed above) may be used when only inorganic constituents are of concern. The 142 mm size filter holder is recommended.

TABLE 5.—SUITABLE FILTER MEDIA

Company	Location	Model	Pore size [1]
[redacted] Products, Inc.	Clifton, NJ (201) 772-5600	GFF	0.7

[redacted]

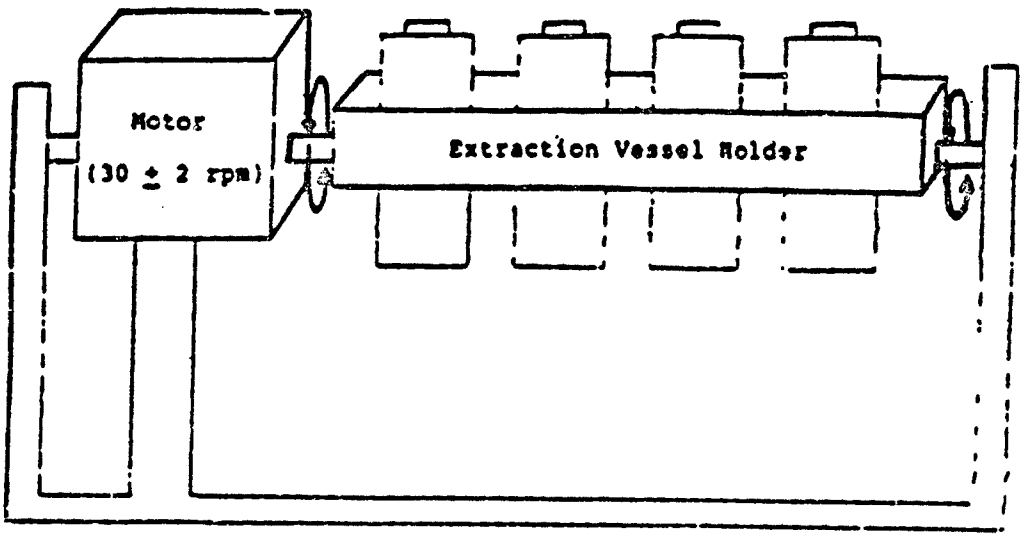


Figure 2: Rotary Agitation

BILLING CODE 6560-50-C

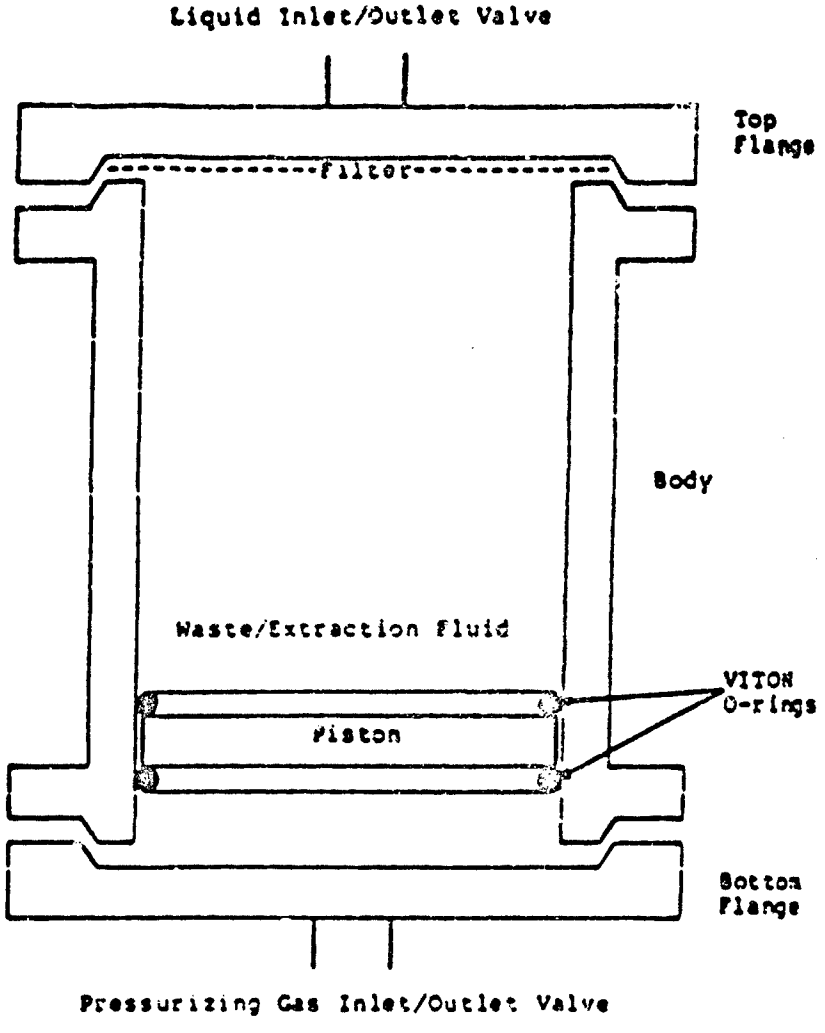


Figure 3: Zero-Headspace Extraction Vessel

APPENDIX E

DESCRIPTION OF THE CEM SAMPLING SYSTEM

E. DESCRIPTION OF CEM SAMPLING SYSTEM

The CEM system used for gaseous pollutant monitoring consisted of EPA Methods 3, 3A, 10 and 25A.

E.1 Sampling System. Exhaust gas is drawn from the duct or stack through a heated stainless steel (S.S.) probe that is inserted into the duct or stack through one of the test ports. A S.S. valve is located at the probe exit to permit introduction of certified zero and calibration span gases. A heated Teflon line is used to transport the sample or zero/ calibration gases to the Continuous Emissions Monitoring (CEM) trailer. Temperatures are monitored at the exit of each section of line to ensure temperatures above the sample dew point. Once inside the CEM trailer, the sample is split into fractions, and each fraction is directed to one of the following:

(a) Exemplar Model PEL-3 Sample Gas Conditioner
(b) Direct Connection to Total Hydrocarbon Analyzers.

The Exemplar Model PEL-3 is an extractive sample conditioner that removes particulates and moisture from the sample gas. The extracted sample gas is passed through a sintered stainless (S.S.) bypass filter, which removes particulates down to 1 micron or less by an inertial filtration technique. The filter is maintained at a temperature above the dew point of the sample gases.

The clean, filtered sample is then introduced to a permeation dryer where moisture is removed without condensation or dilution to achieve a sample dew point well below that of the ambient temperature. The clean, dried sample is then directed to the carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2) analyzers using a Teflon-headed sample pump.

In the J.U.M. Engineer VE-7 Total Hydrocarbons Analyzer, a S.S. sample filter and detector are contained in a temperature controlled oven. This permitted the direct analysis of total hydrocarbons on a wet basis without condensation or loss of sample.

E.2 CEM System Calibration Procedures. Calibrations are conducted on a daily basis. The following procedures are also performed each day of testing:

(a) Analyzer calibration error (pretest).
(b) Sampling system bias check (pretest).
(c) Sampling system bias check (post-test).

Calibrations employed cylinder gas standards are prepared according to EPA Protocol 1, where available. All other calibration gases are traceable to National Bureau of Standards (NBS) standards.

E.3 CEM System Data Collection. Signals from the CEM sampling system are recorded in hard copy from a Molytek strip-chart recorder/data logger.

APPENDIX F

SAMPLING AND ANALYTICAL METHODS FOR AFTERBURNER OUTLET GAS TESTING

- EPA METHOD 2
- EPA METHOD 3
- EPA METHOD 3A
- EPA METHOD 10
- EPA METHOD 25A

EPA METHOD 2

METHOD 2—DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

1. *Principle and Applicability*

1.1 Principle. The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Staumscheibe or reverse type) pitot tube.

1.2 Applicability. This method is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow.

This procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 2.1. Also, the method cannot be used for direct measurement in cyclonic or swirling gas streams. Section 2.4 of Method 1 shows how to determine cyclonic or swirling flow conditions. When unacceptable conditions exist, alternative procedures, subject to the approval of the Administrator, U.S. Environmental Protection Agency, must be employed to make accurate flow rate determinations; examples of such alternative procedures are: (1) to install straightening vanes; (2) to calculate the total volumetric flow rate stoichiometrically, or (3) to move to another measurement site at which the flow is acceptable.

2. *Apparatus*

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

2.1 Type S Pitot Tube. The Type S pitot tube (Figure 2-1) shall be made of metal tubing (e.g. stainless steel). It is recommended that the external tubing diameter (dimension D_t, Figure 2-2b) be between 0.48 and 0.95 centimeter (3/16 and 3/8 inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B, Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

The Type S pitot tube shall have a known coefficient, determined as outlined in Section 4, an identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube.

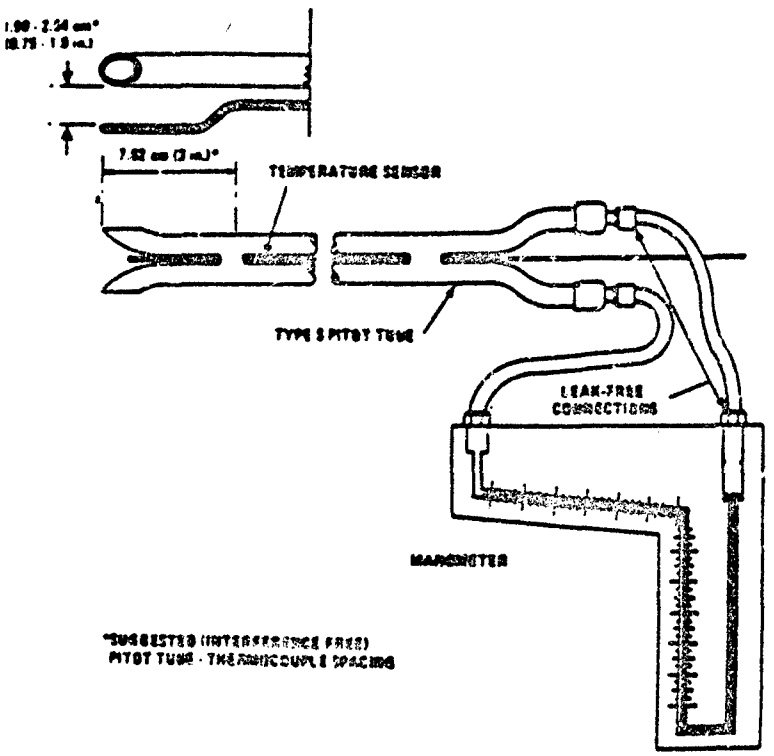
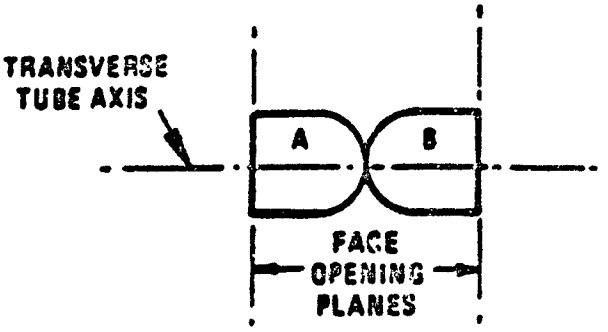
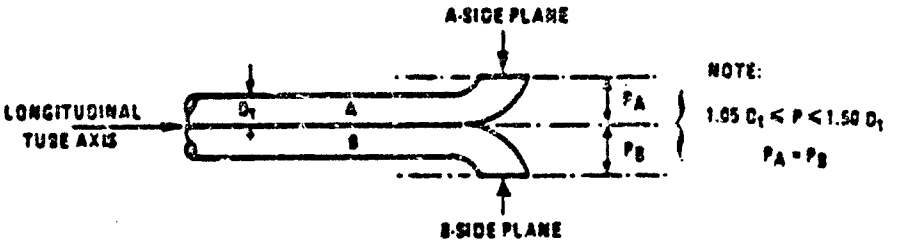


Figure 2-1. Type S pitot tube manometer assembly.



(a)



(b)

(c)

Figure 2-2. Properly constructed Type S pitot tube, shown in: (a) end view; face opening planes perpendicular to transverse axis; (b) top view; face opening planes parallel to longitudinal axis; (c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.

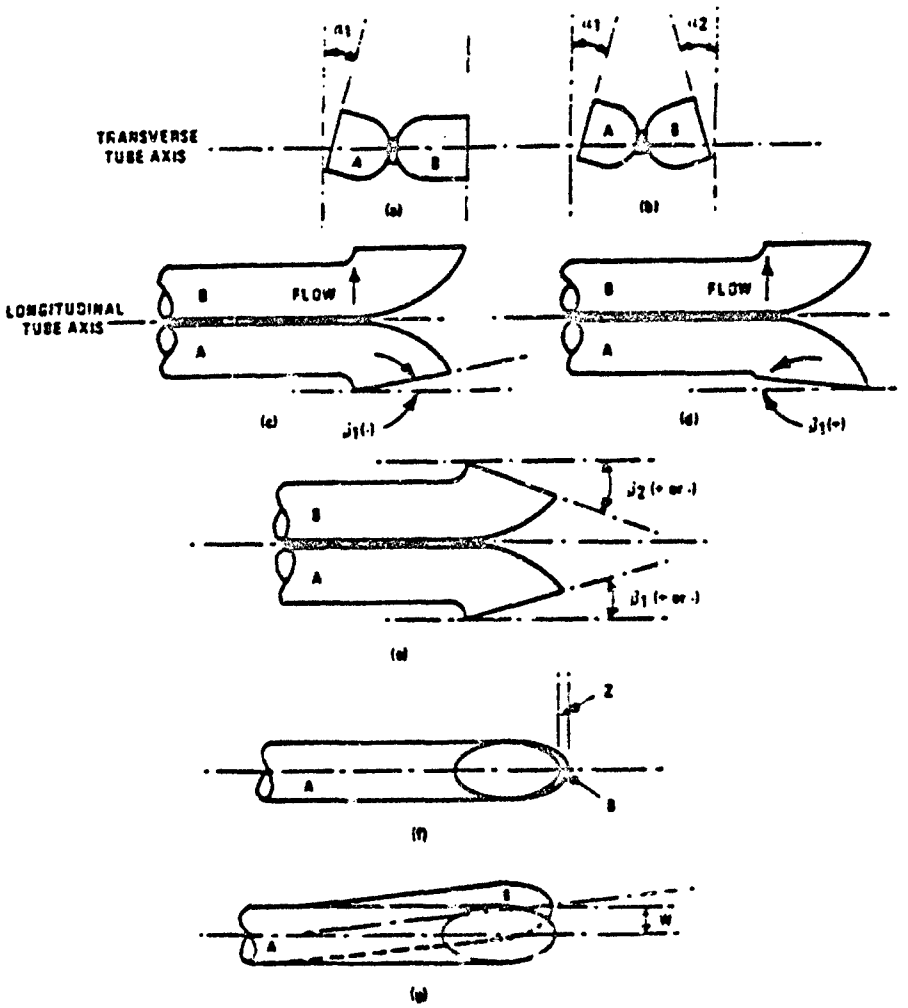


Figure 2-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of Cp(s) so long as $\alpha 1$ and $\alpha 2$ 10°, $\beta 1$ and $\beta 2$ 5°, z 0.32 cm (1/8 in.) and w 0.08 cm (1/32 in.) (citation 11 in Section 6).

A standard pitot tube may be used instead of a Type S, provided that it meets the specifications of Sections 2.7 and 4.2; note, however, that the static and impact pressure holes of standard pitot tubes are susceptible to plugging in particulate-laden gas streams. Therefore, whenever a standard pitot tube is used to perform a traverse, adequate proof must be furnished that the openings of the pitot tube have not plugged up during the traverse period; this can be done by taking a velocity head (Δp) reading at the final traverse point, cleaning out the impact and static holes of the standard pitot tube by "back-purging" with pressurized air, and then taking another Δp reading. If the Δp readings made before and after the air purge are the same (±5 percent), the traverse is acceptable. Otherwise, reject the run. Note that if Δp at the final traverse point is unsuitably low, another point may be selected. If "back-purging" at regular intervals is part of the procedure, then comparative Δp readings shall be

taken, as above, for the last two back purges at which suitably high Δp readings are observed.

2.3 Differential Pressure Gauge. An inclined manometer or equivalent device is used. Most sampling trains are equipped with a 10-in. (water column) inclined-vertical manometer, having 0.01-in. H_2O divisions on the 0-to 1-in. inclined scale, and 0.1-in. H_2O divisions on the 1- to 10-in. vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of Δp values as low as 1.3 mm (0.05 in.) H_2O. However, a differential pressure gauge of greater sensitivity shall be used (subject to the approval of the Administrator), if any of the following is found to be true: (1) the arithmetic average of all Δp readings at the traverse points in the stack is less than 1.3 mm (0.05 in.) H_2O; (2) for traverses of 12 or more points, more than 10 percent of the individual Δp readings are below 1.3 mm (0.05 in.) H_2O; (3) for traverses of fewer than 12 points, more than one Δp reading is below 1.3 mm (0.05 in.) H_2O. Citation 18 in Section 6 describes commercially available instrumentation for the measurement of low-range gas velocities.

As an alternative to criteria (1) through (3) above, the following calculation may be performed to determine the necessity of using a more sensitive differential pressure gauge:

$$T = \frac{\sum_{i=1}^{n} \sqrt{\Delta p_i} + K}{\sum_{i=1}^{n} \sqrt{\Delta p_i}}$$

where:

Δp = Individual velocity head reading at a traverse point, mm H_2O (in. H_2O).

n = Total number of traverse points.

K = 0.13 mm H_2O when metric units are used and 0.005 in H_2O when English units are used.

If T is greater than 1.06, the velocity head data are unacceptable and a more sensitive differential pressure gauge must be used.

Note: If differential pressure gauges other than inclined manometers are used (e.g. magnehelic gauges), their calibration must be checked after each test series. To check the calibration of a differential pressure gauge, compare Δp readings of the gauge with those of a gauge-oil manometer at a minimum of three points, approximately representing the range of Δp values in the stack. If, at each point, the values of Δp as read by the differential pressure gauge and gauge-oil manometer agree to within 5 percent, the differential pressure gauge shall be considered to be in proper calibration. Otherwise, the test series shall either be voided, or procedures to adjust the measured Δp values and final results shall be used subject to the approval of the Administrator.

2.3 Temperature Gauge. A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge, capable of measuring temperature to within 1.5 percent of the minimum absolute stack temperature shall be used. The temperature gauge shall be attached to the pitot tube such that the sensor tip does not touch any metal; the gauge shall be in an interference-free arrangement with respect to the pitot tube face openings (see Figure 2-1 and also Figure 2-7 in Section 4). Alternate positions may be used if the pitot tube-temperature gauge system is calibrated according to the procedure of Section 4. Provided that a difference of not more than 1 percent in the average velocity measurement is introduced, the temperature gauge need not be attached to the pitot tube; this alternative is subject to the approval of the Administrator.

2.4 Pressure Probe and Gauge. A piezometer tube and mercury- or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) Hg is used. The static tap of a standard type pitot tube or one leg of a Type S pitot tube with the face opening planes positioned parallel to the gas flow may also be used as the pressure probe.

2.5 Barometer. A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm (0.1 in.) Hg per 30-meter (100 foot) elevation increase or vice-versa for elevation decrease.

2.6 Gas Density Determination Equipment. Method 3 equipment, if needed (see Section 3.6), to determine the stack gas dry molecular weight, and Reference Method 4 or Method 5 equipment for moisture content determination; other methods may be used subject to approval of the Administrator.

2.7 Calibration Pitot Tube. When calibration of the Type S pitot tube is necessary (see Section 4), a standard pitot tube is used as a reference. The standard pitot tube shall, preferably, have a known coefficient, obtained either (1) directly from the National Bureau of Standards, Route 270, Quince Orchard Road, Gaithersburg, Maryland, or (2) by calibration against another standard pitot tube with an NBS-traceable coefficient. Alternatively, a standard pitot tube designed according to the criteria given in 2.7.1 through 2.7.5 below and illustrated in Figure 2-4 (see also Citations 7, 8, and 17 in Section 6) may be used. Pitot tubes designed according to these specifications will have baseline coefficients of about 0.99 ± 0.01.

2.7.1 Hemispherical (shown in Figure 2-4), ellipsoidal, or conical tip.

2.7.2 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes.

2.7.3 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90 degree bend.

2.7.4 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration.

2.7.5 Ninety degree bend, with curved or mitered junction.

2.8 Differential Pressure Gauge for Type S Pitot Tube Calibration. An inclined manometer or equivalent is used. If the single-velocity calibration technique is employed (see Section 4.1.2.3), the calibration differential pressure gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in. H_2O). For multivelocity calibrations, the gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in H_2O) for Δp values between 1.3 and 25 mm H_2O (0.05 and 1.0 in. H_2O), and to the nearest 1.3 mm H_2O (0.05 in. H_2O) for Δp values above 25 mm H_2O (1.0 in. H_2O). A special, more sensitive gauge will be required to read Δp values below 1.3 mm H_2O (0.05 in. H_2O) (see Citation 18 in Section 6).

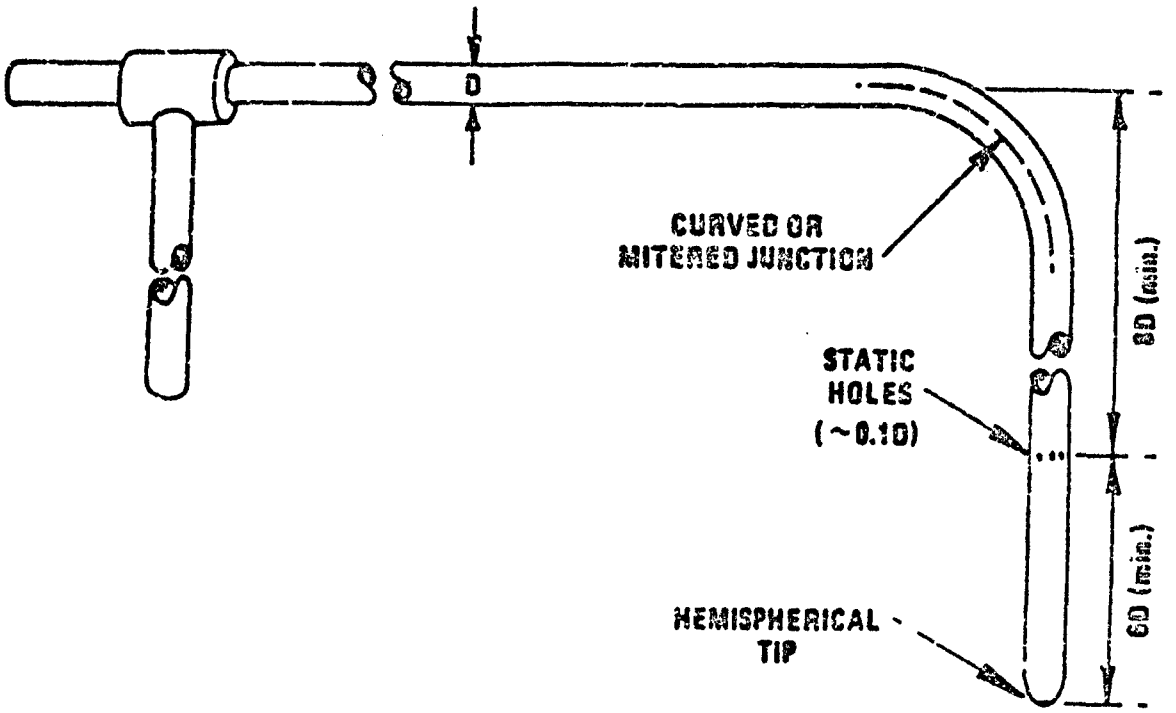


Figure 2-4. Standard pitot tube design specifications.

3 *Procedure*

3.1 Set up the apparatus as shown in Figure 3-1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen Δp fluctuations. It is recommended, but not required, that a pretest leak-check be conducted, as follows: (1) blow through the pitot impact opening until at least 7.6 cm (3 in.) H_2O velocity pressure registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (2) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3 in.) H_2O. Other leak-check procedures, subject to the approval of the Administrator, may be used.

3.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record all necessary data as shown in the example data sheet (Figure 2-5).

3.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of Δp values encountered (see Section 2.2). If it is necessary to change to a more sensitive gauge, do so, and remeasure the Δp and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in Section 3.1 above, to validate the traverse run.

3.4 Measure the static pressure in the stack. One reading is usually adequate.

3.5 Determine the atmospheric pressure.

PLANT _____

DATE _____ RUN NO. _____

STACK DIAMETER OR DIMENSIONS, m(in.) _____

BAROMETRIC PRESSURE, mm Hg (in. Hg) _____

CROSS SECTIONAL AREA, $m^2(ft^2)$ _____

OPERATORS _____

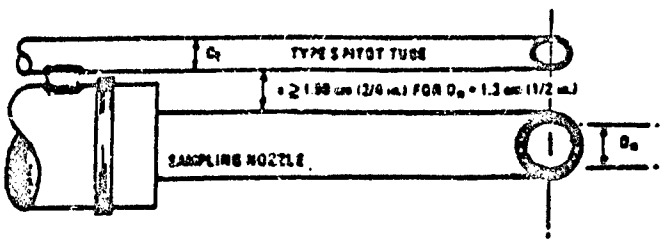
PITOT TUBE I.D. NO _____

AVG. COEFFICIENT, C_p = _____

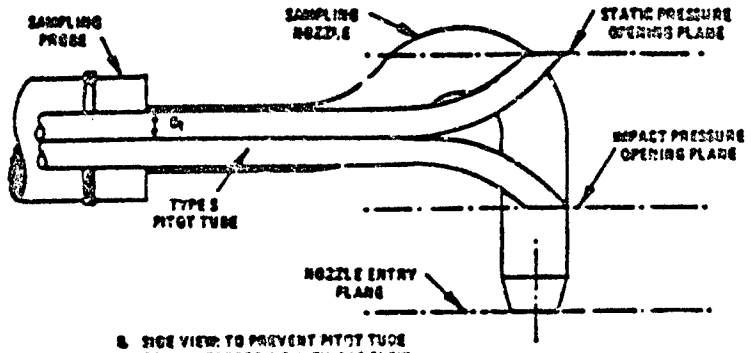
LAST DATE CALIBRATED _____

SCHEMATIC OF STACK CROSS SECTION

Traverse Pt. No.	Vel. Hd., Δp mm (in.) H_2O	Stack Temperature t_s °C (°F)	Stack Temperature T_s °K (°R)	P_g mm Hg (in. Hg)	$\sqrt{\Delta p}$



A. BOTTOM VIEW: ENSURING MINIMUM PITOT-NOZZLE SEPARATION.



B. SIDE VIEW: TO PREVENT PITOT TUBE FROM INTERFERING WITH GAS FLOW STREAMLINES APPROACHING THE NOZZLE, THE IMPACT PRESSURE OPENING PLANE OF THE PITOT TUBE SHALL BE EVEN WITH OR ABOVE THE NOZZLE ENTRY PLANE.

Figure 2-6. Proper pitot tube-sampling nozzle configuration to prevent aerodynamic interference between S-type pitot tubes and nozzles of sampling trains. D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Citation 9 in Section 6); therefore an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-6 through 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm (3/16 and 3/8 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-6 through 2-8 shall be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

NOTE: Do not use any Type S pitot tube assembly which is constructed such that the impact pressure opening plane of the pitot tube is below the entry plane of the nozzle (see Figure 2-6b).

4.1.2 Calibration Setup. If the Type S pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be done in a flow system having the following essential design features:

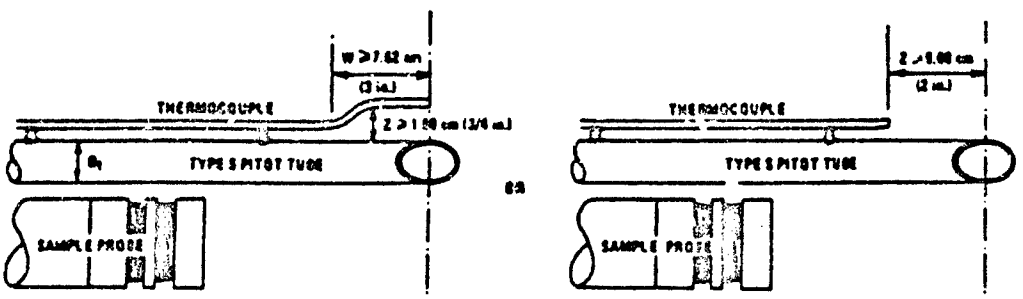


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

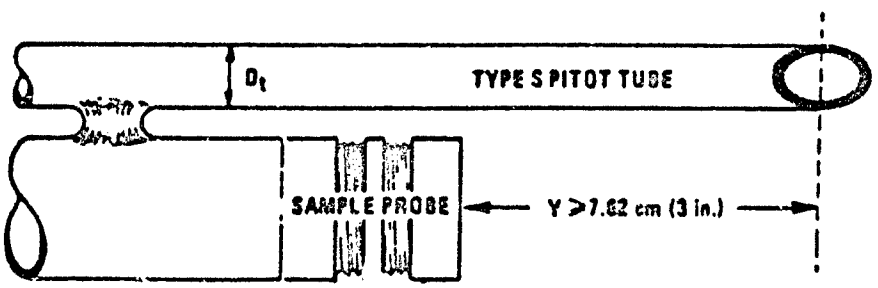


Figure 2-8. Minimum pitot-sampling probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

4.1.2.1 The flowing gas stream must be confined to a duct of definite cross-sectional area, either circular or rectangular. For circular cross-sections, the minimum duct diameter shall be 30.5 cm (12 in.); for rectangular cross-sections, the width (shorter side) shall be at least 30.4 cm (12 in.).

4.1.2.2 The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation, to determine the number of duct diameters:

$$D = \frac{2LW}{(L+W)}$$

Equation 2-1

where:
D = Equivalent diameter
L = Length
W = Width

To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section," the site must be located at least eight diameters downstream and two diameters upstream from the nearest disturbance.

NOTE: The eight- and two-diameter criteria are not absolute; other test section locations may be used (subject to approval of the Administrator), provided that the flow at the test site is stable and demonstrably parallel to the duct axis.

4.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3,000 ft/min) will generally be valid to within ±3 percent for the measurement of velocities above 305 m/min (1,000 ft/min) and to within ±5 to 8 percent for the measurement of velocities between 183 and 305 m/min (600 and 1,000 ft/min). If a more precise correlation between C_p and velocity is desired, the flow system shall have the capacity to generate at least four distinct, time-invariant test-section velocities covering the velocity range from 183 to 1,525 m/min (600 to 5,000 ft/min), and calibration data shall be taken at regular velocity intervals over this range (see Citations 9 and 14 in Section 6 for details).

4.1.2.4 Two entry ports, one each for the standard and Type S pitot tubes, shall be cut in the test section; the standard pitot entry port shall be located slightly downstream of the Type S port, so that the standard and Type S impact openings will lie in the same cross-sectional plane during calibration. To facilitate alignment of the pitot tubes during calibration, it is advisable that the test section be constructed of plexiglas or some other transparent material.

4.1.3 Calibration Procedure. Note that this procedure is a general one and must not be used without first referring to the special considerations presented in Section 4.1.1. Note also that this procedure applies only to single-velocity calibration. To obtain calibration data for the A and B sides of the Type S pitot tube, proceed as follows:

4.1.3.1 Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary.

PITOT TUBE IDENTIFICATION NUMBER: _____ DATE: _____

CALIBRATED BY: _____

	"A" SIDE CALIBRATION			
RUN NO.	Δp_{std} cm H_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	DEVIATION $C_{p(s)} - \bar{C}_p(A)$
1				
2				
3				
		$\bar{C}_p$ (SIDE A)		

	"B" SIDE CALIBRATION			
RUN NO.	Δp_{std} cm H_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	DEVIATION $C_{p(s)} - \bar{C}_p(B)$
1				
2				
3				
		$\bar{C}_p$ (SIDE B)		

$$\text{AVERAGE DEVIATION} = \sigma \text{ (A OR B)} = \frac{\sum_{1}^{3} \left| C_{p(s)} - \bar{C}_p(\text{A OR B}) \right|}{3} \longleftarrow \text{MUST BE} \leq 0.01$$

$$\left| \bar{C}_p \text{ (SIDE A)} - \bar{C}_p \text{ (SIDE B)} \right| \longleftarrow \text{MUST BE} \leq 0.01$$

Figure 2-9. Pitot tube calibration data.

4.1.3.2 Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type S entry port.

4.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.3.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.4 Read ΔP_{std} and record its value in a data table similar to the one shown in Figure 2-8. Remove the standard pitot tube from the duct and disconnect it from the manometer. Seal the standard entry port.

4.1.3.5 Connect the Type S pitot tube to the manometer. Open the Type S entry port. Check the manometer level and zero. Insert and align the Type S pitot tube so that its A side impact opening is at the same point as was the standard pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.6 Read Δp and enter its value in the data table. Remove the Type S pitot tube from the duct and disconnect it from the manometer.

4.1.3.7 Repeat steps 4.1.3.3 through 4.1.3.6 above until three pairs of Δp readings have been obtained.

4.1.3.8 Repeat steps 4.1.3.3 through 4.1.3.7 above for the B side of the Type S pitot tube.

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

4.1.4 Calculations.

4.1.4.1 For each of the six pairs of Δp readings (i.e., three from side A and three from side B) obtained in Section 4.1.3 above, calculate the value of the Type S pitot tube coefficient as follows:

$$C_{pa} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}}$$

Equation 2-2

where:

C_{pa} = Type S pitot tube coefficient

$C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 2.7.1 to 2.7.5 of this method.

Δp_{std} = Velocity head measured by the standard pitot tube, cm H_2O (in. H_2O)

Δp_s = Velocity head measured by the Type S pitot tube, cm H_2O (in H_2O)

4.1.4.2 Calculate $\bar{C}_s$ (side A), the mean A-side coefficient, and $\bar{C}_s$ (side B), the mean B-side coefficient; calculate the difference between these two average values.

4.1.4.3 Calculate the deviation of each of the three A-side values of C_{pa} from $\bar{C}_s$ (side A), and the deviation of each B-side value of C_{pa} from $\bar{C}_s$ (side B). Use the following equation:

$$\text{Deviation} = C_{pa} - \bar{C}_s(\text{A or B})$$

Equation 2-3

4.1.4.4 Calculate σ, the average deviation from the mean, for both the A and B sides of the pitot tube. Use the following equation:

$$\sigma(\text{side A or B}) = \frac{\sum_{i}^{3} |C_{pa} - \bar{C}_s(A \text{ or } B)|}{3}$$

Equation 2-4

4.1.4.5 Use the Type S pitot tube only if the values of σ (side A) and σ (side B) are less than or equal to 0.01 and if the absolute value of the difference between $\bar{C}_s$ (A) and $\bar{C}_s$ (B) is 0.01 or less.

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., $\bar{C}_s$ (side A) and $\bar{C}_s$ (side B), will be valid so long as either (1) the isolated pitot tube is used or (2) the pitot tube is used with other components (nozzle, thermocouple, sample probe) in an arrangement that is free from aerodynamic interference effects (see Figures 3-4 through 2-6).

4.1.5.1.2 For Type S pitot tube-thermocouple combinations (without sample probe), select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The coefficients so obtained will be valid so long as the pitot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 2-5 and 2-6).

4.1.5.1.3 For assemblies with sample probes, the calibration point should be located at or near the center of the duct; however, insertion of a probe sheath into a small duct may cause significant cross-sectional area blockage and yield incorrect coefficient values (Citation 9 in Section 6). Therefore, to minimize the blockage effect, the calibration point may be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical blockage, as determined by a projected-area model of the probe sheath, is 2 percent or less of the duct cross-sectional area, for assemblies without external sheaths (Figure 2-10a), and 3 percent or less for assemblies with external sheaths (Figure 2-10b).

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzle separation distance falls to meet the specification illustrated in Figure 2-6a), the value of C_{pa} depends upon the amount of free-space between the tube and nozzle, and therefore is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (>0.635 cm or ¼ in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 18 in Section 6).

4.1.5.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see Section 4.1.4.4).

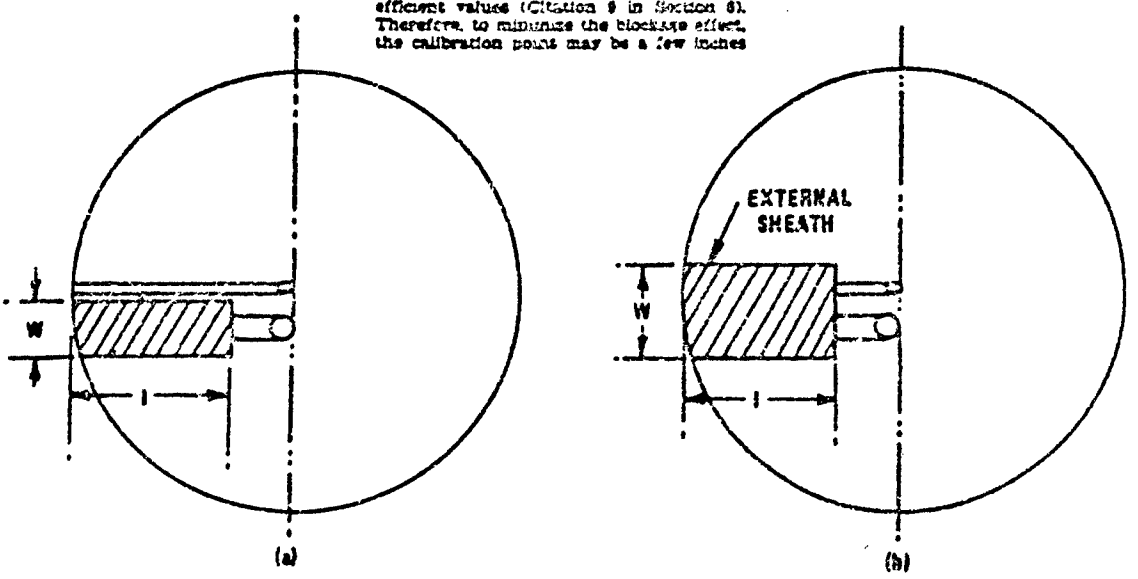


Figure 2-10. Projected-area models for typical pitot tube assemblies.

Figure 2-10. Projected-area models for typical pitot tube assemblies.

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

4.1.6.1.1 When a Type S pitot tube (isolated tube or assembly) is used in the field, the appropriate coefficient value (whether assigned or obtained by calibration) shall be used to perform velocity calculations. For calibrated Type S pitot tubes, the A side coefficient shall be used when the A side of the tube faces the flow, and the B side coefficient shall be used when the B side faces the flow; alternatively, the arithmetic average of the A and B side coefficient values may be used, irrespective of which side faces the flow.

4.1.6.1.2 When a probe assembly is used to sample a small duct (12 to 36 in. in diameter), the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of C_{pa}. Consult Citation 9 in Section 6 for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 12 inches (Citation 10 in Section 6).

4.1.6.2 Recalibration.

4.1.6.2.1 Isolated Pitot Tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot face openings are still aligned within the specifications illustrated in Figure 2-2 or 2-3, it can be assumed that the baseline coefficient of the pitot tube has not changed. If, however, the tube has been damaged to the extent that it no longer meets the specifications of Figure 2-2 or 2-3, the damage shall either be repaired to restore proper alignment of the face openings or the tube shall be discarded.

4.1.6.2.2 Pitot Tube Assemblies. After each field use, check the face opening alignment of the pitot tube, as in Section 4.1.6.2.1; also, remeasure the intercomponent spacings of the assembly. If the intercomponent spacings have not changed and the face opening alignment is acceptable, it can be assumed that the coefficient of the assembly has not changed. If the face opening alignment is no longer within the specifications of Figure 2-2 or 2-3, either repair the damage or replace the pitot tube (calibrating the new assembly, if necessary). If the intercomponent spacings have changed, restore the original spacings or recalibrate the assembly.

4.2 Standard pitot tube (if applicable). If a standard pitot tube is used for the velocity traverse, the tube shall be constructed according to the criteria of Section 2.7 and shall be assigned a baseline coefficient value of 0.99. If the standard pitot tube is used as part of an assembly, the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

4.3 Temperature Gauges. After each field use, calibrate dial thermometers, liquid-filled bulb thermometers, thermocouple-potentiometer systems, and other gauges at a temperature within 10 percent of the average absolute stack temperature. For temperatures up to 405° C (761° F), use an ASTM mercury-in-glass reference thermometer, or equivalent, as a reference; alternatively, either a reference thermocouple and potentiometer (calibrated by NBS) or thermometric fixed points, e.g., ice bath and boiling water (corrected for barometric pressure) may be used. For temperatures above 405° C (761° F), use an NBS-calibrated reference thermocouple-potentiometer system or an alternate reference, subject to the approval of the Administrator.

If, during calibration, the absolute temperatures measured with the gauge being calibrated and the reference gauge agree within 1.5 percent, the temperature data taken in the field shall be considered valid. Otherwise, the pollutant emission test shall either be considered invalid or adjustments (if appropriate) of the test results shall be made, subject to the approval of the Administrator.

4.4 Barometer. Calibrate the barometer used against a mercury barometer.

5. *Calculations*

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation.

5.1 Nomenclature.

A = Cross-sectional area of stack, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.

C_p = Pitot tube coefficient, dimensionless.

K_p = Pitot tube constant,

$$34.97 \frac{m}{sec} \left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{\frac{1}{2}}$$

for the metric system and

$$85.49 \frac{ft}{sec} \left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{\frac{1}{2}}$$

for the English system.

M_d = Molecular weight of stack gas, dry basis (see Section 3.6), g/g-mole (lb/lb-mole).

M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

$= M_d (1 - B_{ws}) + 18.0\ B_{ws}$

Equation 2-4

P_{bar} = Barometric pressure at measurement site, mm Hg (in. Hg).

P_g = Stack static pressure, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

$= P_{bar} + P_g$

Equation 2-5

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).

t_s = Stack temperature, °C (°F).

T_s = Absolute stack temperature, °K, (°R).

$= 273 + t_s$ for metric

Equation 2-7

$= 460 + t_s$ for English

Equation 2-8

T_{std} = Standard absolute temperature, 293 °K (528° R).

v_s = Average stack gas velocity, m/sec (ft/sec).

v_{hd} = Velocity head of stack gas, mm H_2O (in. H_2O).

3,600 = Conversion factor, sec/hr.

18.0 = Molecular weight of water, g/g-mole (lb/lb-mole).

5.2 Average stack gas velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s\,avg}}{P_s M_s}}$$

Equation 2-9

5.3 Average stack gas dry volumetric flow rate.

$$Q_{sd} = 3{,}600 (1 - B_{ws}) v_s A \left(\frac{T_{std}}{T_{s\,avg}}\right) \left(\frac{P_s}{P_{std}}\right)$$

Equation 2-10

"To convert Q_{sd} from dscm/hr (dscf/hr) to dscm/min (dscf/min), divide Q_{sd} by 60."

6. *Bibliography*

1. Mark, L. S. Mechanical Engineers' Handbook. New York, McGraw-Hill Book Co., Inc. 1951.

2. Perry, J. H. Chemical Engineers' Handbook. New York. McGraw-Hill Book Co., Inc. 1960.

3. Shigehara, R. T., W. F. Todd, and W. S. Smith. Significance of Errors in Stack Sampling Measurements. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14-19, 1970.)

4. Standard Method for Sampling Stacks for Particulate Matter. In: 1971 Book of ASTM Standards, Part 23. Philadelphia, Pa. 1971. ASTM Designation D-2928-71.

5. Vennard, J. K. Elementary Fluid Mechanics. New York. John Wiley and Sons, Inc. 1947.

6. Fluid Meters—Their Theory and Application. American Society of Mechanical Engineers, New York, N.Y. 1959.

7. ASHRAE Handbook of Fundamentals. 1972. p. 208.

8. Annual Book of ASTM Standards, Part 26. 1974. p. 648.

9. Vollaro, R. F. Guidelines for Type S Pitot Tube Calibration. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at 1st Annual Meeting, Source Evaluation Society, Dayton, Ohio, September 18, 1975.)

10. Vollaro, R. F. A Type S Pitot Tube Calibration Study. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. July 1974.

11. Vollaro, R. F. The Effects of Impact Opening Misalignment on the Value of the Type S Pitot Tube Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. October 1976.

12. Vollaro, R. F. Establishment of a Baseline Coefficient Value for Properly Constructed Type S Pitot Tubes. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.

13. Vollaro, R. F. An Evaluation of Single-Velocity Calibration Technique as a Means of Determining Type S Pitot Tubes Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. August 1975.

14. Vollaro, R. F. The Use of Type S Pitot Tubes for the Measurement of Low Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.

15. Smith, Marvin L. Velocity Calibration of EPA Type Source Sampling Probe. United Technologies Corporation, Pratt and Whitney Aircraft Division, East Hartford, Conn. 1975.

16. Vollaro, R. F. Recommended Procedure for Sample Traverses in Ducts Smaller than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.

17. Ower, E. and R. C. Pankhurst. The Measurement of Air Flow, 4th Ed., London, Pergamon Press, 1966.

18. Vollaro, R. F. A Survey of Commercially Available Instrumentation for the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976. (Unpublished Paper)

19. Gnyp, A. W., C. C. St. Pierre, D. S. Smith, D. Monzon, and J. Steiner. An Experimental Investigation of the Effect of Pitot Tube-Sampling Probe Configurations on the Magnitude of the S Type Pitot Tube Coefficient for Commercially Available Source Sampling Probes. Prepared by the University of Windsor for the Ministry of the Environment, Toronto, Canada. February 1975.

EPA METHOD 3

METHOD 3—GAS ANALYSIS FOR CARBON DIOXIDE, OXYGEN, EXCESS AIR, AND DRY MOLECULAR WEIGHT

1. Principle and Applicability

1.1 Principle. A gas sample is extracted from a stack, by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analyzed for percent carbon dioxide (CO_2), percent oxygen (O_2), and, if necessary, percent carbon monoxide (CO). If a dry molecular weight determination is to be made, either an Orsat or a Fyrite® analyzer may be used for the analysis. For excess air or emission rate correction factor determination, an Orsat analyzer must be used.

1.2 Applicability. This method is applicable for determining CO_2 and O_2 concentrations, excess air, and dry molecular weight of a sample from a gas stream of a fossil-fuel combustion process. The method may also be applicable to other processes where it has been determined that compounds other than CO_2, O_2, CO, and nitrogen (N_2) are not present in concentrations sufficient to affect the results.

Other methods, as well as modifications to the procedure described herein, are also applicable for some or all of the above determinations. Examples of specific methods and modifications include: (1) a multi-point sampling method using an Orsat analyzer to analyze individual grab samples obtained at each point; (2) a method using CO_2 or O_2 and stoichiometric calculations to determine dry molecular weight and excess air; (3) assigning a value of 30.0 for dry molecular weight, in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Administrator, U.S. Environmental Protection Agency.

2. Apparatus

As an alternative to the sampling apparatus and systems described herein, other sampling systems (e.g., liquid displacement) may be used provided such systems are capable of obtaining a representative sample and maintaining a constant sampling rate, and are otherwise capable of yielding acceptable results. Use of such systems is subject to the approval of the Administrator.

2.1 Grab Sampling (Figure 3-1).

2.1.1 Probe. The probe should be made of stainless steel or borosilicate glass tubing and should be equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other materials inert to O_2, CO_2, CO, and N_2 and resistant to temperature at sampling conditions may be used for the probe; examples of such material are aluminum, copper, quartz glass and Teflon®.

2.1.2 Pump. A one-way squeeze bulb, or equivalent, is used to transport the gas sample to the analyzer.

2.2 Integrated Sampling (Figure 3-2).

2.2.1 Probe. A probe such as that described in Section 2.1.1 is suitable.

2.2.2 Condenser. An air-cooled or water-cooled condenser, or other condenser that will not remove O_2, CO_2, CO, and N_2, may be used to remove excess moisture which would interfere with the operation of the pump and flow meter.

2.2.3 Valve. A needle valve is used to adjust sample gas flow rate.

2.2.4 Pump. A leak-free, diaphragm-type pump, or equivalent, is used to transport sample gas to the flexible bag. Install a small surge tank between the pump and rate meter to eliminate the pulsation effect of the diaphragm pump on the rotameter.

2.2.5 Rate Meter. The rotameter, or equivalent, rate meter, used should be capable of maintaining flow rate to within ±2 percent of the selected flow rate. A flow rate range of 500 to 1000 cm³/min is suggested.

2.2.6 Flexible Bag. Any leak-free plastic (e.g., Tedlar, Mylar, Teflon) or plastic-coated aluminum (e.g., aluminized Mylar) bag, or equivalent, having a capacity consistent with the selected flow rate and time length of the test run, may be used. A capacity in the range of 25 to 90 liters is suggested.

To leak-check the bag, connect it to a water manometer and pressurize the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O). Allow to stand for 10 minutes. Any displacement in the water manometer indicates a leak. An alternative leak-check method is to pressurize the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O) and allow to stand overnight. A deflated bag indicates a leak.

2.2.7 Pressure Gauge. A water-filled U-tube manometer, or equivalent, of about 30 cm (12 in.) is used for the flexible bag leak-check.

2.2.8 Vacuum Gauge. A mercury manometer, or equivalent, of at least 760 mm Hg (30 in. Hg) is used for the sampling train leak-check.

2.3 Analysis. For Orsat and Fyrite analyzer maintenance and operation procedures, follow the instructions recommended by the manufacturer, unless otherwise specified herein.

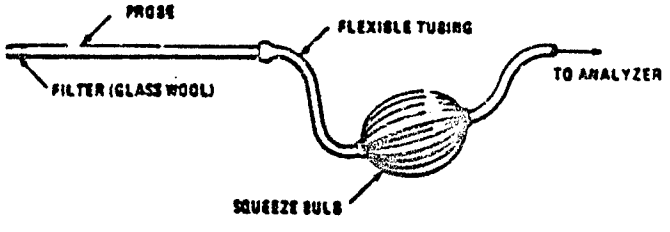


Figure 3-1. Grab sampling train.

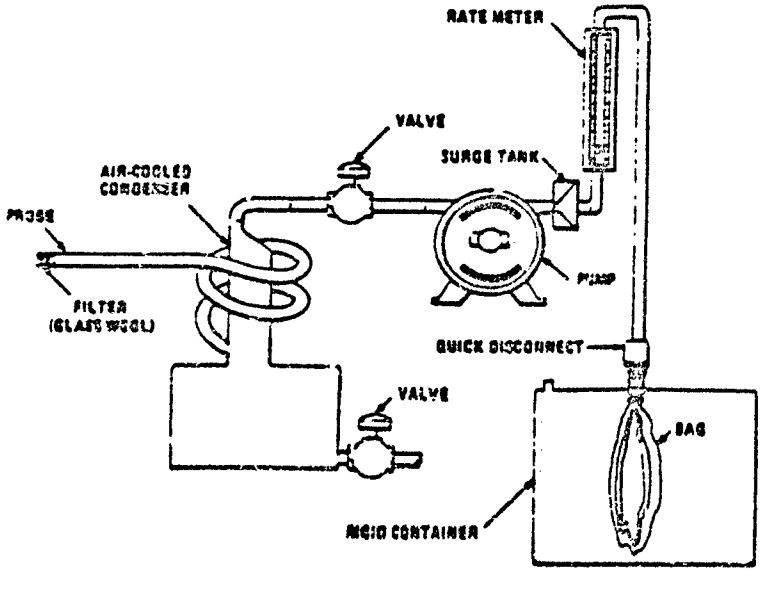


Figure 3-2. Integrated gas-sampling train.

¹Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.3.1 Dry Molecular Weight Determination. An Orsat analyzer or Fyrite type combustion gas analyzer may be used.

2.3.2 Emission Rate Correction Factor or Excess Air Determination. An Orsat analyzer must be used. For low CO_2 (less than 4.0 percent) or high O_2 (greater than 15.0 percent) concentrations, the measuring burette of the Orsat must have at least 0.1 percent subdivisions.

3. *Dry Molecular Weight Determination*

Any of the three sampling and analytical procedures described below may be used for determining the dry molecular weight.

3.1 Single-Point, Grab Sampling and Analytical Procedure.

3.1.1 The sampling point in the duct shall either be at the centroid of the cross section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

3.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. If and Orsat analyzer is used, it is recommended that the analyzer be leak-checked by following the procedure in Section 5; however, the leak-check is optional.

3.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer and immediately analyze it for percent CO_2 and percent O_2. Determine the percentage of the gas that is N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.1.4 Repeat the sampling, analysis, and calculation procedures, until the dry molecular weights of any three grab samples differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (lb/lb-mole).

3.2 Single-Point, Integrated Sampling and Analytical Procedure.

3.2.1 The sampling point in the duct shall be located as specified in Section 3.1.1.

3.2.2 Leak-check (optional) the flexible bag as in Section 2.2.4. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (optional) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum should remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

3.2.3 Sample at a constant rate. The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 30 liters (1.05 ft³) of sample gas is recommended; however, smaller volumes may be collected, if desired.

3.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO_2 and percent O_2 using either an Orsat analyzer or a Fyrite-type combustion gas analyzer. If an Orsat analyzer is used, it is recommended that the Orsat leak-check described in Section 5 be performed before this determination; however, the check is optional. Determine the percentages of the gas that is N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.2.5 Repeat the analysis and calculation procedures until the individual dry molecular weights for any three analyses differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

3.3 Multi-Point, Integrated Sampling and Analytical Procedure.

3.3.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used for all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to approval of the Administrator.

3.3.2 Follow the procedures outlined in sections 3.2.2 through 3.2.5, except for the following: traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

4. *Emission Rate Correction Factor or Excess Air Determination*

NOTE: A Fyrite-type combustion gas analyzer is not acceptable for excess air or emission rate correction factor determination, unless approved by the Administrator. If both percent CO_2 and percent O_2 are measured, the analytical results of any of the three procedures given below may also be used for calculating the dry molecular weight.

Each of the three procedures below shall be used only when specified in an applicable subpart of the standards. The use of these procedures for other purposes must have specific prior approval of the Administrator.

4.1 Single-Point, Grab Sampling and Analytical Procedure.

4.1.1 The sampling point in the duct shall either be at the centroid of the cross-section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

4.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. Leak-check the Orsat analyzer according to the procedure described in Section 5. This leak-check is mandatory.

FIGURE 3-3—SAMPLING RATE DATA

Time	Traverse pt.	Q (cm	% cent
Average			

$^{*}\%\ Dev. = (Q - Q_{avg})/Q_{avg} \times 100$ (Must be $\leq 10\%$)

4.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw sample into the analyzer. For emission rate correction factor determination, immediately analyze the sample, as outlined in Sections 4.1.4 and 4.1.5, for percent CO_2 or percent O_2. If excess air is desired, proceed as follows: (1) immediately analyze the sample as in Sections 4.1.4 and 4.1.5, for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; and (3) calculate percent excess air as outlined in Section 6.2.

4.1.4 To insure complete absorption of the CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.1.5 After the analysis is completed leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis.

NOTE: Since this single-point, grab sampling and analytical procedure is normally conducted in conjunction with a single-point, grab sampling and analytical procedure for a pollutant, only one analysis is ordinarily conducted. Therefore, great care must be taken to obtain a valid sample and analysis. Although in most cases only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Section 4.4 be used to validate the analytical data.

4.2 Single-Point, Integrated Sampling and Analytical Procedure.

4.2.1 The sampling point in the duct shall be located as specified in Section 4.1.1.

4.2.2 Leak-check (mandatory) the flexible bag as in Section 2.2.4. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (mandatory) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum shall remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

4.2.3 Sample at a constant rate, or as specified by the Administrator. The sampling run must be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft³) of sample gas. Smaller volumes may be collected, subject to approval of the Administrator.

4.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. For emission rate correction factor determination, analyze the sample within 4 hours after it is taken for percent CO_2 or percent O_2 (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-check (see Section 5) before the analysis. If excess air is desired, proceed as follows: (1) within 4 hours after the sample is taken, analyze it (as in Sections 4.2.5 through 4.2.7) for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; (3) calculate percent excess air, as outlined in Section 6.2.

4.2.5 To insure complete absorption of the CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.2.6 Repeat the analysis until the following criteria are met:

4.2.6.1 For percent CO_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when CO_2 is greater than 4.0 percent or (b) 0.2 percent by volume when CO_2 is less than or equal to 4.0 percent. Average the three acceptable values of percent CO_2 and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when O_2 is less than 15.0 percent or (b) 0.2 percent by volume when O_2 is greater than or equal to 15.0 percent. Average the three acceptable values of percent O_2 and report the results to the nearest 0.1 percent.

4.2.6.3 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than 0.3 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.7 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 3. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis.

Note: Although in most instances only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Section 4.4.1 be used to validate the analytical data.

4.3 Multi-Point, Integrated Sampling and Analytical Procedure.

4.3.1 Both the minimum number of sampling points and the sampling point location shall be as specified in Section 3.3.1 of this method. The use of fewer points than specified is subject to the approval of the Administrator.

4.3.2 Follow the procedures outlined in Sections 4.2.2 through 4.2.7, except for the following: Traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

4.4 Quality Control Procedures.

4.4.1 Data Validation When Both CO_2 and O_2 Are Measured. Although in most instances, only CO_2 or O_2 measurement is required, it is recommended that both CO_2 and O_2 be measured to provide a check on the quality of the data. The following quality control procedure is suggested.

Note: Since the method for validating the CO_2 and O_2 analyses is based on combustion of organic and fossil fuels and dilution of the gas stream with air, this method does not apply to sources that (1) remove CO_2 or O_2 through processes other than combustion, (2) add O_2 (e.g., oxygen enrichment) and N_2 in proportions different from that of air, (3) add CO_2 (e.g., cement or lime kilns), or (4) have no fuel factor, F_o, values obtainable (e.g., extremely variable waste mixtures). This method validates the measured proportions of CO_2 and O_2 for the fuel type, but the method does not detect sample dilution resulting from leaks during or after sample collection. The method is applicable for samples collected downstream of most lime or limestone flue-gas desulfurization units as the CO_2 added or removed from the gas stream is not significant in relation to the total CO_2 concentration. The CO_2 concentrations from other types of scrubbers using only water or basic slurry can be significantly affected and would render the F_o check minimally useful.

4.4.1.1 Calculate a fuel factor, F_o, using the following equation:

$$F_o = \frac{20.9 - \%O_2}{\%CO_2}$$

Eq. 3-3

Where:

$\%O_2$ = Percent O_2 by volume (dry basis).

$\%CO_2$ = Percent CO_2 by volume (dry basis).

20.9 = Percent O_2 by volume in ambient air.

If CO is present in quantities measurable by this method, adjust the O_2 and CO_2 values before performing the calculation for F_o as follows:

$$\%CO_2(adj) = \%CO_2 + \%CO$$

$$\%O_2(adj) = \%O_2 - 0.5\ \%CO$$

Where: %CO = Percent CO by volume (dry basis).

4.4.1.2 Compare the calculated F_o factor with the expected F_o value. The following table may be used in establishing acceptable ranges for the expected F_o if the fuel being burned is known. When fuels are burned in combination, calculate the combined fuel F_o and F_o factors (as defined in Method 19) according to the procedure in Method 19 Section 5.2.3. Then calculate the F_o factor as follows:

$$F_o = \frac{0.209\ F_d}{F_c}$$

Eq. 3-4

Fuel type		F_o range
Coal		
	Anthracite and lignite	1.016–1.130
	Bituminous	1.083–1.230
Oil		
	Distillate	1.260–1.413
	Residual	1.210–1.370
Gas		
	Natural	1.600–1.836
	Propane	1.434–1.586
	Butane	1.405–1.553
Wood		1.000–1.120
Wood bark		1.003–1.130

Calculated F_o values beyond the acceptable ranges shown in this table should be investigated before accepting the test results. For example, the strength of the solutions in the gas analyzer and the analyzing technique should be checked by sampling and analyzing a known concentration, such as air; the fuel factor should be reviewed and verified. An acceptability range of ±12 percent is appropriate for the F_o factor of mixed fuels with variable fuel ratios. The level of the emission rate relative to the compliance level should be considered in determining if a retest is appropriate, i.e., if the measured emissions are much lower or much greater than the compliance limit, repetition of the test would not significantly change the compliance status of the source and would be unnecessarily time-consuming and costly.

5. *Leak-Check Procedure for Orsat Analyzers*

Moving an Orsat analyzer frequently causes it to leak. Therefore, an Orsat analyzer should be thoroughly leak-checked on site before the flue gas sample is introduced into it. The procedure for leak-checking an Orsat analyzer is:

5.1.1 Bring the liquid level in each pipette up to the reference mark on the capillary tubing and then close the pipette stopcock.

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette and then close the manifold stopcock.

5.1.3 Record the meniscus position.

5.1.4 Observe the meniscus in the burette and the liquid level in the pipette for movement over the next 4 minutes.

5.1.5 For the Orsat analyzer to pass the leak-check, two conditions must be met.

5.1.5.1 The liquid level in each pipette must not fall below the bottom of the capillary tubing during this 4-minute interval.

5.1.5.2 The meniscus in the burette must not change by more than 0.2 ml during this 4-minute interval.

5.1.6 If the analyzer fails the leak-check procedure, all rubber connections and stopcocks should be checked until the cause of the leak is identified. Leaking stopcocks must be disassembled, cleaned, and regreased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. *Calculations*

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).

%EA = Percent excess air.

$\%CO_2$ = Percent CO_2 by volume (dry basis).

$\%O_2$ = Percent O_2 by volume (dry basis).

%CO = Percent CO by volume (dry basis).

$\%N_2$ = Percent N_2 by volume (dry basis).

0.264 = Ratio of O_2 to N_2 in air, v/v.

0.280 = Molecular weight of N_2 or CO, divided by 100.

0.320 = Molecular weight of O_2 divided by 100.

0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%EA = \frac{\%O_2 - 0.5\%\ CO}{0.264\%\ N_2 - (\%O_2 - 0.5\ \%\ CO)} \times 100$$

Equation 3-1

Note: The equation above assumes that ambient air is used as the source of O_2 and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas:

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

Equation 3-2

Note: The above equation does not consider argon in air (about 0.9 percent, molecular weight of 37.7). A negative error of about 0.4 percent is introduced. The tester may opt to include argon in the analysis using procedures subject to approval of the Administrator.

7. *Bibliography*

1. Altshuller, A. P. Storage of Gases and Vapors in Plastic Bags. International Journal of Air and Water Pollution. 6:75–81. 1963.

2. Conner, William D. and J. S. Nader. Air Sampling with Plastics Bags. Journal of the American Industrial Hygiene Association. 25:291–297. 1964.

3. Burrell Manual for Gas Analysis. Seventh edition. Burrell Corporation, 2223 Fifth Avenue, Pittsburgh, Pa. 15219. 1951.

4. Mitchell, W. J. and M. R. Midgett. Field Reliability of the Orsat Analyzer. Journal of Air Pollution Control Association 26:491–495. May 1976.

5. Shigehara, R. T., R. M. Neulicht, and W. S. Smith. Validating Orsat Analysis Data from Fossil Fuel-Fired Units. Stack Sampling News. 4(2):21–24. August, 1976.

Method 3A—Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)

1. *Applicability and Principle.*

1.1 Applicability. This method is applicable to the determination of oxygen (O_2) and carbon dioxide (CO_2) concentrations in emissions from stationary sources only when specified within the regulations.

1.2 Principle. A sample is continuously extracted from the effluent stream; a portion of the sample stream is conveyed to an instrumental analyzer(s) for determination of O_2 and CO_2 concentration(s). Performance specifications and test procedures are provided to ensure reliable data.

2. *Ranges and Sensitivity.*

Same as Method 6C, Sections 2.1 and 2.2, except that the span of the monitoring system shall be selected such that the average O_2 or CO_2 concentration is not less than 20 percent of the span.

3. *Definitions.*

3.1 Measurement System. The total equipment required for the determination of the O_2 or CO_2 concentration. The measurement system consists of the sample matrix subsystems as defined in Method 6C, Sections 3.1.1, 3.1.2, and 3.1.3.

3.2 Span, Calibration Gas, Analyzer Calibration Error, Sampling System Bias, Zero Drift, Calibration Drift, Response Time, and Calibration Curve. Same as Method 6C, Sections 3.2 through 3.9, and 3.13.

3.3 Interference Response. The output response of the measurement system to a component in the sample gas, other than the gas component being measured.

4. *Measurement System Performance Specifications.*

Same as Method 6C, Sections 4.1 through 4.4.

5. *Apparatus and Reagents.*

5.1 Measurement System. Any measurement system for O_2 or CO_2 that meets the specifications of this method. A schematic of an acceptable measurement system is shown in Figure 6C-1 of Method 6C. The essential components of the measurement system are described below:

5.1.1 Sample Probe. A leak-free probe, of sufficient length to traverse the sample points.

5.1.2 Sample Line. Tubing, to transport the sample gas from the probe to the moisture removal system. A heated sample line is not required for systems that measure the O_2 or CO_2 concentrations on a dry basis, or transport dry gases.

5.1.3 Sample Transport Line, Calibration Value Assembly, Moisture Removal System, Particulate Filter, Sample Pump, Sample Flow Rate Control, Sample Gas Manifold, and Data Recorder. Same as Method 6C, Sections 5.1.3 through 5.1.9, and 5.1.11, except that the requirements to use stainless steel, Teflon, and noncorrosive glass fittings do not apply.

5.1.4 Gas Analyzer. An analyzer to determine continuously the O_2 or CO_2 concentrations in the sample gas stream. The analyzer shall meet the applicable performance specifications of Section 4. A means of controlling the analyzer flow rate and a device for determining proper sample flow rate (e.g., rotameter, pressure gauge downstream of all flow controls, etc.) shall be provided at the analyzer. The requirements for measuring and controlling the analyzer flow rate are not applicable if data are presented that demonstrate the analyzer is insensitive to flow variations over the range encountered during the test.

5.2 Calibration Gases. The calibration gases for CO_2 analyzers shall be CO_2 in N_2 or CO_2 in air. Alternatively, CO_2/O_2, O_2/CO_2, or $O_2/CO_2/N_2$ concentrations in N_2 may be used. These calibration gases, as specified in Sections 3.2.1 through 3.2.3 of Method 6C, shall be used. For O_2 monitors, a ambient analyzer zero gas, a calibration gas concentration equivalent to less than 10 percent of the span may be used in place of zero gas.

6. *Measurement System Performance Test Procedures.*

Perform the following procedures before measurement of emissions (Section 7).

6.1 Calibration Concentration Verification. Follow Section 6.1 of Method 6C, except if calibration gas analysis is required, use Method 3 and change the acceptance criteria for agreement among Method 3 results to 0.5 percent or 0.2 percent by volume, whichever is greater.

6.2 Interference Response. Conduct an interference response test of the analyzer prior to its initial use in the field. Thereafter, recheck the measurement system if changes are made in the instrumentation that could alter the interference response (e.g., changes in the type of gas detector). Conduct the interference response in accordance with Section 6.4 of Method 3B.

6.3 Measurement System Performance, Analyzer Calibration Error, and Sampling System Bias Check. Follow Sections 6.2 through 6.4 of Method 6C.

7. *Emissions Test Procedure.*

7.1 Selection of Sampling Site and Sampling Points. Select a measurement site and sampling points using the same criteria that are applicable to tests performed using Method 1.

7.2 Sample Collection. Position the sampling probe at the first measurement point, and begin sampling at the same rate as used during the sampling system bias check. Maintain constant rate sampling (i.e., ±10 percent) during the entire run. The sampling time per point shall be the same as for tests conducted using Method 3 plus twice the system response time. For each run, use only those measurements obtained after twice the response time of the measurement system has elapsed to determine the average effluent concentration.

7.3 Zero and Calibration Drift Test. Follow Section 7.4 of Method 6C.

8. *Quality Control Procedures.*

The following quality control procedures are recommended when the results of this method are used for an emission rate correction factor, or excess air determination. The owner should select one of the following options for validating measurement results:

8.1 If both O_2 and CO_2 are measured using Method 3A, the procedures described in Section 4.4 of Method 3 should be followed to validate the O_2 and CO_2 measurement results.

8.2 If only O_2 is measured using Method 3A, measurements of the sample stream CO_2 concentration should be obtained at the sample by-pass vent discharge using an Orsat or Fyrite analyzer, or equivalent. Duplicate samples should be obtained concurrent with at least one run. Average the duplicate Orsat or Fyrite analysis results for each run. Use the average CO_2 values for comparison with the O_2 measurements in accordance with the procedures described in Section 4.4 of Method 3.

8.3 If only CO_2 is measured using Method 3A, measurement measurements of the sample stream CO_2 concentration should be obtained using an Orsat or Fyrite analyzer as described in Section 8.2. For each run, differences greater than 0.5 percent between the Method 3A results and the average of the duplicate Fyrite analysis should be investigated.

9. *Emissions Calculation.*

For all CO_2 analyzers, and for O_2 analyzers that can be calibrated with zero gas, follow Section 8 of Method 6C, except express all concentrations as percent, rather than ppm.

For O_2 analyzers that use a low-level calibration gas in place of a zero gas, calculate the effluent gas concentration using Equation 3A-1.

$$C_{wo} = \frac{C_{wo} - C_{wa}}{C_{ma} - C_a}\,(\bar{C} - C_a) + C_{wo} \qquad \text{Eq. 3A-1}$$

where:

C_{wo} = Effluent gas concentration, dry basis, percent.

C_{wo} = Actual concentration of the upscale calibration gas, percent.

C_{wa} = Actual concentration of the low-level calibration gas, percent.

C_{ma} = Average of initial and final system calibration bias check responses for the upscale calibration gas, percent.

C_a = Average of initial and final system calibration bias check responses for the low-level gas, percent.

$\bar{C}$ = Average gas concentration indicated by the gas analyzer, dry basis, percent.

10. *Bibliography.*

Same as Bibliography of Method 6C.

METHOD 10—DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability.*

1.1 *Principle.* An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a Luft-type nondispersive infrared analyzer (NDIR) or equivalent.

1.2 *Applicability.* This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

2. *Range and sensitivity.*

2.1 *Range.* 0 to 1,000 ppm.

2.2 *Sensitivity.* Minimum detectable concentrations is 20 ppm for a 0 to 1,000 ppm span.

3. *Interferences.* Any substance having a strong absorption of infrared energy will interfere to some extent. For example, the determination ratios for water (H_2O) and carbon dioxide (CO_2) are 3.5 percent H_2O per 1 ppm CO and 10 percent CO_2 per 10 ppm CO, respectively, for devices measuring in the 1,000 to 3,000 ppm range. For devices measuring in the 0 to 100 ppm range, interference ratios can be as high as 3.5 percent H_2O per 25 ppm CO and 10 percent CO_2 per 10 ppm CO. The use of silica gel and ascarite traps will alleviate the water interference problems. The measured gas volume must be corrected if these traps are used.

4. *Precision and accuracy.*

4.1 *Precision.* The precision of most NDIR analyzers is approximately ±2 percent of span.

4.2 *Accuracy.* The accuracy of most NDIR analyzers is approximately ±5 percent of span after calibration.

5. *Apparatus.*

5.1 *Continuous sample* (Figure 10-1).

5.1.1 *Probe.* Stainless steel or borosilicate Pyrex[1] glass, equipped with a filter to remove particulate matter.

5.1.2 *Air-cooled condenser or equivalent.* To remove any excess moisture.

5.1.3 *Integrated sample* (Figure 10-2).

5.1.1 *Probe.* Stainless steel or borosilicate Pyrex glass, equipped with a filter to remove particulate matter.

5.1.2 *Air-cooled condenser or equivalent.* To remove any excess moisture.

5.1.3 *Valve.* Needle valve, or equivalent, to adjust flow rate.

5.1.4 *Pump.* Leak-free diaphragm type, or equivalent, to transport gas.

5.1.5 *Rate meter.* Rotameter, or equivalent, to measure a flow range from 0 to 1.0 liter per min. (0.035 cfm).

5.1.6 *Flexible bag.* Tedlar, or equivalent, with a capacity of 60 to 90 liters (2 to 3 ft.³). Leak-test the bag in the laboratory before using by evacuating bag with a pump fol-

[1] Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

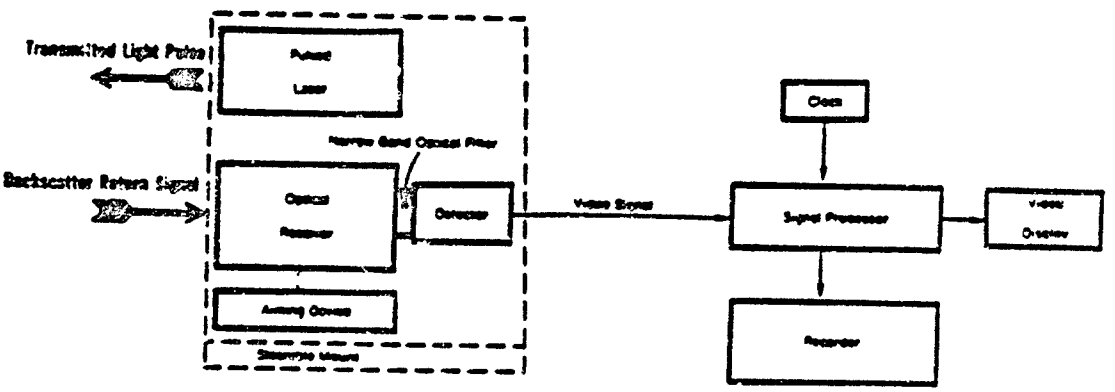


Figure A-11.1-2. Functional Block Diagram of a Beam Lidar System

lowed by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

5.2.7 *Pitot tube.* Type S, or equivalent, attached to the probe so that the sampling rate can be regulated proportional to the stack gas velocity when velocity is varying with the time or a single traverse is conducted.

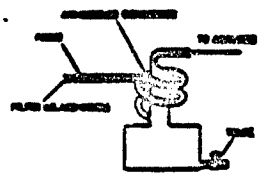
5.3 *Analysis* (Figure 10-3).

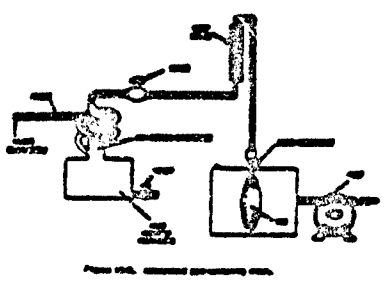
5.3.1 *Carbon monoxide analyzer.* Nondispersive infrared spectrometer, or equivalent. This instrument should be demonstrated, preferably by the manufacturer, to meet or exceed manufacturer's specifications and those described in this method.

5.3.2 *Drying tube.* To contain approximately 200 g of silica gel.

5.3.3 *Calibration gas.* Refer to paragraph 6.1.

5.3.4 *Filter.* As recommended by NDIR manufacturer.





5.3.5 *CO_2 removal tube.* To contain approximately 500 g of ascarite.

5.3.6 *Ice water bath.* For ascarite and silica gel tubes.

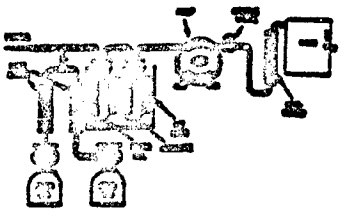
5.3.7 *Valve.* Needle valve, or equivalent, to adjust flow rate.

5.3.8 *Rate meter.* Rotameter or equivalent to measure gas flow rate of 0 to 1.0 liter per min. (0.035 cfm) through NDIR.

5.3.9 *Recorder* (optional). To provide permanent record of NDIR readings.

6. *Reagents.*

6.1 *Calibration gases.* Known concentration of CO in nitrogen (N_2) for instrument span, prepurified grade of N_2 for zero, and two additional concentrations corresponding approximately to 60 percent and 20 percent span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within ±2 percent of the specified concentration.



6.2 *Silica gel.* Indicating type, 6 to 16 mesh, dried at 175° C (350° F) for 2 hours.

6.3 *Ascarite.* Commercially available.

7. *Procedure.*

7.1 *Sampling.*

7.1.1 *Continuous sampling.* Set up the equipment as shown in Figure 10-1 making sure all connections are leak free. Place the probe in the stack at a sampling point and purge the sampling line. Connect the analyzer and begin drawing sample into the analyzer. Allow 5 minutes for the system to stabilize, then record the analyzer reading as required by the test procedure. (See 7.1.3 and 8). CO_2 content of the gas may be determined by using the Method 3 integrated sample procedure (40 CFR 60), or by weighing the ascarite CO_2 removal tube and subtracting CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.1.2 *Integrated sampling.* Evacuate the flexible bag. Set up the equipment as shown in Figure 10-2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are leak free. Sample at a rate proportional to the stack velocity. CO_2 content of the gas may be determined by using the Method 3 integrated sample procedure (40 CFR 60), or by weighing the ascarite CO_2 removal tube and subtracting CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.2 *CO Analysis.* Assemble the apparatus as shown in Figure 10-3, calibrate the instrument, and perform other required operations as outlined in paragraph 5. Purge analyzer with N_2 prior to introduction of each sample. Direct the sample stream through the instrument for the test period, recording the readings. Check the zero and span again after the test to ensure that any drift or malfunction is detected. Record the sample data as Table 10-1.

8. *Calibration.* Assemble the apparatus according to Figure 10-4. Generally an instrument requires a warm-up period before stability is attained. Follow the manufacturer's instructions for special procedures. Allow a minimum time of 1 hour for warm-up. During this time check the sample conditioning equipment, i.e., filter, ascarite, drying tube, and CO_2 removal tube, to ensure that these components are in good operating condition. Zero and calibrate the instrument according to the manufacturer's procedures using N_2 gas and the calibration gases.

TABLE 10-1—FIELD DATA

	Comments
Location	
Test	
Date	
Operator	
Grab data	Analyzer reading, time and results of any calibration

8. *Calculation—Concentration of carbon monoxide.* Calculate the concentration of carbon monoxide in the stack using equation 10-1.

$$C_{co\ stack} = C_{co\ read}(1 - F_{co_2})$$

Where:

$C_{co\ stack}$ = concentration of CO in stack, dry basis, ppm by volume (dry basis).

$C_{co\ read}$ = concentration of CO measured by NDIR analyzer, ppm by volume (dry basis).

F_{co_2} = volume fraction of CO_2 in sample, i.e., percent CO_2 from Orsat analysis divided by 100.

10. *Bibliography.*

10.1 Mallory, Frank. The Interpark NDIR-CO Analyzer. Presented at 11th Methods Conference on Air Pollution, University of California, Berkeley, Calif., April 1, 1970.

10.2 Jacobs, M. B., et al. Continuous Determination of Carbon Monoxide and Hydrocarbons in Air by a Modified Infrared Analyzer. J. Air Pollution Control Association, XIX 110-114, August 1969.

10.3 MSA LIRA Infrared Gas and Liquid Analyzer Instruction Book. Mine Safety Appliances Co., Technical Products Division, Pittsburgh, Pa.

10.4 Models 315A, 315A, and 415A Infrared Analyzers. Beckman Instruments, Inc., Scientific Instruments 1632-B, Fullerton, Calif., October 1967.

10.5 Continuous CO Monitoring System, Model A4411. Intertech Corp., Princeton, N.J.

10.6 UNOR Infrared Gas Analyzers. Bendix Corp., Ransomware, West Virginia.

ADDENDA—A. PERFORMANCE SPECIFICATIONS FOR NDIR CARBON MONOXIDE ANALYZERS.

Noise response	0-1000 ppm.
Output response	0-5 volts.
Minimum detectable sensitivity	20 ppm.
Response time: 90 percent point	25 seconds.
Rise time: 90 percent point	25 seconds.
Zero drift (maximum)	10% in 8 hours.
Span drift (maximum)	10% in 8 hours.
Precision (maximum)	±2% of full scale.
Noise (maximum)	1% of full scale.
Linearity (maximum deviation)	±1% of full scale.
Ambient temperature limits	0°—110° F; 0°—43° C.

APPENDIX G

SUMMARY TABLES OF FIELD DATA AND ANALYTICAL RESULTS

THIS PAGE IS INTENTIONALLY BLANK.

Table G-1. Summary of values of test variables during demonstration

Parameter	Test No. 1	2	3	4
A. Independent Variables				
a. Ambient air				
1) Temperature (°F)	78	68	72	65
2) Relative humidity (%)	84	80	88	90
3) VOC concentration	ND	ND	ND	ND
b. Feed soil				
1) Contaminant concentrations	(a)	(b)	(c)	(d)
2) Moisture content (% by wt.)	14	13	15	23
3) Temperature (°F)	74	73	93	74
B. Control Variables				
1. Held constant				
a. Thermal processor				
1) Draft	-0.065	-0.063	-0.042	-0.010
2) Discharge gas temperature (°F)	325	262	240	265
b. Condenser				
1) Discharge gas temperature (°F)	143	118	133	128
c. Afterburner				
1) Discharge gas temperature (°F)	1,804	1,805	1,805	1,806
d. Scrubber				
1) Inlet gas temperature (°F)	272	341	396	412
2) Scrubber liquor recirculation flow rate (gpm)	491	505	300	300
3) Average Scrubber liquor pH	7.6	8.2	7.6	7.2

WESTON

Table G-1. (continued)

Parameter	Test No. 1	2	3	4
2. Controlled to various levels				
a. Feed soil				
1) Residence time in the processor (minutes)	40	40	35	40
b. Oil heater				
1) Hot oil temperature (°F)	600	400	400	500
C. Response Variables				
a. Feed soil				
1) Mass flow rate (lb/hr)				
(a) During stabilization	17,031	20,722	22,124	18,919
(b) During test	12,196	12,150	20,470	18,346
b. Processed soil				
1) Discharge temperature (°F)	383	224	214	270
2) Contaminant concentration	(a)	(b)	(c)	(d)
3) Moisture content (percent by wt.)	2.0	3.0	3.0	1.0
c. Oil Heater				
1) Return oil temperature (°F)	552	378	358	443
d. Fabric filter				
1) Dust composition	(e)	(e)	(e)	(e)
2) Dust mass flow rate (lb/hr)	*	20	35	*
e. Condenser				
1) Condensate mass flow rate (lb/hr)	*	*	*	*
f. Afterburner				
1) Inlet gas (°F) temperature)	143	118	133	128

* Sufficient data not available
(a) Data found on Table G-2
(b) Data found on Table G-3
(c) Data found on Table G-4
(d) Data found on Table G-5
(e) Data found in Appendix H

8632B

WESTERN

Table G-2. Summary of analytical results for Test 1

Test Conditions: Oil temperature = 600°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Volatiles					
Chloromethane	< 3,500	< 4.0	(b)	0.2	NE
Bromomethane	< 3,500	< 4.0	(b)	0.2	NE
Vinyl chloride	< 3,500	< 4.0	(b)	0.2	50
Chloroethane	< 3,500	< 4.0	(b)	0.2	NE
Dichloromethane	< 1,800	< 2.0	(b)	0.1	960
Trichlorofluoromethane	350 J	< 2.0	99.43	0.1	NE
1,1-Dichloroethene	< 1,800	< 2.0	(b)	0.1	100
1,1-Dichloroethane	< 1,800	< 2.0	(b)	0.1	NE
trans-1,2-Dichloroethene	760 J	2.0 J	99.74	0.1	NE
Chloroform	140 J	< 2.0	>98.57	0.1	70
1,2-Dichloroethane	< 1,800	< 2.0	(b)	0.1	400
1,1,1-Trichloroethane	< 1,800	< 2.0	(b)	0.1	410
Carbon tetrachloride	< 1,800	< 2.0	(b)	0.1	NE
Bromodichloromethane	< 1,800	< 2.0	(b)	0.1	NE
1,2-Dichloropropane	< 1,800	< 2.0	(b)	0.1	NE
cis-1,3-Dichloropropene	< 1,800	< 2.0	(b)	0.1	NE
trans-1,3-Dichloropropene	< 1,800	< 2.0	(b)	0.1	NE
Trichloroethene	37,250	5.4	99.986	0.3	70
Dibromochloromethane	< 1,800	< 2.0	(b)	0.1	NE
1,1,2-Trichloroethane	< 1,800	< 2.0	(b)	1.1	NE
2-Chloroethyl vinyl ether	< 1,800	< 2.0	(b)	0.1	NE
Bromoform	< 3,500	< 4.0	(b)	0.2	NE
1,1,2,2-Tetrachloroethane	< 1,800	< 2.0	(b)	0.1	NE
Tetrachloroethene	2,760 J	< 2.0	>99.93	0.1	50
Acetone	<11,000	<12.0	(b)	0.6	NE
2-Butanone	<11,000	<12.0	(b)	0.6	750
Benzene*	< 1,800	< 2.0	(b)	0.1	70
Toluene*	< 1,800	< 2.0	(b)	0.1	330

(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
NE Not established.

WESTON

Table G-2. (continued)

Test Conditions: Oil temperature = 600°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Chlorobenzene*	< 1,800	< 2.0	(b)	0.1	50
Ethylbenzene*	< 1,800	< 2.0	(b)	0.1	53
m-Xylene*	3,650 J	< 4.0	>99.89	0.2	(1)
o,p-Xylenes*	2,250 J	< 4.0	>99.82	0.2	(1)
Semivolatiles					
1,2-Dichlorobenzene	35,000	540 J	98.46	6 J	125
1,4-Dichlorobenzene	8,700	<3,200	>63.22	5 J	10,800
2-Methylnaphthalene*	< 3,300	<3,200	(b)	<10	NE
1,3-Dichlorobenzene	3,500	<3,200	> 8.57	<10	NE
Fluoranthene*	< 3,300	1,700 J	(b)	<10	140
Naphthalene*	4,300	130 J	96.98	<10	NE
Benzo(a)anthracene*	< 3,300	<3,200	(b)	<10	8.7
Benzo(a)pyrene*	< 3,300	<3,200	(b)	<10	15
Benzo(b)fluoranthene*	< 3,300	<3,200	(b)	<10	8.7
Chrysene*	< 3,300	<3,200	(b)	<10	100
Dibenzo(a,h)anthracene*	< 3,300	<3,200	(b)	<10	20
Acenaphthene*	< 3,300	<3,200	(b)	<10	1,200
Acenaphthylene*	< 3,300	<3,200	(b)	<10	660
Anthracene*	60 J	<3,200	(b)	<10	660
Benzo(g,h,i)perylene*	< 3,300	<3,200	(b)	<10	51
Fluorene*	< 3,300	<3,200	(b)	<10	140
Indeno(1,2,3-c,d)pyrene*	< 3,300	<3,200	(b)	<50	29
Phenanthrene*	790 J	460 J	>41.77	<10	660
Pyrene*	280 J	310 J	(b)	<10	180
Benzo(k)fluoranthene*	< 3,300	<3,200	(b)	<10	11
4-Chloroaniline	220 J	380 J	(b)	<10	NE
2-Chloronaphthalene*	< 3,300	<3,200	(b)	<10	NE

(1) Total Xylenes GCL = 150 ug/L.
(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
* Potential constituents of JP-4 fuel.
NE Not established.

86323

WESTON

Table G-3. Summary of analytical results for Test 2

Test Conditions: Oil temperature = 400°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Volatiles (VOCs)					
Chloromethane	< 3,600	< 4.0	(b)	0.2	NE
Bromomethane	< 3,600	< 4.0	(b)	0.2	NE
Vinyl chloride	< 3,600	< 4.0	(b)	0.2	50
Chloroethane	< 3,600	< 4.0	(b)	0.2	NE
Dichloromethane	< 1,800	< 2.0	(b)	0.1	960
Trichlorofluoromethane	330 J	< 2.0	>99.39	0.1	NE
1,1-Dichloroethene	< 1,800	< 2.0	(b)	0.1	100
1,1-Dichloroethane	< 1,800	< 2.0	(b)	0.1	NE
trans-1,2-Dichloroethene	790 J	< 2.0	>99.75	0.1	NE
Chloroform	180 J	< 2.0	>98.89	0.1	70
1,2-Dichloroethane	< 1,800	< 2.0	(b)	0.1	400
1,1,1-Trichloroethane	< 1,800	< 2.0	(b)	0.1	410
Carbon tetrachloride	< 1,800	< 2.0	(b)	0.1	NE
Bromodichloromethane	< 1,800	< 2.0	(b)	0.1	NE
1,2-Dichloropropane	< 1,800	< 2.0	(b)	0.1	NE
cis-1,3-Dichloropropene	< 1,800	< 2.0	(b)	0.1	NE
trans-1,3-Dichloropropene	< 1,800	< 2.0	(b)	0.1	NE
Trichloroethene	111,000(c)	5.0	99.995	0.3	70
Dibromochloromethane	< 1,800	< 2.0	(b)	0.1	NE
1,1,2-Trichloroethane	< 1,800	< 2.0	(b)	0.1	NE
2-Chloroethyl vinyl ether	< 1,800	< 2.0	(b)	0.1	NE
Bromoform	< 3,600	< 4.0	(b)	0.2	NE
1,1,2,2-Tetrachloroethane	< 1,800	< 2.0	(b)	0.1	NE
Tetrachloroethene	3,985 J	< 2.0	>99.95	0.1	50
Acetone	<11,000	<12	(b)	0.6	NE
2-Butanone	<11,000	<12	(b)	0.6	750
Benzene*	< 1,800	< 2.0	(b)	0.1	70
Toluene*	8,300	< 2.0	>99.98	0.1	330

(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
(c) Higher than detection range, estimated value. Replicate indicated an estimated value less than detection limit; however, sample replicate integrity is suspect.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
NE Not established.

WESTON

Table G-3. (continued)

Test Conditions: Oil temperature = 400°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Chlorobenzene*	< 1,800	< 2.0	(b)	0.1	50
Ethylbenzene*	960 J	< 2.0	>99.79	0.1	53
m-Xylene*	7,100	< 4.0	>99.94	0.2	(1)
o,p-Xylenes*	4,300	< 4.0	>99.91	0.2	(1)
Semivolatiles					
1,2-Dichlorobenzene	15,000	950 J	>93.67	10 J	125
1,4-Dichlorobenzene	3,600 J	220 J	>93.89	<100	10,800
2-Methylnaphthalene*	2,400 J	<3,400	(b)	<100	NE
1,3-Dichlorobenzene	1,500 J	100 J	>93.33	<100	NE
Fluoranthene*	2,900 J	<3,400	(b)	<100	140
Naphthalene*	5,000	130 J	>97.40	<100	NE
Benzo(a)anthracene*	< 3,800	<3,400	(b)	<100	8.7
Benzo(a)pyrene*	< 3,800	<3,400	(b)	<100	15
Benzo(b)fluoranthene*	< 3,300	<3,400	(b)	<100	12
Chrysene*	< 3,800	<3,400	(b)	<100	100
Dibenzo(a,h)anthracene*	< 3,800	<3,400	(b)	<100	20
Acenaphthene*	< 3,800	<3,400	(b)	<100	1,200
Acenaphthylene*	< 3,800	<3,400	(b)	<100	660
Anthracene*	770 J	<3,400	(b)	<100	660
Benzo(g,h,i)perylene*	< 3,800	<3,400	(b)	<100	51
Fluorene*	< 3,800	200 J	>94.74	<100	140
Indeno(1,2,3-c,d)pyrene*	< 3,800	<3,400	(b)	<500	29
Phenanthrene*	820 J	670 J	18.29	<100	660
Pyrene*	90 J	500 J	(b)	<100	180
Benzo(k)fluoranthene*	< 3,800	<3,400	(b)	<100	11
4-Chloroaniline	540 J	630 J	(b)	<100	NE
2-Chloronaphthalene*	< 3,800	<3,400	(b)	<100	NE

(1) Total Xylenes GCL = 150 ug/L.
(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
* Potential constituents of JP-4 fuel.
NE Not established.

Table G-4. Summary of analytical results for Test 4

Test Conditions: Oil temperature = 400°F, Residence time = 35 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Volatiles (VOCs)					
Chloromethane	< 1,600	< 4.0	(b)	0.2	NE
Bromomethane	< 1,600	< 4.0	(b)	0.2	NE
Vinyl chloride	< 1,600	< 4.0	(b)	0.2	50
Chloroethane	< 1,600	< 4.0	(b)	0.2	NE
Dichloromethane	< 800	< 2.0	(b)	0.1	960
Trichlorofluoromethane	< 800	< 2.0	(b)	0.1	NE
1,1-Dichloroethene	< 800	< 2.0	(b)	0.1	100
1,1-Dichloroethane	< 800	< 2.0	(b)	0.1	NE
trans-1,2-Dichloroethene	273 J	2.7 J	99.03	0.1	NE
Chloroform	< 800	< 2.0	(b)	0.1	70
1,2-Dichloroethane	< 800	< 2.0	(b)	0.1	400
1,1,1-Trichloroethane	< 800	< 2.0	(b)	0.1	410
Carbon tetrachloride	< 800	< 2.0	(b)	0.1	NE
Bromodichloromethane	< 800	< 2.0	(b)	0.1	NE
1,2-Dichloropropane	< 800	< 2.0	(b)	0.1	NE
cis-1,3-Dichloropropene	< 800	< 2.0	(b)	0.1	NE
trans-1,3-Dichloropropene	< 800	< 2.0	(b)	0.1	NE
Trichloroethene	10,575	23.4	99.78	1.2	70
Dibromochlormethane	< 800	< 2.0	(b)	0.1	NE
1,1,2-Trichloroethane	< 800	< 2.0	(b)	0.1	NE
2-Chloroethylvinylether	< 800	< 2.0	(b)	0.1	NE
Bromoform	< 1,600	< 4.0	(b)	0.2	NE
1,1,2,2-Tetrachloroethane	< 800	< 2.0	(b)	0.1	NE
Tetrachloroethene	613 J	0.5 J	99.92	0.0	50
Acetone	< 4,800	<12	(b)	0.6	NE
2-Butanone	< 4,800	<12	(b)	0.6	750
Benzene*	745 J	1.3 J	99.83	0.1	70
Toluene*	200 J	1.1 J	99.45	0.1	330

(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
J Less than detection limit, estimated value.
* Potential constituents of JP-4 fuel.
NE Not established.

WESTON

Table G-4. (continued)

Test Conditions: Oil temperature = 400°F, Residence time = 35 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Chlorobenzene*	< 800	< 2.0	(b)	0.1	50
Ethylbenzene*	< 800	< 2.0	(b)	0.1	53
m-Xylene*	< 1,600	< 4.0	(b)	0.2	(1)
o,p-Xylenes*	< 1,600	< 4.0	(b)	0.2	(1)
1,2-Dichlorobenzene	53,000	565 J	98.93	6 J	125
1,4-Dichlorobenzene	14,750	155 J	98.95	1 J	10,800
2-Methylnaphthalene*	4,200 J	505 J	87.98	3 J	NE
1,3-Dichlorobenzene	6,400 J	< 3,400	>46.88	1 J	NE
Fluoranthene*	1,750 J	950 J	45.71	10 J	140
Naphthalene*	3,200 J	120 J	96.25	1 J	NE
Benzo(a)anthracene*	< 3,900	< 3,400	(b)	<10	8.7
Benzo(a)pyrene*	< 3,900	< 3,400	(b)	<10	15
Benzo(b)fluoranthene*	< 3,900	< 3,400	(b)	<10	12
Chrysene*	< 3,900	< 3,400	(b)	10 J	100
Dibenzo(a,h)anthracene*	< 3,900	< 3,400	(b)	10 J	20
Acenaphthene*	< 3,900	< 3,400	(b)	10 J	1,200
Acenaphthylene*	370 J	< 3,400	(b)	10 J	660
Anthracene*	120 J	40 J	>66.67	10 J	660
Benzo(g,h,i)perylene*	< 3,900	50 J	(b)	<10	51
Fluorene*	325 J	155 J	>52.31	<10	140
Indeno(1,2,3-c,d)pyrene*	<20,000	<17,000	(b)	<50	29
Phenanthrene*	960 J	490 J	48.96	1 J	660
Pyrene*	785 J	405 J	48.41	<10	180
Benzo(k)fluoranthene*	< 3,900	< 3,400	(b)	<10	11
4-Chloroaniline	395 J	325 J	17.72	<10	NE
2-Chloronaphthalene*	< 3,900	< 3,400	(b)	<10	NE

(1) Total Xylenes GCL = 150 ug/L.
(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
* Potential constituents of JP-4 fuel.
NE Not established.

WESTERN

Table G-5. Summary of analytical results for Test 8

Test Conditions: Oil temperature = 500°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Volatiles (VOCs)					
Chloromethane	<1,600	< 4.0	(b)	0.2	NE
Bromomethane	<1,600	< 4.0	(b)	0.2	NE
Vinyl chloride	<1,600	< 4.0	(b)	0.2	50
Chloroethane	<1,600	< 4.0	(b)	0.2	NE
Dichloromethane	< 800	< 2.0	(b)	0.1	960
Trichlorofluoromethane	< 800	7.8	>99.03	0.4	NE
1,1-Dichloroethene	< 800	< 2.0	(b)	0.1	100
1,1-Dichloroethane	< 800	< 2.0	(b)	0.1	NE
trans-1,2-Dichloroethene	370 J	8.0	97.84	0.4	NE
Chloroform	< 800	< 2.0	(b)	0.1	70
1,2-Dichloroethane	< 800	< 2.0	(b)	0.1	400
1,1,1-Trichloroethane	< 800	< 2.0	(b)	0.1	410
Carbon tetrachloride	< 800	< 2.0	(b)	0.1	NE
Bromodichloromethane	< 800	< 2.0	(b)	0.1	NE
1,2-Dichloropropane	< 800	< 2.0	(b)	0.1	NE
cis-1,3-Dichloropropene	< 800	< 2.0	(b)	0.1	NE
trans-1,3-Dichloropropene	< 800	< 2.0	(b)	0.1	NE
Trichloroethene	8,500	46.0	99.46	2.3	70
Dibromochlormethane	< 800	< 2.0	(b)	0.1	NE
1,1,2-Trichloroethane	< 800	< 2.0	(b)	0.1	NE
2-Chloroethylvinylether	< 800	< 2.0	(b)	0.1	NE
Bromoform	<1,600	< 4.0	(b)	0.2	NE
1,1,2,2-Tetrachloroethane	< 800	< 2.0	(b)	0.1	NE
Tetrachloroethene	650 J	1.0 J	99.85	0.1	50
Acetone	<4,800	<12	(b)	0.6	NE
2-Butanone	<4,800	<12	(b)	0.6	750
Benzene*	130 J	8.7	93.60	0.4	70
Toluene*	18 J	0.9 J	94.86	0.0	330

(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).
(b) Cannot be determined.
< Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
NE Not established.

WESTON

Table G-5. (continued)

Test Conditions: Oil temperature = 500°F, Residence time = 40 min

Analyte	Concentration		Removal Efficiency (%)	Processed Soil Concentration from TCLP Extract (ug/L)(a)	Goal Cleanup Level in TCLP Extract (ug/L)
	Feed Soil (ug/kg)	Processed Soil (ug/kg)			
Chlorobenzene*	< 800	< 2.0	(b)	0.1	50
Ethylbenzene*	< 800	2.1	(b)	0.1	53
m-Xylene*	< 1,600	0.3 J	(b)	0.0	(1)
o,p-Xylenes*	9.5 J	0.8 J	91.58	0.0	(1)
1,2-Dichlorobenzene	13,500	300 J	97.78	4 J	NE
1,4-Dichlorobenzene	4,300 J	< 3,400	<20.93	1 J	10,800
2-Methylnaphthalene*	1,500 J	270 J	82.00	< 20	NE
1,3-Dichlorobenzene	1,350 J	< 3,400	(b)	< 20	NE
Fluoranthene*	795 J	760 J	4.40	< 20	140
Naphthalene*	1,625 J	70 J	93.17	2 J	NE
Benzo(a)anthracene*	< 4,300	< 3,400	(b)	< 20	8.7
Benzo(a)pyrene*	< 4,300	< 3,400	(b)	< 20	15
Benzo(b)fluoranthene*	< 4,300	< 3,400	(b)	< 20	12
Chrysene*	< 4,300	< 3,400	(b)	< 20	100
Dibenzo(a,h)anthracene*	< 4,300	< 3,400	(b)	< 20	20
Acenaphthene*	< 4,300	< 3,400	(b)	< 20	1,200
Acenaphthylene*	< 4,300	< 3,400	(b)	< 20	660
Anthracene*	< 4,300	40 J	(b)	< 20	660
Benzo(g,h,i)perylene*	< 4,300	< 3,400	(b)	< 20	51
Fluorene*	< 4,300	< 3,400	(b)	< 20	140
Indeno(1,2,3-c,d)pyrene*	<22,000	<17,000	(b)	<100	29
Phenanthrene*	320 J	300 J	6.25	< 20	660
Pyrene*	185 J	220 J	(b)	< 20	180
Benzo(k)fluoranthene*	< 4,300	< 3,400	(b)	< 20	11
4-Chloroaniline	210 J	230 J	(b)	3 J	NE
2-Chloronaphthalene*	< 4,300	< 3,400	(b)	< 20	NE

(1) Total Xylenes GCL = 150 ug/L

(a) TCLP extract for VOCs was determined by dividing soil concentration by 20, thus simulating a worst-case leachate scenario (all contaminants leached by TCLP).

(b) Cannot be determined.

< Not detected at the specified detection limit.

J Less than detection limit, estimated value

* Potential constituents of JP-4 fuel

NE Not established

APPENDIX H

ANALYTICAL DATA

ROY F. WESTON. INC.

VOLATILE ORGANIC CASE NARRATIVE

CLIENT: USATHAMA, TINKER A.F.B
RFW #: 8907TK01

1. This set of samples consisted of 2 soil samples collected on 7/18/89.

2. These samples were analyzed on 7/25/89.

3. All required holding times for these samples were met.

4. All blanks analyzed were below allowable limits of detection.

5. Calibration criteria was not met for Dichloromethane and Chloroform due to background interferences.

6. Surrogate recoveries were between 26-166%.

7. Feed soils were prepared using the mid-level extraction procedure due to the expected high concentrations.

The following data qualifiers are used in this report:

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limit.

Approved by: Robert K. Collins Date: 13 Oct 89

Test 1

VOA Prep Batch No: 89TKD01 Date Analyzed: 25 JULY 89 page 1

Sample Information	Cust ID:	FEED SOIL	FEED SOIL	PROCESS SOIL	PURGE MIX B/C.
	RFW Batch #:	8907TK01	8907TK01	8907TK01	89TKD01
	Sample No:	01	01R	02	MB-3
	Matrix:	Soil	Soil	Soil	Water
	D.F.:	168	168	1	1
	Units:	ug/kg	ug/kg	ug/kg	% REC
Analytes					
Chloromethane		3300 U	3300 U	4.0 U	83 %
Bromomethane		3300 U	3300 U	4.0 U	108 %
Vinyl Chloride		3300 U	3300 U	4.0 U	110 %
Chloroethane		3300 U	3300 U	4.0 U	
Dichloromethane		1700 U	1800 U	2.0 U	11 %
Trichlorofluoromethane		460 J	240 J	2.0 U	
1,1-Dichloroethylene		1700 U	1800 U	2.0 U	
1,1-Dichloroethane		1700 U	1800 U	2.0 U	
trans-1,2-Dichloroethene		1700 U	760 J	2.0 U	
Chloroform		130 J	150 J	2.0 U	
1,2-Dichloroethane		1700 U	1800 U	2.0 U	68 %
1,1,1-Trichloroethane		1700 U	1800 U	2.0 U	72 %
Carbon Tetrachloride		1700 U	1800 U	2.0 U	
Bromodichloromethane		1700 U	1800 U	2.0 U	89 %
1,2-Dichloropropane		1700 U	1800 U	2.0 U	
cis-1,3-Dichloropropene		1700 U	1800 U	2.0 U	93 %
trans-1,3-Dichloropropene		1700 U	1800 U	2.0 U	159 %
Trichloroethene		2500	72000	5.4	
Dibromochloromethane		1700 U	1800 U	2.0 U	
1,1,2-Trichloroethane		1700 U	1800 U	2.0 U	
2-Chloroethylvinylether		1700 U	1800 U	2.0 U	
Bromoform		3300 U	3500 U	4.0 U	79 %
1,1,2,2-Tetrachloroethane		1700 U	1800 U	2.0 U	74 %
Tetrachloroethylene		520 J	5000	2.0 U	
Acetone		10000 U	11000 U	12.0 U	
2-Butanone		10000 U	11000 U	12.0 U	
Benzene		1700 U	1800 U	2.0 U	52 %
Toluene		1700 U	1800 U	2.0 U	57 %
Chlorobenzene		1700 U	1800 U	2.0 U	
Ethylbenzene		1700 U	1800 U	2.0 J	58 %
m-Xylene		2300 J	5000	4.0 U	
o,p-Xylene		1300 J	3200 J	4.0 U	
Surrogate Recoveries					
Bromochloromethane		73.6 %	73.1 %	26.8 %	
a,a,a-Trifluorotoluene		157.3 %	166.5 %	35.4 %	

Test 1
(continued)

VOA Prep Batch No: 89TKD01 Date Analyzed: 23 JULY 89 page 2

Sample Information	Cust ID:	PURGE MIX A/XYL	BLANK + SS
	RFW Batch #:	89TKD01	89TKD01
	Sample No:	MB-3	MB-1
	Matrix:	Water	Water
	D.F.:	1	1
	Units:	% REC	ug/L
Analytes			
Chloromethane			
Bromomethane			
Vinyl Chloride			
Chloroethane			
Dichloromethane			
Trichlorofluoromethane		96 %	
1,1-Dichloroethylene		136 %	
1,1-Dichloroethane		132 %	
trans-1,2-Dichloroethene			
Chloroform		121 %	
1,2-Dichloroethane			
1,1,1-Trichloroethane			
Carbon Tetrachloride		89 %	
Bromodichloromethane			
1,2-Dichloropropane		135 %	
cis-1,3-Dichloropropene			
trans-1,3-Dichloropropene			
Trichloroethene		146 %	
Dibromochloromethane			
1,1,2-Trichloroetnane		157 %	
2-Chloroethylvinylether			
Bromoform			
1,1,2,2-Tetrachloroethane			
Tetrachloroethylene		182 %	
Acetone			
2-Butanone			
Benzene			
Toluene			
Chlorobenzene		99 %	
Ethylbenzene			
m-Xylene		83 %	
o,p-Xylene		82 %	
Surrogate Recoveries			
Bromochloroethane			156 %
a,a,a-Trifluorotoluene			97 %

ROY F. WESTON INC.

SEMIVOLATILE ORGANICS CASE NARRATIVE

Client: USATHAMA, Tinker A.F.B.
RFW # : 8907TK01

1. This set of samples consisted of 2 soil samples collected on 7/18/89. The TLCP leachate was prepared from the processed soil.

2. The samples were extracted on 7/24/89.

3. These samples were analyzed on 7/25/89.

4. All required holding times for these samples were met.

5. All blanks analyzed were below allowable limits of detection.

6. Calibration criteria was met for DFTPP.

7. Surrogate recoveries were between 12% and 83%.

8. The blank leachate gave no recovery for 2,4,6-Bromophenol.

9. The feed and process soil samples could not be concentrated to the extent permitted by the method due to the high organic content of these samples. Further concentration resulted in the formation of a precipitate in the extract. Feed and processed soil appeared to contain asphalt paving material.

10. The blank leachate was analyzed at a dilution factor of 20.

The following data qualifiers are used in this report.

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limits.

Approved by: _____ Date: 13 Nov 89

WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8907TK01 Client: TEST 9 Page: 1

	Cust ID:	FEED	PROCESS	LEACHATE	BK LEACHATE
	RFWW:	8907TK0101	8907TK0102	8907TK0103	8907TKE01MB1
	Matrix:	Soil	SOIL	Water	Water
	D.F.:	330	320	1	20
	Units:	ug/kg	ug/kg	ug/L	ug/L
Surrogate Recovery (%)	Nitrobenzene-d5:	54 %	12 %	17 %	34 %
	2-Fluorobiphenyl:	57 %	14 %	19 %	39 %
	p-Terphenyl-d14:	83 %	23 %	30 %	60 %
	Phenol-d5:	31 %	19 %	34 %	34 %
	2-Fluorophenol:	28 %	22 %	39 %	39 %
	2,4,6-Br3-phenol:	38 %	26 %	36 %	0 %
1,2-Dichlorobenzene		35000	540	6 J	200 U
1,4-Dichlorobenzene		8700	100 U	6 J	200 U
2-Methylnaphthalene		3300 U	100 U	10 U	200 U
1,3-Dichlorobenzene		3500	100 U	10 U	200 U
Fluoranthene		3300 U	1700	10 U	200 U
Naphthalene		4300	130	10 U	200 U
Benzo (a) anthracene		3300 U	100 U	10 U	200 U
Benzo(a)Pyrene		3300 U	100 U	10 U	200 U
Benzo(b)Fluoranthene		3300 U	100 U	10 U	200 U
Chrysene		3300 U	100 U	10 U	200 U
Dibenz(a,h)Anthracene		3300 U	100 U	10 U	200 U
Acenaphthene		3300 U	100 U	10 U	200 U
Acenaphthylene		3300 U	100 U	10 U	200 U
Anthracene		60 J	100 U	10 U	200 U
Benzo(g,h,i)Perylene		3300 U	100 U	10 U	200 U
Fluorene		3300 U	100 U	10 U	200 U
Indeno(1,2,3-cd)Pyrene		3300 U	100 U	50 U	1000 U
Phenanthrene		790	3200	10 U	200 U
Pyrene		280	310	10 U	200 U
Benzo(k)Fluoranthene		3300 U	100 U	10 U	200 U
4-Chloroaniline		220	380	10 U	200 U
2-Chloronaphthalene		3300 U	100 U	10 U	200 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.

Test 1
(continued)

ROY F. WESTON. INC.

VOLATILE ORGANIC CASE NARRATIVE

CLIENT: USATHAMA, TINKER A.F.B
RFW #: 8907TK02

1. This set of samples consisted of 2 soil samples collected on 7/19/89.

2. These samples were analyzed on 7/25/89.

3. All required holding times for these samples were met.

4. All blanks analyzed were below allowable limits of detection.

5. Calibration criteria was not met for Dichloromethane and Chloroform due to background interferences.

6. Surrogate recoveries were between 28-188%.

7. Feed soils were prepared using the mid-level extraction procedure due to the expected high concentrations.

The following data qualifiers are used in this report:

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limit.

Approved by: Robert K Collins Date: 13 Nov 89

Test 2

VOA Prep Batch No: 89TKD02 Date Analyzed: 25 JULY 89 page 1

Sample Information	Cust ID:	FEED SOIL	FEED SOIL	PROCESS SOIL	PURGE B/C/SS
	RFW Batch #:	8907TK02	8907TK02	8907TK02	89TKD01
	Sample No:	01	01R	02	MB-3
	Matrix:	Soil	Soil	Soil	Water
	D.F.:	182	182	1	1
	Units:	ug/kg	ug/kg	ug/kg	% REC
Analytes					
Chloromethane		3600 U	3600 U	4.0 U	83 %
Bromomethane		3600 U	3600 U	4.0 U	108 %
Vinyl Chloride		3600 U	3600 U	4.0 U	110 %
Chloroethane		3600 U	3600 U	4.0 U	
Dichloromethane		1800 U	1800 U	2.0 U	11 %
Trichlorofluoromethane		360 J	300 J	2.0 U	
1,1-Dichloroethylene		1800 U	1800 U	2.0 U	
1,1-Dichloroethane		1800 U	1800 U	2.0 U	
trans-1,2-Dichloroethene		790 J	1800 U	2.0 U	
Chloroform		180 J	1800 U	2.0 U	
1,2-Dichloroethane		1800 U	1800 U	2.0 U	68 %
1,1,1-Trichloroethane		1800 U	1800 U	2.0 U	72 %
Carbon Tetrachloride		1800 U	1800 U	2.0 U	
Bromodichloromethane		1800 U	1800 U	2.0 U	89 %
1,2-Dichloropropane		1800 U	1800 U	2.0 U	
cis-1,3-Dichloropropene		1800 U	1800 U	2.0 U	93 %
trans-1,3-Dichloropropene		1800 U	1800 U	2.0 U	159 %
Trichloroethene		111000.0 E	1200 J	5.0	
Dibromochloromethane		1800 U	1800 U	2.0 U	
1,1,2-Trichloroethane		1800 U	1800 U	2.0 U	
2-Chloroethylvinylether		1800 U	1800 U	2.0 U	
Bromoform		3600 U	3600 U	4.0 U	79 %
1,1,2,2-Tetrachloroethane		1800 U	1800 U	2.0 U	74 %
Tetrachloroethylene		7600	370 J	2.0 U	
Acetone		11000 U	11000 U	12 U	
2-Butanone		11000 U	11000 U	12 U	
Benzene		1800 U	1800 U	2.0 U	52 %
Toluene		8300	1800 U	2.0 U	57 %
Chlorobenzene		1800 U	1800 U	2.0 U	
Ethylbenzene		960 J	1800 U	2.0 U	58 %
m-Xylene		7100	3600 U	4.0 U	
o,p-Xylene		4300	3600 U	4.0 U	
Surrogate Recoveries					
Bromochloromethane		69.1 %	36.8 %	28.0 %	
a,a,a-Trifluorotoluene		188.5 %	92.1 %	39.0 %	

Test 2
(continued)

VOA Prep Batch No: 89TKD02 Date Analyzed: 25 JULY 89 page 2

Sample Information	Cust ID:	PURGE A/XYL	BLANK + SS
	RFW Batch #:	89TKD01	89TKD01
	Sample No:	MB-3	MB-1
	Matrix:	Water	Water
	D.F.:	1	1
	Units:	% REC	% REC
Analytes			
Chloromethane			
Bromomethane			
Vinyl Chloride			
Chloroethane			
Dichloromethane			
Trichlorofluoromethane			
1,1-Dichloroethylene		136 %	
1,1-Dichloroethane		132 %	
trans-1,2-Dichloroethene			
Chloroform		121 %	
1,2-Dichloroethane			
1,1,1-Trichloroethane			
Carbon Tetrachloride		89 %	
Bromodichloromethane			
1,2-Dichloropropane		135 %	
cis-1,3-Dichloropropene			
trans-1,3-Dichloropropene			
Trichloroethene		146 %	
Dibromochloromethane			
1,1,2-Trichloroethane		157 %	
2-Chloroethylvinylether			
Bromoform			
1,1,2,2-Tetrachloroethane			
Tetrachloroethylene		182 %	
Acetone			
2-Butanone			
Benzene			
Toluene			
Chlorobenzene		99 %	
Ethylbenzene			
m-Xylene		83 %	
o,p-Xylene		82 %	
Surrogate Recoveries			
Bromochloromethane			156 %
a,a,a-Trifluorotoluene			97 %

ROY F. WESTON INC.

SEMIVOLATILE ORGANICS CASE NARRATIVE

Client: USATHAMA, Tinker A.F.B.
RFW # : 8907TK02

1. This set of samples consisted of 2 soil samples collected or 7/19/89. The TLCP leachate was prepared from the processed soil.

2. The samples were extracted on 7/25/89.

3. These samples were analyzed on 7/25/89.

4. All required holding times for these samples were met.

5. All blanks analyzed were below allowable limits of detection.

6. Calibration criteria was met for DFTPP.

7. Surrogate recoveries were between 14% and 159%.

8. The blank leachate surrogate spike contained no 2,4,6-Bromophenol.

9. The leachate, feed and process soil samples could not be concentrated to the extent permitted by the method due to the high organic content of these samples. Further concentration resulted in the formation of a precipitate in the extract. Feed and processed soil appeared to contain asphalt paving material.

10. The blank leachate was analyzed at a dilution factor of 20.

The following data qualifiers are used in this report.

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limits.

Approved by: _____ Date: 13 Nov 89

GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8907TK-02 Client: Test 1 Page: 1

	Cust ID:	FEED	PROCESS	LEACHATE	BK LEACHATE
	RFWN:	8907TK0201	8907TK0202	8907TK0203	8907TK02MB1
	Matrix:	Soil	Soil	Water	Water
	D.F.:	380	340	10	20
	Units:	ug/kg	ug/kg	ug/L	ug/L
Surrogate Recovery (%)	Nitrobenzene-d5:	112 %	57 %	30 %	22 %
	2-Fluorobiphenyl:	38 %	55 %	39 %	29 %
	p-Terphenyl-d14:	39 %	94 %	51 %	42 %
	Phenol-d5:	34 %	127 %	16 %	14 %
	2-Fluorophenol:	36 %	159 %	24 %	22 %
	2,4,6-Br3-phenol:	0 %	0 %	0 %	0 %
1,2-Dichlorobenzene		15000	950 J	10 J	200 U
1,4-Dichlorobenzene		3600 J	220 J	100 U	200 U
2-Methylnaphthalene		2400 U	3400 U	100 U	200 U
1,3-Dichlorobenzene		1500 J	100 J	100 U	200 U
Fluoranthene		2900 J	3400 U	100 U	200 U
Naphthalene		5000	130 J	100 U	200 U
Benzo (a) anthracene		3800 U	3400 U	100 U	200 U
Benzo(a)Pyrene		3800 U	3400 U	100 U	200 U
Benzo(b)Fluoranthene		3800 U	3400 U	100 U	200 U
Chrysene		3800 U	3400 U	100 U	200 U
Dibenz(a,h)Anthracene		3800 U	3400 U	100 U	200 U
Acenaphthane		3800 U	3400 U	100 U	200 U
Acenaphthylene		3800 U	3400 U	100 U	200 U
Anthracene		770 J	3400 U	100 U	200 U
Benzo(g,h,i)Perylene		3800 U	3400 U	100 U	200 U
Fluorene		3800 U	200 J	100 U	200 U
Indeno(1,2,3-cd)Pyrene		3800 U	3400 U	500 U	1000 U
Phenanthrene		820 J	670 J	100 U	200 U
Pyrene		90 J	500 J	100 U	200 U
Benzo(k)Fluoranthene		3800 U	3400 U	100 U	200 U
4-Chloroaniline		540 J	630 J	100 U	200 U
2-Chloronaphthalene		3800 U	3400 U	100 U	200 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.

Test 2 (continued)

ROY F. WESTON. INC.

VOLATILE ORGANIC CASE NARRATIVE

CLIENT: USATHAMA, TINKER A.F.B
RFW #: 8907TK03

1. This set of samples consisted of 6 soil samples collected on 8/1/89.

2. These samples were analyzed on 8/2/89.

3. All required holding times for these samples were met.

4. All blanks analyzed were below allowable limits of detection.

5. Calibration criteria was not met for Dichloromethane, Trichlorofluoromethane, 1,1-Dichloroethene, trans-1,3-Dichloropropene, Dibromochloromethane, and 1,1,2-Trichloroethene due to background interferences and co-eleution of peaks.

6. Surrogate recoveries were between 7-140%.

7. Feed soils were prepared using the mid-level extraction procedure due to the expected high concentrations.

The following data qualifiers are used in this report:

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limit.

Approved by: _____ Date: 8/4/89

Test 4

VOA Prep Batch No: 89TKD07 Date Analyzed: 02 Aug 89 page 1

Sample Information	Cust ID:	LT304 Dust	PROCESS SOIL	PROCESS SOIL	FIELD BLANK
	RFW Batch #:	8908TK03	8908TK03	8908TK03	8908TK03
	Sample No:	03	06	02	04
	Matrix:	Water	Soil	Soil	Water
	D.F.:	1	1	1	1
	Units:	ug/L	ug/kg	ug/kg	ug/L
Analytes					
Chloromethane		4.0 U	4.0 U	4.0 U	4.0 U
Bromomethane		4.0 U	4.0 U	4.0 U	4.0 U
Vinyl Chloride		4.0 U	4.0 U	4.0 U	4.0 U
Chloroethane		4.0 U	4.0 U	4.0 U	4.0 U
Dichloromethane		2.0 U	2.0 U	2.0 U	2.0 U
Trichlorofluoromethane		2.0 U	2.0 U	2.0 U	2.0 U
1,1-Dichloroethylene		2.0 U	2.0 U	2.0 U	2.0 U
1,1-Dichloroethane		2.0 U	2.0 U	2.0 U	2.0 U
trans-1,2-Dichloroethene		5.2	4.7	0.6 J	2.0 U
Chloroform		2.0 U	2.0 U	2.0 U	2.0 U
1,2-Dichloroethane		2.0 U	2.0 U	2.0 U	2.0 U
1,1,1-Trichloroethane		2.0 U	2.0 U	2.0 U	2.0 U
Carbon Tetrachloride		2.0 U	2.0 U	2.0 U	2.0 U
Bromodichloromethane		2.0 U	2.0 U	2.0 U	2.0 U
1,2-Dichloropropane		2.0 U	2.0 U	2.0 U	2.0 U
cis-1,3-Dichloropropene		2.0 U	2.0 U	2.0 U	2.0 U
trans-1,3-Dichloropropene		2.0 U	2.0 U	2.0 U	2.0 U
Trichloroethene		2.0 U	41.0 E	5.7	2.0 U
Dibromochloromethane		2.0 U	2.0 U	2.0 U	2.0 U
1,1,2-Trichloroethane		2.0 U	2.0 U	2.0 U	2.0 U
2-Chloroethylvinylether		2.0 U	2.0 U	2.0 U	2.0 U
Bromoform		4.0 U	4.0 U	4.0 U	4.0 U
1,1,2,2-Tetrachloroethane		2.0 U	2.0 U	2.0 U	2.0 U
Tetrachloroethylene		2.8	0.8 J	0.2 J	2.0 U
Acetone		12.0 U	12.0 U	12.0 U	12.0 U
2-Butanone		12.0 U	12.0 U	12.0 U	12.0 U
Benzene		1.0 J	1.3 J	2.0 U	2.0 U
Toluene		1.5 J	1.1 J	2.0 U	2.0 U
Chlorobenzene		0.6 J	2.0 U	2.0 U	2.0 U
Ethylbenzene		0.5 J	2.0 U	2.0 U	2.0 U
m-Xylene		0.4 J	4.0 U	4.0 U	4.0 U
o,p-Xylene		0.9 J	4.0 U	4.0 U	4.0 U
Surrogate Recoveries					
Bromochloromethane		140 %	48 %	11 %	86 %
a,a,a-Trifluorotoluene		52 %	27 %	73 %	89 %

Test 4
(continued)

VOA Prep Batch No: 89TKD07 Date Analyzed: 02 Aug 89 page 2

Sample Information	Cust ID:	FEED SOIL	FEED SOIL	FEED SOIL	FEED SOIL
	RFW Batch #:	8908TK03	8908TK03	8908TK03	8908TK03
	Sample #:	01	01R	05	05R
	Matrix	Soil	Soil	Soil	Soil
	D.F.:	1	1	1	1
	Units:	ug/kg	ug/kg	ug/kg	ug/kg
Analytes					
Chloromethane		1600 U	1600 U	1600 U	1600 U
Bromomethane		1600 U	1600 U	1600 U	1600 U
Vinyl Chloride		1600 U	1600 U	1600 U	1600 U
Chloroethane		1600 U	1600 U	1600 U	1600 U
Dichloromethane		800 U	800 U	800 U	800 U
Trichlorofluoromethane		800 U	800 U	800 U	800 U
1,1-Dichloroethylene		800 U	800 U	800 U	800 U
1,1-Dichloroethane		800 U	800 U	800 U	800 U
trans-1,2-Dichloroethene		270 J	800 U	350 J	200 J
Chloroform		800 U	800 U	800 U	800 U
1,2-Dichloroethane		800 U	800 U	800 U	800 U
1,1,1-Trichloroethane		800 U	800 U	800 U	800 U
Carbon Tetrachloride		800 U	800 U	800 U	800 U
Bromodichloromethane		800 U	800 U	800 U	800 U
1,2-Dichloropropane		800 U	800 U	800 U	800 U
cis-1,3-Dichloropropene		800 U	800 U	800 U	800 U
trans-1,3-Dichloropropene		800 U	800 U	800 U	800 U
Trichloroethene		13000	7300	13000	9000
Dibromochloromethane		800 U	800 U	800 U	800 U
1,1,2-Trichloroethane		800 U	800 U	800 U	800 U
2-Chloroethylvinylether		800 U	800 U	800 U	800 U
Bromoform		1600 U	1600 U	1600 U	1600 U
1,1,2,2-Tetrachloroethane		800 U	800 U	800 U	800 U
Tetrachloroethylene		840	430 J	630 J	550 J
Acetone		4800 U	4800 U	4800 U	4800 U
2-Butanone		4800 U	4800 U	4800 U	4800 U
Benzene		970	450 J	920	640 J
Toluene		260 J	130 J	200 J	210 J
Chlorobenzene		800 U	800 U	800 U	800 U
Ethylbenzene		800 U	800 U	800 U	800 U
m-Xylene		1600 U	1600 U	1600 U	1600 U
o,p-Xylene		1600 U	1600 U	1600 U	1600 U
Surrogate Recoveries					
Bromochloromethane		23 %	16 %	15 %	14 %
a,a,a-Trifluorotoluene		13 %	8 %	7 %	10 %

Test 4
(continued)

VOA Prep Batch No: 89TKD07 Date Analyzed: 02 Aug 89 page 3

Sample Information	Cust ID:	BLANK SPIKE	BLANK SPIKE	BLANK + SS
	RFW Batch #:	8908TK03	8908TK03	8908TK03
	Sample No:	MBS	MBSR	MB-3
	Matrix:	Water	Water	Water
	D.F.:	1	1	1
	Units:	% REC	% REC	% REC
Analytes				
Chloromethane		82 %	91 %	
Bromomethane		103 %	85 %	
Vinyl Chloride		92 %	102 %	
Chloroethane		98 %	102 %	
Dichloromethane		150 %	155 %	
Trichlorofluoromethane		45 %	48 %	
1,1-Dichloroethylene		43 %	51 %	
1,1-Dichloroethane		48 %	42 %	
trans-1,2-Dichloroethene		62 %	52 %	
Chloroform		79 %	76 %	
1,2-Dichloroethane		97 %	27 %	
1,1,1-Trichloroethane		108 %	111 %	
Carbon Tetrachloride		75 %	82 %	
Bromodichloromethane		72 %	78 %	
1,2-Dichloropropane		79 %	78 %	
cis-1,3-Dichloropropene		58 %	47 %	
trans-1,3-Dichloropropene		43 %	45 %	
Trichloroethene		42 %	51 %	
Dibromochloromethane		45 %	35 %	
1,1,2-Trichloroethane		51.0 %	47 %	
2-Chloroethylvinylether		97.0 %		
Bromoform		78.0 %	71 %	
1,1,2,2-Tetrachloroethane				
Tetrachloroethylene		92 %	88 %	
Acetone				
2-Butanone		10 %		
Benzene		73 %	79 %	
Toluene		76 %	78 %	
Chlorobenzene		71 %	68 %	
Ethylbenzene		59 %	65 %	
m-Xylene		85 %	72 %	
o,p-Xylene		85 %	86 %	
Surrogate Recoveries				
Bromochloromethane				120 %
a,a,a-Trifluorotoluene				85 %

ROY F. WESTON INC.

SEMIVOLATILE ORGANICS CASE NARRATIVE

Client: USATHAMA, Tinker A.F.B.
RFW # : 8907TK03

1. This set of samples consisted of 6 samples collected on 8/1/89. The TLCP leachates were prepared from the processed soil.

2. The samples were extracted on 8/5/89.

3. These samples were analyzed on 8/19/89.

4. All required holding times for these samples were met.

5. All blanks analyzed were below allowable limits of detection.

6. Calibration criteria was met for DFTPP.

7. Surrogate recoveries were between 7% and 150%.

8. The feed and process soil samples could not be concentrated to the extent permitted by the method due to the high organic content of these samples. Further concentration resulted in the formation of a precipitate in the extract. Feed and processed soil appeared to contain asphalt paving material.

The following data qualifiers are used in this report.

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limits.

Approved by: _____ Date: 13 Nov 89

WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8908TK03 Client: LT304 Page: 1

	Cust ID:	FEED	PROCESS	DUST	FIELD BK	FEED	PROCESS
	RFW#:	8908TK0301	8908TK0302	8908TK0303	8908TK0304	8908TK0305	8908TK0306
	Matrix:	Soil	Soil	Water	Water	Soil	Soil
	D.F.:	380	340	450	1	390	340
	Units:	ug/kg	ug/kg	ug/L	ug/L	ug/kg	ug/kg
Surrogate Recovery (%)	Nitrobenzene-d5:	50 %	42 %	86 %	80 %	64 %	40 %
	2-Fluorobiphenyl:	59 %	47 %	99 %	71 %	82 %	46 %
	p-Terphenyl-d14:	88 %	75 %	150 %	73 %	147 %	72 %
	Phenol-d5:	108 %	36 %	19 %	15 %	59 %	36 %
	2-Fluorophenol:	116 %	129 %	28 %	23 %	137 %	133 %
	2,4,6-Br3-phenol:	117 %	124 %	70 %	69 %	124 %	123 %
1,2-Dichlorobenzene		24000	600 J	4500 U	23 J	82000	530 J
1,4-Dichlorobenzene		6500	180 J	4500 U	4 J	23000	130 J
2-Methylnaphthalene		2100 J	510 J	4500 U	8 J	6300	500 J
1,3-Dichlorobenzene		2800 J	3400 U	4500 U	1 J	10000	3400 U
Fluoranthene		1000 J	930 J	4500 U	10 U	2500 J	970 J
Naphthalene		1700 J	130 J	4500 U	5 J	4700	110 J
Benzo (a) anthracene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Benzo(a)Pyrene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Benzo(b)Fluoranthene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Chrysene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Dibenz(a,h)Anthracene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Acenaphthene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
Acenaphthylene		3800 U	3400 U	4500 U	10 U	370 J	3400 U
Anthracene		100 J	40 J	4500 U	10 U	140 J	3400 U
Benzo(g,h,i)Perylene		3800 U	3400 U	4500 U	10 U	3900 U	50 J
Fluorene		180 J	170 J	4500 U	10 U	470 J	140 J
Indeno(1,2,3-cd)Pyrene		17000 U	17000 U	23000 U	50 U	20000 U	17000 U
Phenanthrene		520 J	470 J	4500 U	1 J	1400 J	510 J
Pyrene		470 J	410 J	4500 U	10 U	1100 J	400 J
Benzo(k)Fluoranthene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U
4-Chloroaniline		360 J	370 J	4500 U	10 U	430 J	280 J
2-Chloronaphthalene		3800 U	3400 U	4500 U	10 U	3900 U	3400 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.

Test 4
(continued)

WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8908TK03 Client: TEST LT304 Page: 2

	Cust ID:	LEACHATE	LEACHATE	LEACHATE	BK LEACHATE	BLANK
	RFW#:	8908TK0307	8908TK0308	8908TK0309	89TKT04MB1	89TKS05MB1
	Matrix:	Water	Water	Water	Water	Soil
	D.F.:	1	1	1	1	1
	Units:	ug/L	ug/L	ug/L	ug/L	ug/kg
Surrogate Recovery (%)	Nitrobenzene-d5:	35 %	60 %	61 %	75 %	18 %
	2-Fluorobiphenyl:	31 %	55 %	58 %	81 %	31 %
	p-Terphenyl-d14:	49 %	38 %	100 %	105 %	40 %
	Phenol-d5:	18 %	12 %	15 %	18 %	12 %
	2-Fluorophenol:	22 %	17 %	20 %	26 %	12 %
	2,4,6-Br3-phenol:	67 %	63 %	71 %	58 %	7 %
1,2-Dichlorobenzene		10 J	5 J	3 J	10 U	10 U
1,4-Dichlorobenzene		10 U	1 J	1 J	10 U	10 U
2-Methylnaphthalene		4 J	2 J	2 J	10 U	10 U
1,3-Dichlorobenzene		1 J	10 U	1 J	10 U	10 U
Fluoranthene		10 J	10 U	10 U	10 U	10 U
Naphthalene		2 J	1 J	1 J	10 U	10 U
Benzo (a) anthracene		10 U	10 U	10 U	10 U	10 U
Benzo(a)Pyrene		10 U	10 U	10 U	10 U	10 U
Benzo(b)Fluoranthene		10 U	10 U	10 U	10 U	10 U
Chrysene		10 J	10 U	10 U	10 U	10 U
Dibenz(a,h)Anthracene		10 J	10 U	10 U	10 U	10 U
Acenaphthene		10 J	10 U	10 U	10 U	10 U
Acenaphthylene		10 J	10 U	10 U	10 U	10 U
Anthracene		10 J	10 U	10 U	10 U	10 U
Benzo(g,h,i)Perylene		10 U	10 U	10 U	10 U	10 U
Fluorene		10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)Pyrene		50 U	50 U	50 U	50 U	50 U
Phenanthrene		10 U	10 U	1 J	10 U	10 U
Pyrene		10 U	10 U	10 U	10 U	10 U
Benzo(k)Fluoranthene		10 U	10 U	10 U	10 U	10 U
4-Chloroaniline		10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene		10 U	10 U	10 U	10 U	10 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.

ROY F. WESTON. INC.

VOLATILE ORGANIC CASE NARRATIVE

CLIENT: USATHAMA, TINKER A.F.B
RFW #: 8907TK04

1. This set of samples consisted of 4 soil samples collected on 8/9/89.

2. These samples were analyzed on 8/11/89.

3. All required holding times for these samples were met.

4. All blanks analyzed were below allowable limits of detection for all compounds with the exception of Trichloroethene due to high background concentrations.

5. Calibration criteria was not met for Dichloromethane, Trichlorofluoromethane, 1,1-Dichloroethene, trans-1,3-Dichloropropene, Dibromochloromethane, and 1,1,2-Trichloroethene due to background interferences and co-elution of peaks.

6. Surrogate recoveries were between 30-161%.

7. Feed soils were prepared using the mid-level extraction procedure due to the expected high concentrations.

The following data qualifiers are used in this report:

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limit.

Approved by: [signature] Date: 13 Nov 89

Test 8

VOA Prep Batch No: 89TKD09 Date Analyzed: 11 AUG 89 page 1

Sample Information	Cust ID:	FEED SOIL	FEED SOIL	PROCESSED SOIL	BAG HOUSE SLURRY
	RFW Batch #:	8908TK04	8908TK04	8908TK04	8908TK04
	Sample No:	01	01R	02	03
	Matrix:	Soil	Soil	Soil	Water
	D.F.:	1	1	1	10
	Units:	ug/kg	ug/kg	ug/kg	ug/L
Analytes					
Chloromethane		1600 U	1600 U	4.0 U	40 U
Bromomethane		1600 U	1600 U	4.0 U	40 U
Vinyl Chloride		1600 U	1600 U	4.0 U	40 U
Chloroethane		1600 U	1600 U	4.0 U	40 U
Dichloromethane		800 U	800 U	2.0 U	20 U
Trichlorofluoromethane		800 U	800 U	7.8	6.4 J
1,1-Dichloroethylene		800 U	800 U	2.0 U	20 U
1,1-Dichloroethane		800 U	800 U	2.0 U	20 U
trans-1,2-Dichloroethene		380 J	360 J	8.0	150
Chloroform		800 U	800 U	2.0 U	20 U
1,2-Dichloroethane		800 U	800 U	2.0 U	20 U
1,1,1-Trichloroethane		800 U	800 U	2.0 U	20 U
Carbon Tetrachloride		800 U	800 U	2.0 U	20 U
Bromodichloromethane		800 U	800 U	2.0 U	20 U
1,2-Dichloropropane		800 U	800 U	2.0 U	20 U
cis-1,3-Dichloropropene		800 U	800 U	2.0 U	20 U
trans-1,3-Dichloropropene		800 U	800 U	2.0 U	20 U
Trichloroethene		8700	8300	46	5500
Dibromochloromethane		800 U	800 U	2.0 U	20 U
1,1,2-Trichloroethane		800 U	800 U	2.0 U	20 U
2-Chloroethylvinylether		800 U	800 U	2.0 U	20 U
Bromoform		1600 U	1600 U	4.0 U	40 U
1,1,2,2-Tetrachloroethane		800 U	800 U	2.0 U	20 U
Tetrachloroethylene		800	650 J	1.0 J	100
Acetone		4800 U	4800 U	12 U	120 U
2-Butanone		4800 U	4800 U	12 U	120 U
Benzene		99 J	173 J	8.7	7.6 J
Toluene		15 J	20 J	0.9 J	5.0
Chlorobenzene		800 U	800 U	2.0 U	40
Ethylbenzene		800.0 U	800.0 U	2.1	70
m-Xylene		1600.0 U	800 U	0.3 J	3.2 J
o,p-Xylene		1600.0 U	9.5 J	0.8 J	94
Surrogate Recoveries					
Bromochloromethane		156.4 %	161.2 %	102.6 %	116.6 %
a,a,a-Trifluorotoluene		32.1 %	79.4 %	30.3 %	56.5 %

Test 8
(continued)

VOA Prep Batch No: 89TKD09 Date Analyzed: 11 AUG 89 page 2

Sample Information	Cust ID:	FIELD BLANK	METHOD BLANK	BLANK SPIKE	SPIKE DUP
	RFW Batch #:	8908TK04	8908TK04	8908TK04	8908TK04
	Sample No:	04	05	06	07
	Matrix:	Water	Water	Water	Water
	D.F.:	1	1	1	1
	Units:	ug/L	ug/L	% REC	% REC
Analytes					
Chloromethane		4.0 U	4.0 U	89 %	82 %
Bromomethane		4.0 U	4.0 U	78 %	82 %
Vinyl Chloride		4.0 U	4.0 U	79 %	72 %
Chloroethane		4.0 U	4.0 U	61 %	75 %
Dichloromethane		2.0 U	2.0 U	160 %	135 %
Trichlorofluoromethane		0.7 J	2.0 U	91 %	95 %
1,1-Dichloroethylene		2.0 U	2.0 U	87 %	85 %
1,1-Dichloroethane		2.0 U	2.0 U	45 %	48 %
trans-1,2-Dichloroethene		3.8	2.0 U	63 %	62 %
Chloroform		2.0 U	2.0 U	75 %	78 %
1,2-Dichloroethane		2.0 U	2.0 U	79 %	93 %
1,1,1-Trichloroethane		2.0 U	2.0 U	98 %	81 %
Carbon Tetrachloride		2.0 U	2.0 U	80 %	92 %
Bromodichloromethane		2.0 U	2.0 U	82 %	79 %
1,2-Dichloropropane		2.0 U	2.0 U	72 %	78 %
cis-1,3-Dichloropropene		2.0 U	2.0 U	32 %	45 %
trans-1,3-Dichloropropene		2.0 U	2.0 U	42 %	45 %
Trichloroethene		42	18	42 %	39 %
Dibromochloromethane		2.0 U	2.0 U	56 %	62 %
1,1,2-Trichloroethane		2.0 U	2.0 U	58 %	65 %
2-Chloroethylvinylether		2.0 U	2.0 U	81 %	85 %
Bromoform		4.0 U	4.0 U	83 %	85 %
1,1,2,2-Tetrachloroethane		2.0 U	2.0 U		
Tetrachloroethylene		0.9 J	1.1 J	87 %	83 %
Acetone		12 U	12 U		
2-Butanone		12 U	12 U	5 %	7 %
Benzene		5.5	1.1 J	86 %	88 %
Toluene		2.0 U	0.3 J	86 %	92 %
Chlorobenzene		2.0 U	2.0 U	77 %	71 %
Ethylbenzene		2.0 U	2.0 U	62 %	85 %
m-Xylene		9.4	4.0 U	76 %	91 %
o,p-Xylene		7.7	4.0 U	82 %	75 %
Surrogate Recoveries					
Bromochloromethane		112.9 %	134.9 %		
a,a,a-Trifluorotoluene		88.8 %	76.1 %		

Test 8
(continued)

VOA Prep Batch No: 89TKD09 Date Analyzed: 11 AUG 89 page 3

Sample Information	
Cust ID:	BLANK + SS
RFW Batch #:	8908TK04
Sample No:	08
Matrix:	Water
D.F.:	1
Units:	% REC

Analytes

Chloroethane
Bromoethane
Vinyl Chloride
Chloroethane
Dichloroethane
Trichlorofluoroethane
1,1-Dichloroethylene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Carbon Tetrachloride
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
2-Chloroethylvinylether
Bromoform
1,1,2,2-Tetrachloroethane
Tetrachloroethylene

Acetone
2-Butanone
Benzene
Toluene
Chlorobenzene
Ethylbenzene
m-Xylene
o,p-Xylene

Surrogate Recoveries

Bromochloromethane	97 %
a,a,a-Trifluorotoluene	130 %

ROY F. WESTON INC.

SEMIVOLATILE ORGANICS CASE NARRATIVE

Client: USATHAMA, Tinker A.F.B.
RFW # : 8907TK04

1. This set of samples consisted of 4 samples collected on 8/9/89. The TLCP leachates were prepared from the processed soil.

2. The samples were extracted on 8/10/89.

3. These samples were analyzed on 8/11/89.

4. All required holding times for these samples were met.

5. All blanks analyzed were below allowable limits of detection.

6. Calibration criteria was met for DFTPP.

7. Surrogate recoveries were between 0% and 96%.

8. The feed and process soil samples could not be concentrated to the extent permitted by the method due to the high organic content of these samples. Further concentration resulted in the formation of a precipitate in the extract. Feed and processed soil appeared to contain asphalt paving material.

The following data qualifiers are used in this report.

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was present below detection limits.

Approved by: _____ Date: 13 Nov 89

WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8908TK04 Client: LT30A Page: 1

	Cust ID:	FEED	FEED REP	PROCESS	DUST SLURRY	FIELD BK	LEACHATE
	RFW#:	8908TK0401	8908TK0401	8908TK0402	8908TK0403	8908TK0404	8908TK0405
	Matrix:	Soil	Soil	Soil	Water	Water	Water
	D.F.:	430	430	336	529	2	2
	Units:	ug/kg	ug/kg	ug/kg	ug/L	ug/L	ug/L
Surrogate Recovery (%)	Nitrobenzene-d5:	18 %	14 %	13 %	0 %	71 %	71 %
	2-Fluorobiphenyl:	24 %	19 %	17 %	39 %	60 %	67 %
	p-Terphenyl-d14:	30 %	23 %	22 %	54 %	47 %	89 %
	Phenol-d5:	11 %	8 %	8 %	0 %	17 %	18 %
	2-Fluorophenol:	11 %	8 %	8 %	13 %	19 %	25 %
	2,4,6-Br3-phenol:	14 %	12 %	9 %	23 %	66 %	66 %
1,2-Dichlorobenzene		14000	13000	300 J	184000 E	4 J	4 J
1,4-Dichlorobenzene		4300 U	4300 J	3400 U	59000 E	1 J	1 J
2-Methylnaphthalene		1400 J	1600 J	270 J	69000 E	20 U	20 U
1,3-Dichlorobenzene		1400 J	1300 J	3400 U	28000	20 U	20 U
Fluoranthene		840 J	750 J	760 J	4500 J	20 U	20 U
Naphthalene		1100 J	950 J	70 J	36000	20 U	2 J
Benzo (a) anthracene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Benzo(a)Pyrene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Benzo(b)Fluoranthene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Chrysene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Dibenz(a,h)Anthracene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Acenaphthene		4300 U	4300 U	3400 U	1500 J	20 U	20 U
Acenaphthylene		4300 U	4300 U	3400 U	1500 J	20 U	20 U
Anthracene		4300 U	4300 U	40 J	5300 U	20 U	20 U
Benzo(g,h,i)Perylene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
Fluorene		4300 U	4300 U	3400 U	2700 J	20 U	20 U
Indeno(1,2,3-cd)Pyrene		4300 U	22000 U	17000 U	26000 U	100 U	100 U
Phenanthrene		340 J	300 J	300 J	4800 J	20 U	20 U
Pyrene		190 J	180 J	220 J	1500 J	20 U	20 U
Benzo(k)Fluoranthene		4300 U	4300 U	3400 U	5300 U	20 U	20 U
4-Chloroaniline		220 J	200 J	230 J	2200 J	20 U	3 J
2-Chloronaphthalene		4300 U	4300 U	3400 U	5300 U	20 U	20 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.
E= Indicates the compound is greater thab 100ng on column.

Test 8
(continued)

WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

RFW Batch Number: 8908TK04 Client: LT308 Page: 2

	Cust ID:	LEACHATE	BLANK	BLANK
	RFW#:	8908TK0406	89TKS05MB1	89TKS06MB1
	Matrix:	Water	Soil	Soil
	D.F.:	2	1	1
	Units:	ug/L	ug/kg	ug/kg
Surrogate Recovery (%)	Nitrobenzene-d5:	62 %	75 %	19 %
	2-Fluorobiphenyl:	70 %	81 %	37 %
	p-Terphenyl-d14:	96 %	105 %	49 %
	Phenol-d5:	16 %	18 %	18 %
	2-Fluorophenol:	21 %	26 %	18 %
	2,4,6-Br3-phenol:	70 %	58 %	13 %
1,2-Dichlorobenzene		4 J	10 U	10 U
1,4-Dichlorobenzene		1 J	10 U	10 U
2-Methylnaphthalene		2 J	10 U	10 U
1,3-Dichlorobenzene		20 U	10 U	10 U
Fluoranthene		20 U	10 U	10 U
Naphthalene		1 J	10 U	10 U
Benzo (a) anthracene		20 U	10 U	10 U
Benzo(a)Pyrene		20 U	10 U	10 U
Benzo(b)Fluoranthene		20 U	10 U	10 U
Chrysene		20 U	10 U	10 U
Dibenz(a,h)Anthracene		20 U	10 U	10 U
Acenaphthene		20 U	10 U	10 U
Acenaphthylene		20 U	10 U	10 U
Anthracene		20 U	10 U	10 U
Benzo(g,h,i)Perylene		20 U	10 U	10 U
Fluorene		20 U	10 U	10 U
Indeno(1,2,3-cd)Pyrene		20 U	50 U	50 U
Phenanthrene		1 J	10 U	10 U
Pyrene		20 U	10 U	10 U
Benzo(k)Fluoranthene		20 U	10 U	10 U
4-Chloroaniline		20 U	10 U	10 U
2-Chloronaphthalene		20 U	10 U	10 U

Note : U= Analyzed,not detected.
J=Present at less than detection limit. NR=Not requested.

Test 8
(continued)

APPENDIX I

PERMIT DOCUMENTS

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFLC)
TINKER AIR FORCE BASE, OKLAHOMA 73145

RECEIVED
WESTON SERVICES, INC.
MAR 06 1990
THERMAL SYSTEMS DIVISION

U.S. Environmental Protection Agency
Regional Administrator Region VI
Suite 1200
1445 Ross Avenue
Dallas TX 75202

Dear Mr Layton

Per direction in your letter dated 25 Jan 89, we formally submit an application for a Hazardous and Solid Waste Amendments of 1984 (HSWA) Research, Development and Demonstration (RD&D) permit for the demonstration project entitled "Thermal Stripping of JP4 and other VOCs from Soils at Tinker Air Force Base." We propose that the demonstration test plan, titled as above and dated November 1988, serve as our technical application. That document is currently under review by Ms. Laurie Burch in your permits section. The Health and Safety Plan enclosed should also be part of the technical submittal.

Due to the small quantity of soil being processed and the short duration of the demonstration, we formally request waiving the requirements in accordance with para. 2, page 11 in the Guidance Manual for Research, Development and Demonstration Permits (EPA/530-SW-86-008).

Please advise whether the waiver of requirements is acceptable and the information supplied is adequate; also if additional information is required. We appreciate your efforts in expediting this permit process.

Our point of contact on this matter is Mr Al Aguilar or Major Darrel Cornell, OC-ALC/EMR at extension (405)-734-3058.

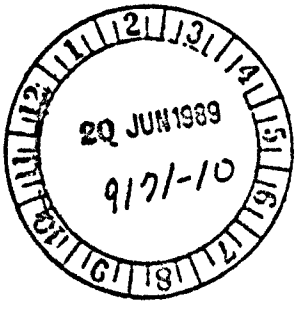
RAY D. REAVES, Col, USAF
Director, Environmental Management

1 Atch
Health & Safety Plan

cc Al Davis
Damon Wingfield

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TEXAS 75202

June 15, 1989



CERTIFIED - RETURN RECEIPT REQUESTED

Ray D. Reaves, Col., USAF
Director, Environmental Management
Department of the Air Force
Headquarters Oklahoma City Air Logistics Center
Tinker Air Force Base, Oklahoma 73145

RE: Transmittal of Research, Development and Demonstration Permit for Tinker Air Force Base OK1571724391

Dear Colonel:

Enclosed is a Research, Development and Demonstration (RD&D) permit to operate the Low-Temperature Thermal Treatment Process at Tinker Air Force Base in Oklahoma City, Oklahoma.

All operations shall be conducted in accordance with the terms and conditions of this permit and all standards and rules promulgated pursuant to the Resource Conservation and Recovery Act as amended. This permit is issued subject to the provisions listed in the permit and it should be made a part of your permanent records. This permit will expire 120 days from the date of permit issuance.

You may request a review of this permit decision, as described in 40 CFR 124.19, within thirty days from the date of issuance. Such petitions should be submitted to both the U.S. Environmental Protection Agency (EPA), 401 M Street, S.W., Washington, D.C. 20460, and EPA, Region 6.

If you have any questions, please call me or have your staff contact Bill Gallagher at (214) 655-6775.

Sincerely yours,

Allyn M. Davis For

Director
Hazardous Waste Management Division (6H)

Enclosures

cc: Damon Wingfield,
Oklahoma State Department of Health

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION 6

RESEARCH, DEVELOPMENT AND DEMONSTRATION

HAZARDOUS WASTE TREATMENT PERMIT

Permittee: TINKER AIR FORCE BASE
Number: OKI571724391
Location of RD&D Activity: Oklahoma City, Oklahoma

This permit is issued by the United States Environmental Protection Agency (EPA) under authority of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended, 42 USC 6901 et seq. (RCRA) and EPA regulations to TINKER AIR FORCE BASE (hereafter called the Permittee), to operate a hazardous waste research, development and demonstration activity located in Oklahoma City, Oklahoma, on TINKER AIR FORCE BASE, OC-ALC/EM, (at latitude 35°25'36" N and longitude 97°22'20" W). The project will test the Low-Temperature Thermal Treatment process design as a waste treatment process to decontaminate soils that are contaminated with hazardous wastes.

The Permittee must comply with all terms and conditions of this permit. This permit consists of the conditions contained herein, including those in the Attachments, and the regulations contained in 40 CFR Parts 260 through 265, 124, and 270 as specified in this permit.

This permit is based on the assumption that the information submitted in the permit application dated October 1988 and referenced in the Permittee' letter dated February 17, 1989, (hereafter referred to as the application) is accurate and that the activity will be constructed and/or operated as specified in the application. Any inaccuracies found in this information may be grounds for the termination or modification of this permit (see 40 CFR Parts 270.41, 270.42, 270.43, and 270.65(c) and potential enforcement action (42 USC 6925(g)). The Permittee must inform EPA of any deviation from or changes in the information in the application which would affect the Permittee's ability to comply with the applicable regulations or permit conditions.

This permit is effective as of June 15, 1989, and shall remain in effect until October 16, 1989, and shall not exceed 120 operating days after commencement of experimental treatment, unless revoked and reissued, or terminated in accordance with 40 CFR Parts 270.41, 270.42, 270.43 or 270.65.

Issued this 15th day of June, 1989.

by: _____
Allyn M. Davis, Director
Hazardous Waste Management Division

RESPONSE TO COMMENTS
TINKER AIR FORCE BASE
R D & D PERMIT
JUNE 1989

I. BACKGROUND INFORMATION

1. Facility Location: near Oklahoma City, Oklahoma

2. Facility Activities and Waste Handling: Aircraft Maintenance Operations facility which will demonstrate how soils contaminated with volatile organic compounds can be decontaminated using a Low-Temperature Thermal Treatment Process.

3. Public Notice: The public notice of the proposed Research, Development and Demonstration (RD&D) permit satisfied the public notice requirements specified in 40 CFR 124.17. The public notice announcement was published on April 10, 1989, and broadcast on a local radio station. In addition, this announcement was sent to the facility, appropriate State agencies, and any other individuals identified on the mailing list. The public notice comment period closed on May 24, 1989. No public hearing was requested or held.

II. CHANGES MADE IN FINALIZING THE RD&D PERMIT

1. Quality assurance/quality control procedures for laboratory analysis of samples were added to Attachment 1, Research Plan.

2. Details regarding the closure of the RD&D project have been added to Attachment 4, Closure Plan.

3. Maximum operating temperature in the thermal processor has been increased from 350°F to 450°F.

4. Maximum moisture content of the feed soil has been increased from 20 to 30 percent.

III. SIGNIFICANT COMMENTS RECEIVED

The only comments on the proposed RD&D permit came from Weston, who will be operating the thermal process unit at Tinker.

Comment #1:
The commentor requested an increase in the maximum thermal process temperature from 350°F to 450°F. The greater temperature range is needed to perform the matrix of test runs during the demonstration.

Response #1: Provision III.D.1.
The permit now states that the temperature for the thermal processor shall be between 250°F and 450°F.

Comment #2:
The commentor requested an increase in the moisture content of the feed soil from 20 to 30 percent in order to perform a matrix of test runs using various temperatures, residence times, water and solvent contents during the demonstration.

Response #2: Provision III.D.4
The permit now states that the total moisture content of the feed soil shall not exceed 30 percent.

Comment #3:
The commentor identified an inconsistency in the permit regarding excess oxygen in the stack gas.

Response #3: Provision III.D.13.a.
The permit has been corrected to state that a minimum of 3 percent excess oxygen shall be maintained in the stack gas on an hourly rolling average basis.

Comments #4 & #5:
The commentor requested clarification regarding the waste feed cut-off requirements.

Responses #4 & #5: Provision III.D.13.b and c.
The permit has been modified to read that the limitations on carbon monoxide and total hydrocarbons is based on an hourly rolling average.

Comment #6:
The commentor requested that the permit be modified to clearly state which parameters are continously monitored.

Response #6: Provision III.F.
The permit has been modified to read that oxygen, carbon monoxide, carbon dioxide, and total hydrocarbons shall be continuously monitored in the stack and recorded. In addition, the Permittee shall continuously monitor and record the waste feed rate and combustion temperatures in the thermal processor and afterburner.

The Permittee is also required to control hydrogen chloride (HCL) emissions by removing 99 percent of the HCL in the stack.

PART I - STANDARD CONDITIONS

A. EFFECT OF PERMIT

This permit authorizes only the research on hazardous waste treatment expressly described in this permit and does not authorize any other management of hazardous waste. EPA will consider compliance with the terms of this permit to be compliance with the requirements of RCRA Subtitle C and EPA regulations concerning the management of hazardous waste listed or described in this permit. Issuance of this permit does not convey property rights of any sort or any exclusive privilege; nor does it authorize any injury to persons or property, any invasion of other private rights, or any infringement of State or local laws or regulations. Compliance with the terms of this permit does not constitute a defense to any action brought under Section 7003 of RCRA (42 USC 6973), Section 106 (a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 USC 9606(a) commonly known as CERCLA), or any other law governing protection of public health or the environment.

B. PERMIT ACTIONS

1. Modification, Revocation, and Termination. This permit may be modified, revoked and reissued, or terminated for cause as specified in 40 CFR Parts 270.41, 270.43, 270.42 and 270.65. The filing of a request for a permit modification, revocation and reissuance, or termination or the notification of planned changes or anticipated noncompliance on the part of the Permittee does not stay the applicability or enforceability of any permit condition.

2. Protection of Human Health and the Environment. The Regional Administrator may order an immediate termination of all operations under this permit at any time he determines that termination is necessary to protect human health at the environment. (See 40 CFR Part 270.65(c).)

C. SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

D. DEFINITIONS

For the purpose of this permit, terms used herein shall have the same meaning as those in Title 40 of the Code of Federal Regulations (40 CFR Parts 260 through 264 and 270), unless this permit specifically states otherwise; where terms are not otherwise defined by a standard dictionary reference or the generally accepted scientific or industrial meaning of the term. "Regional Administrator" is the Regional Administrator of the United States Environmental Protection Agency, Region 6, Office located in Dallas, Texas.

E. REPORTS, NOTIFICATIONS AND SUBMISSIONS TO THE REGIONAL ADMINISTRATOR

All reports, notifications or other submissions which are required by this permit to be sent or given to the Regional Administrator should be sent certified mail or given to:

Mr. William K. Honker
Chief
RCRA Permits Branch
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, Texas 75202-2733

F. SIGNATORY REQUIREMENTS

All reports or other information submitted to the Regional Administrator shall be signed and certified as required by 40 CFR Part 270.11.

G. DOCUMENTS TO BE MAINTAINED AT THE ACTIVITY SITE

The Permittee shall maintain at the activity site, until closure is completed and certified by an independent registered professional engineer, the following documents and amendments, revisions and modifications to these documents:

1. Research plan.

2. Personnel safety plan.

3. Emergency response plan.

4. Closure plan.

5. Operating record, including an operating log used for recording purposes.

H. DUTIES AND REQUIREMENTS

1. Duty to Comply. The Permittee shall comply with all conditions of this permit, except to the extent and for the duration such noncompliance is authorized by an emergency permit. Any other permit noncompliance constitutes a violation of RCRA and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or denial of a permit renewal application.

2. Duty to Reapply. If the Permittee wishes to continue an activity allowed by this permit after the expiration date of this permit, the Permittee shall submit a complete application for a new permit at least 60 days before this permit expires.

3. Need to Halt or Reduce Activity Not a Defense. It shall not be a defense for the Permittee in an enforcement action to argue that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

4. Duty to Mitigate. In the event of noncompliance with this permit, the Permittee shall take all reasonable steps to minimize releases to the environment, and shall carry out such measures as are reasonable to prevent significant adverse impacts on human health or the environment.

5. Proper Operation and Maintenance. The Permittee shall at all times properly operate and maintain all activities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary systems or similar systems only when necessary to comply with the conditions of the permit.

6. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause as specified in 40 CFR Parts 270.41, 270.42, 270.43, and 270.65(c). The filing of a request for a permit modification, revocation and reissuance, or temination, or the notification of planned changes or anticipated noncompliance on the part of the Permittee does not stay the applicability or enforceability of any permit condition.

7. Property Rights. The permit does not convey any property rights of any sort, or any exclusive privilege.

8. Duty to Provide Information. The Permittee shall furnish to the Regional Administrator, within a reasonable time, any relevant information which the Regional Administrator may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The Permittee shall also furnish to the Regional Administrator, upon request, copies or records required to be kept by this permit.

9. Inspection and Entry. The Permittee shall allow the Regional Administrator, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

   a. Enter at reasonable times upon the Permittee's premises where a regulated activity is located or conducted, or where records must be kept under the conditions of this permit;

   b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

   c. Inspect at reasonable times any activities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

   d. Sample or monitor, at reasonable times for the purposes of assuring permit compliance or as otherwise authorized by RCRA, any substances or parameters at any location.

10. Monitoring and Records.

   a. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity in accordance with the Research plan in Attachment 1.

   b. The Permittee shall retain the final project report and records of all data used to complete the application for this permit for a period of at least five (5) years from the date of the sample, measurement, report or application. These periods may be extended by request of the Regional Administrator at any time and are automatically extended during the course of any unresolved enforcement action regarding this facility.

   c. Records of monitoring information shall specify:

      (1) The dates, exact place, and times of sampling or measurements;

      (2) The individuals who performed the sampling or measurements;

(3) The dates analyses were performed;

(4) The individuals who performed the analyses;

(5) The analytical techniques or methods used; and

(6) The results of such analyses.

11. Prospective Changes in Operation. If the Permittee wishes to make any changes in the operation of the RD&D unit, he must notify the Regional Administrator no less than fourteen (14) calendar days before the date he intends to make the change. This notification must be by certified mail. Changes in the operation of the RD&D unit include, but are not limited to, alteration of the treatment technology, use of different pollution control devices, and any changes in the operation of the activity not authorized in this permit that may affect human health or the environment.

12. Anticipated Noncompliance. The Permittee shall give advance notice to the Regional Administrator of any planned changes in the permitted activity which may result in noncompliance with permit requirements.

13. Certification of Construction or Modification. The Permittee may not commence of hazardous waste at the facility until:

a. The Permittee (and a registered professional engineer) have notified the Regional Administrator that the activity has been (constructed/modified) in compliance with the permit; followed by a letter signed by the Permittee (and a registered professional engineer) stating that the activity has been (constructed/modified) in compliance with the permit; and

b. (i) The Regional Administrator has either inspected the modified or newly constructed activity and finds it is in compliance with the conditions of the permit; or

b. (ii) The Regional Administrator has either waived the inspection or has not within 72 hours notified the Permittee of his or her intent to inspect.

14. Twenty-Four Hour Reporting. The Permittee shall report to the Regional Administrator any noncompliance which may endanger human health or the environment. Information shall be provided orally with twenty-four (24) hours from the time the Permittee becomes aware of the circumstances. This report shall include the following:

a. Information concerning release of any hazardous waste that may cause an endangerment to public drinking water supplies.

b. Any information of a release or discharge of hazardous waste, or of a fire or explosion from the hazardous waste research, development and demonstration activity, which could threaten the environment or human health outside the activity. The description of the occurrence and its cause shall include:

(1) Name, address, and telephone number of the owner or operator;

(2) Name, address, and telephone number of the activity site;

(3) Date, time, and type of incident;

(4) Name and quantity of material(s) involved;

(5) The extent of injuries, if any;

(6) An assessment of actual or potential hazard to the environment and human health outside the activity, where this is applicable; and

(7) Estimated quantity and disposition of recovered material that resulted from the incident.

A written submission shall also be provided to the Regional Administrator within five (5) days of the time the Permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the periods of noncompliance (including exact dates and times) if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance. The Permittee need not comply with the 5-day written notice requirement if the Regional Administrator waives that requirement and the Permittee submits a written report within fifteen (15) days of the time the Permittee becomes aware of the circumstances.

15. Other Noncompliance. The Permittee shall report all other instances of noncompliance not otherwise required to be reported above, at the time monitoring reports are submitted. The reports shall contain the information listed in permit condition 14.

16. Other information. Whenever the Permittee becomes aware that he or she failed to submit any relevant facts in the permit application, or submitted incorrect information in a permit application or in any report to the Regional Administrator, the Permittee shall promptly submit such facts or information to the Regional Administrator.

17. Transfer of Permit. This permit may not be transferred to a new owner and operator unless it is modified or revoked and reissued pursuant to 40 CFR Part 270.41(b)(2) or 270.42(d).

I. CONFIDENTIAL INFORMATION

Any information required to be submitted by this permit may be claimed as confidential in accordance with 40 CFR Parts 270.12 (Confidentiality of Information) and 2.203(b) (Public Information, Subpart B-Confidential Business Information).

PART II - GENERAL OPERATING CONDITIONS

A. DESIGN AND OPERATION OF HAZARDOUS WASTE RD&D ACTIVITY

The Permittee shall maintain and operate the activity to minimize the possibility of a fire, explosion, or any unplanned sudden or non-sudden release of hazardous waste constituents to air, soil, or surface water which could threaten human health or the environment. (See 40 CFR 264.31.)

B. RESEARCH PLAN

The Permittee shall follow the procedures described in the attached Research plan, Attachment 1.

C. PERSONNEL QUALIFICATIONS

The Permittee shall ensure that personnel are qualified to manage hazardous waste as provided in Attachment 2. All personnel involved with activities under this permit shall receive training prior to initiation of activities under this program as described in Attachment 2.

D. PREPAREDNESS AND PREVENTION

1. Required Equipment. At a minimum, the Permittee shall provide the activity with the equipment set forth in the emergency response plan, Attachment 3.

2. Testing and Maintenance of Equipment. The Permittee shall maintain the equipment specified in the previous permit condition and in Attachment 3 as necessary to assure its proper operation in time of emergency.

E. EMERGENCY RESPONSE PLAN

1. Implementation of Plan. The Permittee shall immediately carry out the provisions of the emergency response plan, Attachment 3, and follow the emergency procedures described by 40 CFR 264.56 whenever there is an imminent or actual fire, explosion, or release of hazardous waste or constituents which threatens or could threaten human health or the environment.

2. Copies of Plan. The Permittee shall comply with the requirements of 40 CFR 264.53.

3. Amendments to Plan. The Permittee shall review and immediately amend, if necessary, the emergency response plan, as required by 40 CFR 264.54.

4. Emergency Coordinator. The Permittee shall comply with the requirements of 40 CFR 264.55.

F. CLOSURE

1. Performance Standard. The Permittee shall close the activity as required by 40 CFR 264.111 and in accordance with the closure plan, Attachment 4.

2. Amendment to Closure Plan. The Permittee shall amend the closure plan in accordance with 40 CFR 264.112(b) whenever necessary.

3. Notification of Closure. The Permittee shall notify the Regional Administrator by certified mail at least 30 days prior to the date he expects to begin closure.

4. Time Allowed for Closure. After treating the final volume of hazardous waste in the LT^3 process unit, the Permittee shall complete closure activities in accordance with the schedules specified in the closure plan, Attachment 4.

5. Disposal or Decontamination of Equipment. The Permittee shall decontaminate and/or dispose of all equipment used in the RD&D activity as required by 40 CFR 264.114 and the closure plan, Attachment 4.

6. Certification of Closure. The Permittee shall certify that the activity has been closed in accordance with the specifications in the closure plan, Attachment 4, as required by 40 CFR 264.115.

G. MANIFEST SYSTEM

The Permittee shall comply with the manifest requirements of 40 CFR 264.71, 264.72, and 264.76, for any wastes disposed of off-site.

H. SECURITY

The Permittee shall comply with the security provisions of 40 CFR 264.14(b) and (c).

I. GENERAL REQUIREMENTS FOR IGNITABLE, REACTIVE, OR INCOMPATIBLE WASTE

The Permittee shall comply with the requirements of 40 CFR 264.17(a).

J. GENERAL WASTE ANALYSIS

The Permittee shall follow the procedures described in the attached Research Plan, Attachment 1.

PART III - SPECIFIC OPERATING CONDITIONS

A. CONSTRUCTION AND MAINTENANCE

The Permittee shall construct and maintain the unit and the testing activity in accordance with the design plans and specifications in Attachment 1.

B. WASTE IDENTIFICATION

The Permittee may treat the hazardous wastes identified in Table 1, subject to the terms of this permit.

C. MAXIMUM WASTE TO BE TREATED

The Permittee shall not treat more than 1500 cubic yards during the term of this permit.

D. OPERATING CONDITIONS

The Permittee shall operate the unit only under the following conditions and as specified in Attachment 1 of this permit:

1. The thermal processor (combustion) temperature shall be between 250 and 450° F.

2. The residence time in the thermal processor shall be between 30 and 90 minutes.

3. The maximum waste feed rate shall be between 6 and 8 cubic yards/hour.

4. The total moisture content of the feed soil shall not exceed 30 percent.

5. The addition of a solvent to the waste feed shall be limited to one percent (by weight) of solvent.

6. The afterburner temperature shall be between 1750 and 1850° F.

7. The stack gas concentration of carbon monoxide shall be less than 25 ppmv hourly rolling average basis.

8. The stack gas concentration of total hydrocarbons shall be less than 20 ppmv hourly rolling average basis.

9. The scrubber liquid shall be maintained at a pH between 6.5 and 8.5.

10. The Permittee shall have no visible emissions and shall control fugitive emissions from the thermal processor and afterburner by use of an induced-draft fan and by controlling the thermal processing rate as specified in Attachment 1.

11. A minimum of 3 percent excess oxygen shall be maintained in the stack gas on an hourly rolling average basis.

12. During start-up and shut-down of the unit, hazardous wastes may not be introduced into the unit unless the unit is operating within the conditions specified in permit condition III.D.

13. The Permittee shall immediately stop the feed of hazardous waste when any of the operating conditions exceed limits designated in this permit, as specified below:

    a. O_2 limit less than 3 percent in the afterburner outlet stack.
    b. CO limit greater than 25 ppmv hourly rolling average basis in the afterburner stack.
    c. THC limit greater than 20 ppmv hourly rolling average basis in the afterburner stack.
    d. Afterburner flame failure.
    e. Positive pressure (greater than 0.0 inches water gauge in w.g.) in thermal processor.
    f. Temperature less than 1750^0 F in the afterburner stack.
    g. Waste feed rate to the thermal processor exceeds 8 cubic yds/hour.

14. The Permittee shall monitor and analyze the parameters specified in the test plan, Attachment 1, according to the methods and frequency specified in Attachment 1. The Permittee shall implement the QA/QC program specified in Attachment 1.

E. TEST PLAN AND REPORTING

1. Test Plan. The Permittee shall operate and monitor the unit during the term of the permit and as specified in Attachment 1.

2. POHCs. The principal organic hazardous constituents (POHCs) are Tetrachloroethene and 1,2 - Dichlorobenzene.

3. Incinerator Performance Standards. The Permittee shall verify that the operating conditions established in this permit achieve the performance standards stated below:

    a. The incinerator must achieve a destruction removal efficiency (DRE) of 99.99 percent for each POHC designated in this permit for each waste feed. DRE shall be determined by:

$$DRE = \frac{(W_{in} - W_{out})}{W_{in}} \times 100$$

    Where:

    W in = Mass feed rate of one POHC in waste stream feeding the incinerator, and

    W out = Mass emission rate of the same POHC present in exhaust emissions prior to release to the atomsphere.

b. The Permittee must control hydrogen chloride (HCL) emissions, such that the rate of the emissions is no greater than the larger of either 1.8 kg/hr (4 lb/hr) or one percent of the HCL in the stack gas prior to entering any pollution control equipment.

c. The incinerator must not emit particulate matter in excess of 180 milligrams per dry standard cubic meter (0.08 grains per dry standard cubic foot) when corrected to 7 percent oxygen.

d. Compliance with the operating conditions specified in this permit will be regarded as compliance with the above performance standards.

4. Test Data Submissions. The Permittee shall submit a report to the Regional Administrator upon completion of the tests, but not later than 120 days following the term of the permit. This report will summarize the test results and discuss the feasibility or infeasibility of the experimental activities based on the operating conditions specified in this permit. QA/QC results shall be submitted with this report. All submissions must be certified in accordance with 40 CFR 270.11. The Permittee shall make any raw data available to EPA upon written request.

F. STACK SAMPLING AND MONITORING PLAN

The Permittee shall calibrate all continuous monitoring systems prior to start and shall monitor and record the following parameters in the stack:

1. oxygen, O_2, continuous

2. carbon monoxide, CO, continuous

3. carbon dioxide, CO_2, continuous

4. total hydrocarbons, THC, continuous

The Permittee shall continuously monitor and record the waste feed rate to the thermal processor and the combustion temperatures in the thermal processor and afterburner.

LIST OF ATTACHMENTS

1. Research Plan
2. Personnel Safety Plan
3. Emergency Response Plan
4. Closure Plan

Table 1 Contaminant concentrations in Landfill 3 soil borings and cleanup objectives

Contaminant	Organic Concentration (ug/kg) max.	avg.	Goal Cleanup Level in Extract (ug/L)
Trichloroethene	6100000	743270	70 a
trans-1,2-Dichloroethene	370000	115875	N.A.
Tetrachloroethene	446900	76266	50 b
Toluene	270000	39341	330 b
1,2-Dichlorobenzene	570000	37066	125 b
Bis(2-ethylhexyl) phthalate	120000	30000	N.A.
2-Butanone	97000	18218	750 b
4-Methyl-2-pentanone	117320	16192	N.A.
Total xylenes	131000	13044	150 b
1,4-Dichlorobenzene	59000	12085	10800 a
Methylene chloride	84740	11152	960 b
4-Methylphenol	43000	10750	N.A.
1,2,4-Trichlorobenzene	24000	6675	N.A.
2-Methylnaphthalene	19000	4750	N.A.
2,4-Dimethylphenol	19000	4750	N.A.
2-Methylphenol	19000	4750	N.A.
1,3-Dichlorobenzene	52000	4309	N.A.
Fluoranthene	17000	4250	140 c
2-Hexanone	13000	3250	N.A.
2-Chloroethylvinylether	9200	3064	N.A.
Ethylbenzene	19280	2710	53 b
Acetone	5700	2083	N.A.
Naphthalene	6800	1700	N.A.
Diethyl phthalate	3800	950	N.A.
Chlorobenzene	3200	621	50 b
1,1-Dichloroethene	2200	550	100 a
1,1,1-Trichloroethane	980	352	410 b
Vinyl chloride	1200	314	50 a
Vinyl acetate	1000	250	N.A.
1,2-Dichloroethane	680	233	400 a

a - Remedial Design Bog Creek Farm Site, Superfund Project, Howell Township, New Jersey, U.S. Army Corps of Engineers, DACW 41-88-R-0162.

b - California List, 40 CFR Part 268, Subpart D.

c - Substances Toxic to Aquatic Life, Support B: General Use Waters Quality Standards of Illinois (February, 1986).

N.D. - None detected.

N.A. - Not assigned.

Table 1
(continued)

Contaminant	Organic Concentration (ug/kg) max.	avg.	Goal Cleanup Level in Extract (ug/L)
Benzene	490	123	70 a
Chloroform	11	3	70 a
Carbon disulfide	5	1†	4810 b
Benzo(a)anthracene	N.D.	N.D.	8.7 c
Benzo(a)pyrene	N.D.	N.D.	15 c
Benzo(b)fluoranthene	N.D.	N.D.	12 c
Chrysene	N.D.	N.D.	100 c
Dibenzo(a,h)anthracene	N.D.	N.D.	20 c
Acenaphthene	N.D.	N.D.	1200 c
Acenaphthylene	N.D.	N.D.	660 c
Anthracene	N.D.	N.D.	660 c
Benzo(g,h,i)perylene	N.D.	N.D.	51 c
Benzo(k)fluoranthene	N.D.	N.D.	11 c
Fluorene	N.D.	N.D.	140 c
Indeno(1,2,3-c,d)pyrene	N.D.	N.D.	29 c
Phenanthrene	N.D.	N.D.	660 c
Pyrene	N.D.	N.D.	180 c

a - Remedial Design Bog Creek Farm Site, Superfund Project, Howell Township, New Jersey, U.S. Army Corps of Engineers, DACW 41-88-R-0162.
b - California List, 40 CFR Part 268, Subpart D.
c - Substances Toxic to Aquatic Life, Support B: General Use Waters Quality Standards of Illinois (February, 1986).
N.D. - None detected.
N.A. - Not assigned.

* U.S. GOVERNMENT PRINTING OFFICE: 1990 261-016/20094