AD-A222 283

US ARMED FORCES

FINAL REPORT

Title: Order of
Remuneration of
Terror and/or Family of CPA-4
and Other Victims from Cells
at Tikrit Air Force Base
Cadmian City, Oklahoma

Contract Number DAA115-87-D-0010

March 1988
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FINAL REPORT

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

Contract Number DAAA15-88-D-0010

March 1990

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Demonstration of Thermal Stripping of JP-4 and other VOCs from Soils at Tinker Air Force Base, Oklahoma City, Oklahoma

Peter J. Marks, John W. Noland, Roger K. Nielson

Several test were conducted to verify the effectiveness of the LT³ System. While meeting all goal cleanup objectives, a processing rate of 20,000 lb/hr was demonstrated with a projected LT³ 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.
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SECTION 1

EXECUTIVE SUMMARY
1. EXECUTIVE SUMMARY

The patented Roy F. Weston, Inc. (WESTON) Low Temperature Thermal Treatment (LT₃ₓ) 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 LT₃₃ 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 LT₃₃ 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 LT₃₃ 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 LT³ 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 (USATHA) is evaluating technologies to treat soils contaminated with organic compounds including JP-4 and TCE. USATHA commissioned WESTON to conduct a demonstration of a full-scale LT³ 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 LT³ 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 LT³ Process for the following:

- The effectiveness of the LT³ 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:

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<td>Conclusions</td>
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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 LT³ 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 LT³ 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.
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 LT3 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 3-5. Tinker Air Force Base Landfill 3 LT Study System site after excavation.
Table 3-1. Summary of soil excavation at Tinker Air Force Base Landfill 3 site

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Description</th>
<th>Volume (cubic yds)</th>
<th>PCB Concentration (ppm)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main excavation area</td>
<td>3,500</td>
<td>NA</td>
<td>Excavation hole; contains some sludge</td>
</tr>
<tr>
<td>1</td>
<td>Sludge in main excavation area</td>
<td>---</td>
<td>5,900a</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>Excavation area stockpile</td>
<td>50</td>
<td>270</td>
<td>Pending treatment</td>
</tr>
<tr>
<td>3</td>
<td>South feed stockpile</td>
<td>200</td>
<td>78</td>
<td>Pending treatment</td>
</tr>
<tr>
<td>4</td>
<td>Middle feed stockpile</td>
<td>30</td>
<td>24</td>
<td>Pending treatment</td>
</tr>
<tr>
<td>5</td>
<td>North feed stockpile</td>
<td>300</td>
<td>28</td>
<td>Pending treatment</td>
</tr>
<tr>
<td>6</td>
<td>West processed stockpile</td>
<td>50</td>
<td>40</td>
<td>Processed through LT¹ System</td>
</tr>
<tr>
<td>7</td>
<td>East processed stockpile</td>
<td>20</td>
<td>91</td>
<td>Processed through LT¹ System</td>
</tr>
<tr>
<td>8</td>
<td>Asphalt overburden 1,200</td>
<td>1,200</td>
<td>b</td>
<td>Some asphalt material was used to construct evaporation ponds</td>
</tr>
<tr>
<td>9</td>
<td>Asphalt overburden 350</td>
<td>350</td>
<td>b</td>
<td>Assumed to be PCB-contaminated due to proximity to contaminated soil</td>
</tr>
<tr>
<td>10</td>
<td>Clean soil</td>
<td>800</td>
<td>c</td>
<td>Clay cap over the asphalt cap</td>
</tr>
</tbody>
</table>

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 over-pressure 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

<table>
<thead>
<tr>
<th>Discovery Date</th>
<th>Drum</th>
<th>Status of Drum</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 July 1989</td>
<td>1</td>
<td>Overpacked drum -- oil adsorbent, rags, oil layer on bottom (2 to 3 gallons)</td>
</tr>
<tr>
<td>21 July 1989</td>
<td>2</td>
<td>Overpacked drum -- oil adsorbent, rags.</td>
</tr>
<tr>
<td>22 July 1989</td>
<td>3</td>
<td>Overpacked drum -- oil adsorbent, rags.</td>
</tr>
<tr>
<td>22 July 1989</td>
<td>4</td>
<td>Overpacked drum -- oil adsorbent, rags.</td>
</tr>
<tr>
<td>22 July 1989</td>
<td>5</td>
<td>Unopened drum left in excavation area -- unknown contents.</td>
</tr>
</tbody>
</table>
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 LT₃ Process (U.S. Patent No. 4,733,206) is a demonstrated technology that provides evaporation of VOs from contaminated soil without heating the soil matrix to combustion temperatures.

The primary element of the LT₃ 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 LT₃ Process can be described by separating the system into three main areas: soil treatment, emissions control, and water treatment. A schematic diagram of the LT₃ Process is shown in Figure 4-1. The LT₃ 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 LT₃ 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 LTP System.
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 LT³ 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 LT³ 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 LT₃w System showing the inclined feed conveyor, the feed hopper, and the exhaust ducts.
Photograph No. 4. Variable speed drives on the LT² 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 100°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
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 LT3 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 LT3 Process.

4.5 Utilization. Operating the LT3 System requires the following utilities:
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°F, 500°F, 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.
### Table 5-1. Contaminant concentrations in Landfill 3 soil borings and cleanup objectives

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

**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 5: General Use Water Quality Standards of Illinois (February, 1986).

**ND** - None detected.

**NA** - Not assigned.

5-2
Table 5-1. (continued)

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Concentration (ug/kg)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Avg</td>
</tr>
<tr>
<td>Benzene</td>
<td>490</td>
<td>123</td>
</tr>
<tr>
<td>Chloroform</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Chrysene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Anthracene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Benzo(k)fluoranthene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Fluorene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Pyrene</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Residence time (minutes)</th>
<th>Oil temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Ts = 150</td>
</tr>
<tr>
<td></td>
<td>Ts = 250</td>
</tr>
<tr>
<td></td>
<td>Ts = 350</td>
</tr>
<tr>
<td>45</td>
<td>Ts = 200</td>
</tr>
<tr>
<td></td>
<td>Ts = 300</td>
</tr>
<tr>
<td></td>
<td>Ts = 400</td>
</tr>
<tr>
<td>60</td>
<td>Ts = 250</td>
</tr>
<tr>
<td></td>
<td>Ts = 350</td>
</tr>
<tr>
<td></td>
<td>Ts = 450</td>
</tr>
</tbody>
</table>

Ts = Estimated processed soil temperature

Figure 5-1. Test matrix for determination of optimum operating conditions.
Identity Upper Limit
Operate at HOT=600°F and RT=60 Minutes
Review Analytical Results From Processed Soil

- Increase RT by 15 Minutes
- Review Analytical Results From Processed Soil
- Evaluate RT
  - Yes
    - Is RT=120 Minutes?
  - No

Discuss Further Action With USATHAMA

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.
Identify Upper Limit
Operate at HOT=600°F
and RT=60
Minutes

Review Analytical Results
From Processed Soil

Is Contaminant
Concentration
Above GCL?

No

Upper Limit Identified

Establish Lower Limit
Operate at HOT=400°F
RT=RT=30 Minutes

Review Analytical Results
From Processed Soil

Is Contaminant
Concentration
Above GCL?

No

Decrease HOT
by 100°F

Review Analytical Results
From Processed Soil

Is Contaminant
Concentration
Above GCL?

Yes

Decrease HOT
by 100°F

No

Evaluate HOT

Discuss Further Action
With USATHAMA

Yes

HOT=200°F?

No

Lower Limit Identified

Adjust Matrix as Necessary
Conduct Remainder of Matrix Test Runs

Review Analytical Results
From Processed Soil

Select Optimum Conditions
- Contaminant Concentration(s)
  - Lowest RT
  - Lowest HOT

Run Test at Optimum
Conditions to Verify Data
(Stock Test 1)

T10

Run Test at HOT Opt
and RT Opt 15 Minutes
(Stock Test 2)

T11

Run T11
With Hexane Addition

T12

Run T11
With Water Addition

T13

Conduct Test at RT Opt
and HOT=100°F
With Hexane Addition

T14

Conduct Test at RT Opt
and HOT=100°F
With Water Addition

T15

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

5-5
<table>
<thead>
<tr>
<th>Soil resistance time (minutes)</th>
<th>30</th>
<th>35</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>Test 3&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Test 4&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Test 2&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
<td>Test 7&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>450</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>Test 5&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Test 8&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>600</td>
<td>Test 9&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Test 6&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Test 1&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

(1) Completed  
(2) Partially completed  
(3) Aborted

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

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Field Code</th>
<th>Test Date</th>
<th>Soil Residue Time (min.)</th>
<th>Oil Temperature (°F)</th>
<th>Processed Soil Temperature (°F)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I-9</td>
<td>07/17/89</td>
<td>40</td>
<td>600</td>
<td>330</td>
<td>Partially completed (only 3 samples collected)</td>
</tr>
<tr>
<td>2</td>
<td>I-1</td>
<td>07/19/89</td>
<td>40</td>
<td>400</td>
<td>224</td>
<td>Completed</td>
</tr>
<tr>
<td>3</td>
<td>TK-03</td>
<td>07/27/89</td>
<td>30</td>
<td>300</td>
<td>197</td>
<td>Aborted</td>
</tr>
<tr>
<td>4</td>
<td>LT3-04</td>
<td>08/01/89</td>
<td>35</td>
<td>400</td>
<td>214</td>
<td>Completed</td>
</tr>
<tr>
<td>5</td>
<td>LT3-05</td>
<td>08/03/89</td>
<td>35</td>
<td>500</td>
<td></td>
<td>Aborted</td>
</tr>
<tr>
<td>6</td>
<td>LT3-06</td>
<td>08/03/89</td>
<td>35</td>
<td>500</td>
<td></td>
<td>Aborted</td>
</tr>
<tr>
<td>7</td>
<td>LT3-07</td>
<td>08/04/89</td>
<td>40</td>
<td>450</td>
<td></td>
<td>Aborted</td>
</tr>
<tr>
<td>8</td>
<td>LT3-08</td>
<td>08/09/89</td>
<td>40</td>
<td>500</td>
<td>269</td>
<td>Completed</td>
</tr>
<tr>
<td>9</td>
<td>LT3-09</td>
<td>08/10/89</td>
<td>30</td>
<td>500</td>
<td></td>
<td>Aborted</td>
</tr>
</tbody>
</table>
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 LT³ 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 LT³ 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.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Time of day (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant operator and sampling technician arrive on-site</td>
<td>0500 - 0700</td>
</tr>
<tr>
<td>Heat up</td>
<td>0800 - 1000</td>
</tr>
<tr>
<td>Stabilization</td>
<td>1100 - 1200</td>
</tr>
<tr>
<td>Site manager/field safety officer, field technicians/equipment operators and CEM technician arrive on-site</td>
<td>1300 - 1400</td>
</tr>
<tr>
<td>Prepare sample bottles</td>
<td>1500 - 1600</td>
</tr>
<tr>
<td>Excavation activities*</td>
<td>1700 - 1900</td>
</tr>
<tr>
<td>Instrument checkout</td>
<td>2000</td>
</tr>
<tr>
<td>Begin feeding soil</td>
<td></td>
</tr>
<tr>
<td>Conduct formal test, monitor LT₃, System, and collect samples</td>
<td></td>
</tr>
<tr>
<td>Composite samples</td>
<td></td>
</tr>
<tr>
<td>Purge thermal processor with clean material</td>
<td></td>
</tr>
<tr>
<td>Equipment shutdown</td>
<td></td>
</tr>
<tr>
<td>Secure area</td>
<td></td>
</tr>
<tr>
<td>Operators and test crew leave site</td>
<td></td>
</tr>
</tbody>
</table>

*Typically, excavation activities were conducted when process equipment was shut down and technicians were available.

Figure 6-1. Typical schedule of daily on-site activities.
<table>
<thead>
<tr>
<th>Activity</th>
<th>88 Nov</th>
<th>88 Dec</th>
<th>89 Jan</th>
<th>89 Feb</th>
<th>89 Mar</th>
<th>89 Apr</th>
<th>89 May</th>
<th>89 Jun</th>
<th>89 Jul</th>
<th>89 Aug</th>
<th>89 Sep</th>
<th>89 Oct</th>
<th>89 Nov</th>
<th>89 Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment delivery</td>
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<tr>
<td>Installation of process equipment</td>
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<tr>
<td>Permitting</td>
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<td>Tests</td>
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<td></td>
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<tr>
<td>End of test program</td>
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<td></td>
</tr>
<tr>
<td>Decontamination of equipment</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Implementation of Exit Plan</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment demobilization</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Figure 6-2. Overall project schedule.
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 LT³ 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

<table>
<thead>
<tr>
<th>A. Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ambient air conditions</td>
</tr>
<tr>
<td>- Temperature</td>
</tr>
<tr>
<td>- Relative humidity</td>
</tr>
<tr>
<td>- VOC concentrations</td>
</tr>
<tr>
<td>• Feed soil</td>
</tr>
<tr>
<td>- Contaminant concentrations</td>
</tr>
<tr>
<td>- Moisture content</td>
</tr>
<tr>
<td>- Temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Control Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hold Constant</td>
</tr>
<tr>
<td>• Feed soil</td>
</tr>
<tr>
<td>- Preparation and handling (including shredding and conveying procedures)</td>
</tr>
<tr>
<td>• Thermal processor</td>
</tr>
<tr>
<td>- Draft (i.e., static pressure)</td>
</tr>
<tr>
<td>- Discharge gas temperature</td>
</tr>
<tr>
<td>• Condenser</td>
</tr>
<tr>
<td>- Discharge gas temperature</td>
</tr>
<tr>
<td>• Afterburner</td>
</tr>
<tr>
<td>- Discharge gas temperature</td>
</tr>
<tr>
<td>- Discharge draft</td>
</tr>
<tr>
<td>• Scrubber</td>
</tr>
<tr>
<td>- Inlet gas temperature</td>
</tr>
<tr>
<td>- Scrubber liquor recirculation flow rate</td>
</tr>
<tr>
<td>- Blowdown volumetric flow rate*</td>
</tr>
<tr>
<td>- Scrubber liquor pH</td>
</tr>
</tbody>
</table>

*Not measured during demonstration.
### Table 7-1. (continued)

<table>
<thead>
<tr>
<th>Controlled to Various Levels</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed soil</td>
<td>- Residence time in processor (i.e., feed rate)</td>
</tr>
<tr>
<td></td>
<td>- Type of solvent addition (i.e., hexane or water)*</td>
</tr>
<tr>
<td></td>
<td>- Solvent addition rate*</td>
</tr>
<tr>
<td>Oil heater</td>
<td>- Oil temperature</td>
</tr>
<tr>
<td>C. Response Variables</td>
<td></td>
</tr>
<tr>
<td>Feed soil</td>
<td>- Mass flow rate (i.e., tons per hour)</td>
</tr>
<tr>
<td>Processed soil</td>
<td>- Discharge temperature</td>
</tr>
<tr>
<td></td>
<td>- Contaminant concentration</td>
</tr>
<tr>
<td></td>
<td>- Moisture content</td>
</tr>
<tr>
<td>Oil heater</td>
<td>- Return oil temperature</td>
</tr>
<tr>
<td>Thermal processor</td>
<td>- Sweep air temperature*</td>
</tr>
<tr>
<td></td>
<td>- Sweep air volumetric flow rate*</td>
</tr>
<tr>
<td></td>
<td>- Sweep air composition*</td>
</tr>
<tr>
<td>Fabric filter</td>
<td>- Dust composition</td>
</tr>
<tr>
<td></td>
<td>- Dust mass flow rate</td>
</tr>
<tr>
<td>Condenser</td>
<td>- Condensate mass flow rate</td>
</tr>
<tr>
<td></td>
<td>- Condensate composition*</td>
</tr>
</tbody>
</table>

*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 LT3 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:

\[
\text{RE} = \frac{M_1 - M_2}{M_1} \times 100 \text{ percent}
\]

where:

- \( \text{RE} \) = Contaminant removal efficiency for the specific contaminant and process conditions.
- \( M_1 \) = Initial mass of contaminant in the soil.
- \( M_2 \) = 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 7.

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

<table>
<thead>
<tr>
<th>Parameters Sampled and Analyzed</th>
<th>Feed</th>
<th>Processed Soil</th>
<th>Dust</th>
<th>Ambient Air</th>
<th>Afterburner Outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatiles</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td>(1) d</td>
</tr>
<tr>
<td>Semivolatiles</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCBs (3)</td>
<td>(2)</td>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td></td>
<td>(2)</td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td></td>
<td>(2)</td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td></td>
<td>(2)</td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Total Hydrocarbons</td>
<td></td>
<td>(2)</td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Moisture Content</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key

(1) - Tests 1, 2, 4, and 8.
(2) - Test 4.
(3) - Wipes, 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)
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-Trichloroethene
- 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)

<table>
<thead>
<tr>
<th>Semivolatile Organics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3-Dichlorobenzene</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
</tr>
<tr>
<td>Naphthalene*</td>
</tr>
<tr>
<td>4-Chloroaniline</td>
</tr>
<tr>
<td>2-Methylnaphthalene*</td>
</tr>
<tr>
<td>2-Chloronaphthalene*</td>
</tr>
<tr>
<td>Acenaphthylene*</td>
</tr>
<tr>
<td>Acenaphthene*</td>
</tr>
<tr>
<td>Fluorene*</td>
</tr>
<tr>
<td>Phenanthrene*</td>
</tr>
<tr>
<td>Anthracene*</td>
</tr>
<tr>
<td>Fluoranthenes*</td>
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<tr>
<td>Pyrene*</td>
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<tr>
<td>Benzo(a)anthracene*</td>
</tr>
<tr>
<td>Chrysene*</td>
</tr>
<tr>
<td>Benzo(b)fluoranthenes*</td>
</tr>
<tr>
<td>Benzo(k)fluoranthenes*</td>
</tr>
<tr>
<td>Benzo(a)pyrene*</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene*</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene*</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylenes*</td>
</tr>
</tbody>
</table>

*May be a constituent of jet propulsion fuel (JP-4).
**Table 8-3. Sampling and analysis procedures for the feed soil**

<table>
<thead>
<tr>
<th>Sampling Point Number</th>
<th>(Feed Soil)</th>
</tr>
</thead>
</table>

**Test Objective:** Determine Initial Composition of Feed Soil

**Sampling Objective:** Collect a Representative Sample

<table>
<thead>
<tr>
<th>Parameters to be Tested</th>
<th>Volatile Organics (On-Site)</th>
<th>Semivolatile Organics (On-Site)</th>
<th>PCBs (Lionville)</th>
<th>Moisture Content</th>
<th>Mass Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Runs Sampled</td>
<td>Tests 1, 2, 4 and 8</td>
<td>Test 4</td>
<td>Tests 1, 2, 4 and 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporting Limit</td>
<td>Determined On-Site</td>
<td>Determined On-Site</td>
<td>&lt;1 ppm</td>
<td>0.1%</td>
<td>20 lb</td>
</tr>
<tr>
<td>Sampling or Monitoring Method</td>
<td>Grab Sample Collected From Feed Hopper Every Hour, Composted into a Single Sample for Analysis</td>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sample Extraction/Analysis Method(s):**

| EPA Methods 5030 8010 8020 and TCLP for Volatiles | Modified USATIAMA Method for Semivolatile Organics in Soil | EPA Methods 3540 8080 | ASTM Method D2218 | 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.
Table 8-4. Sampling and analysis procedures for the processed soil

<table>
<thead>
<tr>
<th>Sampling Point Number</th>
<th>2 (Processed Soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Objective</td>
<td>Determine Final Composition of Processed Soil</td>
</tr>
<tr>
<td>Sampling Objective</td>
<td>Collect a Representative Sample</td>
</tr>
<tr>
<td>Parameters to be Tested</td>
<td>Volatile Organs 1 (On Site)</td>
</tr>
<tr>
<td>Test Runs Sampled</td>
<td>Tests 1, 2, 4 and 8</td>
</tr>
<tr>
<td>Detection Limit</td>
<td>Determined On Site 2</td>
</tr>
<tr>
<td>Sampling or Monitoring Method</td>
<td>Grab Sample Collected From Discharge Conveyor Every Hour Composed into a Single Sample for Analysis</td>
</tr>
<tr>
<td>Sample Extraction/Analysis Method(s)</td>
<td>EPA Methods 5030 6010 8020 and TCLP for Volatiles</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Sampling Point Number</th>
<th>3 (Fabric Filter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Objective:</td>
<td>Determine Composition of Dust from Fabric Filter</td>
</tr>
<tr>
<td>Sampling Objective:</td>
<td>Collect a Representative Sample</td>
</tr>
<tr>
<td>Parameters to be Tested:</td>
<td>Volatile Organics (On-Site)</td>
</tr>
<tr>
<td>Test Runs Sampled:</td>
<td>Tests 1, 2, 4 and 8</td>
</tr>
<tr>
<td>Detection Limit:</td>
<td>Determined On-Site</td>
</tr>
<tr>
<td>Sampling or Monitoring Method</td>
<td>Grab Sample Collected From Fabric Filter Only</td>
</tr>
<tr>
<td>Sample Extraction/Analysis Method(s)</td>
<td>EPA Methods 5030 8010 8020 and TCLP for Volatiles</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Sampling Point Number</th>
<th>4 (Ambient Air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Objective:</td>
<td>Determine Characteristics of Ambient Air</td>
</tr>
<tr>
<td>Sampling Objective:</td>
<td>Collect a Representative Sample</td>
</tr>
<tr>
<td>Parameters to be Tested:</td>
<td>Volatile Organics (On-Site)</td>
</tr>
<tr>
<td>Test Runs Sampled:</td>
<td>Tests 1, 2, 4 and 8</td>
</tr>
<tr>
<td>Sampling or Monitoring Frequency</td>
<td>Continuous</td>
</tr>
<tr>
<td>Sample Extraction/ Monitoring Method</td>
<td>Flame Ionization Detector (FID)</td>
</tr>
</tbody>
</table>

Key
1. Strip chart recorder
Table 8-7. Sampling and analysis procedures for the afterburner outlet gas

<table>
<thead>
<tr>
<th>Sampling Point Number</th>
<th>7 (Afterburner Outlet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Objective:</td>
<td>Determine Composition of Afterburner Outlet Gas</td>
</tr>
<tr>
<td>Sampling Objective:</td>
<td>Collect a Representative Sample</td>
</tr>
<tr>
<td>Parameters to be Tested:</td>
<td>Total Hydrocarbons</td>
</tr>
<tr>
<td>Test Runs Sampled:</td>
<td>Tests 1, 2, 4 and 8</td>
</tr>
<tr>
<td>Detection Limit:</td>
<td>1 ppm as Methane</td>
</tr>
<tr>
<td>Sampling or Monitoring Method:</td>
<td>EPA Method 25A</td>
</tr>
<tr>
<td>Sample Extraction/ Analysis Method(s):</td>
<td>Flame Ionization Detector</td>
</tr>
</tbody>
</table>

Key
1. Sampling and analytical procedures are presented in Appendix E.
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:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analytical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile organic compounds</td>
<td>EPA Methods 5030, 8010, and 8020, Toxicity Characteristic Leaching Procedure (TCLP)</td>
</tr>
<tr>
<td>Semivolatile organic compounds</td>
<td>Modified USATHAMA method for semivolatile organics, TCLP</td>
</tr>
<tr>
<td>Polychlorinated biphenyls (PCBs)</td>
<td>EPA methods 3540 and 8080</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>±2 percent of full scale at 72°F -- all ranges</td>
</tr>
<tr>
<td>Response Time</td>
<td>30 seconds for 90 percent response, 10 seconds typical for small step change</td>
</tr>
<tr>
<td>Stability</td>
<td>±2 percent of full scale over 30 days typical</td>
</tr>
</tbody>
</table>
Table 8-9. Specifications for the gas phase correlation filter analyzer to monitor carbon monoxide

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>±0.1 ppm</td>
</tr>
<tr>
<td>Linearity</td>
<td>±1 percent full scale</td>
</tr>
<tr>
<td>Minimum Detectable Limit</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Zero Drift</td>
<td>±1 percent full scale/24 hours</td>
</tr>
<tr>
<td>Span Drift</td>
<td>±1 percent full scale/24 hours</td>
</tr>
<tr>
<td>Rejection Ratio</td>
<td>Negligible interference from water vapor and carbon dioxide</td>
</tr>
<tr>
<td>Response Time</td>
<td>95 percent of reading in 1 minute with 30-second integration period</td>
</tr>
<tr>
<td>Recorder Output</td>
<td>0 to 10 volts</td>
</tr>
</tbody>
</table>
Table 8-10. Specifications for the nondispersive infrared gas analyzer to monitor carbon dioxide

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability/ Accuracy</td>
<td>±1 percent of full scale</td>
</tr>
<tr>
<td>Linearity:</td>
<td>±1 percent of full scale</td>
</tr>
<tr>
<td>Noise Level:</td>
<td>±1 percent of full scale</td>
</tr>
<tr>
<td>Zero Drift:</td>
<td>±1 percent of full scale/24 hours</td>
</tr>
<tr>
<td>Span Drift:</td>
<td>±1 percent of full scale/24 hours</td>
</tr>
<tr>
<td>Response Time:</td>
<td>90 percent of reading in 30 seconds</td>
</tr>
<tr>
<td>Recorder Output:</td>
<td>0 to 100 millivolts (mv)</td>
</tr>
</tbody>
</table>
Table 8-11. Specifications for the CEM flame ionization detector used to monitor total hydrocarbons

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis Method:</td>
<td>Flame ionization detector</td>
</tr>
<tr>
<td>Sensitivity:</td>
<td>Maximum: 1 ppm hydrocarbons</td>
</tr>
<tr>
<td>Response Time:</td>
<td>90 percent of full scale in less than 1 second</td>
</tr>
<tr>
<td>Zero Drift:</td>
<td>±1 percent of full scale per 24 hours</td>
</tr>
<tr>
<td>Span Drift:</td>
<td>±1 percent of full scale per 24 hours</td>
</tr>
<tr>
<td>Linearity:</td>
<td>±1 percent of selected range</td>
</tr>
<tr>
<td>Ranges:</td>
<td>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</td>
</tr>
<tr>
<td>Outputs:</td>
<td>0 to 10 volts DC</td>
</tr>
<tr>
<td>Display:</td>
<td>Analog meter in ppm hydrocarbons</td>
</tr>
</tbody>
</table>
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.
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 VCCs 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 LT₃ 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 LT₃ 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.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Test 1 Oil Temperature 600°F Residence Time 40 min.</th>
<th>Test 2 Oil Temperature 400°F Residence Time 40 min.</th>
<th>Test 4 Oil Temperature 400°F Residence Time 35 min.</th>
<th>Test 5 Oil Temperature 500°F Residence Time 40 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil Concentration</td>
<td>Soil Concentration</td>
<td>Soil Concentration</td>
<td>Soil Concentration</td>
</tr>
<tr>
<td></td>
<td>Feed (ug/kg)</td>
<td>Processed (ug/kg)</td>
<td>Feed (ug/kg)</td>
<td>Processed (ug/kg)</td>
</tr>
<tr>
<td><strong>Volatile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>&lt;3,500</td>
<td>0.2</td>
<td>&lt;3,600</td>
<td>0.2</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>&lt;1,900</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>&lt;1,900</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>Chloroform</td>
<td>140 J</td>
<td>0.1</td>
<td>180 J</td>
<td>0.1</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>&lt;1,800</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>1,1,1-Trichloroethene</td>
<td>&lt;1,800</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>37,250</td>
<td>0.3</td>
<td>111,000 (b)</td>
<td>0.3</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>2,760 J</td>
<td>0.1</td>
<td>3,905 J</td>
<td>0.1</td>
</tr>
<tr>
<td>2-Butanone</td>
<td>&lt;1,600</td>
<td>0.6</td>
<td>&lt;1,000</td>
<td>0.6</td>
</tr>
<tr>
<td>Benzene*</td>
<td>&lt;1,600</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>Toluene*</td>
<td>&lt;1,800</td>
<td>0.1</td>
<td>8,300</td>
<td>0.1</td>
</tr>
<tr>
<td>Chlorobenzene*</td>
<td>&lt;1,800</td>
<td>0.1</td>
<td>&lt;1,800</td>
<td>0.1</td>
</tr>
<tr>
<td>Ethylbenzene*</td>
<td>&lt;1,800</td>
<td>0.1</td>
<td>960 J</td>
<td>0.1</td>
</tr>
</tbody>
</table>

(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.
<table>
<thead>
<tr>
<th>Analyte</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 4</th>
<th>Test 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feat</td>
<td>Processed</td>
<td>Feat</td>
<td>Processed</td>
</tr>
<tr>
<td></td>
<td>(ug/kg)</td>
<td>(ug/L)(a)</td>
<td>(ug/kg)</td>
<td>(ug/L)(a)</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>35,000</td>
<td>6 J</td>
<td>15,000</td>
<td>10 J</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>8,700</td>
<td>6 J</td>
<td>3,600</td>
<td>100</td>
</tr>
<tr>
<td>Fluoranthene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Benzo(a)anthracene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Chrysene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Acenaphthylene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Acenaphthylene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Anthracene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Benzo[g,h,i]perylene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Fluorene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Phenanthrene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Pyrene*</td>
<td>&lt;3,300</td>
<td>&lt;10</td>
<td>&lt;3,300</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

(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.
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
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 3x 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
Table 9-2. Contaminant removal efficiencies for detected compounds.

<table>
<thead>
<tr>
<th>Test Number</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Temperature (°F)</td>
<td>600</td>
<td>400</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Residence Time (min)</td>
<td>40</td>
<td>40</td>
<td>35</td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Contaminant Removal Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatiles</strong></td>
<td></td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>&gt;99.43 (&gt;95.39  ND  &gt;99.03</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>&gt;99.74 (&gt;99.75 &gt;99.03  &gt;97.84</td>
</tr>
<tr>
<td>Chloroform</td>
<td>&gt;98.57 (&gt;98.89  ND  ND</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>&gt;99.98 (&gt;99.99 &gt;99.78 &gt;99.46</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>&gt;99.93 (&gt;99.95 &gt;99.92 &gt;99.85</td>
</tr>
<tr>
<td>Benzene</td>
<td>ND  ND  &gt;99.83 &gt;93.60</td>
</tr>
<tr>
<td>Toluene</td>
<td>ND  &gt;99.98 &gt;99.45 &gt;94.86</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>ND  &gt;99.79 ND  &gt;99.74</td>
</tr>
<tr>
<td>m-Xylene</td>
<td>&gt;99.89 &gt;99.94 ND  &gt;99.98</td>
</tr>
<tr>
<td>o,p-Xylenes</td>
<td>&gt;99.82 &gt;99.91 ND  &gt;91.58</td>
</tr>
<tr>
<td><strong>Semi-Volatiles</strong></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>&gt;98.46 (&gt;93.67 &gt;98.93 &gt;97.78</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>&gt;63.22 (&gt;93.89 &gt;98.95 &gt;20.93</td>
</tr>
<tr>
<td>2-Methylnaphthalene</td>
<td>ND  ND  &gt;87.98 &gt;82.00</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>&gt;8.57 (&gt;93.33 &gt;46.88 ND</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>&gt;48.48 ND  &gt;45.71 &gt;4.40</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>&gt;96.98 &gt;97.40 &gt;96.25 &gt;93.17</td>
</tr>
<tr>
<td>Anthracene</td>
<td>ND  ND  &gt;66.67 ND</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene</td>
<td>ND  ND  &gt;98.72 ND</td>
</tr>
<tr>
<td>Fluorene</td>
<td>ND  &gt;94.74 &gt;52.31 ND</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>&gt;41.77 (&gt;18.29 &gt;48.96 &gt;6.25</td>
</tr>
<tr>
<td>Pyrene</td>
<td>ND  ND  &gt;48.41 ND</td>
</tr>
<tr>
<td>4-Chloroaniline</td>
<td>ND  ND  &gt;17.72 ND</td>
</tr>
</tbody>
</table>

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 coil 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 6-3. 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 LT3 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 LT3 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.

9-12
### Table 9-3. Performance of tests

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

(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 LT³ 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 LT3 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 LT3 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. 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 LT³ Process for treating JP-4 and chlorinated organic contaminated soil. This section presents estimated costs for a contractor-owned and operated LT³ 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 LT³ 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
Table 9-4. Summary of the variable cost elements and the basis for estimation

<table>
<thead>
<tr>
<th>Variable Cost</th>
<th>Cost Estimating Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane (10.7 mm Btu/hr)</td>
<td>Per ton processed</td>
</tr>
<tr>
<td>Electric power (600 amps)</td>
<td>Hourly rate</td>
</tr>
<tr>
<td>Loader fuel</td>
<td>Hourly rate</td>
</tr>
<tr>
<td>Front-end loader</td>
<td>Monthly lease rate</td>
</tr>
<tr>
<td>Carbon and disposal</td>
<td>Per ton processed</td>
</tr>
<tr>
<td>Separator disposal</td>
<td>Per ton processed</td>
</tr>
<tr>
<td>Miscellaneous expenses</td>
<td>Daily rates</td>
</tr>
<tr>
<td>Dump trucks</td>
<td>Monthly lease rate</td>
</tr>
<tr>
<td>Propane tanks</td>
<td>Monthly lease rate</td>
</tr>
<tr>
<td>Calibration gases</td>
<td>Daily rate</td>
</tr>
<tr>
<td>Caustic</td>
<td>Per ton processed</td>
</tr>
<tr>
<td>Out-of-town expenses</td>
<td>Daily rate</td>
</tr>
<tr>
<td>Sanitary facilities and phone</td>
<td>Monthly lease rate</td>
</tr>
<tr>
<td>Office Labor</td>
<td>Hours worked</td>
</tr>
<tr>
<td>Field labor</td>
<td>Hours worked</td>
</tr>
<tr>
<td>Equipment usage fee</td>
<td>Weekly usage fee</td>
</tr>
</tbody>
</table>
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 LT3 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 LT3 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 LT3 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 LT3 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 LT3 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.
LT³ Variable Costs

Cost (dollars/ton)

Processing Rate (tons/hour)

Note - Mobilization and demobilization costs are not included

Figure 9-6. LT³ System variable costs for various processing rates.
Figure 9-7. LT³ Total Costs: 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 10,000 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.
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 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 LT³ System, maximum use of the processors is desired. Economics dictate that the limiting factor in processing capacity should be the thermal capacity of the LT³ 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 LT³ 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 LT³ Process for removing JP-4 and chlorinated solvents from contaminated soils. The demonstration showed conclusively that the LT³ 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 LT³ 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 LT³ 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


APPENDIX A

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 scapy, 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 cm². The wipe test procedure is described in Section 5.3 of this plan. If the wipe test results exceed 10 ug/100 cm², 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 cm² is based on 40 CFR 761.125.C.4 - "Requirements for Decontaminating Spills in Non-Restricted Access Areas".

A-2
Tank #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
evacuating, screening, and handling equipment will be
physically removed using dry, stiff brushes, shovels, or
scrapers 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-0 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 100 centimeter square (cm²) 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

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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 Analysis

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 1989

Contract DAAA 15-88-D-0010
USATHTHA 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) 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:

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Main Excavation Area: This excavation hole is approximately one hundred and twenty five feet by ten feet 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.</td>
</tr>
<tr>
<td>#2</td>
<td>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.</td>
</tr>
</tbody>
</table>
Figure B-1. Tinker Air Force Base Landfill 3 LT3 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 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 were 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 LT3 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.
Exit Plan

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 \times 60 \times \text{bulk weight})/(\text{feed rate})

or

residence time = (60 \times \text{trough volume})/(0.75 \times \text{speed} \times \text{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:

$$(60 \times 212.4)/(0.75 \times 1 \times 183) = 92.85 \text{ minutes}$$

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 2030
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 1 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.

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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-μL, 25-μL, 100-μL, 250-μL, 500-μL, and 1,000 μL: 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 cm 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 5010, 5020, and 5030.

Note: All lines between Trap and GC should be heated to 80°C.
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-μL or 25-μL 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 μL 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>
<thead>
<tr>
<th>Analysis Method</th>
<th>8010</th>
<th>8015</th>
<th>8020</th>
<th>8030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purge gas</td>
<td>Nitrogen or Helium</td>
<td>Nitrogen or Helium</td>
<td>Nitrogen or Helium</td>
<td>Nitrogen or Helium</td>
</tr>
<tr>
<td>Purge gas flow rate (mL/min)</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Purge time (min)</td>
<td>11.0 ± 0.1</td>
<td>15.0 ± 0.1</td>
<td>12.0 ± 0.1</td>
<td>15.0 ± 0.1</td>
</tr>
<tr>
<td>Purge temperature (°C)</td>
<td>Ambient</td>
<td>85 ± 2</td>
<td>Ambient</td>
<td>85 ± 2</td>
</tr>
<tr>
<td>Desorb temperature (°C)</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Backflush inert gas flow (mL/min)</td>
<td>20-60</td>
<td>20-60</td>
<td>20-60</td>
<td>20-60</td>
</tr>
<tr>
<td>Desorb time (min)</td>
<td>4</td>
<td>1.5</td>
<td>4</td>
<td>1.5</td>
</tr>
</tbody>
</table>
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 photoionization 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 only 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 µL, but not
more than 100-µL 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

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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 μL 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 μL) 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

<table>
<thead>
<tr>
<th>Approximate Concentration Range</th>
<th>Volume of Methanol Extract^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-10,000 ug/kg</td>
<td>100 µL</td>
</tr>
<tr>
<td>1,000-20,000 ug/kg</td>
<td>50 µL</td>
</tr>
<tr>
<td>5,000-100,000 ug/kg</td>
<td>10 µL</td>
</tr>
<tr>
<td>25,000-500,000 ug/kg</td>
<td>100 µL of 1/50 dilution ^b</td>
</tr>
</tbody>
</table>

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 µL added to the syringe.

^b Dilute an aliquot of the methanol extract and then take 100 µL 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

METHOD 5030
PURGE-AND-TRAP METHOD

Start

7.1
Calibrate GC system and prepare standards

7.1.4
Assemble purge-and-trap device and condition trap

7.1.5
Connect to gas chromatograph

7.1.6
Prepare final solutions

7.1.7

A

7.1.8
Carry out purge-and-trap analysis

7.1.9
Calculate responses or calibration factors for each analyte (Method 6060, Section 7.4)

B

7.1.10
Calculate average RF for each compound

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Date September 1986
EPA METHOD 8010
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 8030.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly chlorofluorocarbons and ethylene 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, gasses, 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 12% SP-1000 on Carbopack-D 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-octadecyl on Porasil-C 100/120 mesh (Durapore) 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-μL with a 0.005 in i.d. needle (Hamilton 702M or equivalent) and a 100-μL.

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 organochlorides, 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, unstopped, 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-μL 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., bromocnathane, chloroform, chloroform, 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 (#226200). Attach Teflon tubing to the side-arm relief valve and direct a gentle stream of gas into the methanol meniscus.

5.3.3 Reweight, dilute to volume, stopper, and then mix by inverting the flask several times. Calculating the concentration in micrograms per microliter (μg/μl) from the not gain in weight. When compound purity is assayed to be 95% or greater, the tablets 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 of 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.

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

5.5.2 Use a 25-μL Hamilton 70211 microsyringe or equivalent (variations in needle geometry will adversely affect the ability to deliver reproducible volumes of alcoholic 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 μg/mL of each internal standard compound. The addition of 10 μL of this standard to 5.0 mL of sample or calibration standard would be equivalent to 30 μg/L.

5.6.3 Analyze each calibration standard according to Section 7.0, adding 10 μL 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—Demechloromethane, 1-bromo-1-chloropropane, and 1,1,1-trichloroethane—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 μg 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/μL. Add 10 μL of this surrogate spiking solution directly into the 5-μL 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, CH₃OH. 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 5 minutes; then program a 6°C/min temperature rise to 175°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).

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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 8000 (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 6000, Step 8.6.

8.2.1 The quality control check sample concentrate (Method 6000, Step 8.6) should contain each parameter of interest at a concentration of 10 μg/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 6000, 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 μg/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


<table>
<thead>
<tr>
<th>Compound</th>
<th>Notation time (min)</th>
<th>Method detection limit (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzy1-chloride</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bis(2-chloroethoxy)methane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromobenzene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>13.7</td>
<td>14.6</td>
</tr>
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<td>Bromoform</td>
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<td>19.2</td>
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<tr>
<td>Bromomethane</td>
<td></td>
<td></td>
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<tr>
<td>Carbon tetrachloride</td>
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<td>14.4</td>
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<td>Chlorobenzene</td>
<td>24.2</td>
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<td></td>
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<tr>
<td>Chloroethylene</td>
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<td>18.1</td>
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<td>Trichloroethylene</td>
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<td></td>
</tr>
<tr>
<td>Vinyl chloride</td>
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<td>5.28</td>
</tr>
</tbody>
</table>

* Using purge-and-trap method (as noted above).
* Demonstrated very erratic results when tested by purge-and-trap.
* Demonstrated poor purging efficiency.
TABLE 2.
DETERMINATION OF PRACTICAL QUANTITATION LIMITS
(PQL) FOR VARIOUS MATRICES

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Factor</th>
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<tbody>
<tr>
<td>Ground water</td>
<td>10</td>
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<tr>
<td>Low-level soil</td>
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<tr>
<td>Water miscible liquid waste</td>
<td>500</td>
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<tr>
<td>High-level soil and sludge</td>
<td>1250</td>
</tr>
<tr>
<td>Non-water miscible waste</td>
<td>1250</td>
</tr>
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</table>

aSample PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achievable.

bPQL = [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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range for Q (ug/L)</th>
<th>Limit for s (ug/L)</th>
<th>Range for ( \bar{x} ) (ug/L)</th>
<th>Range ( P, P_s ) (%)</th>
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<tbody>
<tr>
<td>Bromodichloromethane</td>
<td>15.2-24.8</td>
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<td>10.7-32.0</td>
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<td>Bromoform</td>
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<td>Bromomethane</td>
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<td>3.4-24.5</td>
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<td>Vinyl chloride</td>
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<td>5.7</td>
<td>8.2-29.9</td>
<td>28-163</td>
</tr>
</tbody>
</table>

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

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

\( \bar{x} \) = Average recovery for four recovery measurements, in ug/L.

\( P, P_s \) = Percent recovery measured.

D = Detected; result must be greater than zero.

*Criteria are from 40 CFR Part 115 for Method 601 and were calculated assuming a QC check sample concentration of 20 ug/L.*

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Accuracy, as recovery, ( x' ) (ug/L)</th>
<th>Single analyst precision, ( s' ) (ug/L)</th>
<th>Overall precision, ( S' ) (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromodichloromethane</td>
<td>1.12 C-1.02</td>
<td>0.11x+0.04</td>
<td>0.20x+1.00</td>
</tr>
<tr>
<td>Bromoform</td>
<td>0.96 C-2.05</td>
<td>0.12x+0.58</td>
<td>0.21x+2.41</td>
</tr>
<tr>
<td>Bromomethane</td>
<td>0.76 C-1.27</td>
<td>0.28x+0.27</td>
<td>0.36x+0.94</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>0.98 C-1.04</td>
<td>0.15x+0.38</td>
<td>0.20x+0.39</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>1.00 C-1.23</td>
<td>0.15x-0.02</td>
<td>0.18x+1.21</td>
</tr>
<tr>
<td>Chloroethane</td>
<td>0.99 C-1.53</td>
<td>0.14x-0.13</td>
<td>0.17x+0.63</td>
</tr>
<tr>
<td>2-Chloroethylvinyl etherb</td>
<td>1.00 C</td>
<td>0.20x+0.38</td>
<td>0.35x</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.93 C-0.39</td>
<td>0.13x+0.15</td>
<td>0.19x-0.02</td>
</tr>
<tr>
<td>Chloromethane</td>
<td>0.77 C+0.18</td>
<td>0.28x-0.31</td>
<td>0.35x+1.31</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>0.94 C+2.72</td>
<td>0.11x+1.10</td>
<td>0.24x+1.65</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>0.93 C+1.70</td>
<td>0.20x+0.97</td>
<td>0.13x+0.13</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>0.95 C+0.43</td>
<td>0.14x+2.33</td>
<td>0.26x+2.34</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>0.93 C-0.03</td>
<td>0.15x+0.29</td>
<td>0.20x+0.41</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>0.95 C-1.03</td>
<td>0.08x+0.17</td>
<td>0.14x+0.94</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>1.04 C-1.05</td>
<td>0.11x+0.70</td>
<td>0.15x+0.94</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>0.96 C-0.67</td>
<td>0.21x-0.23</td>
<td>0.29x-0.04</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>0.97 C-0.16</td>
<td>0.11x+1.46</td>
<td>0.17x+1.46</td>
</tr>
<tr>
<td>1,2-Dichloropropeneb</td>
<td>1.00 C</td>
<td>0.13x+0.62</td>
<td>0.24x+1.33</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropeneb</td>
<td>1.00 C</td>
<td>0.16x+0.62</td>
<td>0.32x</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropeneb</td>
<td>1.00 C</td>
<td>0.18x+0.62</td>
<td>0.32x</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>0.21 C-0.93</td>
<td>0.11x+0.33</td>
<td>0.21x+1.43</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>0.95 C+0.19</td>
<td>0.14x+2.41</td>
<td>0.23x+2.79</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>0.94 C+0.05</td>
<td>0.14x+0.38</td>
<td>0.18x+2.21</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>0.90 C-0.16</td>
<td>0.15x+0.04</td>
<td>0.20x+0.37</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>0.86 C+0.30</td>
<td>0.15x+0.14</td>
<td>0.19x+0.67</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>0.87 C+0.43</td>
<td>0.13x-0.03</td>
<td>0.23x+0.30</td>
</tr>
<tr>
<td>Trichlorofluoroethane</td>
<td>0.85 C+0.07</td>
<td>0.15x+0.67</td>
<td>0.26x+0.91</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>0.97 C-0.35</td>
<td>0.13x+0.65</td>
<td>0.27x+0.40</td>
</tr>
</tbody>
</table>

\( x' \) - Expected recovery for one or more measurements of a sample containing a concentration of \( C \) in \( \text{ug/L} \).

\( s' \) - Expected single analyst standard deviation of measurements at an average concentration of \( x \) in \( \text{ug/L} \).

\( S' \) - Expected interlaboratory standard deviation of measurements at an average concentration found of \( x \) in \( \text{ug/L} \).

\( C \) - True value for the concentration, in \( \text{ug/L} \).

\( x \) - Average recovery found for measurements of samples containing a concentration of \( C \) in \( \text{ug/L} \).

Refer to 40 CFR Part 136 for Method 601.

Estimates based upon the performance in a single laboratory.
FIGURE 1.
GAS CHROMATOGRAM OF HALOGENATED VOLATILE ORGANICS
EPA METHOD 6020
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.

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Revision 0
Date September 1986

D-37
TABLE 1. CHROMATOGRAPHIC CONDITIONS AND METHOD DETECTION LIMITS FOR AROMATIC VOLATILE ORGANICS

<table>
<thead>
<tr>
<th>Compound</th>
<th>Retention time (min)</th>
<th>Method detection limit(\text{a}) (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Col. 1</td>
<td>Col. 2</td>
</tr>
<tr>
<td>Benzene</td>
<td>3.33</td>
<td>2.75</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>9.17</td>
<td>8.02</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>16.8</td>
<td>16.2</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>18.2</td>
<td>15.0</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>25.9</td>
<td>19.4</td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td>8.25</td>
<td>6.25</td>
</tr>
<tr>
<td>Toluene</td>
<td>5.75</td>
<td>4.25</td>
</tr>
<tr>
<td>Xylenes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(\text{a}\) Using purge-and-trap method (Method 5030).

TABLE 2. DETERMINATION OF PRACTICAL QUANTITATION LIMITS (PQL) FOR VARIOUS MATRICES\(\text{a}\)

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Factor(\text{b})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground water</td>
<td>10</td>
</tr>
<tr>
<td>Low-level soil</td>
<td>10</td>
</tr>
<tr>
<td>Water miscible liquid waste</td>
<td>500</td>
</tr>
<tr>
<td>High-level soil and sludge</td>
<td>1250</td>
</tr>
<tr>
<td>Non-water miscible waste</td>
<td>1250</td>
</tr>
</tbody>
</table>

\(\text{a}\) Sample PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achievable.

\(\text{b}\) PQL = [Method detection limit (Table 1)] \times [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: Photolization (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-μL with a 0.006-in I.D. needle (Hamilton 702N or equivalent) and a 100-μL.

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-μL 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 (μg/μL) 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 µL of alcoholic standards into 100 mL of reagent water.

5.4.2 Use a 25-µL Hamilton 702H 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 standard.

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 (Paragraph 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 μL 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 μL syringe may be appropriate. The detection limit is very high (approximately 10,000 μg/L); therefore, it is only permitted when concentrations in excess of 10,000 μg/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 μg/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 μg/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


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range (ug/L)</th>
<th>Limit (ug/L)</th>
<th>Range (ug/L)</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>15.4-24.6</td>
<td>4.1</td>
<td>10.0-27.9</td>
<td>39-150</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>16.1-23.9</td>
<td>3.5</td>
<td>12.7-25.4</td>
<td>55-135</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>13.6-26.4</td>
<td>5.8</td>
<td>10.6-27.6</td>
<td>37-154</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>14.5-25.5</td>
<td>5.0</td>
<td>12.8-25.5</td>
<td>50-141</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>13.9-26.1</td>
<td>5.5</td>
<td>11.6-25.5</td>
<td>42-143</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>12.6-27.4</td>
<td>6.7</td>
<td>10.0-28.2</td>
<td>32-160</td>
</tr>
<tr>
<td>Toluene</td>
<td>15.5-24.5</td>
<td>4.0</td>
<td>11.2-27.7</td>
<td>46-148</td>
</tr>
</tbody>
</table>

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, Pₚ = Percent recovery measured.

*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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Accuracy, as Single analyst Overall precision, $x'$</th>
<th>Single analyst precision, $s_p'$</th>
<th>Overall precision, $S'$ (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>Accuracy: 0.92 ± 0.57</td>
<td>Precision: 0.09 ± 0.59</td>
<td>Overall: 0.21 ± 0.56</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>Accuracy: 0.95 ± 0.02</td>
<td>Precision: 0.09 ± 0.23</td>
<td>Overall: 0.17 ± 0.10</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>Accuracy: 0.93 ± 0.52</td>
<td>Precision: 0.17 ± 0.04</td>
<td>Overall: 0.22 ± 0.53</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>Accuracy: 0.96 ± 0.04</td>
<td>Precision: 0.15 ± 0.10</td>
<td>Overall: 0.19 ± 0.09</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>Accuracy: 0.93 ± 0.09</td>
<td>Precision: 0.15 ± 0.28</td>
<td>Overall: 0.20 ± 0.41</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>Accuracy: 0.94 ± 0.31</td>
<td>Precision: 0.17 ± 0.46</td>
<td>Overall: 0.26 ± 0.23</td>
</tr>
<tr>
<td>Toluene</td>
<td>Accuracy: 0.94 ± 0.65</td>
<td>Precision: 0.09 ± 0.48</td>
<td>Overall: 0.18 ± 0.71</td>
</tr>
</tbody>
</table>

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

$s_p'$ = 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

Start

7.1 Introduce compounds into gas chromatograph by direct injection or purge-and-trap (Method 8030).

7.2 Set gas chromatograph conditions.

7.3 Calibrate (refer to Method 8020).

7.4.1 Introduce volatile compounds into gas chromatograph by direct injection or direct injection.

7.4.2 Follow Section 7.6 in Method 8030 for analysis sequence, etc.

7.4.4 Record volume capped, or injected, or beam size.

7.4.5 Calculate concentration (Section 7.4 Method 8020).

7.4.6 Are analytical interferences suspected? Yes

7.4.8 Analyze using second GC column.

7.4.7 Dilute second eluate, or whatever.

7.6.7 No response for a peak off-scale?

Stop

8020 - 14
Revision 0
Date September 1998
D-50
SEMIVOLATILE PRIORITY POLLUTANT
ORGANIC-SOLVENT
1. SUMMARY

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

<table>
<thead>
<tr>
<th>Compound</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>Phenols</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>*p-Terphenyl-d14</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>Polynuclear Aromatic</td>
</tr>
<tr>
<td>Phthalates</td>
<td>Hydrocarbons</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Compound</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>0.5 – 120 ug/L</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>1.5 – 120 ug/L</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>2.0 – 200 ug/L</td>
</tr>
<tr>
<td>*p-Terphenyl-d14</td>
<td>0.5 – 160 ug/L</td>
</tr>
</tbody>
</table>

B. Sensitivity Factor

<table>
<thead>
<tr>
<th>Compound</th>
<th>Average Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>2.92</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>2.32</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>0.33</td>
</tr>
<tr>
<td>*p-Terphenyl-d14</td>
<td>1.55</td>
</tr>
</tbody>
</table>
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 stop-cocks requiring 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 0°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.

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

<table>
<thead>
<tr>
<th>Mass</th>
<th>Ion Abundance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>30.0 - 60.0 percent of mass 198</td>
</tr>
<tr>
<td>68</td>
<td>less than 2.0 percent of mass 69</td>
</tr>
<tr>
<td>70</td>
<td>less than 2.0 percent of mass 69</td>
</tr>
<tr>
<td>127</td>
<td>40.0 - 60.0 percent of mass 198</td>
</tr>
<tr>
<td>197</td>
<td>less than 1.0 percent of mass 198</td>
</tr>
<tr>
<td>198</td>
<td>base peak, 100 percent relative abundance</td>
</tr>
<tr>
<td>199</td>
<td>5.0 - 9.0 percent of mass 198</td>
</tr>
<tr>
<td>275</td>
<td>10.0 - 30.0 percent of mass 198</td>
</tr>
<tr>
<td>365</td>
<td>greater than 1.00 percent of mass 198</td>
</tr>
<tr>
<td>441</td>
<td>present but less than mass 443</td>
</tr>
<tr>
<td>442</td>
<td>greater than 40.0 percent of mass 198</td>
</tr>
<tr>
<td>443</td>
<td>17.0 - 23.0 percent of mass 442</td>
</tr>
</tbody>
</table>

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:

4240B D-54
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:

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS Number</th>
<th>Primary Ion</th>
<th>Secondary Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorobiphenyl</td>
<td>321-60-8</td>
<td>172</td>
<td>171</td>
</tr>
<tr>
<td>Terphenyl-d₁₄</td>
<td>92-94-4</td>
<td>244</td>
<td>122,212</td>
</tr>
<tr>
<td>2-Fluorophenol</td>
<td>367-12-4</td>
<td>112</td>
<td>64</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>118-79-6</td>
<td>330</td>
<td>332,141</td>
</tr>
</tbody>
</table>
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 H₂SO₄ (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.

<table>
<thead>
<tr>
<th>Reference Standard</th>
<th>Source</th>
<th>Purity</th>
<th>Concentration ug/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorobiphenyl</td>
<td>EPAQAMB</td>
<td>99%</td>
<td>5,000 ± 500</td>
</tr>
<tr>
<td>p-Terphenyl-d14</td>
<td>EPAQAMB</td>
<td>QAT</td>
<td>5,000 ± 500</td>
</tr>
<tr>
<td>2-Fluorophenol</td>
<td>EPAQAMB</td>
<td>QAR</td>
<td>5,000 ± 500</td>
</tr>
</tbody>
</table>

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-d14, phenol-d5, 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.
DNA/Pest Working Calibration Standard Preparation* (*2 uL each injected onto the GC/MS)

<table>
<thead>
<tr>
<th>Calibration Standard</th>
<th>Amount (uL) of Calibration Standard used per 1.0 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>100  80  60  25  0</td>
</tr>
<tr>
<td>D</td>
<td>100  80  60  25  0</td>
</tr>
<tr>
<td>E</td>
<td>0     0    0    0    0</td>
</tr>
<tr>
<td>F</td>
<td>0     0    0    0    0</td>
</tr>
</tbody>
</table>

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-d4, 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.

\[
RRF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x}
\]

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.
Semivolatiles by GC/MS: Water
Revision 1
April 1988
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<table>
<thead>
<tr>
<th>Compound</th>
<th>Target Initial Calib. (ug/ml)</th>
<th>Target Daily Calib. (ug/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>p-Terphenyl-d\textsubscript{14}</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>

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 μL 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:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Column Temperature</td>
<td>50°C for 1 minute Hold</td>
</tr>
<tr>
<td>Column Temperature Program</td>
<td>50-310°C at 10 degrees/min.</td>
</tr>
<tr>
<td>Final Column Temperature Hold</td>
<td>310°C for 10 minutes</td>
</tr>
<tr>
<td>Injector Temperature</td>
<td>220°C</td>
</tr>
<tr>
<td>Transfer Line Temperature</td>
<td>290°C</td>
</tr>
<tr>
<td>Source Temperature</td>
<td>according to manufacturer's specifications</td>
</tr>
<tr>
<td>Injector-Greb-type, splitless</td>
<td></td>
</tr>
<tr>
<td>Sample Volume</td>
<td>1 - 2 μL</td>
</tr>
<tr>
<td>Carrier Gas</td>
<td>Helium at 1 ml/min</td>
</tr>
</tbody>
</table>

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/μL 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:

\[
\text{Concentration (ug/L)} = \frac{(A_w)(I_s)(V_t)}{(I_s)(RRF)(V_o)(V_i)}
\]

Water
Ax = Area of the characteristic ion for the compound to be measured

Ais = Area of the characteristic ion for the internal standard

Is = Amount of internal standard injection in nanograms (ng)

Vo = Volume of water extracted in milliliters (ml)

Vi = Volume of extract injected (ul)

Vt = 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.

Percent Surrogate Recovery = \( \frac{Q_d}{Q_a} \times 100\% \)

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.

<table>
<thead>
<tr>
<th>Surrogate Standard</th>
<th>Volume/ml of 5,000 ug/ml stock</th>
<th>Control Spike Solution Conc. in ug/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>1.0</td>
<td>100</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>0.5</td>
<td>50</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>1.0</td>
<td>100</td>
</tr>
<tr>
<td>p-Terphenyl-d14</td>
<td>0.5</td>
<td>50</td>
</tr>
</tbody>
</table>

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.

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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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GC/MS/DS:</td>
<td>Hewlett Packard MSD</td>
</tr>
<tr>
<td>Electron Energy</td>
<td>70 volts</td>
</tr>
<tr>
<td>Scan Time:</td>
<td>1 sec per scan</td>
</tr>
<tr>
<td>Initial Column Temperature Hold</td>
<td>50°C for 1 minute</td>
</tr>
<tr>
<td>Column Temperature Program</td>
<td>50-310°C at 10 degrees/minute</td>
</tr>
<tr>
<td>Final Column Temperature Hold</td>
<td>310°C for 10 minutes</td>
</tr>
<tr>
<td>Injector Temperature</td>
<td>220°C</td>
</tr>
<tr>
<td>Transfer Line Temperature</td>
<td>290°C</td>
</tr>
<tr>
<td>Source Temperature</td>
<td>190°C</td>
</tr>
<tr>
<td>Injector-Grob type, splitless</td>
<td></td>
</tr>
<tr>
<td>Sample Volume</td>
<td>2 ul</td>
</tr>
<tr>
<td>Carrier Gas</td>
<td>Helium at 1 ml/minute</td>
</tr>
</tbody>
</table>

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DEHYDROVOLATILE PRIORITY POLLUTANT ORGANIC-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
*2-Fluorobiphenyl
*p-Terphenyl-d14
*2,4,6-Tribromophenol
Phthalates
Phenols
Polynuclear Aromatic
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/aceton using an ultrasonic probe. A gel permeation column cleanup is used before analysis.

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II. APPLICATION

Leachates Soils

A. Tested Concentration Range: 0.5 - 200 ug/L 0.017 - 6.7 ug/g

<table>
<thead>
<tr>
<th></th>
<th>Leachates</th>
<th>Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>0.5 - 120</td>
<td>0.017 - 4.0</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>1.5 - 120</td>
<td>0.017 - 4.0</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>2.0 - 200</td>
<td>0.067 - 6.7</td>
</tr>
<tr>
<td>p-Terphenyl-d14</td>
<td>0.5 - 160</td>
<td>0.017 - 5.3</td>
</tr>
</tbody>
</table>

B. Sensitivity Factor

<table>
<thead>
<tr>
<th></th>
<th>Average Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>2.92</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>2.32</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>0.33</td>
</tr>
<tr>
<td>p-Terphenyl-d14</td>
<td>1.55</td>
</tr>
</tbody>
</table>

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 4336B

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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 requiring 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

<table>
<thead>
<tr>
<th>Mass</th>
<th>Ion Abundance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>30.0 - 60.0 percent of mass 198</td>
</tr>
<tr>
<td>68</td>
<td>less than 2.0 percent of mass 69</td>
</tr>
<tr>
<td>70</td>
<td>less than 2.0 percent of mass 69</td>
</tr>
<tr>
<td>127</td>
<td>40.0 - 60.0 percent of mass 198</td>
</tr>
<tr>
<td>197</td>
<td>less than 1.0 percent of mass 198</td>
</tr>
<tr>
<td>198</td>
<td>base peak, 100 percent relative abundance</td>
</tr>
<tr>
<td>199</td>
<td>5.0 - 9.0 percent of mass 198</td>
</tr>
<tr>
<td>275</td>
<td>10.0 - 30.0 percent of mass 198</td>
</tr>
<tr>
<td>365</td>
<td>greater than 1.00 percent of mass 198</td>
</tr>
<tr>
<td>441</td>
<td>present but less than mass 443</td>
</tr>
<tr>
<td>442</td>
<td>greater than 40.0 percent of mass 198</td>
</tr>
<tr>
<td>443</td>
<td>17.0 - 23.0 percent of mass 442</td>
</tr>
</tbody>
</table>

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 silicon-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:

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS Number</th>
<th>Primary Ion</th>
<th>Secondary Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorobiphenyl</td>
<td>321-60-0</td>
<td>172</td>
<td>171</td>
</tr>
<tr>
<td>Terphenyl-d_{14}</td>
<td>92-94-4</td>
<td>244</td>
<td>122,212</td>
</tr>
<tr>
<td>2-Fluorophenol</td>
<td>367-12-4</td>
<td>112</td>
<td>64</td>
</tr>
<tr>
<td>2,4,6-Tribromo phenol</td>
<td>118-79-6</td>
<td>330</td>
<td>332,141</td>
</tr>
</tbody>
</table>

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 H₂SO₄ (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.

<table>
<thead>
<tr>
<th>Reference Standard</th>
<th>Source</th>
<th>Purity</th>
<th>Concentration ug/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorobiphenyl</td>
<td>EPAQAMB</td>
<td>99%</td>
<td>5,000 ± 500</td>
</tr>
<tr>
<td>p-Terphenyl-d₁⁴</td>
<td>EPAQAMB</td>
<td>QAT</td>
<td>5,000 ± 500</td>
</tr>
<tr>
<td>2-Fluorophenol</td>
<td>EPAQAMB</td>
<td>QAR</td>
<td>5,000 ± 500</td>
</tr>
</tbody>
</table>

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 µg/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 µg/ml standard solutions. Mix by inverting several times.

e. Calibration Standard E:

f. Calibration Standard F:

100 µg/ml (2.0 ml) each of 2-fluorobiphenyl, p-terphenyl-d14, phenol-d5, 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.

<table>
<thead>
<tr>
<th>Calibration Standard</th>
<th>Amount (µL) of Calibration Standard used per 1.0 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>100 80 60 25 0</td>
</tr>
<tr>
<td>D</td>
<td>100 80 60 25 0</td>
</tr>
<tr>
<td>E</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>F</td>
<td>0 0 0 0 0</td>
</tr>
</tbody>
</table>

BNA/Pest Working Calibration Standard Preparation* (*2 µL each injected onto the GC/MS)

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Semivolatiles by GC/MS: Soil and TCLP Leachates
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DCF 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 \(-10^\circ\text{C}\) to \(-20^\circ\text{C}\) 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 \(4^\circ\text{C}\).

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.

\[
RRF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x}
\]

Equation 1:  

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.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Target Initial Calib. (ug/ml)</th>
<th>Target Daily Calib. (ug/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>p-Terphenyl-d_{14}</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>
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 standard 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

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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

1. Sample Extraction - Separatory Funnel

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
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 extrac-
tion in the same manner. Label the combined ex-
tract 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 frac-
tion.

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 to 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 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 MICROTP 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 sulfate 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°C 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, 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 - 50°C for 1 minute
- Hold
- Column Temperature Program - 50-310°C at 10 degrees/min.
- Final Column Temperature - 310°C for 10 minutes
- Hold
- 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
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:

\[
\text{Concentration (ug/L) = \frac{(A_x)(Is)(V_t)}{(is)(RRF)(V_o)(V_i)}}
\]

Water

\[
4336B
\]
Semivolatiles by GC/MS: Soil and TCLP Leachates
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\[ AX = \text{Area of the characteristic ion for the compound to be measured} \]

\[ A_{is} = \text{Area of the characteristic ion for the internal standard} \]

\[ I_s = \text{Amount of internal standard injection in nanograms (ng)} \]

\[ V_0 = \text{Volume of water extracted in milliliters (ml)} \]

\[ V_i = \text{Volume of extract injected (ul)} \]

\[ V_t = \text{Volume of total extract. (Use 2000 ul or a factor of this when dilutions are made. The 2000 ul is derived from combining half of the 1 ml BN extract and half of the 1 ml A extract.)} \]

b) Calculate the concentration in the sample using the relative response factor (RRF) and the following equation:

\[
\text{Soil/Sediment Concentration \( \mu g/kg \)} = \frac{(AX)(I_s)(V_t)}{(A_{is})(RRF)(V_i)(W_s)(D)}
\]

(Dry weight basis)

Where:

\[ AX = \text{Area of characteristic ion for the compound to be measured.} \]

\[ A_{is} = \text{Area of characteristic ion for the internal standard.} \]

\[ I_s = \text{Amount of internal standard injection in nanograms (ng).} \]

\[ V_t = \text{Volume of low level total extract (Use 1000 ul or a factor of this when dilutions are made.)} \]
If GPC cleanup is used, the volume is 2000 uL. The 1000 uL is derived from concentrating the 9.5 mL.)

\[ V_i = \text{Volume of extract injected (uL)} \]
\[ D = \frac{100 - \% \text{ moisture}}{100} \]
\[ W_s = \text{Weight of sample extracted (grams)} \]

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.

\[ \text{Percent Surrogate Recovery} = \frac{Q_d}{Q_a} \times 100\% \]

Where: \( Q_d \) = quantity determined by analysis
\( Q_a \) = 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.

<table>
<thead>
<tr>
<th>Surrogate Standard</th>
<th>Volume (ml) of Solution</th>
<th>Control Spike Conc. (ug/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Fluorophenol</td>
<td>1.0</td>
<td>100</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>0.5</td>
<td>50</td>
</tr>
<tr>
<td>2,4,6-Tribromophenol</td>
<td>1.0</td>
<td>100</td>
</tr>
<tr>
<td>p-Terphenyl-d$_{14}$</td>
<td>0.5</td>
<td>50</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>GC/MS/DS:</th>
<th>Hewlett Packard MSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron Energy:</td>
<td>70 volts</td>
</tr>
<tr>
<td>Scan Time:</td>
<td>1 sec per scan</td>
</tr>
</tbody>
</table>

- 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)
WASHINGTON, D.C. 20460, and is available for viewing from 8 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The public may make an appointment to review docket materials by calling Mr. Ronald L. Zarr at (202) 472-7758 or Mr. Kevin S. Goodwin at (202) 472-7756 for appointments. The public may copy a maximum of 50 pages of material from any one regulatory docket at no cost. Additional copies cost $0.25 per page.

FOR FURTHER INFORMATION CONTACT: For general information about this rule contact a representative of the SCERA Meetings, Office of Solid Waste (WH-553), U.S. Environmental Protection Agency, 47 M Street SW., Washington, D.C. 20460, (202) 472-0452 (toll-free) or (202) 472-3020 in the Washington, D.C., metropolitan area.

For information on specific aspects of this rule contact Stephen R. Weil or Jacqueline W. Sales, Office of Solid Waste (WH-553), U.S. Environmental Protection Agency, 47 M Street SW., Washington, D.C. 20460 (202) 472-3772.

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2. Categories Listed

3. Scheduled Wastes

4. Newly Listed Wastes

B. Summary of the Proposed Rule

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2. Variance Based on Lack of National Capacity

3. Petition Process

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J. Treatment Standards and Effective Dates for Solvents

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L. Agency Response to Major Comments on Proposed Rule

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2. Process Waste Utility

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1. Ongoing Operation

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B. Treatment Alternatives (RDAT)
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on land disposal to the extent if treatment standards have not been generated or if a petition has not been granted. In any event, where EPA does not set a treatment standard for a waste by the deadline, it is not precluded from later promulgating a treatment standard for that waste. Similarly, where EPA has not set a treatment standard, it is not precluded from revising that standard after the statutory deadline through rulemaking procedures.

The relevant statutory deadlines are explained in detail in the following sections.

1. Solvents and Dioxins

Effective November 8, 1983, the statute prohibits further land disposal (except by deep well injection) of the following wastes, containing hazardous wastes identified as F222, F232, F242, and F252,1 and solvent-containing hazardous wastes identified as F212, F222, F232, F242, and F252 (RCRA sections 3004(e)(1), e(2), 42 U.S.C. 6924(e)(1), e(2)). These wastes are listed in 40 CFR 261.21.

If EPA fails to set treatment standards or grant petitions for solvents- 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 2, 1983). 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 5, 1979 (32 months from November 5, 1976), the statute prohibits disposal (except with respect to deep well injection) for the following wastes. Listed or identified under RCRA section 3004(a)(1):

a. Liquid hazardous wastes, including free liquids associated with any solid or sludge, containing free cyanides at concentrations greater than or equal to 2,000 mg/L.

b. Liquid hazardous wastes, including free liquids associated with any solid or sludge, containing heavy metals or compounds of these metals (or elements) or compounds of these metals (or elements) at concentrations greater than or equal to those specified:

- Arsenic and/or compounds (as As) 300 mg/L
- Cadmium and/or compounds (as Cd) 10 mg/L
- Chromium (VI) and/or compounds (as Cr VI) 20 mg/L
- Lead and/or compounds (as Pb) 200 mg/L
- Mercury and/or compounds (as Hg) 5 mg/L
- Nickel and/or compounds (as Ni) 15 mg/L
- Selenium and/or compounds (as Se) 150 mg/L
- Thallium and/or compounds (as Tl) 120 mg/L
- Other hazardous wastes containing polychlorinated biphenyls (PCBs) at concentrations greater than or equal to 0.05 ppm.
- Hazardous wastes containing halogenated organic compounds in 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 5, 1977, 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 2, 1983).

EPA will propose treatment standards for California List wastes in a future Federal Register notice.

During the period ending November 8, 1989 (48 months from November 5, 1984), disposal of contaminated soil or debris resulting from a response action taken under sections 104 or 105 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 F01-F025 solvent wastes, dioxin-containing wastes, and wastes covered by the California List. (RCRA sections 3004(d)(3); 42 U.S.C. 6924(d)(3); e(3)).

3. Scheduled Sections

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 5, 1984, under RCRA section 3001. This list excludes solvent and dioxin wastes prohibited under section 3004(c) and California List wastes prohibited under section 3004(e). EPA submitted this schedule to Congress on May 28, 1989 (61 FR 18052).

RCRA section 3004(d)(1) (42 U.S.C. 6924(d)(1)) provides that if EPA fails to set treatment standards or grant petitions by the statutory deadline for any hazardous wastes according to the schedule, such hazardous wastes may be disposed of in landfills or surface impoundments only if facilities in compliance with the minimum technical standards are in place under RCRA section 3004(e), 42 U.S.C. 6924(e). If EPA fails to set treatment standards or grant petitions for any of the scheduled listed wastes by May 28, 1989, 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 EWSA. For any hazardous wastes 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 3007(d)(5), 42 U.S.C. 6927(d)(5)). However, the statute does not impose an automatic prohibition on land disposal if EPA issues a deadline for any newly listed or identified waste.

B. Summary of the Proposed Rule

On January 14, 1985, 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 1035).

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 each treatment in the land.

1 In this situation, placement of such wastes in other types of land disposal units (e.g., direct injection units) will not be treated as land disposal.
disposal environment. The screening levels specified mark the concentration levels discovered at hazardous waste treatment facilities, and omission of individual hazardous waste constituents is a result of screening levels.

The Agency determined that some wastes 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 sets 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 lower the screening level as the treatment standard, subjecting BDAT to less stringent than the screening levels, but BDAT treated substantially to 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 a framework to the waste codes specified in section 3004(e) (i.e., F009-F010, F013 and F017) for dioxin-containing wastes and F021-F025 and the corresponding contaminants listed in 40 CFR 261.32 (e) and (f) for solvent-containing wastes.

The screening levels for dioxin-containing wastes were below the established detection limits achievable using standard EPA analytical methods. Under 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, set of standards under RCRA section 3004(m) based solely on the performance of the test 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 3-year national variance for all dioxin-containing wastes subject to the restrictions. The Agency also proposed to grant a 3-year national variance for F021-F025 solvent wastes containing less than 1 percent by weight total organic constituents, and solvent-containing 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 waste remains hazardous (RCRA sections 3004(c)(1), (c)(1), and (c)(2), 42 U.S.C. (c)(3)1, (c)(4), and (c)(5)). Under the proposed rule, this demonstration will 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 waste remains hazardous" standard could be met if the petitioner demonstrated that, by the time the waste reach a point of potential human exposure, or a controlled 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 interpreted 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 40 CFR Part 261 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 standards.

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 § 261.3 demonstrating that a facility's 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 § 261.3.

Agency code 200-00-33
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(h). The Agency also considers placement in concrete vessels 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 RCRA permits constitutes compliance with Subtitle C.

2. CERCLA Response Actions and RCRA Corrective Action Wastes

Under section 104(a) Congress provided a 30-month exemption (until November 1982) from the land disposal restriction provisions for disposal of contaminated soil and debris from CERCLA 104 and 261 response actions and RCRA corrective actions. Because of this statutory exemption, today's final rule is not applicable to those wastes. The exemption covers the disposal of any soil and debris wastes under sections 104 and 252. All other CERCLA response actions and RCRA corrective actions wastes are subject to this rule.

CERCLA response actions and RCRA corrective actions often address waste situations 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 variations may be required for some soils, debris, and other similar wastes. Therefore, before November 8, 1982, the Agency plans to perform additional characterization of soils and debris and other similar wastes and, when necessary, amend the treatment standards by adding additional standards specifically for these wastes.

Today's final rule provides a 2-year national variance for 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(h). 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 linens. In many cases soils and debris will be mixed with liquids or slurges. 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 to RCRA including section 1001 [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 3010 of RCRA classifying waste as hazardous based on the potential of these wastes to cause harm to human health or the environment if managed improperly. These determinations have included the potential for transport as a result of reactivity, flammability, corrosivity, and toxicity via the ground water or surface water pathways. 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, however, is proposing an air toxicity characteristic in an effort 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 to developing treatment standards for wastes in accordance with section 3004(h). 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 3010(c) and the petition demonstration for continued land disposal under section 3004(h). With respect to the former, section 3004(h) 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), (t), 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 3004 of RCRA. EPA expects that the technical analysis of air emissions that will provide a basis for future rebutting under sections 3001 and 3004(a) will also be used as a guide in making decisions on petitions addressing air emissions concerns.

Implementation of two portions of the regulatory program, notwithstanding, must proceed as the air strategy is being developed. These include the issuance of permits to treat, 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 3001(m) Treatment Standards

As discussed earlier, the Agency proposed two major approaches in setting treatment standards under section 3001(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 on EDAT. The Agency is proposing the second approach as the framework under which disposal of solvents, dioxins, and the planned wastes will be evaluated.

The risk-based methodology proposed by the Agency considered the degree of hazard posed by wastes land disposed in landfills. This led to the development of "maximum acceptable contaminant concentrations" (MACCs) or screening levels, which were based on the expected limit of potential harm to human health and the environment. This approach also recognized that in some cases, any single technology-based level may provide more protection, that 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 "cry" treatment that can be achieved under EDAT, several commenters, including eleven members of Congress, argued strongly that this approach did not distinguish between the various levels 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 technologies.

The Agency believes that the technology-based approach adopted in today's final rule, although not the only approach appropriate under the law, responds to the above-stated comments. Accordingly, the final rule establishes treatment standards under RCRA section 3001(m) based exclusively on levels achievable by EDAT. The Agency believes that the treatment standards will generally be protective of human health and the environment. Levels lower than EDAT 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 3001(m) requires EPA to "promulgate regulations specifying those levels or methods of treatment, if any, which substantially reduce 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" (40 U.S.C. 3001(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 3001(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. 9770, 97th ed., July 23, 1984). Thus, EPA is 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 EDAT.

The Agency believes that its major purpose in adopting the risk-based approach of the proposal (i.e., to allow lower levels of treatment, or, risk, low-hazard waste) may be better addressed through changes in 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-Regret" Petitions) In carrying out the directives of RCRA sections 3024 (39 U.S.C. 6924) and 3025, the Agency proposes to consider petitions to allow land disposal of regulated waste in a manner that will not produce a threat to human health and the environment.

Today's final rule adopts the statutory language regarding petitioners to demonstrate "to a reasonable degree of certainty that there will be no migration of hazardous constituents from the disposal unit or injection well site as long as the wastes remain hazardous." The Agency will allow continued land disposal of hazardous wastes without further treatment only when 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 Affectees as originally proposed. As noted in the proposed rule, a petition must be submitted at any time prior to or after the effective date of the rule as set forth in Unit IV.D. However, authorization of a petition will not stay the effective date of the prohibition.

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 (i.e., 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.D). Following a restriction of the effective date and while the Agency is reviewing the request for variance, the generator may not land dispose the waste. Alternatively, continued land disposal in surface impoundments extending the standards of § 262.34(a)(1) may be feasible for some wastes.

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P. National Variances 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 waste must be managed in facilities that are in compliance with the requirements of section 300.40 [42 U.S.C. 9620(c)].

G. Case-by-Case Extensions

The Agency will consider granting up to a 1-year extension (reasonable case) of the effective date of the regulations in certain cases in which the applicant demonstrates to the Agency that the proposed facilities have been operated into 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 will request from the program that is not the applicant's control and established that the facility cannot reasonably be made available by the effective date. The Agency will determine whether the proposed capacity is sufficient to meet the applicant's needs and whether the proposed facilities are in compliance with the applicable regulations. The Agency will determine whether the proposed facilities are in compliance with the applicable regulations. The Agency will require that the proposed facilities be in compliance with the applicable regulations.

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, and 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 that more time should be allowed for storage. In today's final rule the Agency is revising the 90-day storage limit to 365 days. 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 shall either the hazardous waste by the effective date of the prohibition or comply with the applicable regulations.

I. Treatment Standards and Effective Dates for Solvents

The Agency proposed to establish treatment standards and effective dates for the 10 CFR parts 61, 73, 74, and 75, and 10 CFR part 60. The Agency is proposing to delay the effective date for the treatment standards for facilities that are not in compliance with the applicable regulations. The Agency is proposing to delay the effective date for the treatment standards for facilities that are not in compliance with the applicable regulations.

J. Treatment Standards and Effective Dates for Dioxins

The proposed rule on treatment standards for dioxin-containing wastes under parts 61, 73, 74, and 75 below the current shall be limited to 1 lb for each of the chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) in the list of hazardous substances (HGs). The proposed standards are designed to limit the production of dioxins and furans in the treatment of hazardous wastes. The Agency is proposing to delay the effective date for the treatment standards for facilities that are not in compliance with the applicable regulations. The Agency is proposing to delay the effective date for the treatment standards for facilities that are not in compliance with the applicable regulations.

K. National Variances for Immediate Effective Date

Today's rule provides for an effective date of November 8, 1983. It is clear from the statute that today's rule must go into effect no later than the effective date of the prohibition on storage and disposal in section 300.40. Although any regulations, the proposed standards for storage and disposal in section 300.40 takes effect immediately on November 8, 1983. Therefore, November 8, 1983 is the latest date for facilities to be in compliance with the regulations. Facilities that are in compliance with the regulations that are not in compliance with the regulations will not be required to comply with the regulations that are not in compliance with the regulations.

* In addition to the above requirements, the regulations also include the following requirements: facilities shall be in compliance with the applicable regulations.
must have the same effective date as the applicable regulation promulgated under subsection (a), (b), or (c). Therefore, since the statute clearly provides that the regulations implementing section 313(c)(4) of RCRA to provide for an effective date of November 8, 1988. EPA finds that good cause exists under section 300.7(a)(3) of RCRA to provide for an effective date of November 8, 1988. For the same reason, EPA finds that good cause exists under section 553.3(b)(2) of the Administrative Procedure Act, 5 U.S.C. § 553(b)(2), to waive the requirement that regulations be published at least 30 days before they become effective.

E. 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 (TSD) 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 alternative (BDA) capacity, and disposal facilities are addressed in the background document to this rulemaking (see Comment Response Background Document for the Land Disposal Restrictions Volume I, November 7, 1989), 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 comments 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 most effective for regulating the reaction rate. Thus, these comments argued that EPA should modify the standards in 40 CFR 261.32 to require that hazardous waste produced by small generators be considered hazardous waste.

The Agency has carefully considered the impact that the inclusion of the proposed prohibition of land disposal restrictions on these generators. Given the smaller number of generators that could be affected by the proposed prohibition, the Agency has determined that the inclusion of this prohibition is justified. The Agency believes that the best way to ensure that hazardous waste produced by small generators is handled in a manner that is consistent with its characterization of hazardous waste is to specify that hazardous waste produced by small generators be considered hazardous waste.

The Agency has also considered the impact of making this change. Because hazardous waste produced by small generators is likely to be more difficult to manage, the Agency believes that the inclusion of this prohibition is justified. The Agency believes that the best way to ensure that hazardous waste produced by small generators is handled in a manner that is consistent with its characterization of hazardous waste is to specify that hazardous waste produced by small generators be considered hazardous waste.

B. Treatment Alternatives (BDA)

1. BDA Explained as a Performance Standard

Generally, commentators supported the Agency's interpretation of section 300(d) regarding the criteria for the selection of BDA. The statute specifies that BDA may be expressed as either a performance standard or a method of treatment. Wherever possible, the Agency prefers to establish BDA 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 BDA 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 that concentration-based performance standards offer the regulated community greater flexibility to develop and implement control strategies as well as prompt innovative treatment methodologies.

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 provide for 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 BDA 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 BDA treatment standards.
standards. This analysis is not intended to account for performance deficiencies which occur as a result of treating a waste that is significantly different in composition or for deficiencies which occur from improper or poor treatment of the same waste. Instead, incorporation of a variability factor into the development of a RAC standard is intended to account for variations which arise from mechanical limitations in the equipment used to evaluate treatment parameters or the performance of 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 6, 1986), is the ratio of the calculated 95% percentile concentration, C95, 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 comment asserted that the Agency should document the record to 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 and 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 quality analysis to confirm engineering judgment. The statistical analysis to be used was published in the Federal Register on September 6, 1986 (51 FR 31703). The rationale the Agency used for selecting performance data can be found in the technical support documents.

C. Capacity

1. Capacity for Waste-As-Pay

Several commenters argued that EPA did not consider using waste as a treatment alternative in estimating capacity. As one commenter pointed out, this is a potentially large treatment option that could not be considered in the current determinations. EPA did not consider the alternative because the data were not available. Since the November 16, 1986 proposal, the Agency has developed data from the "Thermal Verification Survey of Commercial Facilities that Manage Selected" (August 1987) data from this survey were analyzed for public comment on September 12, 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 waste because historically they would be considered, and permit conditions may not prohibit accepting off-site waste. EPA capacity may be fully committed to other out-of-region waste. 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 the evidence provided by a private facility is sufficient to demonstrate that the private facility is capable of accepting off-site waste. Because limited information is available, the Agency has made an assumption that the private facilities plan to accept off-site waste. Because limited information is available, the Agency has made an assumption that the private facilities plan to accept off-site waste.

Several commenters stated that only existing permitted treatment facilities should be considered in estimating available capacity. They argued that the interim status facilities may not receive final permits and consequently may not provide available capacity. In calculating available capacity for solvents and cleaners, EPA included capacity that is currently available from some interim status facilities and off permitted facilities. The interim status facilities included do not notify the Agency of an interest in being and, therefore, can be expected to provide capacity for the November 16, 1986, data. For other capacity determinations, EPA will consider, on a case-by-case basis, the number of interim status facilities expected to accept waste.

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 too early to determine whether "planned" facilities will be on-line by the effective date of the restrictions with approved to operate from Federal, State, and local agencies. EPA will include planned capacity only when there is substantial evidence that the planned facilities will be fully operational by the effective date of the restrictions. In the case of boilers and incinerators, all 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 a national capacity. Under section 3004(d)(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 EPA should consider that technical and transportation problems affect the availability of alternative capacity for a particular region. They also noted 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 (H.Rep. No. 87-1016, 87th Cong., 1st Sess. 1941) clearly states that "by available capacity determinations 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 the regional implementing the land disposal restrictions. Accordingly, EPA believes that national capacity determinations under section 3004(d)(2) are necessary to accord with the statutory intent.

D. Potential Destabilizing Effect of Unauthorized Wastes in Protective

1. General Petitions for Facilities With Similar Hydrogeological Properties

Several commenters argued that the Agency accept hydrogeological data that address similar management techniques
Waste protects human alternative, of argued evidence that the standard of capability of without the application of a quality standard. Other commenters argued that rendering "ineligible" those wastes that can be treated to meet an BAT 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 States for petition review, so that resources could be devoted to petitions for untreated wastes.

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 treated wastes be treated prior to land disposal. They also argued that rendering "ineligible" those wastes that can be treated to meet a BAT standard fulfills the spirit of the law and gives a clear signal to industry to plan for expanded treatment capacity.

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(h)(2) and (3) 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.

8 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 30 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 represented 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 due to the non-hazardous waste streams. Because of the small amounts generated, the turnaround time during which waste is accumulated is an amount sufficient for a transporter to pick up consistently takes longer than the 60-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 waste.

Other commenters cited the frequent back-ups and delays at treatment facilities that may require storage for more than 60 days; however, these factors are not directly relevant to the statute, which allows storage only for the purpose of accumulating sufficient quantities for proper recovery, treatment, or disposal.

The alternative suggested by commenters ranged from setting a storage limit of 100 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 258.1(b)(9). This provision allows for a certain period to accumulate for recycling provided that during the calendar year commencing January 1 at least 75 percent of the material accumulated during the preceding time is recycled or is transferred to a different site for recycling.

In the proposed rule, the Agency allowed storage, treatment, and disposal facilities the same time periods for accumulating restricted wastes in tanks and containers as specified under 40 CFR 258.34 for large quantity generators accumulating hazardous waste prior to shipment off-site for treatment or disposal. Effective September 24, 1993, the standard for generators of 100-1000 kg/day can store hazardous waste for 90 or 120 days depending on transportation distances.

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 comments 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 facilitate the possibilities of using long-term storage as a means of avoiding a land disposal prohibition. (S. Rep. No. 924, 92d Cong., 1st Sess. 19 (1972)).

The Agency disagrees with the comments who felt that a system similar to the speculative accumulation provision (60 CFR 331.15(b))[9] should be incorporated 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 an application to EPA, in the event of an enforcement action, the burden of proving compliance with §331.10(b) is on the owner/operator. The Agency believes that this is reasonable because the record for the rulemaking indicates that less than one year should be sufficient time to accumulate stored wastes and be subject to the regulatory requirements.

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 who status will need to accumulate restricted wastes for more than 90 days to comply with Part 331.

Section 331.15(c) allows generators to apply for facility status if their accumulated waste will exceed the time limits of 60 CFR 258.5, as long as the storage necessary to comply with Part 331 exceeds the 90-day period provided. This provision provides that facilities in existence on the effective date of regulating or regulatory changes ... that the facility subject to the requirement to have a permit may qualify for interim status if they make the application of a permit. A generator 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 331.15(e) allows interim status only where new regulations requirements apply to existing facilities and are 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 258. 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 331.

The Part A must be submitted to the Agency by the deadline specified in §258.10(e). Note that the §258.10(e) deadline is the insurer of the following two alternative dates: (1) Six months after publication of regulations which first require the facility to comply with Part 258, or (2) 30 days after the date they first become subject to the standards in Part 258. 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 60 CFR 331.15(c)(3), 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 30-day accumulation period ends. Therefore, it is critical that a generator who will be newly subject to the interim status requirements become familiar with the Part A requirements and submit a Part A application, if necessary.

The Agency believes that generators will ship restricted wastes offshore in accordance with the 30-day provision in 40 CFR 258.5, during the period in which the Part A application is being processed. Therefore, it is required that the Part A application be submitted within 30 days after the effective date of today’s rule. The rule being promulgated today maintains the 30-day limit for the storage of restricted wastes at a transfer facility to allow for the possible transition to normal treatment, storage, and disposal facilities.

To implement the storage provision, the Agency is requiring owners/operators to comply with the storage requirements for dating conditions as set forth in 40 CFR 258.5. Therefore, the owners/operators are required to date all waste storage in accordance with the requirements under §258.5, which are consistent with the intent of Congress to prohibit 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 consistently expressed by the commenter.

F. CERCLA Interface

1. 40-Month Exemption for CERCLA

Several commentators requested clarification of §258.15(b), namely the scope of the 40-month exemption for certain CERCLA wastes (soil or debris) from the fast-track and delayed land disposal restrictions. It was suggested that this exemptions should be defined to include all CERCLA bulk wastes. In addition, it was questioned whether State and/or State-facilities that alternate party-funded response action wastes are granted the same exemption.

The Agency does not believe the 40-month exception can be tailored to include CERCLA bulk wastes that will clearly not be contaminated soil or debris. CERCLA soil and debris have been defined as soil and debris, not pollution and debris, not directly related to contamination and debris, and debris as natural materials such as contaminated waste and equipment, building materials, stormwater, chemicals, and debris. In many cases, soil or debris will be mixed with liquids.
of the Agency had reviewed and approved the document in question.

Recently, revised EPA guidance has been released that addresses the disposal of C wander (as covered by the Resource Conservation and Recovery Act, RCRA) in Class I landfills. This guidance clarifies the requirements for disposing of C wander and establishes new standards for determining whether disposals are consistent with RCRA regulations.

The revised guidance includes new requirements for the proper identification and characterization of C wander, as well as new criteria for assessing the environmental impact of disposals. The guidance also includes new requirements for the labeling and transport of C wander, as well as new requirements for the monitoring and reporting of disposals.

In addition, the guidance includes new requirements for the evaluation of alternative disposal methods, as well as new requirements for the development of remediation plans for sites that are contaminated by C wander.

The Agency has been working to implement the new guidance, and has been providing training and technical assistance to states and other stakeholders to help them comply with the new requirements.

The revised guidance will have a significant impact on the management of C wander, and the Agency is committed to ensuring that it is implemented effectively.
restricted solvents before land disposal of the lab pack.  

Whether the legislative history or the statutory language indicates that lab packs can be excluded from the land disposal restrictions if they contain solvents designated as hazardous under NRRA, the Agency acknowledges that the additional statutory language would have no effect on the context in today's rule regarding solvents because these to make parts disposal or treatment capacity even to substantially lower quantities of dioxin-containing wastes.

2. Treatment Standard for Dioxin-Containing Wastes

One commenter argued that a regulatory requirement to prohibit treatment capacities for dioxin-containing wastes is not feasible. The Agency has adopted the treatment standard that has been made under § 235.2.

H. Dioxin

1. Quantity of Dioxin-Containing Waste Generated

Several commenters argued that the Agency underestimated the actual quantity of dioxin-containing soil subject to the proposed rule. Specifically, one commenter 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 actual quantity of dioxin-containing soil in the lab packs.

In the proposed rule, EPA acknowledged that the estimated quantity of dioxin-contaminated soil in the lab packs was derived by assessing estimates from such contaminated site. 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. The Agency decided to assess 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

From land disposal, the proposed procedure also reduces the quantity of dioxin-containing waste. Conversely, the estimated quantity is based on the detection limit of both organics and hazardous waste. Therefore, no comment has been made under § 235.2.

2. Treatment Standard for Dioxin-Containing Wastes

One commenter argued that the analytical standard improves, increasing amounts of unacceptable levels of dioxin-containing waste, the treatment standard for the dioxin-containing waste is based on the current limits of technology available to treat dioxin-containing waste. The treatment standard for the treatment standard for the dioxin-containing waste is based on the current limits of technology available to treat dioxin-containing waste, the treatment standard for the dioxin-containing waste is based on the current limits of technology available to treat dioxin-containing waste.
This approach by providing that treatment determinations do not have to be made only by waste codes and by authorizing EPA to establish "generic" treatment standards or similar wastes (123 Congressional Record section 2189, daily edition [July 25, 1977].)

EPA believes that in addition to the types of treatability groups described in the proposed rule, grouping and subgrouping wastes by industry or technologically 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 wastewaters from unknown origins.

Finally, as noted in the proposal, EPA intends to focus on the constituent in sections 504(d), (e), and (g) and Appendix VIII to Part 231.

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 commenter position that the determinations should not be based on full-scale operations.

While the Agency did not consider pilot- or bench-scale operations in identifying "demonstrated" treatment technologies for drafter and chlorides, in certain circumstances data from these operations may be used by the Agency in evaluating the performance of demonstrated full-scale treatment options for similar wastes. A full-scale facility would demonstrate circumstances that would permit the use of data from pilot- or bench-scale operations in assessing treatment performance, as well as the manner in which the data were obtained
which such data will be used, is presented below.

2. 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 cannot be obtained from the proposer.
3. The technology provides substantial treatment. Today's final rule includes an additional criterion in the definition of "available" treatment technologies. Treatment technologies that are prohibited under section 3008(b) because of an emission 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 or greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal.

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. These 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 risk 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 risk than land disposal will be excluded. (i.e., considered "unavailable") as a basis for establishing treatment standards. If all demonstrated technologies are determined to present greater risks than land disposal for the waste instability 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 not be prohibited from land disposal unless managed in accordance with the exemption and variance provisions in today's final rule or a new or improved technology emerges that is determined to present lower total risk than land disposal. Treatment technologies identified as riskier than land disposal will therefore be classified as unavailable for purposes of establishing treatment standards. EPA may be required to establish the necessary regulatory controls or prohibitions on the design and operation of these technologies to ensure that their use is not in compliance with the treatment standards. EPA will not consider the technology in its determination of the treatment standard in the proposed rule. EPA explained that proprietary or patented processes will be considered available if the Agency determined that the treatment method could be purchased from the proposer.

b. Proprietary or potential 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 proposer. 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" if it is a technology that is readily available to commercial providers.

EPA received many 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. This Agency believes, however, that if the proposed represents a reasonable compromise that is intended to exclude only those technologies that are not currently 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 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.

c. Substantial treatment. In order to be considered "available", a demonstrated treatment technology must "substantially reduce the likelihood of introduction of hazardous constituents" from the waste to the environment. 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. EPA recognizes that the Agency does not require a treatment method that provides field or an environmental benefit. As part of the proposed regulation, the Agency stated that treatment will always be deemed substantial if it results in measurable levels of the hazardous constituents of concern to the public. In contrast, if the technology can achieve the target treatment standard, the treatment will be considered as "available" even if the Agency determines that the technology itself is not available.

d. Environmental benefits. Environmental benefits are considered for purposes of establishing treatment standards. The Agency recognizes that the treatment standard will not always be a substitute for the treatment standard. Although EPA is required by the statute to establish treatment standards, the Agency also believes that the proposed rule provides the opportunity for continued development of technologies.
individual EDAT doctrines as they are developed. Furthermore, available EPA data show that few, if any, demonstrated treatment technologies will not achieve high percentages of removal, destruction, or immobilization in the wastes for which they are demonstrated. As a result, the Agency favors an alternative to the approach as proposed (outlining, of course, the application of the techniques used to develop the standards).

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 treatment 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.

Whenever 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 wastes judged to be unstable are not available, EPA will use data from bench-scale operations. Similarly, where bench-scale data cannot be used, EPA may examine the use of such data in the preamble or background documents and will request comments on the use of such data.

When a treatment performance for a particular waste or similar wastes are verified by EPA to be inefficient, EPA will gather data and information through sampling and analyzing 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 streams may not be considered in establishing the treatment technology. 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 that IV.A.]. 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 treatment standard for the waste [see the relevant EDAT background document for information regarding the techniques 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, in most cases, on how well the system is designed and operated. In the proposal rule, the Agency stated its intention to use only treatment data from well-designed and operated systems. Comments 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 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 whether the community was doing what it was designed to do and how well the design temperature was 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 whether the community was doing what it was designed to do and how well the design temperature was controlled.

c. Comparison of performance.

In the proposed rule, EPA noted the complexity of the treatment process and the lack of treatment standards for many of these processes. EPA also stated that the Agency did not explain in the preamble whether a treatment process was well designed and operated. In the final rule, the Agency did not explain how it would assess whether a treatment process was well designed and operated.

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determine treatment standards where more than one technology can be used. In response to these comments, EPA revised its methodology for establishing treatment standards. The revised approach incorporates several statistical methods that are presented in EPA's Notice of Availability, Professional Developments, Volume 12, No. 6 (1984).

e. Analysis of variance - This is the statistical method known as analysis of variance (ANOVA) to determine the level of performance that a treatment system can achieve. This method provides a measure of the degree to which the treatment system can reduce the variability of the treatment process.

f. The analysis of variance method is used to determine whether the treatment system can achieve a certain level of performance. The analysis of variance is performed by calculating the variability of the treatment process and comparing it to the variability of the control system. The variability of the treatment process is calculated using the following formula:

\[ S_S = \sum_{i=1}^{k} \left( \frac{\sum_{j=1}^{N} y_{ij}}{N} - \bar{y} \right) \]

where:
- \( S_S \) = sum of squares within treatment data sets
- \( k \) = number of treatment technologies
- \( y_{ij} \) = observation in the set i of the treatment technology j
- \( \bar{y} \) = overall mean of all observations

The degrees of freedom corresponding to \( S_S \) and \( S_M \) are calculated for each treatment technology. The degrees of freedom for treatment technology j is given by \( k - 1 \). For the overall degrees of freedom, the degrees of freedom is given by \( N - k \).

The F-value is calculated as follows:

\[ F = \frac{M_M}{S_S} \]

where:
- \( M_M \) = mean square of the treatment technology
- \( S_S \) = mean square of the treatment system

The F-value is compared with the critical value from an F-distribution table to determine whether the treatment system can achieve the desired level of performance. If the F-value is greater than the critical value, the treatment system can achieve the desired level of performance. Otherwise, the treatment system cannot achieve the desired level of performance.

If the F-value is less than the critical value, the treatment system cannot achieve the desired level of performance. This is an indication that the variability of the treatment process is too high to be controlled by the treatment system. In this case, the Agency may need to consider other treatment technologies or techniques to achieve the desired level of performance.

### Computational Table for the F Value

<table>
<thead>
<tr>
<th>Treatment Technology</th>
<th>Sum of Squares (S_S)</th>
<th>Mean Square (M_M)</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology A</td>
<td>50</td>
<td>20</td>
<td>2.5</td>
</tr>
<tr>
<td>Technology B</td>
<td>40</td>
<td>10</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Notes:**
- S_S = sum of squares within treatment data sets
- M_M = mean square of the treatment technology
- F Value: compares the variability of the treatment process to the variability of the control system.
within a waste treatability group using the statistical calculations 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 mandatory regulations in the National Guidelines Program under the Clean Water Act.

\[
VF = \frac{C_x}{\text{MEAN}}
\]

where:
- \(VF\) = Estimate of daily maximum variability factor determined from a single sample population of daily data
- \(C_x\) = Estimate of performance values for which 99 percent of the daily observations will be below \(C_x\) in calculating the following equation:
- \(C_x = \text{EXP}(y + 1.235x)\) where \(y\) and \(xy\) are the mean and standard deviation, respectively, of the transformed data.
- \(\text{MEAN}\) = 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. 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. 108, Part 1, 99th Cong., 1st Secs. 26 (1986)).

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 regulations 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 prohibitions were limited to Section 3011(a) for the purpose of substituting for adequate treatment under section 3011(e). 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 gauging in accordance with \(\S\) 2537.

b. Dilution to meet the treatment standards. One commenter suggested that EPA reiterate that dilution with non-aqueous agents (e.g., clay, sawdust, or other materials) is also prohibited. As stated in the preamble to the proposed rule (31 FR 1890), 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 SDAT, 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. 194, 99th Cong., 1st Secs. 17 (1986)). In prohibiting dilution that is 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 property operators at existing facilities. For example, treatment facilities could mix compatible wastes in order to treat (e.g., incinerate) at capacity levels rather than treating small batches separately.

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 entering 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 \(\S\) 2537. The Agency believes that the language in \(\S\) 2537 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 prohibitions with the following modifications. One commenter extends to transmitters and landfills which were inadvertently excluded from the proposed prohibition. Since the proposed final legislative history which included the transportation and handling steps within the prohibition for the basis for \(\S\) 2537, the Agency believes that the favorable comments indicate support for such a modification which conforms more closely to congressional intent. In addition, a prohibition was included in the proposed rule to prohibit only dilution and not all waste with the provision that the prohibition would not apply to transmitters. EPA believes that this is consistent with what was intended by EPA. Overall, the comments who supported the prohibition expressed concern with the act of dilution.

E. 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 purposes of establishing treatment standards. Among the criteria considered is whether application of an existing technology, which results in a risk of unacceptable health and/or environmental impacts less than those posed by the land disposal of the waste. Comparative risk analyses were proposed in the preamble to this rule which restricted hazardous wastes from being disposed as mixed wastes, based on the potential that such wastes could be used to dilute other wastes. This provision would encourage treatment technologies by use of technologies which would treat the waste as hazardous rather than dilute it with other non-hazardous wastes.
human health and the environment than
state posed by direct land disposal.

2. Agency Response to Comments

The majority of the comments supported the concept of conducting comparative risk assessment. However, several comments strongly opposed this concept. Each set of comments had
specific criticisms and suggestions.

The comments that 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
commentators. The Agency interprets the
provisions of RCRA as authorizing EPA to set treatment standards which
minimize threats to the “environment” as
applied to all media (i.e., land, soil, and
test). Because there is no language indicating
that this term does not include all media, accordingly, EPA does not believe that the section 3004(a)
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 prohibition. The national policy provisions in section 1002 of this
act 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 (see, e.g., H. Rep. No.
1st Sess. 52 (1985)), 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 comment felt that the use of comparative risk assessments are reasonable, but questioned whether it is
appropriate to use worst case scenarios in asessing the relative risks. The
Agency believes that worst case scenarios are useful in evaluating risks at both
land disposal and alternative treatment facilities. In response to comments, the Agency is not using worst case scenarios.

The Agency has chosen to analyze various land disposal and treatment
facilities to which regulated high, medium, and
low exposure sites. Practically, 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 comments were critical of
EPA’s proposal to evaluate population
risk in comparing comparative risks. The
Agency believes it is useful to consider
population in comparative risk analyses
because it can identify sources of increased risk 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
MSI risks of land disposal. This could be
due to few people living in the immediate cells of an incinerator plume.

The Agency does, however, want to
calculate cases where there may be a
larger population affected by incinerator
emissions.

One commentator was concerned that
the treatment methods for a given waste
could 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 gives 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
method is determined to be less
risks than land disposal it will be used
in the determination of the BTAD.

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 BTAD
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 7 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 risks for applicable
waste treatment standards have been
instituted. Although EPA is planning to
consider
approach to today’s final
draft rules (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
characterization as a hazardous waste.

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 rules (51 FR
22964, June 12, 1986). The Agency is
promulgating the TCLP in today’s final
rule specifically for evaluation of the
solvent and check-containing wastes.

The final TCLP is promulgated as
Appendix I to Part 261.

Because the Agency is continuing to
investigate other means of defining
EC values, a definition of the
concentration of hazardous constituents in
the waste, at least in the case where treatment is based on destruction, EPA will make a decision regarding the
applicability of the TCLP to other
restricted wastes according to the final
schedule for land disposal restrictions
which was promulgated by EPA on
March 29, 1988. In addition, the
Extractions Procedure (EP) will continue to be used
to determine whether liquids of wastes are
hazardous in accordance with the
EC toxicity character of the

The Agency expects to
prospective the TC by early 28.

b. Response to comments. The
general comments EPA received on the
TCLP as it applies to its use in this
release, 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.

The Agency also summarizes modifications to the TCLP
based on further evaluation of the
procedure.

1. Use of the TCLP for

Many of the comments pointed out that use
of the TCLP was preceded. A comment
that was given for TCLP, liquid
residues, that these TCLP be used to
evaluate the effectiveness of treatment
waste treatment facilities,

Due to the Agency’s response to these
comments is not applicable (D-116).
EPA does not believe that these concerns are sufficient reasons to prevent the use of the TCLP in today's regulations. In view of the statutory deadlines, EPA was aware that the time available for public review of the testing protocols 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 procedures, in order to facilitate their evaluation of the test.

The TCLP consists of the equipment needed to conduct the TCLP and is essentially the same or an equivalent test method. EPA believes that the equipment needed to conduct the TCLP is the same as that used for the existing PD tests.

In addition to the data and information made available to the public in the January 14, 1984, proposed rule, many comments on the development and evaluation of the TCLP were received through notices of availability of reports on July 9, 1984 (FEDERAL REGISTER, July 9, 1984), and September 18, 1984 (FEDERAL REGISTER, September 18, 1984). EPA received over 130 comments on the TCLP in response to these proposals and notices. These comments were considered in issuing today's rule. EPA encourages the commenters who do not agree with the commenters' claim that the Agency has not developed and noticed for public comment to allow generators to adequately evaluate the procedures.

Another general concern expressed by commenters related to the belief that the institution of a new test would present unacceptable public or environmental concerns. Although there may be some delay, EPA does not believe that the delay would be so great as to cause the introduction of a new test protocol would not introduce unacceptable hazard to society. Some form of waste analysis is required in order to implement the land disposal restrictions rules. EPA believes that the institution of a new protocol will not cause delay beyond those required to perform a TCLP.

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 general use and had not been properly tested or validated. The TCLP has been the subject of an extensive evaluation. EPA has completed both laboratory and inter-laboratory (collaborative) studies of method reproducibility using a variety of wastes. Industry groups and contractors participated in EPA's TCLP collaborative evaluation. In addition, the Electric Power Research Institute (EPRI) also evaluated the TCLP in a collaborative study. Finally, the industry associations submitted data to the Agency from a collaborative study of the TCLP. The results of these studies are contained in the TCLP Final Protocol Document supporting today's rule (Ref. 5).

EPA believes that the test has been sufficiently evaluated.

(2) The TCLP is inappropriate for use in the land disposal restriction rule. Approximately one third of all commenters addressing the testing test argued that it is inappropriate for such use. Specifically, these commenters argued that the method would be inappropriate because it is not representative of a Subtitle D disposal facility.

Several commenters also disagree with the application of the TCLP because of different test conditions with 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 30-year post-closure period beyond the operating life of a facility. They pointed out that well-engineered hazardous waste disposal systems provide a physical-chemical environment substantially 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 test conducted by a well-engineered Subtitle C landfill that accepts treated wastes as is dedicated to a particular waste. Subtitle C facilities include only those facilities of similar size and type to the TCLP, but all of the facilities of which may be either landfills or which may contain a variety of untreated wastes. The current regulations do not prohibit the handling of similar solid wastes, nor is it unusual to put liquid solid wastes in surface conditions. Thus, a significant number of facilities may not conform to the model proposed by the commenters. In the 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 similar 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 Agency believes the constraint of today's rule is not significantly affected by changes in this predominate approach when used in this TCLP (Ref. 5). Thus, the Agency believes it is justifying its in not introducing another test for regulatory purposes.

(3) Effect of the TCLP on communities other than solvent and chlorine. Because today's rule addresses only solvents and chlorides, EPA is not responding to those comments dealing with groundwater at this time. EPA has received oversubmitted comments regarding the TCLP's use of a "trench" test method used in the TCLP (Ref. 54). Thus, the Agency believes it is justifying its in not introducing another test for regulatory purposes.

(4) Potential laboratory capacity shortfall. Several commenters argued that the TCLP may eventually be required a result of both the head disposal restrictions program and the toxicity characteristics, were commented or potential laboratory capacity shortfall. They indicated that governmental laboratories are currently backlogged with work, and that TCLP requirements, both rules would make the situation critical. We disagree with these commenters. Many commercial laboratories are presently performing TCLP analyses. For example, over 20 laboratories were involved in EPA TCLP collaborative study. In addition, EPA has reviewed that laboratories have been in the process of getting both TCLP analyses, primarily to demonstrate that the TCLP will be part of this part of both land disposal restrictions and the toxicity characteristics. Similar work has been going on to the standardization of both TCLP. We believe that the standardization process will not be completed before this time. Therefore, EPA feels it is justified in using the TCLP for the wastes covered by today's rule.
promulgated until early 1975. 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.

(8) 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., with any treatment levels excepted) 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 designed to investigate the precision of the method for long-term parameters and data specifically with utility industry wastes. This study was conducted to determine the relative contribution to total variability due to the three major components of variability: sampling variability, slurry 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).

EPA'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 dilute extracts by different laboratories. EPRI, however, also indicated that the interpretation of results may depend on the statistical approach used to evaluate the data. Nevertheless, it appears that regardless

of how data are interpreted, analytical variability can account for a major source of variability in results. EPRA's collaborative study addressed the conventional bottle extraction (i.e., for metals, semi-volatile organics, and polychlorinated hydrocarbons) and the Zero-Point-Extraction (ZPE) used for volatile organics. The results of this study, outlined in the September 21, 1979 Federal Register, presented the full results of the precision for the conventional extraction, and a summary of the results for the ZPE extraction.

This report has since been finalized. The general conclusion reached in this study was that "The TCLP should 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 ZPE. This study also examined the precision of the EP to the TCLP, and, like the EPRI study, concluded that the precision of the ZPE 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 inconsistent with EPA's effort in that the data for one of the 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 conclusion 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 many efforts are usually made to collaborate to eliminate variability due to the samples, such efforts are not always entirely successful. When sampling for waste analyses or characterization, 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 this variability is to take multiple "representative" samples of wastes 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 any apparent variability actually existed and exceeded with a certain degree of confidence (e.g., the upper limit of the 95 percent confidence interval). This approach is described in detail in Chap. 3 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 examples (Ref. 3).

(9) Applicability of the TCLP to multi-phase (ol) wastes. EPA also received substantial comments regarding the applicability of the TCLP to "ol" wastes. Commenters were both concerned that the TCLP would not distinguish "liquids" from solid material, 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 aqueous (ol) liquids in an identical manner, whereas these commenters preferred 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 difference is especially critical for oily wastes (which are known to pose filtration problems, especially with the GFF's membrane filter), as extraction of the treatment level can depend very heavily on whether the "solid" oil which the waste is defined as a liquid (i.e., that portion which does not filter and is considered solid) bears the weight of extraction. EPA notes that this is in contrast to a filter that simply rejects the aqueous portion, and believes that it is hopefully unlikely that TCLP be capable of following the movement of oily material, as these materials have been known to migrate from wastes.
Data is available which suggests that the TCLP's GFF might process any material that does the EPA's membrane filter. In developing the TCLP, EPA investigated eleven wastes to determine whether they could be handled by process parameters of the TCLP. During this phase of the development, it was demonstrated that this is effective in handling the "solid" portion of the waste as a whole.

While the CFF was selected mainly for operational reasons, the research also indicated that it was essentially more efficient at detecting contamination due to movement of the cell than was the EPA's membrane filter. The CFF is therefore expected to provide a more reasonable differentiation between liquids and solids.

While the CFF has been an improvement upon the EPA's membrane filter, in terms of its ability to pass oil, the TCLP is continuing to investigate if the TCLP's filtration regime should be altered to better predict movement of the oily phase of 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 hole to the oil phase of a waste, the EPA believes that the TCLP's filtration regime will be sufficiently capable of indicating whether oily waste meets the criteria of TCLP.

(1) Complexity of TCLP Several comments were also concerned that the TCLP is too complex and too difficult to implement. As these comments were suggested changes to the TCLP protocol. Comments further asserted that the procedure was overly burdensome. Especially for wastes containing solids and liquids.

As indicated previously, the TCLP involves a separate procedure with differing equipment. The conventional batch extraction conducted for "conventional constituents" is much simplified over the EP protocol. In fact, one of the conclusions of the EP collaborative study was to eliminate the TCLP's extraction for non-aqueous liquids, involving the ZEE. EPA believes that this analysis familiar with the EP method will have little problem, successfully conducting the TCLP. As with any new procedure, there may be concerns involving the TCLP, especially with regard to the ZEE.

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should be responsible for testing, certification, and recordkeeping. Where agreed by the permittee and the generator, the treatment facility can certify that the waste meets the applicable treatment standards.

Because the approach established in the past does not yet make sense for many waste generators, the Agency believes that the shift towards treatment of restricted waste will place an increased responsibility on treatment facilities to ensure that treated waste meets the applicable treatment standards. Although the provisions in section 120(d) allow for the ultimate responsibility for 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, that only wastes which meet the standards will be transported to disposal facilities, and that the waste generator is responsible for testing and recordkeeping. However, the disposal facility has the ultimate responsibility to ensure that all restricted waste meets applicable treatment standards before being land disposed. The generator also is required to maintain all records.

The rules promulgated today are not intended to force a generator to test or properly dispose of the waste. However, the rules do require that the generator must be able to demonstrate the waste meets the applicable treatment standards before being land disposed.

c. Generator requirements. For today’s final rule, the generator of a restricted waste must notify the treatment facility 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 upon the generator’s knowledge of the waste, the Agency recently ordered that the generator maintain the facility operating record all document and monitoring 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 (HWN) and the applicable treatment standard(s) and waste analysis data (if available). The disposal facility must place the certification of the waste generator in the operating record. A description of the waste, the waste analysis data, and the waste analysis data must be maintained by the disposal facility, and any relevant data submitted is an enforceable waste analysis data, and a notice which includes the EPA Hazardous Waste Number, the manifest number, the applicable treatment standard(s), and waste analysis data (if available). This information is maintained in the operating record, except for the required documentation.

The disposal facility, which is the generator responsible for notifying that only wastes meeting the treatment standards are land disposed, is required to ensure that the waste has been treated or disposed in accordance with the applicable treatment standards. If the treatment or disposal does not occur at the site, the testing and recordkeeping of the disposal facility must be maintained.

d. Disposal facility requirements. The treatment facility is responsible for ensuring that the restricted waste is treated to meet the treatment standard. The disposal facility is the generator responsible for testing and recordkeeping. However, the disposal facility has the ultimate responsibility to ensure that all restricted waste meets applicable treatment standards before being land disposed. The disposal facility also is required to maintain all records. The rules promulgated today are not intended to force a disposal facility to test or properly dispose of the waste. However, the rules do require that the disposal facility must be able to demonstrate the waste meets the applicable treatment standards before being land disposed.

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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, 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 of waste. Less frequent testing may be appropriate where there are fewer and less variable waste streams at the disposal facility, 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 streams, 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 the 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 owner/operator will be able to demonstrate compliance with the waste analysis requirements in § 257.4.

Where the treatment standard for the applicable waste is a specified method of treatment, the last facility to treat the waste must submit 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 § 257.5(b).

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 257.12, 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 of States or local laws). 40 CFR 257.12(e), 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 this proposed rule, the Agency requested comments on whether an amendment to 40 CFR 257.12 is necessary to permit interim status facilities the flexibility to manage restricted wastes. EPA received few comments recommending such a change, however, the comments did not provide data indicating that this provision would prevent modifications needed to comply with today's rule. The Agency is revising this issue and will modify 40 CFR 257.12 if needed, by promulgating a rule at a later date. However, at this time, we believe that the current 40 CFR 257.12 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 permit facilities, the Agency is proposing to allow treatment facilities to manage restricted wastes not listed in their permit after a 'facility modification' (51 FR 12358). 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 waste that could be added to a permit through minor modification procedures.

After reviewing the comments received, the EPA has developed the rule. EPA is proposing to add (to 40 CFR 257.12) a provision holding greater flexibility to manage restricted waste not listed in their permit. This provision would allow a treatment facility to manage restricted waste not listed in their permit if the Federal or State approving agency is still willing to do so and the facility can demonstrate a lack of available capacity.
in response to public comments and to ensure that changes made under this provision are not in fact minor, the EPA has restricted the scope of the new waste to substances listed in Subpart D of Part 252. This will ensure that the treatment is appropriate for the restricted waste. Second, as suggested by the commentators, 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 waste listed in the permit. For example, a facility not already permitted to handle a hazardous waste 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 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 apply only to restricted wastes as described above. The purpose of the amendment is to allow the prompt treatment of restricted wastes to avoid the land disposal restrictions and to increase the availability of treatment capacity. Without these changes, the EPA believes that the ability of permitted facilities to treat restricted waste 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. Both procedures would eliminate the flexibility provided by these minor modifications and could complicate or delay treatment of restricted wastes.

The EPA acknowledges that 39 CFR 722.4(a) by itself does not change the difficulties that will be faced by permitted facilities treating these wastes and estimates that 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 relate more appropriately to changes due to 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 12, 1983 in the Federal Register (48 FR 23937), and anticipates finalizing a proposed rule revising this regulation in 1985.

D. Determination of Alternative Capacity And Bas Effect Data

RCRA section 300 G(7)(a) states that the Agency may grant a nationwide variance of up to 2 years from the statutory effective dates if adequate alternative treatment, recovery, or disposal capacity exists to handle wastes is not available. The EPA will consider several factors when determining 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

The EPA will develop estimates of treatment capacity and recovery and disposal capacity available to determine if adequate alternative 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 grant an alternative effective date based on the basis of the overall date on which adequate alternative treatment, recovery, or disposal capacity exists which protects human health and the environment becomes available. Establishment of the effective date will not be affected by the persistence of petitions under section 300 G(6)(a) of the Act discussed later in this unit.

2. Regional and National Capacity

The Agency will determine both the quantity of restricted wastes generated and the capacity of alternative treatment, recovery, or disposal technologies on a nationwide basis. If there is a significant shortfall in capacity to handle all of the restricted wastes, the Agency will extend the effective date of the prohibitions. If no shortfall exists and technology capacity is only slightly lacking, the EPA may grant a case-by-case effective data extensions while allowing the nationwide prohibitions to go into effect immediately. If national capacity is sufficient, the prohibition will become effective immediately. Even if, for whatever reason, the only capacity for a waste generated in California is located in Ohio, many commenters urged EPA to make region instead of national estimates of the recovery and available capacity.

However, the national approach is consistent with congressional intent.

The Senate legislative history provides that "the available capacity determination is to be made on a national basis" (S. Rep. No. 94, 94th Cong., 1st Sess. 19 (1975)). That is, the effective date of the prohibitions for a given waste in one region of the country is not affected by the availability of recovery and disposal technologies in another region because one region has sufficient alternative capacity and never does. If land disposal is prohibited in only a portion of the country, it is possible that wastes generated in another region could be transported outside of the region, without affecting the record.

In cases where EPA has not granted a nationwide variance, it is not excluded from granting case-by-case extensions. It may be more desirable to grant limited land disposal or recovery extensions to specific applicants who lack alternative capacity only than to allow everyone, even those 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 date.

The EPA also may grant variances of less than 2 years, even though not all facilities may need to be completed. Wastes requiring the capacity from unregulated facilities could be handled by case-by-case extensions, without allowing a constructed but not disposed national sitewide.

If the Agency determines that the effective data is insufficient, it may be appropriate to extend the effective date of the prohibitions. If the available capacity is sufficient, the Agency will extend the effective data of the prohibitions. If, however, the Agency determines that the available capacity is not sufficient, the Agency may grant a case-by-case effective data extension.
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 provisions become effective if available data (including data from case-by-case extensions 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 becomes adequate. However, after EPA promulgates a nationwide effective date, this data is not likely to be amended because it is unlikely that federal rulemaking activities can be completed in a significantly less than 2 years.

4. Determination of Capacity Requirements by Waste Treatment 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 treatment group. These treatment groups will establish EPA to combine 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 rulemaking that affects federal limits on demand for treatment. As necessary, EPA will establish 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 are regulated in the same or in a new rulemaking. However, total capacity may be insufficient to satisfy all existing waste groups. 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 required 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-site facilities, which include permitted facilities and facilities operating under RCRA interim status, and planned facilities and capacity estimates that will be on-line by the effective date of a land disposal prohibition.

Current on-site facilities consist of off-site and on-site facilities, including batch stationary and mobile facilities which have been approved by Federal, State, and local agencies to operate and accept 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, supporting that interim status facilities may not provide final disposal. However, unless EPA determines that the effective capacity of an interim status site is sufficient to meet the RCRA interim status requirements, the Agency will not provide final disposal.

In those cases where standards based on EDAT are not deemed to be fully protective of human health and the environment, the Agency may, as a matter of policy, control the mandatory standard sufficiently to extend the effective date of a prohibition to ensure adequate treatment, or as required by the existing capacity of treatment technologies. The Agency will consider additional treatment technologies in the development of protective treatment technologies. In those cases where EDAT is not fully protective, the Agency believes that waste communities will develop alternative treatment methods, including the use of available data and historical experience, to develop protective alternative treatment methods. The Agency believes that waste disposal and landfills must be demonstrated to provide adequate treatment standards for the waste 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 waste 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.

6. Definition of Alternative Treatment Capacity

The Agency believes that treatment technologies that are available in the standards established under section 3004(m) can be considered available treatment capacity under the provision in section 3004(m).

Section 3004(m) directs EPA to establish standards based on treatment that will maintain 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 EDAT. In most cases, treatment levels or methods based on EDAT are expected to fully protect human health and the environment. Accurately, technologies that form the basis for each standard are considered for the capacity calculations under section 3004(m) and (n).

In those cases where standards based on EDAT are not deemed to be fully protective of human health and the environment, the Agency may, as a matter of policy, control the mandatory standard sufficiently to extend the effective date of a prohibition to ensure adequate treatment, or as required by the existing capacity of treatment technologies. The Agency will consider additional treatment technologies in the development of protective alternative treatment technologies. In those cases where EDAT is not fully protective, the Agency believes that waste communities will develop alternative treatment methods, including the use of available data and historical experience, to develop protective alternative treatment methods. The Agency believes that waste disposal and landfills must be demonstrated to provide adequate treatment standards for the waste 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 waste 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-site recovery and disposal facilities that are protective of human health and the environment. These facilities are disposed of a defined site-specific pollution control strategy. The Agency believes that the site-specific pollution control strategy is adequate to address the hazardous constituents for as long as the waste is actively hazardous (and facilities where A dispos photograph is
pending, but not granted). Planned facilities, including expansion of existing facilities, also will be considered here.

However, alternative land disposal methods (e.g., deep well injection) will not be considered as an 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 an available disposal capacity, until the Agency has determined whether the injection of such waste 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 1972.

3. Estimation of Capacity

EPA will estimate the annual unused or surplus capacity of alternative treatment, recovery, and disposal facilities that are available nationwide to manage wastes restricted from land disposal. The Agency will also determine nationwide capacity (capacity supply) to the quantities of restricted waste generated annually nationwide (capacity demand).

Surplus capacity will be expressed as an annual unused or surplus capacity. Surplus data can be obtained in some instances. EPA may use other available information to calculate capacity, such as the difference between projected 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 are 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 additional private capacity not yet 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 the treatment and disposal of hazardous waste and because EPA has considered only commercial capacity for the surpluses,

In today's final rule, capacity under estimates are based on currently available information, including the Technical Survey of Treatment, Waste Conservation and Disposal Facilities regulated under RCRA (1977 RIA Mail Survey, RCRA Data Booklet), for the purpose, a 1972 EPA study on incineration and incineration capacity (Ref. 14), a 1975 survey of the National Association of Street Department (Ref. 16), and the 1976 EPA Hazardous Waste Survey (Ref. 17). The Agency is developing a new survey of commercial and private treatment facilities which will address the concerns of generators who pointed out the need for an updated data base. EPA intends to use data from this survey in making capacity determinations for future regulations.

4. Application of the Minimum Technological Requirements

Section 300.40(a)(4) provides that during the period of a national variance (Secs. 300.40(a)(1) and (2)) the waste may be disposed in a landfill or surface impoundment only if the facility is in compliance with the applicable treatment standards. EPA proposes to issue a variance to 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 additional private capacity not yet 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 the treatment and disposal of hazardous waste and because EPA has considered only commercial capacity for the surpluses, this does not preclude its use for disposal of these wastes before August 1972.

5. Estimation of Capacity

EPA will estimate the annual unused or surplus capacity of alternative treatment, recovery, and disposal facilities that are available nationwide to manage wastes restricted from land disposal. The Agency will also determine nationwide capacity (capacity supply) to the quantities of restricted waste generated annually nationwide (capacity demand).

Surplus capacity will be expressed as an annual unused or surplus capacity. Surplus data can be obtained in some instances. EPA may use other available information to calculate capacity, such as the difference between projected 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 are 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 additional private capacity not yet 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 the treatment and disposal of hazardous waste and because EPA has considered only commercial capacity for the surpluses, this does not preclude its use for disposal of these wastes before August 1972.
volume of the impoundment, the 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 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
extraction 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),
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 3004(i)(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(i)(11), unless the impoundment
qualifies for certain exemptions.

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 3004(i)(11), 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
3004(i)(14). See "Interim Status Surface
Impoundments Retrospective Variance
Guidance Document," EPA/530-SW-86-
017, July 13, 1988. For information

concerning the requirements specified in
RCRA sections 3004(i)(12) and (i)(11) An
owner or operator of an existing surface
impoundment must apply to the
Administrator prior to November 8,
1983, 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 3004(i)(12) or
(i1). Paragraph (i)(12) pertains to certain
wastewater treatment unit. Paragraph
(i1)(13) pertains to certain impoundments
subject to corrective action
requirements. However, in specifying the
requirements in section 3004(i)(11)(A) for surface
impoundments that are used to treat restricted wastes,
Congress specifically included only the
section 3004(i)(11)(B) and (i)(13) 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 3004(i)(12) or
(i1), nonetheless, would be prohibited from treating restricted wastes.

3. Case-by-Case Extensions

According to section 3004(i)(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
taken 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 final


disposal restrictions, including the conditional
prohibitions on storage under § 258.52.

Any landfill or surface impoundment
depositing waste during the extension
must comply with the ground water
monitoring, liner, and leachate

collection system requirements in
§ 258.4(a)(1).

The majority of the comments
supported the proposed approach for
case-by-case extensions. However, the
Agency received comments requesting
modifications to several aspects of the
proposed rule. Section 3004(i) of today's
final rule incorporates the procedures
for case-by-case extensions essentially
as proposed, but with modifications
based on those comments:

1. Demonstrations Included in
Applications

a. The applicant is made a good-
faith effort to locate and contract with
alternative technologies nationwide.

b. 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(i)(4) 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 § 258.54(a)(1) and
(a)(3).10 EPA's "1985 Hazardous Waste
Treatment Directory" (available at no
cost in limited quantities from the
EPA's Superfund Hotline or available
for sale through the National Technical
Information Service (NTIS) as FES0
4178431/AS) lists commercial treatment
and recycling facilities that are
Identified from the Hazardous Waste
Data Management Systems (RWDMAS).

A up-to-date list of commercial
treatment and recycling facilities is
being prepared from data gathered from
the 1983 National Screening Survey of
Hazardous Waste Treatment,
Disposal, and Recycling Facilities. The
new Treatment Facility Directory.

10 In cases where a waste cannot be treated by
the EDOT method or at the specified land using
EDOT, the generator or owner/operator may
contact the Agency for a waiver than the
治 treatm赖 standards under § 258.54.
prepared from the assessment, no legal action is expected to be available in November 2002.

b. Binding contractual commitments

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 § 222.5(a)(1) 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. EPA does not see any legal or economic reason to limit the on-site alternative capacity that the applicant is authorized to use. The applicant must demonstrate that the facility will be capable of providing the alternative capacity in accordance with § 222.5(a)(1).

7. Drafting a contract

The Agency agrees that the Agency should provide a draft contract for the applicant to use in determining whether the alternative capacity is adequate. EPA believes that the draft contract should be used to assist the applicant in determining whether the alternative capacity is adequate. The draft contract should include the terms and conditions of the contract, including the terms and conditions for the contract. The draft contract should also include the terms and conditions for the contract.

8. Government contracts

The Agency agrees that the applicant must demonstrate that the alternative capacity is adequate. EPA believes that the alternative capacity is adequate if the applicant can demonstrate that the alternative capacity is adequate. The applicant must demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant. The applicant must also demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant.

9. Government responses

The Agency agrees that the application must demonstrate that the alternative capacity is adequate. EPA believes that the application must demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant. The application must also demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant.

10. Government responses

The Agency agrees that the application must demonstrate that the alternative capacity is adequate. EPA believes that the application must demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant. The application must also demonstrate that the alternative capacity is adequate by providing the alternative capacity to the applicant.
lateral expansions and replacements referred to in section 300(d)(4) are, in compliance with the requirements of that section. Because existing units are excluded from section 300(d), they would also not be required to comply with the minimum technological requirements under section 300(h)(6).

Section 300(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 300(h)(1). These requirements include double liners (with limited exceptions).

Construing section 300(h)(4) to require minimum technological requirements for all units would mean that a prohibition 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 300(d). EPA believes that the statute should not be construed to require such an obvious result. Therefore, today's rule requires that the facility be in compliance with the regulatory provisions that incorporate the requirements of section 300(h)(4).

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 "Exhibit: " should be submitted to:

Applications containing confidential information should be sent with only the inner envelope marked "Exhibit: " and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (21 FR 30502, September 2, 1978, as amended by 29 FR 25059).

3. Review of Applications for Extension

Several commentators recommended that the Agency establish regulatory time constraints for reviewing extension applications under § 300.4(4). One commenter specifically required deadlines similar to those for evaluation of delaying petitions pursuant to section 300(h)(4). 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 seven reasons.

First, EPA cannot anticipate the level of resources necessary to process applications. As of August 8, 1984, 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 delaying 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 applicant.

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 agrees with the commenter. "Case-by-case" extension process would be used to cover those rare situations when an individual applicant can demonstrate that capacity will be reasonably available to him even if national capacity is otherwise insufficient. As stated earlier, the variance is based on the "feasibility" of providing alternative capacity.

5. Length of the Case-by-Case Extensions

As discussed in the proposed rule, case-by-case extensions cannot exceed beyond 48 months from the statutory land disposal restriction dates. Therefore, extensions will not exceed the following dates:

- For certain listed dioxin-containing and solvent wastes: August 8, 1984, for wastes identified as California List wastes.
- For the remaining hazardous wastes: June 1, 1985, for the second third of the listed hazardous wastes.

On the applicable effective date, a restricted waste is subject to the provisions of Part 253 until a case-by-case extension is granted. For example, if a person requests an extension on January 1, 1984, for a solvent waste restricted from land disposal on November 8, 1984, the waste is restricted from land disposal on November 8, 1984, until the extension is granted. The extension would not exceed the November 8, 1984, deadline.

The effective date for certain newly listed wastes may fall after the May 8, 1983, date for scheduled wastes. Such wastes may receive extension beyond the May 8, 1983, date. EPA anticipates 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 to 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 1983, 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 permit extensions for restricted solid wastes that anticipate that they may be affected by a specific extension should contact EPA. EPA will consult with appropriate agencies in the affected States as provided by Section 300(g)(2). EPA expects that states interested in extending deadlines will be those interested in further delays in the extension process and those with low capacity under development.
can expedite the review process by submitting information containing how the wastes will be managed in each of the affected States as part of the demonstrations under 40 CFR 236.4.4(b), (c), and (e).

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 leachate arising as long as the wastes remain hazardous. (RCRA section 3004(d), 42 U.S.C. 6924(d)(1)).

In demonstrating "no migration," the Agency 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 assurance that the statutory standard requires. However, these units may satisfy the standard when the petitioner is requesting temporary storage of restricted wastes 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 monofilament located in an arid climate with no ground water recharge.

Another example involves placement of a small volume of combustible waste in a massive and stable salt dome formation. The second would rely on an active chemical or physical process, such as the perchloric acid treatment of hazardous waste in a surface impoundment, where no hazardous waste remains in the unit. This is especially applicable to radioactive waste. The third involves the temporary storage of hazardous waste in a land-based unit, such as an indoor waste pile, where engineered containment systems are effective over the period the waste remains in storage.

The "no migration" standard closely 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 malfunction 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 § 236.4). Two copies of the petition should be submitted (by registered mail) to the Administrator. The Agency will then review the 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 commentators recognized that there may be particular waste streams that cannot be treated to the A+1 level by the method specified by the treatment standard. The Agency agrees with these commentators, and is establishing a procedure to evaluate petitions for a variance from the treatment standard.

The Agency concludes 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 EDAT 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 matrices 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 6, 1973, the Agency published a Notice of Availability of Data to the Federal Register (48 FR 31773) 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. Commentators 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 treatability standards by rulemaking, urged the Agency to adopt a more streamlined variance procedure similar to that used in other EPA rulemaking. 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(d).

The Agency is providing for a variance from the treatment standard under 40 CFR subpart E of today's rule. Consistently, the new provision will allow applicants to use procedures similar to those used for rulemaking petitions under 40 CFR.
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 reclassification. 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 the waste prior to the variance 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 showing that adequate EBAT treatment capacity is unavailable. Such demonstrations can be made according to the provisions in § 264.5 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 Variances" should be submitted to:

Chief, Waste Treatment Branch, Office of Solid Waste (405-S), 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 Variances" and "Confidential Business Information," and the contents marked in accordance with the requirements of 40 CFR Part 2 (45 FR 10282, September 1, 1979, amended by 49 FR 12220).

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 person contact;
(4) The process(e) and feed materials generating the waste and an assessment of whether such process(e) 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 waste considered by the Agency in developing EBAT, 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 EBAT 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 Agency may request the appropriate EBAT 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 system examined by the petitioner, if any, a description of the reasons the system deemed appropriate by the petitioner for the waste in question, and, as appropriate, the concentrations in the treatment residual of 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, concentration, 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 and under § 264.3(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 EBAT, the Agency will evaluate the waste to determine if the waste criteria and/or physical parameters are such that the EBAT 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 Part 265.

V. Treatment Standards for Solvents

A. Introduction

On May 18, 1982 (45 FR 15810), the Agency listed 27 commonly used organic solvents as hazardous wastes which were to be regulated. The solvents were listed in HAZRINTS Waste Nos. F001, F002, F003, F004, and F005. The listed solvents include certain spent haleogelated and cor- heleogelated in events, and still bottoms from the recovery of these solvents. The solvents are listed in the Annex to the Final Rule to the hazardous waste regulations, 40 CFR Part 260, Subpart D.

In the proposed rule to the land disposal restrictions, several comments were received which requested that the Agency clarify the scope of the solvent listings. The Agency recognizes this problem and has included the following comments in its rule to further clarification of the F001-F005 solvent listings.

The solvent listings cover only those solvents that are used in the solvent properties—that is to solubilize (dissolve) or stabilize other constituents. For example, solvents used in degreasing, cleaning, and processes involving as driers, extenders, resins, and synthetic waxes and similar
applications are covered under the
listing (what "spills"). A spill is
considered spent waste if the tank
has been used and is no longer fit for use without being
refilled, replaced, or otherwise
reprocessed.

Manufacturing process waste where
solvents were used as reactants or
reactants in the formulations 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, 1982)
available in the RCRA docket.

Today’s final rule does not include
treatment standards for the commercial
chemical products, manufacturing
chemical intermediates and all
specification commercial chemical
products (P and U wastes) that
correspond to the F001-F005 spent
waste categories. These wastes will be
addressed according to the schedule
promulgated on May 2, 1983 (51 FR
19030). The final rule also does not cover
the four newly listed solvents in the
F001-F005 listing benzene, 2-
ethoxyethanol, 2-propanol, and
1,2,3-trichloroethylene (51 FR 6537). The
Agency currently is gathering data to
tfully 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
categoricals listed in Table CW2:
tetrachloroethylene
trichloroethylene
methylene chloride
1,1,1-trichloroethane
carbon tetrachloride
chlorobenzene
1,1,2-trichloro-1,2,2-trifluorohane
chloroform/chloroform
trichloroethylene
xylene
aceton
ethyl acetate
ethyl benzene
e-ethyl ether
methyl ethyl ketone
n-butyl alcohol
cyclohexane
methanol
cresols (creosote acid)
toluene
isobutyl
carbon disulfide
nitrobenzene
pyridine
methylene chloride

Table: Containing these solvents
also are subject to the treatment
standards promulgated in today’s final
rule.

The treatment standards are also
effective on November 3, 1972, for 63
F001 through F005 spent wastes as which
do not meet any of the criteria
established for national two-year
variance. Solvent wastes that contain
least one of the criteria subject to
the variance and will be restricted from
land disposal effective November 8,
1983. 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 on or
under RCRA 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, 1983.

3. The solvent waste is a solvent-water
mixture, a solvent-containing sludge,
or a solvent-contaminated soil
(non-RCRA or RCRA corrective
action) containing less than 1 percent.

Total F001-F005 solvent categories
listed in Table CW2 is of 201.4.

8. 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 on
the F001-F005 spent solvents. Most of
the F001-F005 spent solvents, as defined in
40 CFR 261.51, are generated from
manufacturing operations where
solvents are used as reactive 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) Pretreatment
(4) Oxidation
(5) Chemo-physical treatment
(6) Carbon adsorption
(7) Air stripping
(8) Wet scrubbing

All of these technologies have
demonstrated and continuously
available. EPA has determined that
none have been found to be either the
lead disposal (see Unit IV. D. for a
detailed discussion)

Below is a brief description of each of
these technologies and their general
applicability to the various solvents.

The DAT background
document provides a detailed discussion
of these technologies:

Batch Distillation. Batch distillation is
used to separate various organic
compounds from a contaminated spent
solvent mixture in order to recover
and reuse the individual compounds. The
separation is accomplished by the
addition of light solvent, which moves
the more volatile components to the top.
Batch distillation generally is used in areas
where the recovered solvent has
sufficient economic value to defray 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 quantities 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 co-axial or as an 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.

Thin Film evaporation. This
technology is also a demonstrated
distillation process. A thin film
evaporation can be used for
processing high-boiling-point,
considerably lower boiling point
fractions in the spent solvent stream.
This film evaporation system is
considerably less complex, more
flexible in this process, and more
economical than batch distillation.

Some of these technologies may
eventually be applied for
spending waste containing one of the
solvents.
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 those 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 developed and relatively 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 FDI-FOX 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 and/or phosphoric acid.

Incineration generates one or two residual wastes that need to be land disposed depending on whether the incinerator includes steam and/or water vapor controls. The residual wastes are the incinerator ash and the scrubber sludges or air emission control dust. The vast majority of incinerator residues that will require land disposal is generated by rotary kiln incinertors 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 questionnaires for facilities capable of performing steam stripping revealed that 17 full-scale facilities perform steam stripping of spent solvent wastes and that three facilities perform steam stripping specifically on FDI-FOX spent solvents.

1. 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, trickling filters, and fixed film processes, anoxic 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 biomass sludge contains dead and living microorganisms containing nonbiodegradable inorganic compounds, as well as any organics that are not degraded (inert refractory organics) and are adsorbed by the biomass. Depending on the composition of the spent solvent wastes, 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 FDI-FOX 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 used in combination with steam stripping or biodegradation treatment.

h. Air stripping. Air stripping is a method for removing low concentrations of volatile organic compounds, such as solvents, from wastewater. During air stripping, air or steam is blown into contact with the water to remove the volatiles. The volatiles are then condensed and removed from the airstream. The technology is used in combination with other treatment processes where the wastewater is not contaminated with spent solvent wastes. The Agency believes that this treatment technology is not applicable to wastewaters contaminated with spent solvent wastes.

2. Determination of Treatment Standards (BTAD) for Spent Solvents.

a. Data base. The majority of the data used in developing BTAD for FDI-FOX solvents were from full scale treatment. The Agency included some bench and pilot-scale data for 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 23 plants in the organic chemicals, plastics, and synthetic fibers industries which manufacture, in total, over 200 different products. These data were from treatment of wastewaters containing FDI-FOX constituents. As a result of these data, the Agency has modified its BTAD for spent solvent wastes. The Agency believes that this treatment technology is not applicable to wastewaters contaminated with spent solvent wastes. The Agency has biological treatment data on six carbon tetrafluoride, chlorobenzene, cresol, 1,1-dichlorobenzene,
The Agency analyzed full scale data from four plants and pilot scale data for treatment of contaminated ground water. The full scale data represented treatment of carbonic COB solvents at one plant, and the remaining three plants were treating wastes containing FOCI-FOB constituents generated as process contaminants. The Agency analyzed stream stripping data on ethylbenzene, ethylene chloride, methyl isobutyl ketone, nitrobenzene, trichloroethylene, and tetrachloroethylene.

For carbon adsorption, the Agency analyzed full scale data from four plants and pilot scale data from one plant. At one of these full scale plants, carbon adsorption was used after biological treatment. The Agency obtained data on chlorobenzene, 1,2-dichlorobenzene, nitrobenzene, toluene, and tetrachloroethylene from this facility. At another full scale plant, carbon adsorption was used after steam stripping. The Agency obtained data on chlorobenzene, 1,2-dichlorobenzene, nitrobenzene, toluene, and tetrachloroethylene from this facility. In the third case, EPA had full scale data from a plant in the pesticides industry which generates wastewater containing creosols. EPA has full scale data for process wastewater containing creosols at the fourth plant. Pilot scale data for tetrachloroethanes are available on treatment of contaminated drinking water. Pilot scale data are also available for ethylbenzene, methyl isobutyl ketone, nitrobenzene, toluene, and chlorobenzene on treatment of runoff water from a waste disposal site.

For wet oxidation, the Agency analyzed pilot scale data for ethylene chlorides, methanol, methyl ethyl ketone, nitrobenzene, toluene, and tetrachloroethylene. 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, tetrachloroethanes, methyl isobutyl ketone, toluene, and ethylbenzene.

The Agency also analyzed the extract of more than 7,000 incinerators at 50 facilities. All incinerators were operating full scale and treating a variety of wastes including paint solvents. The FOCI/FOB constituents for which data were available are acetone, carbon disulfide, chlorobenzene, dichlorobenzene, ethylbenzene, methyl isobutyl ketone, methyl isobutyl ketone, nitrobenzene, and tetrachloroethylene.

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 is derived from an analysis of the performance of the technologies performed significantly better, in cases where the 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 the best technology used. In all cases, the treatment standards are based on the best technology available at the time for estimating treatability. The final standard for the range of physical and chemical properties of the constituents included in the treatability group.

The Agency established separate treatability group for the range of FOCI/FOB constituents and the treatment standards for each group are based on the best technology available at the time. EPA established the treatment standard for the control of FOCI/FOB treatment of wastes containing total creosote carbon of one percent or less. In the general wastewater category, available data supported a separate treatability group for spent solvents. The final treatment standards for spent solvents were based on the best available data.
can be achieved for all PFI-FG solvent solvents. Any changes made to the treatment standards as a result of quantification levels can be found in the EDAT development document.

The Agency revised the proposed data editing procedure which excluded data when the inferred value less than the screening level (inversely 2.0 ppm). In today's final rule all data are used provided inferred concentrations are above quantitation levels.

The departure from the proposed rule which most affected the final treatment standards is the incorporation of a variability factor. The EDAT background document contains all data used to develop the treatment standards and a discussion of procedures used to evaluate these data in determining EDAT for each constituent of concern within a treatability group.

<table>
<thead>
<tr>
<th>Consistencies of PFI-FG solvent solvents</th>
<th>Waste treatability groups for PFI-FG solvent solvents</th>
<th>Treatment standards for PFI-FG solvent solvents</th>
<th>All other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions</td>
<td><em>1,06</em></td>
<td><em>9,13</em></td>
<td><em>0,70</em></td>
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<tr>
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<td><em>1,26</em></td>
<td><em>0,70</em></td>
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<td><em>0,73</em></td>
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<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<td>Ceramides</td>
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<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<tr>
<td>Cyclic primary alcohols</td>
<td><em>1,00</em></td>
<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<tr>
<td>Cyclic secondary alcohols</td>
<td><em>1,00</em></td>
<td><em>9,10</em></td>
<td><em>0,73</em></td>
</tr>
<tr>
<td>Unsaturated alcohols</td>
<td><em>1,00</em></td>
<td><em>9,10</em></td>
<td><em>0,73</em></td>
</tr>
<tr>
<td>Monopolar alcohols</td>
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<td><em>0,73</em></td>
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<tr>
<td>Monopolar primary alcohols</td>
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<td><em>0,73</em></td>
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<tr>
<td>Monopolar secondary alcohols</td>
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<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<td>Monoepoxy alcohols</td>
<td><em>1,00</em></td>
<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<tr>
<td>Peroxide</td>
<td><em>1,00</em></td>
<td><em>9,10</em></td>
<td><em>0,73</em></td>
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<td><em>0,73</em></td>
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<td><em>0,73</em></td>
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<td>Monopolar primary alcohols</td>
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<td>Hydrocarbons</td>
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<td><em>9,13</em></td>
<td><em>0,70</em></td>
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</tbody>
</table>

The Agency has conducted a detailed analysis of these risks. Results of the analysis 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 landfills located in a geographical area that provides optimal containment (e.g., compacted clay).

The Agency stated in the preamble that whenever it is possible that a technology is riskier than land disposal, the Agency is to establish additional regulatory requirements on metals emissions from incineration of metal-bearing solvent wastes within the statutory deadline for solvent waste, because the Agency lacks sufficient data on the feasibility of reducing metal emissions by waste treatment or incinerator controls. However, the Agency has initiated a program under the authority of section 301(1) of the CWA to develop regulatory controls for metal emissions from incineration of hazardous waste, including solvent waste. EPA plans to publish a proposed rule by 1977 and a final rule by 1978 a regulatory program to 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 Waste for Disposal

EPA estimates that 2,300 million gallons per year of solvent waste are managed and disposed and is expected to increase by 490 million gallons per year at today's rate. This is equivalent to a 21% increase over the 1970 activity level if published in the proposed rule. The EPA estimates included in the analyses of PFO, PFO, FOD, POF, and FOC. 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 project 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 11.3 million gal/yr of P and U wastes which were previously included in the proposed rule.

A second modification is more significant. The quantity estimate in the proposed rule included wastes that were mixed with, and sometimes segregated from, spent solvents. All of these other wastes 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 non-solvent wastes. This assumption was based on limited descriptions of the wastes provided by some generators indicating that these wastes primarily contained solvent-water mixtures. In the proposed, EPA also determined that the resultant quantity of concentrated segregated solvent wastes could not be accurately estimated 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 segregated solvent waste 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 non-solvent components (primarily water) without treatment. This change results in an increase in solvent-water mixtures (land disposed 4.631 million gal/yr and off site 1.4 million gal/yr) and a decrease in the quantity of waste code UF30 for P and U wastes (land disposed 18 million gal/yr).

A third modification involved the correction of invalid data used at proposed. The CCR RIA lacked data on a survey of Treatment, Storage, and Disposal (TSD) facilities regulated in 1991. 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 reporting somewhat large quantities of recyclable organic liquids being land disposed, EPA decided to verify whether these facilities had made an entry in the data submitted. EPA performed follow-up inquiries to these facilities in order to modify the estimates of their actual/chemical forms of these wastes and (P and U).

These responses were the subject of a request for comments published in the Federal Register on September 5, 1974 (49 FR 11986). Some of the facilities indicated that they no longer handled these wastes. However, EPA does not believe that these reports of full or partial closure can be extrapolated accurately to the entire 1991 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 that a broad modification to the survey, in order to extrapolate these closures to the universe of facilities, would reasonably disrupt the statistical reliability of the 1991 survey.

However, EPA does believe that telephonic responses support very limited changes to the descriptions of wastes at the facilities in the data base. The responses from two facilities indicated that the 1973 million gal/yr waste and a 21.3 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 1.3 million gal/yr waste that had been identified as an organic sludge was actually a solvent water mixture that had been treated in an incinerator. This waste also had been double-counted as being land disposed in landfill. Two additional waste streams treated in limeponds also had been double-counted as being land disposed in landfill.

Therefore, the quantities of these wastes which were subtracted from the total quantity of waste land disposed and subtracted from the total.

A fourth change to EPA's estimate is based on EPA's determination that none of the CCW RIA Mail survey that were not described should have been added to the total organic liquids land disposed rather than distributing the waste to the land disposal/chemical forms. EPA believes that increasing the underreported waste stream proportions organic liquids in comparison with the type of waste that they identified as the basis for listing these solvent wastes as hazardous. Spent solvents and still bottoms usually are purgeable organic liquids. This modification improves 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 0.4 million gal/yr of solvent wastes from small quantity generators increased from the estimate of 0.3 million gal/yr for the proposed rule as a result of rethinking of calculation error. More importantly, the proposed rule contained no quantifiable estimate for increases in solvent wastes anticipated to result from fossil fuel-related emissions taken by the Agency under CERCLA or RWSA corrective actions. For today's rule, this has been estimated to be 2.5 million gal/yr. The 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 waste, including small quantity generator and CERCLA wastes, is increased to 4.29 million gal/yr for today's rule.

2. Reanalysis of Land Disposal Procedures

The EPA has reassessed the 1973 data account 255,000,000 of the estimate described in the proposed rule. Complete analysis of the data is provided in the Background Document to support today's rule. The following calculations indicate how the previous weight is distributed among the various land disposal management techniques. A change today's rule.

These three factors are taken as the waste which is most widely taken.
disposed correctly. As mentioned earlier, EPA estimates that the quantity of solvent wastes handled in the industry increased by 100 million tons per year for the hazardous waste category and by 20 million tons per year for the non-hazardous waste category. The increase in waste quantities was due to increased production and an increased demand for solvent products by industry.

Several alternative treatment technologies were evaluated by the EPA, such as incineration, stabilization, and chemical treatment. These technologies were evaluated for their ability to reduce the hazardous waste potential of the solvent wastes.

The comments received from industry and environmental groups were reviewed and evaluated. A summary of the alternatives considered is presented below.

5. Summary of Quantities Requiring Treatment

Based on the RIA, the quantities of solvent wastes requiring treatment are estimated to be 240 million gallons per year for hazardous wastes and 40 million gallons per year for non-hazardous wastes.

6. Comments on Types of Treatment Required

Solvent wastes are generally classified as hazardous wastes, and the treatment required is based on the classification. Hazardous wastes are those that are classified as hazardous under the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Non-hazardous wastes are those that do not meet the criteria for hazardous waste classification.

In conclusion, the EPA has evaluated the quantities and types of solvent wastes generated by the industry and has recommended alternative treatment technologies to reduce the waste quantities and improve environmental performance.
Several commenters suggested that defining solvent-water mixtures as those wastes containing less than 1.5 percent total organic carbon (TOC) would exclude many nonhazardous wastewaters which they indicate typically contain greater than 1.5 percent total organic carbon. The Agency has reevaluated its position on the method for determining total organic carbon (TOC). Final, F10, F20, F30, and F40 wastes are considered solvent-water mixtures (wastewaters). For the purposes of today's rule, the Agency is defining an "acoustical solvent waste" as any F01, F02, F03, F10, and F20 solvent waste that is primarily water and contains either (1) less than 0.1 percent total inorganic solids or (2) less than 1.5 percent total solvent (defined as the arithmetic summation of the individual solvent concentrations for those constituents for which all of these definitions apply) for 70 percent total solvent concentration or exceed 1.5 percent total solvent concentration and are therefore considered to be solvent-water mixtures, solvent-inorganic sludge 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 NAWS waste treatment methods that are allowed by the final standards. Some incineration waste will also be directed to pyrolytic technologies, including those used in the chemical industry, to produce fuel. In the event, EPA anticipates the unused capacity that is currently available to treat or recycle solvent wastes.

As explained in Unit 97,347, "Pyrolytic treatment, recycling, and disposal capacities will be considered in two circumstances: (1) If a private or owner operator plans to accept restricted waste commercially on or before the effective data of the restricted use (or 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 study of the capacity of solvent treatment and recycling solvent wastes will be based on estimates of demand capacity at facilities that are or will be offering commercial services by November 1988.

1. Capacity for Incineration Plants

BDAT wastewater treatment methods for solvent-water mixtures and biological degradation processes are commercially available and carbon recovery systems are commercially available and will be based on estimates of demand, carbon recovery systems are commercially available and will be based on estimates of demand.
although not CDAT, 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 Term regulations.

For the proposed rule, the RIA Mail Survey used EPA's only source of data on the existing capacity of tank treatment systems in the United States. Hence, the RIA Mail Survey data does not contain information on the existing capacity of tank treatment systems. In its use of the RIA Mail Survey data, EPA also used the RIA Mail Survey to estimate the commercial status of tank treatment systems and reevaluate the capacity of tank treatment systems. Thus, the RIA Mail Survey data, in combination with the data from the RIA Mail Survey, provides a comprehensive picture of the commercial status of tank treatment systems in the United States. EPA used the RIA Mail Survey to estimate the commercial status of tank treatment systems and reevaluate the capacity of tank treatment systems. Thus, the RIA Mail Survey data, in combination with the data from the RIA Mail Survey, provides a comprehensive picture of the commercial status of tank treatment systems in the United States.

2. Capacity for Fuel Substitution

Commuters expressed concern that in the proposed 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 that the importance of fuel substitution but did not have sufficient data base to develop estimates for the proposed rule. Since the proposed rule was developed a new data base from the 1988 National Screening Survey. This information was included in the Notice of Availability on September 8, 1989.

The new data base shows that at least 18 hazardous waste management facilities in the United States have approximately 19 million gallons of available capacity for fuel substitution and 10,000,000 gallons of available capacity for fuel substitution and 10,000,000 gallons of available capacity for fuel substitution and 10,000,000 gallons of available capacity for fuel substitution and 10,000,000 gallons of available capacity for fuel substitution. Because many facilities that are not regulated hazardous waste management facilities have reported no available capacity for fuel substitution, the available capacity for fuel substitution is greater than 19 million gallons.

4. Capacity for Distillation

In the proposed rule, EPA estimated that the proposed capacity for distillation is 10 million gallons per year. Several commenters questioned the applicability of these capacity estimates to systems requiring hazardous waste management facilities. EPA recognizes that not all waste may be acceptable for all systems. However, the additional capacity available to systems requiring hazardous waste management facilities is only 9 percent of the available capacity. Therefore, EPA assumes that it is reasonable to expect that there is adequate distillation capacity for the additional capacity available to systems requiring hazardous waste management facilities.

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:

<table>
<thead>
<tr>
<th>Estimation of Demand and Available Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment or Recovery Technology</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>Cumulative</strong></td>
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<tr>
<td><strong>Benzene</strong></td>
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<tr>
<td><strong>Toluene</strong></td>
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<tr>
<td><strong>Ethylbenzene</strong></td>
</tr>
<tr>
<td><strong>Xylene</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Analysis of the demand and capacity shows that available treatment and distillation capacity for the restricted solvent wastes will be exhausted by the
regulation but capacity for fuel
substitution and distribution 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 these
technologies. EPA has assigned
the entire capacity demand for CCR/CA
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.

To address the shortage of
incineration capacity, EPA is granting
a two year national variance to CCR/CA
response action and RCRA corrective
action wastes at or below 22,7 million
gal/year) and solvent-containing sludges and solids
(22.7 million gal/year) and small
capacity generator wastes (4.6 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 aggregated because of
EPA's limited data base. Therefore, EPA
will grant a variance to all solvent
wastes because of the significant
capacity deficiency identified.

VI. Treatment Standards for Dioxin-
Containing Wastes

A. Introduction

Today's final rule for dioxin adopts
most of the provisions of the proposed
rule largely without EPA's responses
to major comments received on the
proposed rule. Under today's rule, wastes identified
by the testing facility codes F001, F011, F022, F023, F032, F072, and F073
must be treated to a level below 1 ppb
in the waste extract for each of the
following specific categories of CDDs
and CDFs: ^

* The following terms and definitions are used:
P, C, D, and F designate products of tetra, penta, hexa, and hepta-chlorinated
polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins,
P, C, D, and F designate products of tetra, penta, hexa, and hepta-chlorinated
polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-p-dioxins,

- Cu ppb is the routinely achievable detection limit using method C310 of
- SW-343 [EPA 440-Appendix C]
- These limits also must be treated below the detection limits for
- 2,3,7,8-tetrachlorodibenzo-p-dioxin
- 2,3,7,8-tetrachloro-2,3,7,8-tetrachlorodibenzo-p-dioxin
- 2,3,4,7,8-Penta-chlorodibenzo-p-dioxin
- 2,3,4,7,8-Penta-chlorinated dibenzo-p-dioxin
- 3,4,7,8-Tetra-chlorodibenzo-p-dioxin
- 3,4,7,8-Tetra-chlorinated dibenzo-p-dioxin
- 2,3,4-Tri-chlorodibenzo-p-dioxin
- 2,3,4-Tri-chlorinated dibenzo-p-dioxin
- 6,7,8-Hepta-chlorodibenzo-p-dioxin
- 6,7,8-Hepta-chlorinated dibenzo-p-dioxin
- 1,2,3,6,7,8-Hexa-chlorodibenzo-p-dioxin
- 1,2,3,6,7,8-Hexa-chlorinated dibenzo-p-dioxin
- 1,2,3,7,8-Penta-chlorodibenzo-p-dioxin
- 1,2,3,7,8-Penta-chlorinated dibenzo-p-dioxin
- 1,2,3,4,7,8-Hexa-chlorodibenzo-p-dioxin
- 1,2,3,4,7,8-Hexa-chlorinated dibenzo-p-dioxin
- 1,2,3,4,6,7,8-Hepta-chlorodibenzo-p-dioxin
- 1,2,3,4,6,7,8-Hepta-chlorinated dibenzo-p-dioxin
- 1,2,3,4,5,6,7,8-Octa-chlorodibenzo-p-dioxin
- 1,2,3,4,6,7,8,9-Octa-chlorinated dibenzo-p-dioxin
- 1,2,3,4,5,7,8,9-Octa-chlorodibenzo-p-dioxin
- 1,2,3,4,6,7,8,9-Octa-chlorinated dibenzo-p-dioxin
- The test method is method C310

In the proposed rule, the Agency
stated that it is not necessary to
restrict the disposal of certain wastes
containing dioxins and furans.

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certain wastes containing dioxins and
furans.
imposed by section 307(b). All the other
end-of-pipe, and therefore do not meet the treatment
standards. The Agency maintained that the list of
treatment technologies developed in the last two
years must be considered when determining
whether a particular hazardous waste is
considered nonhazardous. However, the
Agency also acknowledged that there are presently
a number of emerging technological
trends that may be applicable for
treatment of dioxin-contaminating
wastes in order to render them
nonhazardous. It is therefore
possible that some of these
technologies will become
developmental in the near future.

C. Analysis of Treatment Technologies
for Dioxin-Containing Wastes and
Determination of 1986
1. Applicable Treatment Technologies

The dioxin-listing rule sets "Applicable Treatment Standards" for isolation and removal
treatment. It states that
M.
2-3
N
In the proposed rule, the Agency presented
a list of treatment technologies that were
determined to be nonhazardous for the
treatment of dioxin-contaminating wastes.
As stated in today's rule, however, any
technology for the treatment of dioxin-
contaminating wastes must be done in
accordance with the dioxin-listing rule.
Many of the technologies being
analyzed are thermal technologies, or can
be conducted in tanks, including
infrared heating and chemical
destabilization.

2. Comparative Risk Assessment
Determination for Dioxin-Containing
Wastes

In support of today's rule, the Agency
decided to conduct a more detailed
core risk assessment on soils contaminated with
1, 2, 3, 7, 8-PeCDD, which will
be consistent with dioxins and toxaphene,
and with the National Academy of
Sciences' Temporal Risk Assessment
Recommendations.

The dioxin-listing rule requires
the use of the "Applicable Treatment Standards"
for the treatment and storage of
dioxin-contaminating wastes in tanks. Secondary
contamination will be regarded as a permit
criterion for all tanks that treat or store
cellulose, and CTF-containing wastes.
Specifically, the dioxin-listing rule
requires the treatment of dioxin-
containing wastes to be provided
with the following information in
the permit application: specifying the
permitted condition of the secondary
compliance system and its
accompanying leak detection method;
and the choice of construction materials
and specifications, and whether
additional run-on or pretreatment controls are
needed to ensure the system's integrity.
This information will be required by
the EPA before a permit is issued.

As stated in the proposed rule, the
Agency is aware of such research
that currently being conducted to
determine and evaluate treatment technologies
applicable to dioxin-contaminating wastes.

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be conducted in tanks, including
infrared heating and chemical
destabilization.
available data show that chlorine non-
detectable levels of CDAs, CDDs and
tetrachlorophenol would occur as the
total of incineration at the CDAs in the
state to the propensities at the CDAs and
when for chloro-containing waste be
determined using a PCB with a lower
heat of combustion than the CDDs and
CFPs contained in the waste. The same
difficulty is seen in incineration, the
lower the heat of combustion.
Conversely, a consistent with a high
heat of combustion is similar to
incineration. In the case of the PCB waste,
the Agency believes that six to 10 CDDs can
be achieved for the CDDs and CDFs in
these wastes, since PCB waste and
CDDs and CDFs have similar degrees of
incinerability (Table of Combustion).

The Agency has also determined that
incinerators operating in accordance with
the paradigms established in 40 CFR 761.30
for PCB wastes, namely six to 10 destruction, also
meet the demonstrated component of the
EDAT standard. For more information on this determination, the
n. J. is referred to the proposed discussion in the proposed rule (31 FR
1720-1723).

Incineration to six to 10 CDDs achieve
to lower concentrations of CDDs, CDFs
and certain chlorophenols in the
waste to four to six CDDs (current standard for all
RCRA hazardous waste except chloro-containing waste). The efficiency of
incineration has been demonstrated by the
successful success burn at six to eight CDDs
in the EPA MSW at the Donnelly Farm Site
in McDowell, Missouri and the
incineration of PCB wastes at six to
destruction at a number of facilities.

Data indicate that residues resulting
from the incineration of CDDs and CDFs
at six to eight CDDs contain those that are at a concentration of five to seven
orders of magnitude less than those in
the starting material. For example, solid
residue resulting from the incineration
at six to eight CDDs that contain 10 ppm
tCCD may be expected to contain less than 0.1 ppm
tCCD. Additional data from the
incineration of chloro-containing wastes
of six to eight CDDs show no detectable levels of
CDDs/CFDs or the chlorophenols in
the residue. Most of the analytes was
determined in quantities that were
below the limits of detection. Special
methods specified in SW-846 (method
2060) (40 CRF 761 Appendix A)
Additional data indicates that
inincinerators operating at six to eight
achieved extremely low concentrations of
CDDs, CDFs, and PCBs in the
waste to six to eight CDDs. In addition, far
below the limits of detection with
standard analytical techniques. Detailed
information on the determination of
EDAT is available in the proposed
discussion in the proposed rule.

D. Determination of Alternative
Capacity and Effective States
1. Required Alternative Treatment
Capacity and Effective States
Approximately 1.5 billion pounds
(approximately 27 compost cubic
waste are presently covered by the
chloro-containing waste. (A. 11) These wastes
are primarily associated with the gold
production and manufacturing use of oil
and the chloro-containing waste. The Agency
believes that the quantity of chloro-containing
waste currently generated and subject
to today's land disposal restrictions found
amounts to 8 million pounds annually
(1,360 metric tons). For the purposes of this
plan, the Agency estimates that approximately 5 million pounds
(900,000 metric tons) is chloro-
contaminated soil. This assessment is taken from an estimate that 1.1 billion
pounds of chloro-containing soil exist in
the state of Missouri. See the
background document for additional
information. The Agency is continuing to
examine the surface of these wastes.

2. Treatment, Disposal, and Recovery
Capacity Currently Available
Under the land disposal rule, facilities
which intend to treat or dispose of
dichloro-containing wastes must do so
to meet the requirements of the
residual standard that is specified
in the rule (31 FR 17221). Currently, Agency
information on the activities of
operators and treatment, storers, and
disposal facilities indicates that there is
no available disposal or recovery
capacity for dichloro-containing wastes.
In addition, there are no Agency
approved incinerators or other thermal
treatment units to treat dichloro-
containing wastes. Although several
incineration facilities have been acquired by
the Agency, no incineration at these
thermal treatment units have been certified
by the Agency for permit to the
discharge rule.

Owners/operators of incinerators
approved by the Agency are covered by the
provisions of the Toxic Substances
Control Act, which may be in effect to apply
for certification. As pointed out earlier, POC
incinerators are a logical choice to burn
these wastes because they are required
to meet the same performance standards
that CPAs required by the land

disposal rule. There are currently some
commercial incinerators approved under
TCPA to burn PCAs. In addition to these units, several other treatment units under
development may be available
in the future to handle these wastes.

The Agency has full confidence in the
information provided by the method
management standards. EPA is
committed to move rapidly to ensure
that approved capacity is available to
properly manage the land chloro-
containing waste. Agency may authorize
these facilities to further manage these wastes.

VII. State Authority
A. Applicability of Rule to Authorized States
Under sections 3002, EPA may authorize
authorized states to administer and
enforce the RCRA program within the
state. EPA retains enforcement authority under
sections 3002, 3003, and 3004 while
authorized states have authority
enforcement. The standards and requirements for
authority are found in 40 CFR Part
261.

Before the November 8, 1989, RCRA
amendments, a state with final
authorization administrating hazardous waste programs was
administering the Federal program in
that state. The Federal programs were
operated, maintained, and
enforced. The state was authorized to
administer and enforce the RCRA harmless waste programs.

Federal requirements for
authorized state design requirements did not affect the
authorized states with the
requirements for the program.

In contrast, under federal
authorized state design requirements
prohibit the authorizing states from
the effect of authorized states to the
authorized states' time that they had fulfilled
Today's rule is promulgated pursuant to sections 3004(d) through (k) and (l) of the Solid Waste Disposal Act, 42 U.S.C. 6924(d) through (l), as being added to Table 1 in 40 CFR 271.11, which identifies the Federal program requirements that are promulgated pursuant to the newly enacted RCRA provisions and the effect on all States, regardless of their authorization status. States may apply for either initial or final authorization for the provisions in Table 1, as discussed in the following section. Table 1 in 40 CFR 271.11 is being modified and the rule indicates that this rule is a final 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 adopting a program modification may apply to receive either initial or final authorization for that program on or before selecting 3004(c) or 3004(d), respectively, on the basis of requirements that are substantially equivalent or equivalent to EPA's. The procedure and schedule for State program modifications for either initial or final authorization are described in 40 CFR 271.21. It should be noted that the initial authorization date is January 1, 1979 (see 40 CFR 271.34(c)).

40 CFR 271.21(e)(2) requires that States that have final authorization must modify their program 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, 1979. If regulatory changes are necessary, or July 1, 1980, if statutory changes are necessary. The 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. Since 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 those requirements in lieu of EPA until the State program modification is approved.

If a State, having authorized existing standards may continue to administer and enforce their standards as a matter of State law. By 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 must send written comments to the States 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 273, 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 273, 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 management capacity to land dispose. Under § 223.8, 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(b)(6) mandates 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 3004 to grant petitions for exceptions from basic prohibitions on site-specific petitions that do not require the national perspective required to prohibit waste or grant extensions. In accordance with section 3004(b)(6), EPA will publish notice of the States' final decisions on petitions in the Federal Register.

One commenter urged that EPA should publish all petitions submitted by authorized States, as well as publish final decisions. EPA does not believe that section 3004(b)(6) 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 rule. Publication of the final decision in the Federal Register will satisfy the need to inform the general public by informing the public of which States are allowed to receive special variances 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 regulations. EPA does not believe that section 3004(b)(6) mandates this result; this would be for State action without regard to the States. EPA is not required by law to regulate land disposal activity.

VIII. EFFECTS OF THE LAND DISPOSAL RESTRICTIONS PROGRAM ON OTHER ENVIRONMENTAL PROGRAMS

A. Discharges Regulated Under the Clean Water Act

Compliance with land disposal restrictions requirements does not relieve facility owners of the obligation to comply with all other Federal, State, and local environmental requirements.

The Agency emphasizes that, in addition to the requirements of the Clean Water Act, facility owners must comply with any applicable pretreatment requirements (including treatment works and all requirements of an NPDES permit for discharges to surface water).

The Agency emphasizes that, for example, in the case of hazardous wastes, if a facility discharges to surface water under the Clean Water Act, the discharge of such a waste is still subject to RCRA disposal requirements. However, the Agency emphasizes that, for example, the discharge of such a waste to surface water does not relieve the facility of the obligations imposed by RCRA on disposal of such a waste.
discharge to publicly owned sewage treatment works (POTWs). Decisions to discharge restricted wastes requiring these option 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, adequate data on these alternative methods were not available. The Agency concluded that the discharge of solvent wastes 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 Sanitation Acts

Two options, regulated under the Marine Protection, Research, and Sanitation Acts (MPRSA) (33 U.S.C. 1461 et seq.) are ocean dumping and ocean-based incineration. EPA is in the process of reviewing 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 waste failed to comply with one or more of the MPRSA environmental criteria but who successfully demonstrated 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) as a result of the land disposal restrictions on land disposal of solvents, 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., contaminants concentrations, toxicity, solubility, density, and persistence of the waste) associated with ocean disposal of hazardous wastes. The capacity analysis assumes that these wastes have acceptable capacity for ocean disposal, making the majority of ocean disposal including including 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 the costs of ocean transportation to a port located on the East Coast).

The results of the analysis indicated that the quantity of F001-F005 solvents discharged to POTWs could potentially increase by a factor of five times, although it is likely that the actual increase will be much less. The analysis also demonstrated that the discharge of solvent wastes 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.

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 transfers of hazardous constituents into the air. Examples would be the stripping of volatile organic compounds from wastewater and incineration of metal-bearing spent solvents. Unlike air controls are added, these technologies may result in transfer of organics and metals, respectively, to the atmosphere.

The Agency has identified several efforts to address the potential problem, as discussed in the accompanying risk assessment section. The Agency has initiated a program to address control emissions from large plants. EPA also has included two programs under section 106(a) to address air emissions from other sources. The first program will address leaks from equipment, such as pumps, valves, and waste units processing concentrated organic waste streams. Several states identified such EPA in the rulemaking, and EPA will support these states in the program. The second program will address emissions from large plants, such as pumps and valves, and waste units processing concentrated organic waste streams. Several states identified such EPA in the rulemaking, and EPA will support these states in the program. The second program will address emissions from large plants, such as pumps, valves, and waste units processing concentrated organic waste streams. Several states identified such EPA in the rulemaking, and EPA will support these states in the program.
waste is not a restricted waste, it is not subject to land disposal restrictions under Part 258. It must, nevertheless, be managed in accordance Parts 254 and 256.

Sequence 1: Waste Characterization

The Agency is requiring that applicable Part 253 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 253 Subpart D treatment standards are expressed either as performance standards in the waste extract in § 253.41, as required treatment methods in § 253.42, or as concentrations in the waste in § 253.43. After the generator establishes the applicable Part 253 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 date of the Part 253 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 disposed technologies. For those wastes where EPA determines that alternative capacity is adequate, the treatment standards will take effect immediately upon promulgation. When the Part 253 Subpart D treatment standards are expressed as concentrations in the waste extract (§ 253.41), 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 § 253.41, using the Toxicity Characteristic Leaching Procedure (Appendix I to Part 259) 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 253 Subpart D treatment standards are specified as a required method (§ 253.42), it is not necessary for the generator to determine the concentration of the hazardous constituents in the waste or waste extract. When the Part 253 Subpart D treatment standards are expressed as concentrations in the waste (§ 253.43), the need for treatment is determined either through analysis of the hazardous constituents in the waste, as specified in § 253.43, or through knowledge of the hazardous constituents in the waste based on the materials and the manufacturing processes generating the waste.
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(e)(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(e)(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 provide the same information (except for the manifest number) as would be in the notice (§ 268.7(e)(2)(i)) in the operating record of the land disposal facility.

Sequence 2

1. Deep Well Injection
2. Surface Impoundment
3. Landfill
4. Waste Pile
5. Land Treatment
6. Subpart X

Certification

Generator of Restricted Waste (Including Corrective Action and CERCLA)

Does the Waste Meet the Part 268 Subpart D Treatment Standard?

Yes

Go to Sequence B

No

Go to Sequence 3, Sequence 4, Sequence 5, Sequence 6, or Sequence 10

Land Disposal Subtitle C
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 § 253.41 treatment standard; (2) the waste must be treated in accordance with the treatment method required under § 253.42; or (3) the concentration of hazardous constituents in the waste exceeds the applicable § 253.43 treatment standard. In each case, continued placement of the restricted waste in land disposal units as of the applicable effective date specified in Part 252 Subpart C is prohibited.

Generators may store restricted wastes on site in containers and tanks according to the provisions in section 252.50 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 an RCRA permit that allows 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 § 253.71(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 normal 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 253.41 to designate a facility on the manifest which is permitted to accept the waste for off-site management.

The determination that the treatment results meets the applicable § 253.41 treatment standard can be made through knowledge of the hazardous constituents in the waste extract based on the procedures used in the treatment of the waste or by analyzing the treatment residual according to the waste analysis plan using the Toxicity Characteristic Leaching Procedure (Part 253, Appendix A). The determination that the treatment residual meets the applicable § 253.43 performance standard can be made through knowledge of the hazardous constituents in the waste extract based on the procedures used in the treatment of the waste or by analyzing the treatment residual according to the waste analysis plan. In either case, if the concentration of hazardous constituents in the treatment residual extract exceeds § 253.41 treatment performance standards or the concentration of hazardous constituents in the residual extract exceeds § 253.43 treatment standards, additional treatment must be performed before land disposal is permitted. Generators, transporters, handlers, storage facilities, or treatment facilities may not utilize restricted wastes as substitutes for adequate treatment to meet §§ 253.41 or 253.43 treatment standards. Such actions will be considered a violation of the dilution prohibition. In particular, wastes meeting Part 252 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 (§ 258.32). EPA does not intend to disrupt or alter the normal and customary practices of properly operated treatment facilities.

Treatment facilities can site 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 §§ 253.41 or 253.43 treatment standard for any given constituent.

When shipping the treatment residuals to an intertidal status or RCRA permitted land disposal facility, the treatment facility must certify (as specified in 403.70(b)(2)) that the treatment results meets the applicable treatment standards in §§ 253.41 or 253.43, or has been treated using the required method in § 253.41 and, therefore, is no longer a restricted waste. The generator must also send 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 residual where available as specified in 40 CFR 253.72).

If the treatment residuals meet the diluting criteria, the generator for or treatment facility may petition the Agency for an emergency variance under the provisions of 40 CFR 253.22. Diluted residuals can be managed in Subtitle D facilities.

In some cases, the generator or treatment facility may conclude that it is technically infeasible to meet the §§ 253.41 or 253.43 treatment performance standards established for treatment of a waste. If a waste cannot meet the applicable treatment standards, the generator may petition EPA for a variance under 40 CFR 258.44 (see Sequence 7: Variance From a Treatment Standard, for a detailed discussion.)
Generator of Restricted Waste
(Including Corrective Action and CERCLA)

Is the Treatment Standard Effective Immediately?

Yes

Does the Waste Meet the Part 268 Subpart D Treatment Standard?

Yes

Go to Sequence 2, or Sequence 8

No

Go to Sequence 3, Sequence 5, Sequence 6, Sequence 7, Sequence 9, or Sequence 13

No

Delay Effective Data Up to 2 Years

Notice

Land Disposal Subtitle C

Deep Well Injection  Surface Impoundment  Landfill  Waste File  Land Treatment  Subpart X
Sequence 4 in the generator's decision-making process concerns for which wastes where the Agency has made the determination that the capacity is not adequate on a nationwide basis. The Agency may, however, exercise the discretion granted to it under Section 10044(a)(2) and authorize a nationwide variance lasting up to two years from the statutory effective date. The purpose of granting a nationwide variance is to provide time for development of additional treatment, recovery, or disposal capacity. Thereafter, if EPA determines that the capacity is not adequate and that the nationwide variance is not adequate, the Agency may issue a nationwide variance. The nationwide variance is to be in effect and the generator must follow as of the following sequence: Sequence 2, Treatment of a Restricted Waste, Sequence A, Case-by-Case Extensions, Sequence B, No Migration Petition, Sequence C, Deferring, or Sequence 18, Replacing Production Process, Recycle or Don't Produce Waste.
Sequence 3 in the generator's decision-making process commences with a determination that the restricted waste does not comply with the applicable §§ 223.41 or 223.61 treatment standards or that the waste must be treated in accordance with the treatment method required under § 223.43. Continued placement of the restricted waste in land disposal units as of the applicable effective date, as specified in Part 238 Subpart C, is prohibited. The generator may submit an application to EPA, as specified in § 223.48, for an extension of time, which to comply with the Part 238 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 § 223.4(a). The generator must forward a notice, as specified in § 223.7(a)(3), stating that the waste is exempt from the land disposal restrictions in 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 1), submit a non-migration petition (Sequence 2), submit a delisting petition (Sequence 3), change his production processes, or recycle so that restricted wastes are no longer generated (Sequence 10).

Sequence 6: No Migration Petition

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**Generator of Restricted Waste**

(With Corrective Action and CERCLA)

- **No Migration Petition**
  - Yes
    - **Notice**
    - **Land Disposal Subtitle C**
      - Deep Well Injection
      - Surface Impoundment
      - Landfill
      - Waste Pile
      - Land Treatment
      - Subpart X

Go to Sequence 1, Sequence 2, or Sequence 10.

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Sequence 8 of the generator's decision-making process commences with a determination that the waste does not meet the §§ 253.43 of 253.49 treatment standards or that the waste must be treated by the method required in § 253.42 Wastes that do not comply with applicable §§ 253.41 or 253.43 treatment standards or are not treated by the method required in § 253.42 will be prohibited from continued placement in land disposal units as of the applicable effective date, unless the generator is in compliance with a Treatment, Storage, and Disposal Facility (TSDF) or TSCP submits a no migration petition. The petition as specified in § 252.8 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 55A, to manage the waste. The no migration petition will be a difficult demonstration, but the Agency has identified the following four 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 maintaining the waste non-hazardous;
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, allowing the opportunity for pre-application meetings as assistance in preparing a no migration petition. As a result of such a meeting, 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 (§ 252.9) before it can land dispose a restricted waste. The generator must forward a notice as specified in § 252.9(a)(3) stating that the waste is exempt from the land disposal restrictions to the Schedule C facility receiving the restricted waste.

Where a no migration petition is not granted, the generator may follow the process of action in accordance with the following sequence: Sequence 1: Treatment of a Restricted Waste, Sequence 2: Case-by-Case Extensions, Sequence 3: Variance From a Treatment Standard, Sequence 4: Delisting, or Sequence 13: Change Production Process, Recycle, or Don't Produce the Waste.
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 268.44. The generator may submit a petition for a variance from the treatment standard as specified under § 268.44. The Agency envisions that waste is 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 waste 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 obtained, the waste may be managed in accordance with Sequence 6: Treatment of Restricted Waste, Code of Federal Regulations, Subpart D, Extension, Sequence 6: No Intervention Petition, Sequence 6: Determination, and Sequence 10: Change Production Process, Recycle, or Don't Produce the Waste.
Sequence 8 commences with the generator's determination that the waste is restricted (40 CFR Part 258 Subpart C). Upon evaluation of the available waste management options, and possibly after treatment (including treatment not meeting the treatment standards of §§ 258.41–258.43), the generator may decide to submit a petition to EPA for a site-specific delisting, pursuant to the provisions in 40 CFR 258.52. 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 258 Subpart D treatment standard as well as after the denial of any of the exceptions to achieving the Part 258 Subpart D treatment standard.
Sequence 9 in the generator's decision-making process contains a determination by the generator that the restricted waste does not comply with the applicable Part 258 Subpart D treatment standard and will be prohibited from continued placement in land disposal units as of the applicable effective date. The generator may file an application for a variance, the interstate state or RCRA permitted surface impoundment meeting the minimum technology requirements in accordance with 40 CFR 252.2271(f) and 252.2271(n) and that is in compliance with 40 CFR Part 252 or 258 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 258 Subpart D treatment standard applicable to the contents of the surface impoundment. If the applicable Part 258 Subpart D treatment standard is specified in §258.42, 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 §258.44), set under Part 258 Subpart D may be submitted if in the identification of an applicable Part 258 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 §258.41 or on the concentration of the hazardous constituents in the waste itself as specified in §258.41. Therefore, the facility must analyze the contents of the surface impoundment to determine the need for treatment as specified in §258.41. Impoundment residuals that do not meet the applicable Part 258 Subpart D treatment standards (§258.41 or 258.43) 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 Waste, Sequence 4: No Migration Petition, and sequence 8: Diluting. Surface impoundment residuals that meet the applicable Part 258 Subpart D treatment standard are exempt from the statutory prohibitions on land disposal. The residual may be treated as hazardous waste in a Subtitle C facility. If the residual 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 of must be accompanied with the notice and certification as specified in §258.27(a)(3).

Sequence 10: Change Production Process, Recycle or Don't Produce the Waste

The remainder of Unit X describes the economic analysis performed by EPA in support of today's final rule.

1. Cost and Economic Impact

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 modify 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 or less dioxins 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 number 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 wastes treatment, storage, and disposal facilities (TSDFs) and generators and land disposal of affected wastes either directly at the facility site or indirectly through the purchase of commercial land disposal services. This group's waste management practices are assessed to identify costs of sampling programs and increased cost attributable to today's rule.

The number of facilities that land dispose of affected wastes was determined using the EPA's 1981 KIA.
Mail Survey. 19 Waste quantities and management practices for facilities responding to the Mail Survey were scaled up to represent the national population by means of weighting factors developed in the survey. EPA estimates that 74 facilities comprise the total national population of commercial and noncommercial facilities and disposing of affected wastes onsite.

EPA estimates that generating more than 1,000 kilograms per month of waste off-site for management add an additional SISs plant. Generators of less than 1,000 kilograms per month were not included in the mail survey because they were considered exempt at that time.

Because the 1994 RCRA amendments directed EPA to lower the exemption for small quantity generators (SQGs) from 1,000 to 100 kilograms per month by March 1996, SQGs generating between 100 and 1,000 kilograms of waste per month for off-site disposal are also subject to 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 1990. In particular, EPA adjusted waste management practices reported in 1990 to reflect compliance with the provisions of 40 CFR Part 244 of RCRA. In making this adjustment, the agency assumes facilities elect the least costly legal methods of compliance.

A. 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 manually for operation and maintenance (O&M) of alternative modes of waste treatment and disposal. The second component of the compliance cost is capital cost, which is an initial outlay incurred for construction and depreciable assets. Capital costs are estimated at 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.

B. Economic Impact Analysis (1) Non-Commercial TSCDF and OCS. EPA estimates that non-commercial facilities and OCSs are assessed in several steps. First, a cost-benefit analysis compares the possible incremental costs to financial information about firms. Compared by Standard Industrial Classification (SIC) type.

The first set of small quantity generators (SQG) is formed to identify facilities likely to experience adverse economic impacts. 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 costs from operations to cost of compliance. For this ratio, a value of less than 20 is considered to represent a significant adverse impact.

Cost-benefit analysis identifies 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. Costs and Economic Impacts

a. Total costs and economic impacts for commercial waste. Total annualized compliance costs for facilities currently land disposal and generators of waste are $67 million. Commercial TSDFs account for 62 percent of the total, while non-commercial TSDFs account for the rest. Although SICs do not distinguish between commercial facilities and generators of 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 1993 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 waste generated by other plants. Among the 60 non-commercial facilities, twelve appear likely to be significantly affected because of compliance costs imposed by this rule. Based on further analysis, these facilities are existing commercial facilities.

Among commercial facilities (i.e., those which manage the wastes of other firms for a fee) direct effects were imposed only to accounts of companies which generate hazardous waste. The results of this analysis were stated in 1993 dollars as waste management services.

We estimate that 72 commercial facilities will increase their costs as a result of today's Final rule. Forty percent of these commercial facilities have a cost of compliance with today's rule is to be assumed to fall on commercial facilities. A qualitative assessment of economic effects on commercial facilities is significant.

We estimate that 40 percent of these commercial facilities will face increased costs for waste management services.
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-priced treatment services may actually increase first financial viability. For the 27 percent of commercial facilities which offer only land-based management of restricted wastes, on the other hand, the increased emphasis on economic effects presented in this unit 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 examined 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 margins to compliance costs are examined for each of the five sections which sends a waste to each of these 23 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 23 industrial sectors, representing 5,311 plants, generating solvent waste for offsite commercial management. Of these 5,311 plants, 1,004 may experience significant economic impacts. Among the most adversely affected plants are manufacturers of fabricated metal products (SIC 34). This sector includes 718 significantly affected facilities. Other affected sectors include SIC 33, primary metals products, in which 127 plants may close, and SIC 20, the chemical industry, in which 42 plants may close. Based on further analysis, 78 of these facilities appear likely to close. Job loss associated with these closures amounts to 5,203 jobs in the plating and polishing industry and 167 in the industrial inorganic chemical industry.

Total annualized costs for the $4.900 small quantity generators of solvent wastes are $19 million. Based on the estimated cost for offsite incineration, maximum incremental costs for incineration are charged for any individual SQG will not exceed $12,200 annually. Economic returns were estimated for each SQG in each sector identified in the RIA Mail Survey as generating solvent waste. Based on this examination, EPA identified 87 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 $5.6 million. Costs for managing that portion of the estimated 1.1 billion pounds of existing dioxin-contaminated soil for which this regulation will require EDAT treatment are $3.5 million. A preliminary study of dioxin-contaminated soil suggests that only 8 percent of the total quantity will require incineration, and the costs reflect this finding. Ninety-five percent of these soil, 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 2299 as a result of the restriction of dioxin wastes. This sector manufactures industrial organic chemicals, with major products such as solvents, nesycyclic organic, and polyhydric alcohols. One plant may close as a result of restrictions in this group. Other affected SIC sectors include 2870, in which one plant may close. SIC 1579 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 (2000 and 5022) 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 benznl, a factor that is substantially reduced by the reductions in risk to the cost of the permit. The maximum (M2) risk reductions for halogenated solvent wastes disposed in surface impoundments are 0.71. 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 RIA docket entitled LFR-3). Relevant data on the restricted F22-F29 wastes provided in this analysis may be computed to obtain a total incremental benefit (number of cases of cancer or cancer-equivalents avoided) of 96,067 cases avoided or annualized benefits for solvents equal to 1.33 percent avoided. Division of the total annualized cost of the solvents land disposal restrictions, $2.7 million, by the annualized cases avoided, 1.33, determines that the cost of the regulation is $2.1 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 to manmade structures, and risks to the soil, may also be monetized in this analysis. 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 clone- containing wastes. The assessment of risk associated with today's rule depends on 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 and less expensive baseline practices that effectively eliminate risk, it appears that reductions in expected health effects would be beneficial for many of the cited chronic waste. Baseline risk levels were higher than today's levels. The benefits attributable to the restrictions are based on whether disposal of solvent-containing water (with undetectable levels of...
dioxin) from incineration are likely to occur and whether spills and runoff 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 dioxin objects for many types of dioxin wastes, it may reduce the uncertainty about potential risks associated with the current regulatory status for dioxin.

The determination of the incremental benefits for restricting land disposal of dioxin waste results in a calculated annualized dioxin benefit value of zero cases avoided. Although this risk estimate is very dependent on assumptions about population exposed to dioxin analyses performed in this analysis to consider this estimate to dioxin benefits is based on the current database of toxics cases. This estimate, however, may significantly underestimate actual risk reductions.

B. Regulatory Flexibility Analysis

Pursuant to the Regulatory Flexibility Act, 5 U.S.C. 603 et seq., whenever an Agency proposes or publishes 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. 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 to support 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 general small entities of dioxin waste. The universe of small businesses that were included in the analysis here includes two groups: all TSSs employing fewer than 25 people, and all DSSs which are also small businesses. Eleven TSSs are small businesses. None of these exceed threshold values on the cost of production ratios. Twenty-five percent (twelve out of 48) of all non-commercial facilities are expected to experience adverse economic effects.

Of the total of 14,773 small quantity generators examined in this analysis, the vast majority (12,210 or 79 percent) are also small businesses. A total of 83 DSSs (or 8 percent of all businesses) exceeded threshold values on the cost of production ratios. 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 experienced 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 OMB, 1986). Results of the analysis indicate that this rule will not have a significant economic effect on a substantial number of small entities.

Accordingly, I hereby certify that this regulation will not have a significant economic effect 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 in 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 Midwest Corporation "Composition of Hazardous Waste Stream Characteristics," (April 1981) and U.S. EPA, "The KCIH Bulk-Cost Analysis Model," (March 1984). The survey of small facilities and treatment is the major source of data in this group. EPA's Office of Research and Development developed estimates of the types and quantities of wastes containing dioxin and the listing definitions for these wastes.

For financial and valuing of shipment information for the general commodity analysis, 1981 Census data was used, adjusted by 1983 Annual Census of Manufacturers data. Products price indexes were also used to update 1983 dollars to 1984 costs.

2. Responses to Comments

Several commenters contended 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 underestimated. In fact, because EPA's analysis does not allow for changes in 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 hardship, both to the suppliers of highly hazardous inputs and to the manufacturers forced by higher waste treatment costs to switch to higher cost inputs. Other commenters suggest that the Agency has not sufficiently balanced cost and risk in designing regulations restricting land disposal. EPA believes that the consideration of costs and benefits has been comprehensive and consistent with Executive Order 12291.

One commenter stated the EPA's assumption 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-hazardous wastes for alternative uses. Given the cost differential between direct land disposal, which EPA is prohibiting for regulated waste, and treatment through incineration with other municipal waste technology, it is likely that non-hazardous waste will substitute for similar incineration capacity existing.

The commenter correctly points out that the increased demand for waste treatment services may be the effect of driving the price for incineration services, thus making it more expensive for non-
restricted wastes to be treated in CERAT treatments. EPA also believes it likely that alternative capacity will be retained through the market of prices, 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 this and any final rule 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 2050-0012.

This rule modifies another information collection requirement that has been approved by OMB under the Paperwork Reduction Act and gives the months 2000-2012. The appropriate charges to those requirements have been approved by OMB.

XI. References

Background Documents

(6) Other References

[ ] 251.1 [Amended]

3. In § 251.1, paragraph (a)(3) is amended by inserting "120" after the phrase "Part 202 through 220".

§ 251.14 [Amended]

4. By removing from paragraph (c)(1) introductory text of § 251.14 as part number "202" and inserting the part number "203" in its place.

§ 251.15 [Amended]

6. In § 251.15 paragraph (b)(6) introductory text is amended by inserting "202, 203, 204, and 220" after the phrase "Part 202 through 220".

7. By inserting "203" after the phrase "Part 202 through 220".

§ 251.16 [Amended]

8. In § 251.16 paragraph (d)(1) introductory text is amended by inserting part number "203" after the phrase "Part 202 through 220".

9. By inserting paragraph (d)(2) of § 251.16 to read as follows:

§ 251.16 Requirements for recyclable materials.

10. [ ]

[c][1] Owners or operators of facilities that store recyclable materials before they are recycled or processed under all applicable provisions of Chapter A through L of Parts 202 and 220, and under Parts 204, 208, 205, and 220 of this Chapter and the nonrecycling requirements under section 228 of RCRA, except as provided in paragraph (e) of this section. (The recycling process itself is exempt from regulation.)

§ 251.2 [Amended]

6. In § 251.2 paragraphs (a)(2) and (2)(c) are amended by adding the part number "203" after the phrase "Part 202 through 220, or Part 230.

PART 252—STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE

III. In Part 252

1. The authority citation for Part 252 continues to read as follows:

Authority: Secs. 300a, 300b, 300c, 300d, 300e, 300f, 300g, 300h, 300i, 300j, 300k, 300l, 300m, 300n, 300o, 300p, 300q, 300r, 300s, 300t, 300u, 300v, 300w, 300x, 300y, and 300z of the Solid Waste Disposal Act, as amended (42 U.S.C. 6921, 6922, 6923, 6924, 6925, 6926, 6927)

Subpart A—General

2. In § 252.11, paragraph (d) is added to read as follows:

§ 252.11 Hazardous waste characterization.

4. If the waste is determined to be hazardous, the generator must refer to Parts 252, 253, and 254 of this chapter for possible exclusions or restrictions pertaining to management of this specific waste.

PART 253—STANDARDS APPLICABLE TO TRANSPORT OF HAZARDOUS WASTES

IV. In Part 253

1. The authority citation for Part 253 is revised to read as follows:

Authority: Secs. 300a, 300b, 300c, 300d, 300e, 300f, 300g, 300h, 300i, 300j, 300k, 300l, 300m, 300n, 300o, 300p, 300q, 300r, 300s, 300t, 300u, 300v, 300w, 300x, 300y, and 300z of the Solid Waste Disposal Act, as amended (42 U.S.C. 6921, 6922, 6923, 6924, 6925, 6926, 6927).

Subpart D—Compliance, Recordkeeping, and Enforcement

3. In § 254.17, by revising paragraph (b)(4)(ii) and adding paragraph (b)(4)(ii) as follows:

§ 254.17 Operating record.

4. [ ]

[ ] Records and reports of waste analyses performed as required in § 254.17(a), 254.11, 254.12, 254.13, 254.14, and 254.15 of this chapter.

5. [ ]

[ ] Records of the quantities, dates and locations of each delivery of hazardous wastes and the charges therefor, and of each return of hazardous wastes.

6. [ ]

[ ] For a solid waste treatment, storage, or disposal facility, a copy of the notice required by paragraph (c) of this section.

7. [ ]

[ ] For an off-site hazardous waste facility, a copy of the notice required by paragraph (i) of this section.

8. [ ]

[ ] For an on-site hazardous waste, facility, a copy of the notice required by paragraph (j) of this section.

§ 254.19 Hazardous waste analysis.

[a][2] Before an owner or operator submits, stores, or disposes of any hazardous waste, it must obtain a detailed chemical and physical analysis of a representative sample of the waste. (a) At a minimum, this analysis must include all the information that must be known to treat, store, or dispose of the waste in accordance with the requirements of the part of Part 252 of this chapter as with the conditions of a permit issued under Part 252 and Part 253 of this chapter.

[b][3]

[c][4]

[d][5]

[e][6]

[ ] Where applicable, the methods which will be used to comply with the information required under paragraph (a) of this section as specified in § 252.5 or § 252.6.

§ 254.23 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.25 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.27 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.29 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.31 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.33 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.

§ 254.35 Environmental compliance.

[a][2] The procedures described in this section apply to the disposal of waste under § 254.3.

[b][3] The sampling and testing procedures are included in the procedures described in this section.

[c][4] The sampling and testing procedures are included in the procedures described in this section.

[d][5] The sampling and testing procedures are included in the procedures described in this section.

[e][6] The sampling and testing procedures are included in the procedures described in this section.
1. The authority citation for Part 253 continues to read as follows:

Subpart A—General Facility Standards
2. In § 253.13, paragraphs (a)(1) and (b)(9) are revised, and paragraphs (d)(4) and (e)(11) are added to read as follows:
§ 253.13 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. 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 252 of this chapter.

(b) Where applicable, the methods which will be used to meet the additional waste analysis requirements for specific waste management methods as specified in §§ 253.10, 253.22, 253.32, 253.35, 253.27, 253.41, 253.25a, 253.67 and 253.79 of this chapter.
(7) For surface impoundments exempted from land disposal requirements under § 252.4(a)(8) of this chapter, the procedures and schedules for:
(i) The sampling of impoundment contents;
(ii) The analysis of test data; and
(iii) The annual testing of residuals which does not meet the standards of Part 252 Subpart D of this chapter.

Subpart B—Facility Systems, Records, Reporting, and Synthetic Linings
3. In § 253.27, by revising paragraph (b)(1) and adding paragraph (b)(2) through (b)(12) to read as follows:
§ 253.27 Operating record.

(b) Records and results of waste analysis and test data performed as specified in §§ 252.13, 252.19, 253.22, 253.32, 253.67, 253.35, 253.41, 253.37, 253.60, 253.67, 253.54(a) and (b)(2) of this chapter.

8. In the authority citation for Part 253, continue to read as follows:

2. By adding Subparts A, C, D, E, and F to Part 253 to read as follows:

Subpart A—General

Subpart C—Prohibitions on Land Disposal

Subpart D—Treatment Standards

3. In § 253.13, by revising paragraph (e)(11) to read as follows:

4. In § 253.13, add paragraphs (e)(12) and (e)(13) to read as follows:

5. In § 253.27, by revising paragraph (b)(12) and adding paragraphs (b)(13) through (b)(19) to read as follows:

6. In § 253.27, by revising paragraph (b)(19) and adding paragraphs (b)(20) through (b)(27) to read as follows:

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(b) All other terms have the meanings given under § 231.12, 231.21, or 231.31 of this chapter.


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.

§ 230.7. Treatment surface impoundment emission.

(a) The requirements of this part do not apply to a person treating hazardous wastes for a surface impoundment or series of impoundments provided that:

(1) The generator, transporter, handler, or owner or operator of the treatment, storage, or disposal facility designates this method of waste treatment as a surface impoundment emission; and

(2) The residual of the treatment are analyzed, as specified in § 231.7, to determine if they meet the applicable treatment standards in § 231.17. The sampling method specified in the waste analysis plan under § 231.13 or § 231.17, must be designed such that representative samples of the sludge and the supernatant are tested separately rather than diluted to form homogenous samples. The treatment residues (including any liquid waste) that do not meet the treatment standards promulgated under Subpart D of this part may not be diluted under § 230.7 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 regularly is in greater than the volume of the impoundment or impoundments, this flow-through constitutes removal of the impoundment for the purpose of this requirement. The procedures and schedules for the securing of impoundment contents, the analysis of test data, and the removal of residues will be set forth in the Subpart D treatment standards to be specified in this facility's waste analysis plan as required under § 231.13 or 231.31 of this chapter.

(b) The impoundment must meet the design requirements of § 231.70(b) or (c) and Subpart D(a) and the chapter, regardless that the unit may not be new, expanded, or modified as a replacement or in compliance with applicable ground water monitoring requirements of Subpart F of Parts 234 or Part 221 of this chapter unless

(1) Exempted pursuant to § 231.3 (3) or (4) of this chapter, or to § 231.21 (d) or (e) of this chapter or

(2) Upon application by the owner or operator, the Administrator has granted a waiver of the requirements on the basis that the removal or treatment unit:

(A) Has at least two lines, for which there is no evidence that such lines have been used;

(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 permit.

(3) Upon application by the owner or operator to the Administrator has granted a modification to the requirements on the basis that the removal or treatment unit:

(A) Has one line, for which there is no evidence that such line has been used;

(B) Is located more than one-quarter mile from an underground source of drinking water; and

(C) Is not in compliance with generally applicable ground water monitoring requirements for facilities with permit.

(4) The owner or operator must submit to the Regional Administrator a written certification that the requirements of § 230.9 of this part have been met and submit a copy of the waste analysis plan required under § 230.7 of this part. The following certification is required:

I certify under penalty of law that the requirements of § 230.9 of this part have been met for all surface impoundments being used to treat restricted wastes. I believe that the submitted information is true, correct, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of imprisonment and imprisonment.

§ 230.5. 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 contact with treatment, recovery, or disposal facilities facilities to meet the requirements for a treatment system with the appropriate capability as required under Subpart C of this Part;

(2) He has entered into a binding contract with a contractor or otherwise provides alternative treatment, recovery, or disposal facilities, facilities that meet the requirements for a treatment system with the appropriate capability as required under Subpart C of this Part;

(3) Due to circumstances beyond the applicant's control, such alternative capacity cannot reasonably be made available by the applicable effective date.

The demonstration may include a showing that the technical and financial capabilities associated with providing the alternative capacity will result in the capacity not being available by the applicable effective date.

(b) The capacity being constructed or otherwise provided by the applicant will be sufficient to manage the quantity of waste that is the subject of the application.

(c) He provides a detailed schedule for obtaining required operating and construction permits on an on-site of how and when alternative capacity will be available.

(d) He has arranged for adequate capacity to manage the waste during an extension and has demonstrated in the application the location of all sites at which the waste will be managed and the capacity.

(e) There is a waiver of a surface impoundment emission which is the extension period will satisfy the requirements of paragraph (b) of this section.

§ 230.6. As an authorized representative of the applicant as described under paragraph (2) of section (a) of this section shall make the following certification:

I certify under penalty of law that I have personally examined and found this application to be true and complete. I am familiar with the information submitted in this document and all attachments and I hereby certify, on the basis of my knowledge and belief that the requirements are true, correct, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

(a) After receiving an application for an extension, the Administrator may request any additional information which he deems as necessary to evaluate the application.

(b) An extension will apply only to the waste generated at the individual facility covered by the application and will not apply to restricted wastes disposed at any other facility.

(c) On the basis of the information submitted, the Administrator may grant an extension of up to 1 year from the date of the application. The Administrator shall notify the applicant in writing of the extension, the terms of the extension, and the date on which the extension will expire.
the effective data. The Administrator may review this application for up to 1 additional year upon the receipt of the application if the demonstration required in [paragraph (f) of this section] can still be made. In no event will an extension extend beyond 36 months from the applicable effective date specified in Subpart C of Part 236. The length of any extension shall be determined by the Administrator based on the time required to construct or obtain the type of facility specified in the application. 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.

Any person granted an extension under this section must immediately notify the Administrator as soon as he has knowledge of any changes in the conditions specified in the application.

Any person granted an extension under this section shall submit written progress reports at intervals designated by the Administrator. Each report must describe the overall progress made toward compliance with the conditions for each step taken thus far and the status of the extension. The Administrator can revoke the extension at any time if the applicant does not meet a goal as specified in the schedule for compliance, or if the Agency deems that any required permit, limitation, or condition specified in the application has been violated or any violation of the regulations.

Whereas the Administrator establishes an extension to an effective date under the section, during the time which such extensions may be in effect:

(1) The emergency situation under § 236.3(d) is not any longer in existence;

(2) Such extensions would not be in the public interest as provided in § 236.3(d), and (3) Such extensions would be consistent with the environmental protection provided for under Subpart C of Part 236 for (a) and (b) of this chapter.

The surface improvement is required to comply with all requirements on land disposal under this part and the effective data for the waste has been reached.

(2) To allow land disposal of a waste described under Subpart C of Part 236.

(3) Any person seeking an exemption from a prohibition under Subpart C of this part for the disposal of a restricted hazardous waste at a particular unit or waste 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 disposed unit or injection zone for as long as the waste remains hazardous. The demonstration must be documented as follows:

(1) A description of the specific waste and the specific unit or waste for which the demonstration will be made;

(2) A waste characterization to describe fully the chemical and physical characteristics of the subject waste including an analysis of background air, soil, and water quality.

(3) The methodology referred to in paragraph (c) 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 analysis techniques for chemical and physical properties of the waste and all environmental parameters must have been approved by the Administrator.

(3) Calculations must have been conducted for specific toxic and other characteristics, and validated for accuracy by comparison with actual measured data.

(4) A quality assurance and quality control plan that describes all aspects of the demonstration must be approved by the Administrator.

An analysis must be performed to identify and estimate any aspects of the demonstration that may significantly be in error. This analysis must include an evaluation of the continued predictability of future events, including but not limited to, earthquakes, floods, severe storms, droughts, or other natural phenomena.

Each petition must be submitted to the Administrator.

Each petition must include the following statement signed by the petitioner or an authorized representative:

I hereby certify that I have personally examined and am familiar with the information submitted in this petition and all attached documents, and that, based on my inspection of these documents, individually, I believe that such information is true, accurate, and complete. I hereby certify that there are no significant penalties for submitting false information, including the possibility of fines and imprisonment.

After receiving a petition, the Administrator may request any additional information that reasonably may be required to evaluate the demonstration.

If the petition is 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 at any other disposal unit.

The Administrator will publish 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.

The term of a petition granted under this section shall be no longer than the term of the RCRA permit if the disposed unit is operating under a RCRA permit, or up to a maximum of 10 years from the date of approval provided under paragraph (j) of this section if the unit is operating under other status. In either case, the term of the granted petition shall expire upon termination or denial of the RCRA permit, or upon the termination of the disposal unit or when the waste is set aside in a manner that land disposed during the term of the permit is reclayminated.
§ 268.3 Waste analysis.

(a) The generator must test its 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 exempt from land disposal restrictions.

(b) For wastes that are treated, the test method described in Appendix I of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(c) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(d) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(e) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(f) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(g) The generator must determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(h) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(i) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(j) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(k) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(l) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(m) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(n) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(o) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(p) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(q) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(r) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(s) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(t) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(u) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(v) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(w) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(x) A manifest must be associated with the shipment of waste and waste analysis data, where available.

(y) If a generator determines that it is managing a restricted waste under this part and that the waste is exempt from land disposal restrictions, the owner or operator of the facility must notify the generator in writing of the appropriate treatment standard set forth in Subpart D of this part, or using knowledge of the waste, the generator must conduct the appropriate treatment standard in writing of the appropriate treatment standard set forth in Subpart D of this part, and determine that the waste can be land disposed without Part 268 treatment for each shipment of waste.

(z) A manifest must be associated with the shipment of waste and waste analysis data, where available.

{At this point, the text continues with more paragraphs and sections, likely discussing various waste management and disposal regulations.}
§ 258.31 Waste specific prohibitions—

Shall contain wastes.

(a) Effective November 1, 1978, the

disposal—containing wastes specified in 40
CFR 258.31 or EPA Hazardous Waste
Nos. F01, F02, F03, F04, F05, and
F06, are prohibited from land disposal.

(b) The requirements of paragraph (a)

of this section do not apply to

(1) The wastes are treated to meet the

standards of Subpart D of this part on

(2) The wastes are disposed of at a

facility that has been granted a permit

under § 258.36;

(3) An extension has been granted

under § 258.37.

(c) Between November 1, 1978, and

November 1, 1980, 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 § 258.52.

Subpart E—Treatment Standards

§ 258.46 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 best

method of Appendix C of this part does

not exceed the values shown in Table

CCWS of § 258.46 for any hazardous

constituent listed in Table CCWS for

that waste. A restricted waste for which

a treatment deficiency is specified

under § 258.42(e) may be land disposed

after it is treated using the specified

technology or another treatment

method approved by the Administrator

under the procedures set forth in

§ 258.42(d).

§ 258.47 Treatment standards expressed

as concentration limits in waste units.

(a) Table CCWS 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 best

method of Appendix C of this part for

the allowable land disposal of such waste.

(Appendix C of this part provides

Agency guidance on the best methods

that have been shown to achieve the

CCWS levels for the respective

wastes. Appendix C is not a regulatory

requirement but is provided to assist

generators and owners/operators in

their selection of appropriate treatment

methods.)

(b) When wastes with differing

treatment standards for a constituent of

concern are combined for purposes of

treatment, the treatment residual must

meet the lowest treatment standard for

the constituent of concern.

§ 258.48 Treatment standards expressed

as specified treatment techniques.

(a) The following wastes must be

treated using the identified technology

or technology, or an equivalent method

approved by the Administrator.

[b) (Reserved)

§ 258.51 Treatment standards expressed

as treatment techniques.

(a) 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. 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.

§ 258.53 Treatment standards expressed

as treatment techniques.

(a) When 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 petition must

demonstrate that because the physical

or chemical properties of the waste

differ significantly from wastes

analyzed in developing the specified

technology, the waste cannot be treated

to specified levels by the specified

methods.

(b) Such petitions must be submitted

in accordance with the procedures in

§ 258.36.

(c) After receiving a petition for

variance from a treatment standard, the

Administrator may require any

additional information or samples which

he may require to evaluate the petition.

Additional copies of the petition may be

required as needed to be sent to affected

generators and Regional

Officials.

(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.

§ 258.54 Prohibitions on sludge.

(a) Preparing or accepting

transportation or treatment

of restricted wastes and

wastes in concentrations that exceed

the treatment levels specified in

appendices or in other applicable

appendices is prohibited.

(b) Except as provided in paragraph

3(b) of this section, the

wastes...
of hazardous wastes contained from
in the disposal under Subpart C of this
Part is prohibited unless the written
requirements are met.
(1) A generator uses each wastes
on site solely for the purpose of the
collection of such quantities of
hazardous wastes as necessary to
facilitate proper recovery, treatment,
or disposal and the generator complies
with the requirements in §209.34 of this
chapter. Provided the generator is in
existence on the effective date of a
regulation under this part and who must
store hazardous wastes for longer than
60 days due to the regulations under this
Part becomes an owner/operator of a
site-by-site facility and must obtain an RCRA
permit. Such a facility may qualify for
interim status upon compliance with the
regulations governing interim status
under 40 CFR 268.70.
(2) An owner/operator of a hazardous
treaty storage, disposal or disposal
facility stores such wastes solely for
the purpose of the accumulation of such
collections. It is necessary to facilitate
proper recovery, storage, or disposal,
facilities that each container or tank is clearly marked
to identify its contents and the date it
entered storage.
(3) A transport by any mode
manifested changing of such wastes at a
transfer facility if 70 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
storage was not solely for the purpose
of the accumulation of such quantities of
hazardous wastes as necessary to
facilitate proper recovery, treatment,
or disposal.
(c) An owner/operator of a treatment,
storage or disposal facility may store
such wastes beyond one year however,
the owner/operator bears the burden of
demonstrating that such storage was solely for
the purpose of the accumulation of such
quantities of hazardous wastes as
necessary to facilitate proper recovery,
treatment, or disposal.
(d) The provisions in paragraph (3) of
this section do not apply to the wastes
which are the subject of an approved
petition under §209.63 as an exempted
waste.
(2) The provisions in paragraph (1) of
this section do not apply to hazardous
waste that meet the treatment
standards specified under §262.41 -
262.42 and 262.43 or the treatment
standards specified under the variance
for §262.44.
Appendix to Part 262—Test Facility
Characteristics Loading 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 multi-walled wastes treated,
(1) A total analysis of the waste
contaminates幻想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
may not be run.
1.2 SUMMARY OF METHOD (see Figure 1)
1.2.1 For Liquid wastes (i.e., those
containing inorganic solid material).
2.1 For solids comprised of solids or for
wastes containing sufficient 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 in mg total weight of the solid
phase. The extraction fluid employed is a
function of the solubility of the solid phase
of the waste. A typical extraction procedure
is used when testing for vanadium (the Table 3).
2.2 following extraction, the solid extract can be
separated from the liquid phase by by the
appropriate glass filter.
3.1.1.2.2.1 The solid extract will not
form an emulsion with the liquid.
2.3.1.2.2.1.1 The liquid phase of the waste is added to the liquid
extract, and these extracts are analyzed
immediately if intact, or analyzed at
subsequent time intervals if intact.
3.2 INTERPRETATION
3.2.1 Potential interference that may be
encountered during testing are discussed in
the individual analytical methods.
4.0 APPARATUS AND MATERIALS
4.1 Apparatus extraction
An acceptable
apparatus for the waste as specified
in the Table 1 is required. The
extraction vessel (see Table 1) is
required to be evaluated.
4.2 Extraction Vessel
4.2.1 Zero-Headspace Extraction Vessel
(225 ml). The device is to be used
when the waste is to be tested for the mobility of
volatile compounds (see Table 1). The
225 ml is an extraction vessel that allows for partial
solid separation within the device, and which
effectively extracts a portion of the waste
as described in Table 1. The type of material chosen
(1) initially used is a polystyrene foam
and final extraction is with a toluene extract.
3.5.2 The vessel should have internal volume of 225 ml
be selected to accommodate a typical
Volume of 225 devices listed in §262.44
and be identified in Table 1. These devices
when OCLP which should be replaced
regularly.
For the OCLP to be acceptable for use, the
plastic within the OCLP should be able to be
melted with approximately 259 of water if
such one quarter of the plastic is
OCLP in the device should be replaced. If
this does not occur, the plastic, the OCLP
is unsuitable for TCLP analysis and the
manufacturer should be contacted.

The OCLP should be checked after every
extraction. If the device contained in the
pressure group, pressure the device to 10
pet, and rinse it with methanol for 10
minutes, and should be replaced if
the pressure group, the pressure of the
device to 10 pet

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These devices shall have a minimum internal volume of 200 ml and be equipped as recommended in a container filter size of 42 mm filter holder having an internal capacity of 200 ml filter holders (or equivalent). Stainless steel equipment may be used when evaluating the mobility of both organic and inorganic components. Devices made of high-density polyethylene (HDPE) polyolefins, etc. may be used only when evaluating the mobility of metals. Borosilicate glass bottles are recommended over other types of glass bottles, especially when inorganic compounds are of concern.

Filters: Filters shall be made of borosilicate glass fiber, and both contain no binder materials, and shall have an effective pore size of 0.15-1.0 μm, equivalent. Filters known to EPA to meet these specifications are identified in Table 5. Prefilters are not used. When evaluating the mobility of metals, there shall be acid-washed prior to use by rinsing with 1 N nitric acid followed by three consecutive rinses with distilled deionized water (a minimum of 1 L per rinse is recommended). Glass fiber filters are fragile and should be handled with care.

6.1 pH: pH: Any of the commonly available pH meters are acceptable.

6.2 TCLP extract collection devices: TLDEAR® 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 TCLP device. The devices listed are recommended for use under the following conditions.

6.2.1 If a waste contains a significant amount of non-aqueous initial liquid phase (i.e., >1% of total waste), the TLDEAR® bag(s) may be used for both the initial liquid phase and the final extract filtration. However, analysis should be done on the other, not both.

6.2.2 If a waste contains no initial liquid phase (i.e., 90% solids) or has an insignificant small amount of non-aqueous liquid (i.e., <1% of total waste), the TLDEAR® bag(s) may be used. If the system is used, discard the first 3 mL of liquid rinsed from the device. The remaining aliquots are used for analysis.

6.2.3 Refer to the manufacturer's instructions.

6.3.1 Solid phase extraction (SPE) is performed using an appropriate sampling plan.

6.3.2 At least two separate representative samples of the waste should be collected. If liquid waste samples of low volume, a third sample should be collected. The first sample is used in several preliminary TCLP evaluations (i.e., to determine the percent solids of the waste; to determine if the waste contains inorganic solids; to determine if the solid portion of the waste requires portable-solid-reduction and be determined which of the two extraction solvents are to be used for the non- soluble TCLP extraction of the wastes). The preliminary evaluations are identified in Section 2.8. The second and third samples are extracted using the TCLP non-soluble procedure (Section 2.8) and analyzed by the procedure (Section 2.8).

6.4 Preservatives shall not be added to samples.

6.5 Samples can be refrigerated unless refrigeration results in irreversible physical change to the waste (i.e., precipitation).

6.6 When the waste is to be evaluated for volatile contaminants, care shall be taken to minimize the loss of volatiles. Samples shall be taken and stored in a manner to prevent the loss of volatile components. If possible, samples should be sealed and stored completely inside a glove bag or glove box.

6.7 TCLP extracts should be prepared for analysis and analyzed as soon as possible following extraction. If this cannot be done, the extracts should be stored at a temperature not exceeding 4 °C and protected from light. Prior to analysis, if samples have been stored, they should be brought to room temperature.

7.0 PRELIMINARY TCLP EVALUATIONS

The preliminary TCLP evaluations are performed on a 100-g representative sample of the waste that will not actually undergo TCLP extraction (designated as the first sample in Step 4.3). These evaluations include preliminary determination of the percent solids of the waste, determination of whether the waste contains inorganic solids, determination of whether the waste contains volatile organics, and determination of which of the two extraction solvents are to be used for the non-soluble TCLP extraction of the wastes.

7.1 Preliminary determination of percent solids: Percent solids is defined as that fraction of the waste sample (as a percentage of the total sample) from which no liquid may be forced out by any applied pressure, as described below.

7.1.1 If the waste will obviously yield no free liquid when subjected to pressure filtration (i.e., 100% solid), proceed to Step 7.4.

7.1.2 If the sample is liquid or pasty material, liquid/solids separation may be made by preliminary determination of percent solids by centrifugation. This involves the filtration device described in Step 6.4 and its related instructions. Refer to 5.8.

7.1.3 Pre-wash the filter and the container, but not the dividers. 

7.1.4 Assemble the filter holder and filter following the manufacturer's instructions.
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 is not 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., less than 0.1% liquid, see Step 9.1), weigh and record a representative subsample of the waste (100 gram minimum) and proceed to Step 8.8.

8.2 If the sample is liquid or multicomponent, liquid/solid separation is required. This involves the filtration device described in Step 4.5 and is outlined in Steps 8.3 to 8.6.

8.3 Pre-weight the container set to 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 metal (see Step 6.4). Cautions: Acid washed filters may be used for all but the last extraction 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 <0.1% dry solids (Step 7.1), 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 >0.1% dry solids (Steps 7.1 or 7.2), use the permute 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 solvents to stand to permit the solid phase to settle. Washes that settle slowly may be centrifuged prior to filtration. Centrifugation is to be avoided as an aid to filtration. If used, the liquid should be decanted and filtered followed by filtration of the solids through the same filter system.

8.7 Quantitatively transfer the waste solids to the filter holder (see Step 4.2). If filtration of the waste at 6°C reduces the amount of extractable metals beyond detectable limits by expression 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.

8.8 Slowly add the amount of appropriate extraction fluid (see Step 7.4) to the TCLP extract vessel. Close the extractor bottle tightly (it is recommended that Tygon tape be used to ensure a tight seal), secure in rotary extraction device, and rotate at 96.2 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 to ensure as near identical conditions as possible.

Note: As agitation continues, pressure may build up within the extractor bottle, therefore, some types of wastes (e.g., lead or cadmium containing wastes) may evolve gases such as carbon dioxide). To reduce excess pressure, the extractor bottle may be periodically opened (e.g., after 72 minutes, 24 minutes and 1 hour) and vented into a hood. 8.9 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 6.4) if evaluating the mobility of metals.

8.10 The TCLP extract is now prepared as follows:

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08.12 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 97 is used in all cases (see Step 8.1). 8.12.1 With the ZHE in the vertical position, place the lid onto the extraction fluid reservoir to the liquid inlet/outlet valve. The lid used shall contain fresh extraction fluid and should be positioned with fluid to eliminate any air pockets in the ZHE. Release gas pressure on the ZHE 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 until the appropriate amount of fluid has been introduced into the device. 8.12.2 After the extraction fluid has been added, immediately close the liquid inlet/outlet valve and disconnect the extraction fluid hose. Check the ZHE device to ensure that all valves are in their closed positions. 8.13 Physically rotate the device in an end-to-end manner between 2 and 3 times. Reposition the ZHE in the vertical position with the liquid inlet/outlet valve to the top. Put 1-1.5 psi behind the valve (if necessary) and slowly open the liquid inlet/outlet valve to bleed out any backpressure (into a bottle) that may have been introduced due to the addition of extraction fluid. The bleeding shall be stopped at the first appearance of liquid from the valve. Repressurize the ZHE with 3-5 psi and check all ZHE fittings to ensure that they are closed. 8.12.3 Place the ZHE in the rotary extraction apparatus (if it is not already there) and rotate the ZHE at 30±1 rpm for 18±3 hours. Ambient temperature (i.e., temperature of room in which extraction is to occur) shall be maintained at 22±3°C during agitation. 8.13 Following the 18±3 hour agitation period, check the pressure behind the ZHE plates by quickly opening and closing the gas inlet/outlet valve and noticing 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 leaks as specified in Step 8.11, and only then proceed with a new sample of waste. If the pressure within the device has been maintained, physically rotate the device in an end-to-end manner to separate the component liquid and solid phases. If this waste contained no initial liquid phase, the liquid may be filtered directly into the same filtrate collection container (i.e., TEFLON® bag) holding the initial liquid phase of the waste, unless doing so would create multiple phases, or unless there is not enough volume left in the filtrate collection container. A separate filtrate collection container must be used in these cases. Filter the glass fiber filter, using the ZHE device as described in Step 8.8. All extract shall be filtered and collected to the TEFLON® bag to be used. If the extract is multiple phases, or if the waste contained an initial liquid phase (see Steps 8.4 and 8.5). 8.14 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. 8.15 If the original waste contained no initial liquid phase, the filtered liquid material obtained from Step 8.5 is defined as the TCP extract. If the waste contained an initial liquid phase, the filtered liquid material obtained from Step 8.5 and the initial liquid phase (Step 8.6) are collectively defined as the TCP extract. 8.16 Following collection of the TCP extract, the extract should be immediately aliquoted for analysis and stored with minimal backpressure (into a bottle) at 4°C until analysis. The TCP extracts 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 (see 2.10.1) and analyze the appropriate analyses, then combine the results mathematically by using a simple volume weight-average:

\[
\text{Final Analyte Concentration} = \frac{(V_1g_1 + V_2g_2)}{V_1 + V_2}
\]

where:

- \(V_1\) = The volume of the first phase (L)
- \(g_1\) = The concentration of the constituent of concern in the first phase (mg/L)
- \(V_2\) = The volume of the second phase (L)
- \(g_2\) = The concentration of the constituent of concern in the second phase (mg/L)

1.00 QUALITY ASSURANCE REQUIREMENTS

10.1 All data, including quality assurance data, should be maintained and available for reference inspections.

10.2 A minimum of one blank (extraction fluid #1) for each 10 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 TCP extract has been generated (i.e., should not occur prior to performance of the TCP procedure). The purpose of the matrix spike is to monitor the adequacy of the analytical methods used on the TCP extract 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 to verify recovery of the compound from the TCP extract is not between 50 and 150%, or 20% if the concentration of the compound 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 shall be applied only once and the percent recoveries applied to the remainder of the extractions.

10.6 Samples must undergo TCP extraction within the following time period after sample receipt: Valinatos: 14 days; Semivolatile: 40 days; Mercury: 21 days; and other Metals: 180 days. Beyond the end of the solid portion of the waste should be initiated as soon as possible following initial solid separation. TCP extracts shall be analyzed after generation and preservation within the following time period: Valinatos: 14 days; Semivolatile: 40 days; Mercury: 21 days; and other Metals: 180 days.
### Table 2—Suitable Rotary Actuation Apparatus 1—Continued

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### Table 3—Suitable Zero-Headface Extractor Vessels

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### Table 5—Suitable Filter Media

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Figure 2: Rotary Agitation
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 (CO₂), and oxygen (O₂) 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 (NES) 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 CUTLET 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 VOLATILE FLOW RATES (TYPE S PILOT 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 (plumbable or reverse type) pilot tube.

1.2. Applicability. This method is applicable for measurement of the average velocity of a gas stream and for quantifying the flow.

This procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 1.4. Also, the method cannot be used for direct measurement in systems having gas streams which are subject to any unacceptable 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. An example of such alternative procedures are (1) the method of straightening vanes, (2) the method of measuring the total volumetric flow rate simultaneously, 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 equipment 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 Pilot Tube. The Type S pilot tube (Figure 2-1) shall be made of metal tubing (e.g., stainless steel). It is recommended that the internal tubing diameter (diameter A Figure 2-2) be between 0.48 and 0.78 inches (1.2 and 1.9 cm). There shall be an equal distance of the pilot tube to the nozzle opening plane of 1.0 inches (2.5 cm). The flow shall be a) 1.2 to 1.5 times the external tube diameter. The flow shall be adjusted to the flow rate of the pilot tube shall, preferably, be allowed as shown in Figure 2-3; however, slight measurements of the openings are permissible (see Figure 2-3).

The Type S pilot tube shall have a known composition, determined as outlined in Section 4. An identification number shall be assigned to the pilot tube; this number shall be permanently marked or engraved on the body of the tube.

![Figure 2-1. Type S pilot tube manometer assembly.](image-url)
Figure 2-2. Properly constructed Type B count 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 concentric consistent when viewed from both sides. Stack exit coefficient values of 0.24 may be assigned to count tubes constructed this way.
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 (Ap) 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 Ap reading. If the Ap readings made before and after the air purge are the same (±5 percent), the traverse is acceptable. Otherwise, reject the run. Note that if Ap 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 Ap readings shall be.
taken, as above, for the last two back processes at which suitably high A readings are observed.

3.3 Differential Pressure Gauges. An inclined manometer or equivalent device is used. Most sampling tubes are equipped with a 1/4-in. (water column) inclined manometer, having 0.01-in. H2O divisions on the 0- to 1-in. inclined scale and 0.01-in. H2O divisions on the 1 to 10th vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of as small a pressure difference as 1.3 mm (0.05 in.) H2O. However, a differential pressure gauge of greater sensitivity shall be used to indicate the pressure reading at each point, at least at the start of the sampling process, or if any of the following is found to be true: (1) the arithmetic average of all as readings at the traverse point is less than 1.3 mm (0.05 in.) H2O; or (2) for traverses of 12 or more points, more than 10 percent of the individual as readings are below 1.3 mm (0.05 in.) H2O; or (3) for traverses of fewer than 12 points, more than one as reading is below 1.3 mm (0.05 in.) H2O. Section 3.6 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 used to determine the necessity of using a more sensitive differential pressure gauge:

\[
T = \left( \frac{\sum \sqrt{A_i} + K}{\sum \sqrt{A_i}} \right)
\]

where:

- \( A_i \) = individual velocity head reading at each traverse point.
- \( K \) = total number of traverse points.
- \( N \) = number of traverse points per traverse when English units are used.
- \( 0.005 \) in H2O when English units are used.

If \( T \) is greater than 0.06, the velocity head reading may be obtained from a barometric reading. If \( T \) is less than 0.06, the velocity head reading may be obtained from a barometric reading. If \( T \) is less than 0.06, the velocity head reading may be obtained from a barometric reading. If \( T \) is less than 0.06, the velocity head reading may be obtained from a barometric reading.

3.4 Calibration Pilot Tube. When calibration of the Type 3 pilot tube is necessary (see Section 3.4), a standard pilot tube is used as a reference. The standard pilot tube shall, preferably, have a known coefficient, obtained by direct measurement from the National Bureau of Standards. A standard pilot tube is designed according to the criteria given in 2.1 through 2.1.3 and illustrated in Figure 2.4, sections 3.4.1 through 3.4.5. A standard pilot tube is designed according to the criteria given in 2.1 through 2.1.3 and illustrated in Figure 2.4, sections 3.4.1 through 3.4.5. A standard pilot tube is designed according to the criteria given in 2.1 through 2.1.3 and illustrated in Figure 2.4, sections 3.4.1 through 3.4.5.

3.5 Barometric. A mercury, aneroid, or other barometer capable of measuring air pressure to within 1.3 mm Hg (0.1 in Hg) may be used. As a last resort, the barometric reading may be obtained from a nearby national weather service station. In any case, the difference between the barometric reading and the sampling point shall be recorded and an adjustment for elevation difference between the weather station and the sampling point shall be applied to the pressure reading at the sampling point.

3.6 Density Determination Equipment. A method 3 equipment is needed (see Section 3.6), to determine the mass of the air mass in the stack. The Reference Method 4 equipment is used for moisture content determinations; other methods may be used subject to approval of the Administrator.

3.7 Calibration Pilot Tube. When calibration of the Type 3 pilot tube is necessary (see Section 4), a standard pilot tube is used as a reference. The standard pilot tube shall, preferably, have a known coefficient, obtained by direct measurement from the National Bureau of Standards. A standard pilot tube is designed according to the criteria given in 2.1 through 2.1.3 and illustrated in Figure 2.4, sections 3.4.1 through 3.4.5. A standard pilot tube is designed according to the criteria given in 2.1 through 2.1.3 and illustrated in Figure 2.4, sections 3.4.1 through 3.4.5.
Figure 2.4. Standard pitot tube design specifications.

1. Procedure

1.1 Set up the apparatus as shown in Figure 2.1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen air fluctuations. It is recommended, but not required, that a pressure leak-check be conducted, as follows: (1) blow through the pitot insert opening until at least 76 cm (3 in.) H2O velocity pressure registers on the manometer; then, close off the insert 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 76 cm (3 in.) H2O. Other leak-check procedures, subject to the approval of the Administrator, may be used.

1.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverses. Record all necessary data as shown in the example data sheet (Figure 2.3).

1.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure range is being used for the range of AP values encountered (see Section 2.1). If it is necessary to change to a more sensitive gauge, do so, and remeasure the AP 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.

1.4 Measure the static pressure in the stack. This reading is usually adequate.

1.5 Determine the atmospheric pressure.
### Figure 2-5. Velocity traverse data.

<table>
<thead>
<tr>
<th>Traverse Pt. No.</th>
<th>Vol. Mls. of Air (m³)</th>
<th>Stack Temperature</th>
<th>$P_1$ (mm Hg)</th>
<th>$T_1$ (°F)</th>
<th>$T_2$ (°F)</th>
<th>$\sqrt{\frac{D}{12}}$</th>
</tr>
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<tbody>
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</tbody>
</table>

### 3.1 Determining the stack gas dry molecular weight

For combustion processes or processes that emit essentially CO, CO₂, and NOₓ, use Method 3. For processes emitting essentially air, an analysis need not be conducted, use a dry molecular weight of 28.9. For other processes, other methods, subject to the approval of the Administrator, must be used.

### 3.1.2 Obtain the moisture content from Reference Method 4 (or equivalent) or from Method 9.

### 3.8 Determine the cross-sectional area of the stack or duct as the sampling location. Whenever possible, physically measure the stack dimensions rather than using blueprints.

### 4. Calibration

#### 4.1 Type S Pitot Tube

Before the initial use, carefully examine the Type S pitot tube in the stack wall and end views to verify that the plane openings of the tube are aligned within the specifications illustrated in Figure 2-1 or 2-2. The pitot tube shall not be used if it fails to meet these alignment specifications.

After verifying the above alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D, Figure 2-2a); and (b) the base-to-opening plane distance (dimensions $P_1$ and $P_2$, Figure 2-2b). If $D$ is between 0.48 and 0.60 in. ($4$ and 5 in.) and $P_1$ and $P_2$ are equal and between 1.05 and 1.50 in., there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 4.1.3 through 4.1.3 below, or (2) a baseline (untested) tube coefficient value of 0.54 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 4.1.11).

If $D$, $P_1$, and $P_2$ are outside the specific limits, the pitot tube must be calibrated outlined in 4.1.3 through 4.1.3 below.
A. Bottom View: Ensuring Minimum Pitot Nozzle Separation.

B. Top View: Preventing Pitot Tube Interference with Sample Flow Straws.

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 8 in Section 4). Therefore, an assembly for otherwise known baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficients values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 4-6 and 4-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.64 and 0.25 cm (4/8 in. or 3/32 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 4-6 through 4-8 shall be calibrated according to the procedure outlined in Sections 4.1.3 through 4.1.1 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe shroud) 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 4-6).

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_h between 0.48 and 0.95 cm (3/16 and 3/8 in.).

Figure 2.8. Minimum pitot-sample probe separation needed to prevent interference: D_h between 0.48 and 0.95 cm (3/16 and 3/8 in.).
4.1.1.3 The flowing gas stream must be contained in a duct or wall to obtain cross-sectional areas with circular, rectangular, or some other cross-sectional shape. For circular cross-sections, the duct or wall area shall be at least 12\% of the total cross-sectional area. For rectangular cross-sections, the width (outer side) shall be at least 2.5 \( L_e \) wide.

4.1.1.4 The cross-sectional area of the calibration duct must be constant over a distance of 8\% of the duct diameter. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation to determine the number of duct diameters.

\[
D = \frac{2L}{(L+W)}
\]

where
\( D \) = Equivalent diameter
\( L \) = Length
\( W \) = Width

To ensure the presence of steady, 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 turbulence.

4.1.1.5 The eight- and two-diameter criteria are not absolute; other test section locations may be used subject to approval of the Administrator. The flow at the test site is steady, and the flow is parallel to the duct axis.

4.1.1.6 When a flow system has a capacity to produce a test section velocity above 200 ft/min (6.10 m/min) and an average of at least 1\% for the measurement of velocities above 200 ft/min (6.10 m/min), it may be used to measure gas flow. If a precision of 1\% for the measurement of velocities above 200 ft/min (6.10 m/min) is desired, the flow system shall have the capacity to produce at least four distinct, time-invariant test section velocities covering the velocity ranges from 100 to 1.31 m/min (600 to 1.31 ft/min), and the data shall be taken at regular velocity intervals over this range (see Classes B and C in Section 4 for details).

4.1.1.7 Two entry ports, each for the standard and Type B pitot tube, shall be cut in the test section. The standard port entry shall be located at least 1\% of the downstream of the Type B port so that the standard and Type B impact openings will be 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 plastic, glass, or some other transparent material.

4.1.1.8 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 4.1.3. Note also that this procedure supersedes only the standard-velocity calibration. To proceed with this calibration, begin at the first aid station. Figure 2.9 shows the pitot tube identification number.

<table>
<thead>
<tr>
<th>CALIBRATION</th>
<th>RUN NO.</th>
<th>( \Delta P_{\text{in}} ) (in. H2O)</th>
<th>( \Delta P_{\text{out}} ) (in. H2O)</th>
<th>( C_p(d) )</th>
<th>DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot; SIDE CALIBRATION</td>
<td>1</td>
<td>( \Delta P_{\text{in}} ) (in. H2O)</td>
<td>( \Delta P_{\text{out}} ) (in. H2O)</td>
<td>( C_p(d) )</td>
<td></td>
</tr>
<tr>
<td>&quot;B&quot; SIDE CALIBRATION</td>
<td>1</td>
<td>( \Delta P_{\text{in}} ) (in. H2O)</td>
<td>( \Delta P_{\text{out}} ) (in. H2O)</td>
<td>( C_p(d) )</td>
<td></td>
</tr>
</tbody>
</table>

AVERAGE DEVIATION = \( \frac{1}{n} \sum \frac{1}{2} | C_p(d) - \bar{C}_p(d) | \) -- MUST BE \( \leq 0.21 \)

\( \bar{C}_p(d) \) SIDE A \( \bar{C}_p(d) \) SIDE B

Figure 2.9. Pitot tube calibration data.

4.1.1.9 Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type A entry port.

4.1.1.10 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.11), and align the tube so that it is pointed directly into the flow. Particular care should be taken to ensure the tube is aligned properly. Make sure that the entry port surrounding the tube is properly sealed.

4.1.1.11 Read \( \Delta P_{\text{in}} \) and \( \Delta P_{\text{out}} \) and record its value in a data table similar to the one shown in Figure 2.9. Repeat the standard pitot tube from the duct and disconnect it from the manometer. Seal the standard entry port. Repeat the Type B pitot tube into the manometer. Close the Type A entry port. Close the manometer level and zero the manometer and align the Type B 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.

4.1.1.12 Read \( \Delta P_{\text{in}} \) and \( \Delta P_{\text{out}} \) and record its value in the data table. Remove the Type B pitot tube from the duct and disconnect it from the manometer.

4.1.1.13 Repeat steps 4.1.1.12 through 4.1.1.11 above until three pairs of \( \Delta P_{\text{in}} \) readings have been obtained.

4.1.1.14 Repeat steps 4.1.1.12 through 4.1.1.11 above for the B side of the Type B pitot tube.

4.1.1.15 Perform calculations, as described in Section 4.1.1 below.

4.1.1.16 Calculations. Note also that the six pairs of all readings (i.e., three from side A and three from side B) obtained in Section 4.1.1 above, calculate the value of the Type B pitot tube coefficient as follows.

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4.1.4.1 Use the Type 3 pilot tube only if the values of C (side A) and C (side B) are less than or equal to 0.93 and if the absolute value of the difference between C (A) and C (B) is 0.01 or less.

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

4.1.5.2 When an isolated Type 3 pilot 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 3 pilot coefficients as obtained, i.e., C (side A) and C (side B), will be valid, so long as either (1) the isolated pilot tube is used or (2) the pilot tube is used with other components (mocula, thermocouple, static probe) in an arrangement that is free from any significant interference effects (see Figures 3-4 through 3-6).

4.1.5.3 For Type 3 pilot 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 as long as the pilot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 3-4, 3-5, and 3-6).

4.1.5.4 For assemblies with sample probes, the calibration point should be located at or near the center of the duct however, introduction of a probe shroud into a small duct may cause significant cross-sectional area blockage and yield incorrect coefficients (Charts 7 in Section 6). Therefore, to minimize the blockage effect, the calibration point must be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical shape, as determined by a perimeter area model of the probe shroud, is 2 percent or less of the duct cross-sectional area, for assemblies without external shrouds (Figure 3-1a), and 3 percent or less for assemblies with external shrouds (Figure 3-1b).

4.1.5.5 For those probes assemblies in which pilot tube-thermocouple interference is a factor (i.e., those in which the pilot-thermocouple separation distance falls to meet the specifications illustrated in Figure 1-1b), the value of C must depend 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 (0.0254 cm or 1/4 in.) are not ordinarily used for isokinetic sampling at velocities around 913 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 19 in Section 6).

4.1.5.6 For a probe assembly constructed such that its pilot tube is always used in the same orientation, only one side of the pilot tube need be calibrated (one side will face the flow). The point of calibration must still meet the alignment specifications of Figure 2-1 or 2-2, however, and must have an average deviation from the mean of 0.01 or less (see Section 4.1.4).

Figure 2-10. Projected area model for typical pitot tube assemblies.
4.1.3 When a probe assembly is used to sample a small duct (12 in. or less in diameter), the sample point must be located at the direction from which the gas flows. In this case, the sample point must be located at the leading edge of the duct, and the air flow rate must be measured using an air flow meter. If a pitot tube is used, the air flow rate must be measured using a pitot tube or a pitot-static tube assembly.

4.1.3.1 Isolated Pitot Tube. After each flow test, the pitot tube shall be thoroughly cleaned in warm, soapy water, and then dried. If the pitot tube is used to measure the air flow rate, the pitot tube shall be cleaned immediately before and after each test.

4.1.3.2 Pitot Tube Assembly. After each flow test, the pitot tube assembly shall be thoroughly cleaned in warm, soapy water, and then dried. If the pitot tube assembly is used to measure the air flow rate, the pitot tube assembly shall be cleaned immediately before and after each test.

4.1.4 Field Use and Recalibration. After each test, the pitot tube assembly shall be recalibrated to ensure accurate measurements.

4.1.5 Spring Coefficient (C). The spring coefficient of the pitot tube assembly shall be determined using the method described in Section 4.1.1.1. The spring coefficient is determined by measuring the air flow rate at known velocities and comparing the measured air flow rate to the air flow rate calculated using the spring coefficient.

4.1.6 Flow Velocity Calibration Method. The flow velocity calibration method shall be determined using the method described in Section 4.1.1.1. The flow velocity is determined by measuring the air flow rate at known velocities and comparing the measured air flow rate to the air flow rate calculated using the flow velocity.

4.1.7 Absolute Temperature. The absolute temperature shall be determined using the method described in Section 4.1.1.1. The absolute temperature is determined by measuring the air flow rate at known temperatures and comparing the measured air flow rate to the air flow rate calculated using the absolute temperature.

5. Calculations

5.1 Flow Rate

\[ Q = \frac{P_2 - P_1}{Z_2 - Z_1} \]

5.2 Average Stack Gas Dry Volumetric Flow Rate

\[ Q_v = \frac{Q}{\rho_g} \]

Equation 2-9

5.3 Average Stack Gas Dry Volumetric Flow Rate

\[ Q_v = \frac{Q}{\rho_g} \]

Equation 2-10

To convert from \( Q_v \) in ft³/s to \( Q_v \) in m³/s or \( Q_v \) in m³/min, use the following equation:

\[ Q_v = \frac{Q_v}{V} \]

where \( V \) is the conversion factor from ft³/s to m³/s or m³/min.


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 carbon dioxide, carbon monoxide, and oxygen concentrations, and if necessary, for water vapor content (60). If a gas analyzer is used, the determination is to be made on a continuous basis, unless otherwise specified. Otherwise, the gas sample may be used for the analysis for carbon dioxide or carbon monoxide by means of the bomb calorimeter, or by means of an Oechsler instrument, and the results may be used for the analysis for carbon dioxide or carbon monoxide by means of the bomb calorimeter, or by means of an Oechsler instrument.

1.2 Applicability. The method is applicable for determining carbon dioxide and carbon monoxide concentrations, excess air, and dry molecular weights of a sample from a gas stream of a combustion process. The method may also be applicable to other processes where it is determined that compounds other than CO₂, CO, and oxygen (60) are not present in concentrations sufficient to affect the results.

Other methods, as well as modifications to the procedure described herein, are applicable for some or all of the above determinations. Examples of specific methods and modifications include (1) a single-point sampling method using an Oechsler analyzer to analyze individual samples obtained at each point; (2) a method using CO₂, CO, and carbon dioxide concentrations to determine dry molecular weight and excess air; or (3) assigning a value of 19.2 for dry molecular weight, in lieu of actual measurements, for purposes of determining carbon dioxide, carbon monoxide, or carbon dioxide.

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., isothermal samplers) may be used, provided such systems are capable of obtaining a representative sample and are designed to obtain a constant sample rate, and are otherwise capable of yielding acceptable results. The 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 equivalent metal, and should be equipped with an impact or out-swing door to remove particulate matter. A plug of steel wool is satisfactory for this purpose. Any other materials must be resistant to temperatures of sampling conditions. The materials must be free of all materials that are able to seal, cause, or be entrained in the stack.

2.1.2 Probe. A capture cover with a cover plate is used to capture the gas sample to the analyzer.

2.2 Integrated Sampling (Figure 3-3).

2.2.1 Probe. A probe is used that is described in Section 2.2.1 is acceptable.

3. Sampling Procedures

3.1 None of the gases analyzed or results obtained are subject to control by the Environmental Protection Agency.

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Figure 3-1. Grab sampling train.

Figure 3-3. Integrated gas-sampling train.
1.1 Dry Molecular Weight Determination

An Air sampler or Pyrrhic type combustion gas analyzer may be used.

1.1.1 Reporting of Correction Factor or Excess Air Determination. An Air sampler or Pyrrhic type combustion gas analyzer and an Air sampler or Pyrrhic type combustion gas analyzer may be used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.1.2 Repeat the analysis and calculation procedures until the incremental dry molecular weight for any three samples differ from their mean by more than 0.3 g/mole (±0.03). Average these three molecular weights, and report the results in the form of 0.1 g/mole ± 0.01 g/mole.

1.1.3 Repeat the analysis and calculation procedures until the incremental dry molecular weight for any three samples differ from their mean by more than 0.3 g/mole (±0.03). Average these three molecular weights, and report the results in the form of 0.1 g/mole ± 0.01 g/mole.

1.1.4.1 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.1.5 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.2.1 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.2.2 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.2.3 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.

1.2.4 The sampling point in the stack, with the tip of the probe positioned at the same point on the stack, is different for each separate test. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used. For emission rate determinations, the Air sampler or Pyrrhic type combustion gas analyzer is used.
To ensure complete absorption of the CO, or if possible, of the CO2, the sample gas must be passed through each absorbing solution until two consecutive readings are the same. Several portions (three or four) should be made between readings. If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.

4.2 Repeat the analysis until the following criteria are met:

4.2.1 For percent CO2, repeat the analytical procedure until the results of any three analyses differ by no more than ±0.3 percent by volume when CO is greater than 4.8 percent or ±0.3 percent by volume when CO is less than or equal to 4.8 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.1.1 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than ±0.3 percent by volume when CO is less than 1.8 percent or ±0.3 percent by volume when CO is greater than or equal to 1.8 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.2 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than ±0.3 percent by volume. For the results of the analysis to be valid, the percent CO must pass this test before an after the analysis.

Note: Although in most instances only CO or O2 is required, it is recommended that both CO and O2 be measured, and that the data 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 3.1.1 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 Section 4.2 through 4.4.7, 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 2-5.

4.4 Quality Control Procedures

4.4.1 Cross Validation When both CO and CO2 are measured. Aliquots in most instances, only CO or CO2 measurement is required. It is recommended that both CO and CO2 be measured to provide a check on the quality of the data. The following quality control procedure is suggested.

Some flows in the method for validating the CO and CO2 analysis is based on combustion of organic and fossil fuels and a solution of the gas streams with air. This method does not apply to sources that do not burn or burn with a flame. The CO2 content is measured by titration, (2) add CO2 to a gas stream at a rate different from that of air, (3) add CO (e.g., excess) to air, and (4) have no fuel factor. CO values obtained by this method should not be used to validate the source's entire gas mixture. This method validates the method's performance of CO and CO2 for the flow test. Therefore, the test should be done several times resulting from leaks during or after sample collection. The method is applicable for sample collected downstream of most lines or lines of flue-gas desulfurization units that the CO2 added or removed from the gas stream is not significant in relation to the total CO2 concentration. The CO2 concentration from other types of scrubbers using only water or basic slurry can be significantly affected and would render the P2 check insignificant.

4.4.2.1 Calculate a fuel factor, Fp, using the following equation:

\[ F_p = \frac{F_{bC}}{F_{bO}} \]

Where:

\[ F_bC = \text{Fuel factor for CO2} \]
\[ F_{bO} = \text{Fuel factor for CO} \]

4.4.3 The calculated fuel factor should be less than 1.50.

4.5 Leak Check Procedure for Great Analyses

Moving an ozone analyzer frequently causes it to leak. Therefore, an ozone analyzer should be continuously leak-proofed on site before the flux gas sample is transmitted into it. The procedure for leak-checking an ozone analyzer is as follows:

1.1 Inspect the liquid level in each pipette to the reference mark on the collapsible tubing and then close the manometer stopcock.

1.2 Record the manometer position.

1.3 Observe the bubbles in the burette and the liquid level in the pipette for movement over the next 4 minutes.

1.4 For the ozone analyzer to pass the leak-check, the conditions must be met:

1.4.1 The liquid level in each pipette must not fall below the bottom of the collapsible tubing during this 4-minute interval.

1.4.2 The manometer position may not change by more than 0.2 ml during this 4-minute interval.

1.5 If the analyzer fails the leak-check procedure, all rubber connections should be checked until the cause of the leak is identified. Leaking connections must be reseated, and the analyzer reassembled. The leak-check procedure must be repeated.

4.6 Calculations

4.6.1 Mole, - Dry molecular weight, g/mole (lb/mole).

4.6.2 Percent CO, CO2, O2, NOx, and NO. Each measured.

4.6.3 Percent CO, CO2, O2, NOx, and NO. Each measured.

4.6.4 Molecular weight of CO, CO, and O2. Divided by 100.

4.6.5 Molecular weight of CO, CO, and O2. Divided by 100.

4.6.6 Percent CO, CO2, O2, NOx, and NO. Each measured.

4.6.7 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent CO2, CO, and O2 (calculated from Section 4.6.3 or 4.6.4) into Equation 3-1.

\[ %EA = \frac{100 - 2.85\%N}{100} \]

Equation 3-1

Note: The equation above assumes that any excess air is used as the agent for oxidation of CO and that the fuel does not contain appreciable amounts of N2 to reduce excess air for calculations. However, the amount of N2 in waste products is not known. Furthermore, the amount of N2 is not known. Furthermore, the amount of excess air is not known. Furthermore, the amount of excess air is not known. Furthermore, the amount of excess air is not known.

4.6.8 Dry Molecular Weight. To calculate the dry molecular weight of the stack gas:

\[ M_d = \frac{M_{CO}}{80\%CO} + \frac{M_{CO2}}{80\%CO2} + \frac{M_{O2}}{80\%O2} \]

Equation 3-2
Note: The above equation does not consider argon in air (about 0.9 percent, molecular weight of 39.94). A positive error of about 0.6 percent is introduced. The factor may opt to include argon in the analysis using procedures subject to approval of the Administrator.

7. Bibliography


F-16

EPA STATIONARY SOURCE SAMPLING METHODS
Page 3-9 REV 2 3/88
METHOD 10
RULES AND REGULATIONS/MARCH 8, 1979

Section 10 - Determination of Carbon Monoxide Emissions From Continuous Sources

1. Principles and Availability

1.1 Principles. An exhaust gas analysis and gas smoke is extracted from a sample point and analyzed for carbon monoxide (CO) emissions using a Lahn-type continuous-flow infrared analyzer (Model or equivalent).

1.2 Determination. The method is applicable for the determination of carbon monoxide emissions from stationary sources only whose operation is by the test procedure for determining emissions with the same performance standards. The test procedure will elucidate whether a continuous or an integrated sample is to be used.

2. Results and Accuracy

2.1 Accuracy. The accuracy of the method is approximately 2.5 percent of full scale.

2.2 Reproducibility. The accuracy of the method is approximately 2.5 percent of full scale emission.

2.3 Repeatability. The accuracy of the method is approximately 2.5 percent of full scale emission.

3. Interferences. Any emissions causing a serious absorption of infrared energy will interfere in excess almost. For example, the absorbation ratios for water (H₂O) and carbon dioxide (CO₂) are 3.30 parts per 18 parts CO and 18 parts CO₂ per 18 parts CO₂, respectively, for 0.01 percent CO₂ in the 1.550 to 1.580 parts per 18 parts CO₂. The degree of interference is in the 0 to 1.50 parts per 18 parts CO₂. Interference ratios can be as high as 3.30 parts per 18 parts CO₂ and 18 parts CO₂ per 18 parts CO₂. The use of other CO₂ and compounds will alleviate the interferences problems. The removed gas volume must be corrected if these steps are used.

4. Precision and Accuracy

4.1 Precision. The precision of the method is approximately 2.5 percent of full scale.

4.2 Accuracy. The accuracy of the method is approximately 2.5 percent of full scale emission.

4.3 Repeatability. The accuracy of the method is approximately 2.5 percent of full scale emission.

5. Apparatus

5.1 Continuous samples. For continuous samples, a filter to remove particulate matter.

6. Apparatus

6.1 Continuous samples. For continuous samples, a filter to remove particulate matter.

6.2 Air-cooled condenser or equivalent. To remove gas sample condensation.

6.3 Absorption solution. The use 10 percent KOH or other solvent.

6.4 Pressure. The use of 0 to 1.50 bars or other solvent.

6.5 Temperature. The use of 0 to 1.50 bars or other solvent.

7. Installation and Maintenance

7.1 Maintenance. The equipment is maintained according to the Environmental Protection Agency.
led by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

2.2.5he final type of equipment attached to the probe so that the sampling probe can be mounted perpendicular to the stack gas velocity when velocity is greater than 200 ft/min or a sample traverse is conducted.

2.2.5 Analysis (Figure 2-3)

2.2.5.1 Carbon monoxide (CO) concentration. The analyzer used was the Hitachi 1111A which is accurate to ±1%. This analyzer should be calibrated periodically by the manufacturer's instructions and then calibrated at least once every six months.

2.2.5.1.1 Chemiluminescent CO analyzers available.

1. Procedure

1.1 Preparation

1.1.1 Carbon monoxide analysis. Set up the equipment as shown in Figure 2-4. Mount the analyzers on the stack and the stack is analyzed. Connect the analyzer and make certain that the stack is connected. Attach the sampling line to the stack and make sure that the sample is taken from the probe. Make certain that the CO gas probe is properly connected and that the stack is complete. Connect the analyzer and make certain that the stack is connected. Make certain that the CO gas probe is properly connected and that the stack is complete.

2. Procedure

2.1 Preparation

2.1.1 Carbon monoxide concentration. To measure CO in the gas stream, see Figure 2-4. Mount the analyzers on the stack and the stack is analyzed. Connect the analyzer and make certain that the stack is connected. Attach the sampling line to the stack and make sure that the sample is taken from the probe. Make certain that the CO gas probe is properly connected and that the stack is complete. Connect the analyzer and make certain that the stack is connected. Make certain that the CO gas probe is properly connected and that the stack is complete.

2.2 Procedure

2.2.1 Calibration. First, remove the sampling line from the stack gas. Proceed with the calibration as shown in Figure 2-4. Make certain that the stack is connected. Attach the sampling line to the stack and make sure that the sample is taken from the probe. Make certain that the CO gas probe is properly connected and that the stack is complete. Connect the analyzer and make certain that the stack is connected. Make certain that the CO gas probe is properly connected and that the stack is complete.

3. Calibration

3.1.1 Carbon monoxide concentration. To measure CO in the gas stream, see Figure 2-4. Mount the analyzers on the stack and the stack is analyzed. Connect the analyzer and make certain that the stack is connected. Attach the sampling line to the stack and make sure that the sample is taken from the probe. Make certain that the CO gas probe is properly connected and that the stack is complete. Connect the analyzer and make certain that the stack is connected. Make certain that the CO gas probe is properly connected and that the stack is complete.

4. Conclusion

4.1 Analysis. The Hitachi 1111A analyzer is accurate to ±1%. The CO concentration can be measured to within 10% of the actual concentration.
APPENDIX G

SUMMARY TABLES OF FIELD DATA AND ANALYTICAL RESULTS
THIS PAGE IS INTENTIONALLY BLANK.
### Table 3-1. Summary of values of test variables during demonstration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test No.</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A. Independent Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Ambient air</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Temperature (°F)</td>
<td></td>
<td>78</td>
<td>68</td>
<td>72</td>
</tr>
<tr>
<td>2) Relative humidity (%)</td>
<td></td>
<td>84</td>
<td>80</td>
<td>53</td>
</tr>
<tr>
<td>3) VOC concentration</td>
<td></td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>b. Feed soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Contaminant concentrations</td>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>2) Moisture content (% by wt.)</td>
<td></td>
<td>14</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>3) Temperature (°F)</td>
<td></td>
<td>74</td>
<td>73</td>
<td>93</td>
</tr>
<tr>
<td>B. Control Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Held constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Thermal processor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Draft</td>
<td></td>
<td>-0.065</td>
<td>-0.063</td>
<td>-0.042</td>
</tr>
<tr>
<td>2) Discharge gas temperature (°F)</td>
<td></td>
<td>325</td>
<td>262</td>
<td>240</td>
</tr>
<tr>
<td>b. Condenser</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Discharge gas temperature (°F)</td>
<td></td>
<td>143</td>
<td>112</td>
<td>133</td>
</tr>
<tr>
<td>c. Afterburner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Discharge gas temperature (°F)</td>
<td></td>
<td>1,804</td>
<td>1,605</td>
<td>1,805</td>
</tr>
<tr>
<td>d. Scrubber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Inlet gas temperature (°F)</td>
<td></td>
<td>272</td>
<td>341</td>
<td>396</td>
</tr>
<tr>
<td>2) Scrubber liquor recirculation</td>
<td></td>
<td>491</td>
<td>505</td>
<td>300</td>
</tr>
<tr>
<td>flow rate (gpm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Average Scrubber liquor pH</td>
<td></td>
<td>7.6</td>
<td>8.2</td>
<td>7.6</td>
</tr>
</tbody>
</table>
Table G-1. (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
| 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)                 | 300     | 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-4
(c) Data found on Table G-5
(e) Data found in Appendix H
### Table G-2. Summary of analytical results for Test 1

**Test Conditions:** Oil temperature = 600°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP (ug/L)(a)</th>
<th>Soil Cleanup Goal Extract Level in TCLP (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloromethane</td>
<td>&lt;3,500</td>
<td>&lt;4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Bromomethane</td>
<td>&lt;3,500</td>
<td>&lt;4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>&lt;3,500</td>
<td>&lt;4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>50</td>
</tr>
<tr>
<td>Chloroethane</td>
<td>&lt;3,500</td>
<td>&lt;4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>980</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>350 J</td>
<td>&lt;2.0</td>
<td>99.43</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>100</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>760 J</td>
<td>2.0 J</td>
<td>99.74</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Chloroform</td>
<td>140 J</td>
<td>&lt;2.0</td>
<td>&gt;88.57</td>
<td>0.1</td>
<td>70</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>400</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>410</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>cis-1,1-Dichloropropane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,1-Dichloropropane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>37,250</td>
<td>5.4</td>
<td>99.986</td>
<td>0.3</td>
<td>70</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>1.1</td>
<td>NE</td>
</tr>
<tr>
<td>2-Chloroethyl vinyl ether</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromoform</td>
<td>&lt;3,500</td>
<td>&lt;4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethene</td>
<td>&lt;1,800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>2,760 J</td>
<td>&lt;2.0</td>
<td>&gt;99.93</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Acetone</td>
<td>&lt;11,000</td>
<td>&lt;12.0</td>
<td>(b)</td>
<td>0.6</td>
<td>NE</td>
</tr>
<tr>
<td>2-Butanone</td>
<td>&lt;11,000</td>
<td>&lt;12.0</td>
<td>(b)</td>
<td>0.5</td>
<td>750</td>
</tr>
<tr>
<td>Benzene*</td>
<td>&lt;1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>70</td>
</tr>
<tr>
<td>Toluene*</td>
<td>&lt;1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>330</td>
</tr>
</tbody>
</table>

(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.
Table G-2. (continued)

Test Conditions: Oil temperature = 500°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (ug/L)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorobenzene*</td>
<td>&lt;1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Ethylbenzene*</td>
<td>&lt;1,800</td>
<td>&lt;2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>53</td>
</tr>
<tr>
<td>m-Xylene*</td>
<td>3,650 J</td>
<td>&lt;4.0</td>
<td>&gt;99.89</td>
<td>0.2</td>
<td>(1)</td>
</tr>
<tr>
<td>o,p-Xylenes*</td>
<td>2,250 J</td>
<td>&lt;4.0</td>
<td>&gt;99.82</td>
<td>0.2</td>
<td>(1)</td>
</tr>
</tbody>
</table>

Semivolatiles

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (ug/L)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>35,000</td>
<td>540 J</td>
<td>98.46</td>
<td>6 J</td>
<td>125</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>8,700</td>
<td>&lt;3,200</td>
<td>&gt;61.22</td>
<td>5 J</td>
<td>10,800</td>
</tr>
<tr>
<td>2-Methylnapthalene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>3,500</td>
<td>&lt;3,200</td>
<td>&gt;8.57</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
<tr>
<td>Fluoranthene*</td>
<td>3,300</td>
<td>1,700 J</td>
<td>(b)</td>
<td>&lt;10</td>
<td>140</td>
</tr>
<tr>
<td>Naphthalene*</td>
<td>4,300</td>
<td>130 J</td>
<td>95.98</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
<tr>
<td>Benzo(a)anthracene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>8.7</td>
</tr>
<tr>
<td>Benzo(a)pyrene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>15</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>8.7</td>
</tr>
<tr>
<td>Chrysene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>100</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>20</td>
</tr>
<tr>
<td>Acenaphthene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>1,200</td>
</tr>
<tr>
<td>Acenaphthylene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>660</td>
</tr>
<tr>
<td>Anthracene*</td>
<td>60 J</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>650</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>51</td>
</tr>
<tr>
<td>Fluorene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>140</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>29</td>
</tr>
<tr>
<td>Phenanthrene*</td>
<td>790 J</td>
<td>460 J</td>
<td>&gt;41.77</td>
<td>&lt;10</td>
<td>660</td>
</tr>
<tr>
<td>Fluorene*</td>
<td>280 J</td>
<td>310 J</td>
<td>(b)</td>
<td>&lt;10</td>
<td>180</td>
</tr>
<tr>
<td>Benzo(k)fluoranthene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>11</td>
</tr>
<tr>
<td>4-Chloroaniline</td>
<td>220 J</td>
<td>380 J</td>
<td>(b)</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
<tr>
<td>2-Chloronaphthalene*</td>
<td>3,300</td>
<td>&lt;3,200</td>
<td>(b)</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
</tbody>
</table>

(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-3. Summary of analytical results for Test 2

Test Conditions: Oil temperature = 400°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Concentration Feed Soil (µg/kg)</th>
<th>Processed Soil (µg/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (µg/L)(a)</th>
<th>Goal Cleanup Level in TCLP Extract (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatiles (VOCs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloromethane</td>
<td>&lt; 3,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Bromomethane</td>
<td>&lt; 3,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>&lt; 3,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>50</td>
</tr>
<tr>
<td>Chloroethane</td>
<td>&lt; 3,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>960</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>330 J</td>
<td>&lt; 2.0</td>
<td>&gt;99.39</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>100</td>
</tr>
<tr>
<td>1,1-Dichloroethanol</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>790 J</td>
<td>&lt; 2.0</td>
<td>&gt;99.75</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Chloroform</td>
<td>180 J</td>
<td>&lt; 2.0</td>
<td>&gt;98.89</td>
<td>0.1</td>
<td>70</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>400</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>410</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>111,000(c)</td>
<td>5.0</td>
<td>99.995</td>
<td>0.3</td>
<td>70</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>2-Chloroethyl vinyl ether</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromoform</td>
<td>3,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>3,985 J</td>
<td>&lt; 2.0</td>
<td>&gt;99.95</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Acetone</td>
<td>&lt;11,000</td>
<td>&lt;12</td>
<td>(b)</td>
<td>0.6</td>
<td>NE</td>
</tr>
<tr>
<td>2-Butanone</td>
<td>&lt;11,000</td>
<td>&lt;12</td>
<td>(b)</td>
<td>0.6</td>
<td>750</td>
</tr>
<tr>
<td>Benzene*</td>
<td>&lt; 1,600</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>70</td>
</tr>
<tr>
<td>Toluene*</td>
<td>8,300</td>
<td>&lt; 2.0</td>
<td>&gt;99.98</td>
<td>0.1</td>
<td>330</td>
</tr>
</tbody>
</table>

(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.

NE: Not detected at the specified detection limit.
> Greater than.
J: Less than detection limit, estimated value.
NE: Not established.
Table G-3. (continued)

Test Conditions: Oil temperature = 400°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Soil Concentration from TCLP Extract (ug/L)(a)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorobenzene*</td>
<td>&lt; 1,800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Ethylbenzene*</td>
<td>960 J</td>
<td>&lt; 2.0</td>
<td>&gt;99.79</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>m-Xylene*</td>
<td>7,100 J</td>
<td>&lt; 4.0</td>
<td>&gt;99.94</td>
<td>0.2</td>
<td>(1)</td>
</tr>
<tr>
<td>o,p-Xylenes*</td>
<td>4,300 J</td>
<td>&lt; 4.0</td>
<td>&gt;99.91</td>
<td>0.2</td>
<td>(1)</td>
</tr>
</tbody>
</table>

Semivolatiles

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Soil Concentration from TCLP Extract (ug/L)(a)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>15,000</td>
<td>950 J</td>
<td>&gt;95.67</td>
<td>10 J</td>
<td>125</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>3,600 J</td>
<td>220 J</td>
<td>&gt;93.89</td>
<td>&lt;100</td>
<td>10,800</td>
</tr>
<tr>
<td>2-Methylphenanthrene*</td>
<td>2,400 J</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>1,500 J</td>
<td>&lt;100 J</td>
<td>&gt;93.33</td>
<td>&lt;100</td>
<td>NE</td>
</tr>
<tr>
<td>Fluorethane*</td>
<td>2,900 J</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Naphthalene*</td>
<td>5,000 J</td>
<td>&lt;100 J</td>
<td>&gt;97.40</td>
<td>&lt;100</td>
<td>NE</td>
</tr>
<tr>
<td>Benzo(a)anthracene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Benzo(a)pyrene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Benzo(b)fluoranthene*</td>
<td>&lt; 3,300</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Chrysene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Acenaphthene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Acenaphthylene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>650</td>
<td></td>
</tr>
<tr>
<td>Anthracene*</td>
<td>770 J</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>650</td>
<td></td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene*</td>
<td>&lt; 3,800</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Fluorene*</td>
<td>&lt; 3,000</td>
<td>&lt;100 J</td>
<td>&gt;94.74</td>
<td>&lt;100</td>
<td>140</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene*</td>
<td>&lt; 3,000</td>
<td>&lt;1,400 (b)</td>
<td>&gt;500</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Phenanthrene*</td>
<td>820 J</td>
<td>670 J</td>
<td>18.29</td>
<td>&lt;100</td>
<td>560</td>
</tr>
<tr>
<td>Pyrene*</td>
<td>90 J</td>
<td>500 J</td>
<td>18.29</td>
<td>&lt;100</td>
<td>180</td>
</tr>
<tr>
<td>Benzo(k)fluoranthene*</td>
<td>&lt; 3,600</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>4-Chloroaniline*</td>
<td>540 J</td>
<td>530 J</td>
<td>&gt;100</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>2-Chloronaphthalene*</td>
<td>&lt; 3,600</td>
<td>&lt;3,400 (b)</td>
<td>&gt;100</td>
<td>NE</td>
<td></td>
</tr>
</tbody>
</table>

(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

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Concentration</th>
<th>Processed Soil Concentration</th>
<th>Removal Efficiency</th>
<th>Processed Soil Concentration from TCLP</th>
<th>Goal Cleanup Level in TCLP Extract</th>
<th>NE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ug/kg)</td>
<td>(ug/kg)</td>
<td>(%)</td>
<td>(ug/L)(a)</td>
<td>(ug/L)</td>
<td></td>
</tr>
<tr>
<td><strong>Vocals (VOCs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloromethane</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Bromomethane</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Chloroethane</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>960</td>
<td></td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>273 J</td>
<td>2.7 J</td>
<td>99.03</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>410</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>cis-1,1,2-Dichloropropane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>trans-1,1,2-Dichloropropane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>10,575</td>
<td>23.4</td>
<td>99.78</td>
<td>1.2</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Dibromochlormethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>2-Chloroethylvinylether</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Bromoform</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>613 J</td>
<td>0.5 J</td>
<td>99.92</td>
<td>0.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>&lt; 4,800</td>
<td>&lt; 12</td>
<td>(b)</td>
<td>0.6</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>2-Butanone</td>
<td>&lt; 4,800</td>
<td>&lt; 12</td>
<td>(b)</td>
<td>0.6</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>Benzene*</td>
<td>745 J</td>
<td>1.3 J</td>
<td>99.83</td>
<td>0.7</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Toluene*</td>
<td>200 J</td>
<td>1.1 J</td>
<td>99.45</td>
<td>0.1</td>
<td>330</td>
<td></td>
</tr>
</tbody>
</table>

(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.
TABLE G-4. (continued)

Test Conditions: Oil temperature = 400°F, Residence time = 35 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (ug/L)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorobenzene*</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Ethylbenzene*</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>53</td>
</tr>
<tr>
<td>m-Xylene*</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>(1)</td>
</tr>
<tr>
<td>o,p-Xylenes*</td>
<td>&lt; 1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>(1)</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>53,000</td>
<td>565 J</td>
<td>98.93</td>
<td>6 J</td>
<td>125</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>14,750</td>
<td>155 J</td>
<td>98.95</td>
<td>3 J</td>
<td>10,800</td>
</tr>
<tr>
<td>2-Methylnaphthalene*</td>
<td>4,200 J</td>
<td>505 J</td>
<td>87.98</td>
<td>1 J</td>
<td>NE</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>6,400 J</td>
<td>&lt; 3,400</td>
<td>&gt;46.88</td>
<td>1 J</td>
<td>NE</td>
</tr>
<tr>
<td>Fluoranthene*</td>
<td>1,750 J</td>
<td>950 J</td>
<td>45.71</td>
<td>10 J</td>
<td>140</td>
</tr>
<tr>
<td>Naphthalene*</td>
<td>3,200 J</td>
<td>120 J</td>
<td>96.25</td>
<td>1 J</td>
<td>NE</td>
</tr>
<tr>
<td>Benzo(a)anthracene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>&lt;10</td>
<td>8.7</td>
</tr>
<tr>
<td>Benzo(a)pyrene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>&lt;10</td>
<td>15</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>&lt;10</td>
<td>12</td>
</tr>
<tr>
<td>Chrysene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>10 J</td>
<td>100</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>10 J</td>
<td>20</td>
</tr>
<tr>
<td>Acenaphthene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>10 J</td>
<td>1,200</td>
</tr>
<tr>
<td>Acenaphthylene*</td>
<td>370 J</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>10 J</td>
<td>660</td>
</tr>
<tr>
<td>Anthracene*</td>
<td>120 J</td>
<td>40 J</td>
<td>&gt;68.67</td>
<td>10 J</td>
<td>660</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene*</td>
<td>&lt; 3,900</td>
<td>50 J</td>
<td>(b)</td>
<td>&lt;10</td>
<td>51</td>
</tr>
<tr>
<td>Fluorene*</td>
<td>325 J</td>
<td>155 J</td>
<td>&gt;52.31</td>
<td>&lt;10</td>
<td>140</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene*</td>
<td>&lt;20,000</td>
<td>&lt;17,000</td>
<td>(b)</td>
<td>&lt;10</td>
<td>29</td>
</tr>
<tr>
<td>Phenanthrene*</td>
<td>960 J</td>
<td>490 J</td>
<td>48.96</td>
<td>1 J</td>
<td>660</td>
</tr>
<tr>
<td>Pyrene*</td>
<td>785 J</td>
<td>405 J</td>
<td>48.41</td>
<td>&lt;10</td>
<td>180</td>
</tr>
<tr>
<td>Benzo(k)fluoranthane*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>&lt;10</td>
<td>11</td>
</tr>
<tr>
<td>4-Chloroaniline</td>
<td>395 J</td>
<td>325 J</td>
<td>17.72</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
<tr>
<td>2-Chloronaphthalene*</td>
<td>&lt; 3,900</td>
<td>&lt; 3,400</td>
<td>(b)</td>
<td>&lt;10</td>
<td>NE</td>
</tr>
</tbody>
</table>

(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.
< Less than detection limit, estimated value.
* Potential constituents of JP-4 fuel.
NE Not established.
Table G-5. Summary of analytical results for Test 8

Test Conditions: Oil temperature = 500°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (ug/L)(a)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatiles (VOCs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloromethane</td>
<td>&lt;1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Bromomethane</td>
<td>&lt;1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>&lt;1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>50</td>
</tr>
<tr>
<td>Chloroethane</td>
<td>&lt;1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>960</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>&lt; 800</td>
<td>7.8</td>
<td>&gt;99.03</td>
<td>0.4</td>
<td>NE</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>&lt; 800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>100</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>&lt; 800</td>
<td>2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>370 J</td>
<td>8.0</td>
<td>97.84</td>
<td>0.4</td>
<td>NE</td>
</tr>
<tr>
<td>Chloroform</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>70</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>400</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>410</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>8,500</td>
<td>46.0</td>
<td>99.46</td>
<td>2.3</td>
<td>70</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>2-Chloroethylvinylether</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Bromoform</td>
<td>&lt;1,600</td>
<td>&lt; 4.0</td>
<td>(b)</td>
<td>0.2</td>
<td>NE</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethene</td>
<td>&lt; 800</td>
<td>&lt; 2.0</td>
<td>(b)</td>
<td>0.1</td>
<td>NE</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>650 J</td>
<td>1.0 J</td>
<td>99.85</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>Acetone</td>
<td>&lt;4,800</td>
<td>&lt;12</td>
<td>(b)</td>
<td>0.6</td>
<td>NE</td>
</tr>
<tr>
<td>2-Butanone</td>
<td>&lt;4,800</td>
<td>&lt;12</td>
<td>(b)</td>
<td>0.6</td>
<td>750</td>
</tr>
<tr>
<td>Benzene*</td>
<td>110 J</td>
<td>8.7</td>
<td>93.60</td>
<td>0.4</td>
<td>70</td>
</tr>
<tr>
<td>Toluene*</td>
<td>18 J</td>
<td>0.9 J</td>
<td>94.86</td>
<td>0.0</td>
<td>330</td>
</tr>
</tbody>
</table>

(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) Not detected at the specified detection limit.
> Greater than.
J Less than detection limit, estimated value.
NE Not established.
**Table G-5.** (continued)

Test Conditions: Oil temperature = 500°F, Residence time = 40 min

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Feed Soil Concentration (ug/kg)</th>
<th>Processed Soil Concentration (ug/kg)</th>
<th>Removal Efficiency (%)</th>
<th>Processed Soil Concentration from TCLP Extract (ug/L) (a)</th>
<th>Goal Cleanup Level in TCLP Extract (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorobenzene*</td>
<td>&lt; 800</td>
<td>&lt; 2.0 (b)</td>
<td>(b) 0.1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Ethylbenzene*</td>
<td>&lt; 800</td>
<td>2.1 (b)</td>
<td>0.1 53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m-Xylene*</td>
<td>&lt; 1,600</td>
<td>0.3 J (b)</td>
<td>0.0 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o,p-Xylenes*</td>
<td>9.5 J</td>
<td>0.8 J</td>
<td>91.58 (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 1,2-Dichlorobenzene       | 13,500                          | 300 J                               | 97.78 4 J             | NE                                                       |                                        |
| 1,4-Dichlorobenzene       | 4,300 J                         | < 3.400 J                           | < 20.91 1 J           | 10,800                                                  |                                        |
| 2-Methylnaphthalene*      | 1,500 J                         | 270 J                               | 82.09 < 20            | 20 NE                                                   |                                        |
| 1,3-Dichlorobenzene       | 1,350 J                         | < 3.400 J                           | < 20 NE               |                                                           |                                        |
| Fluoranthene*             | 795 J                            | 760 J                               | 4.40 < 20             | 140                                                     |                                        |
| Naphthalene*              | 1,625 J                         | 70 J                                | 93.17 < 20            | NE                                                      |                                        |
| Benzo(a)anthracene*       | < 4,300                         | < 3.400 J                           | < 20 8.7              |                                                           |                                        |
| Benzo(a)pyrene*           | < 4,300                         | < 3.400 J                           | < 20 15               |                                                           |                                        |
| Benzo(b)fluoranthe*       | < 4,300                         | < 3.400 J                           | < 20 12               |                                                           |                                        |
| Chrysene*                 | < 4,300                         | < 3.400 J                           | < 20 100              |                                                           |                                        |
| Dibenzo(a,h)anthracene*   | < 4,300                         | < 3.400 J                           | < 20 20               |                                                           |                                        |
| Acenaphthenes*            | < 4,300                         | < 3.400 J                           | < 20 1,200            |                                                           |                                        |
| Acenaphthylene*           | < 4,300                         | < 3.400 J                           | < 20 660              |                                                           |                                        |
| Anthracene*               | < 4,300                         | 40 J (b)                            | < 20 660              |                                                           |                                        |
| Benzo(g,h,i)perylene*     | < 4,300                         | < 3.400 J                           | < 20 51               |                                                           |                                        |
| Fluorene*                 | < 4,300                         | < 3.400 J                           | < 20 140              |                                                           |                                        |
| Indeno(1,2,3-c.d)pyrene*  | < 22,000                        | < 17,000 J                          | < 100 29              |                                                           |                                        |
| Phenanthrene*             | 320 J                            | 300 J                               | 6.25 < 20             | 660                                                     |                                        |
| Pyrene*                   | 185 J                            | 220 J                               | < 20 180              |                                                          |                                        |
| Benzo(k)fluoranthe*       | < 4,300                         | < 3.400 J                           | < 20 11               |                                                          |                                        |
| 4-Chloroaniline           | 210 J                            | 210 J (b)                           | 3 J (1)               | NE                                                      |                                        |
| 2-Chloronaphthalene*      | < 4,300                         | < 3.400 J                           | < 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

G-11
APPENDIX H

ANALYTICAL DATA
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: [Signature] Date: 13/6/89
**Test 1**

<table>
<thead>
<tr>
<th>Sample Information</th>
<th>Cust ID:</th>
<th>FEED</th>
<th>FEED</th>
<th>PROCESS</th>
<th>PURGE</th>
<th>MIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFW Batch #: 8907TK01 8907TK01 8907TK01 89TKD01</td>
<td>01 01R 02 MB-3</td>
<td>Soil</td>
<td>Soil</td>
<td>Soil</td>
<td>Water</td>
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<td>Matrix:</td>
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<td>Soil</td>
<td>Soil</td>
<td>Water</td>
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<tr>
<td>D.F.I:</td>
<td>168</td>
<td>168</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Units:</td>
<td>ug/kg</td>
<td>ug/kg</td>
<td>ug/kg</td>
<td>% REC</td>
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### Analytes

<table>
<thead>
<tr>
<th>Analyte</th>
<th>FEED U</th>
<th>FEED U</th>
<th>% REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroethane</td>
<td>3300</td>
<td>3500</td>
<td>4.0</td>
</tr>
<tr>
<td>Bromoethane</td>
<td>3300</td>
<td>3500</td>
<td>4.0</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>3300</td>
<td>3500</td>
<td>4.0</td>
</tr>
<tr>
<td>Chloroethane</td>
<td>3300</td>
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<td>4.0</td>
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<tr>
<td>Dichloroethane</td>
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<td>Trichloroethane</td>
<td>460</td>
<td>240</td>
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<tr>
<td>1,1-Dichloroethylene</td>
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<td>1,1-Dichloroethane</td>
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<td>2.0</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethylene</td>
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<td>Chloroform</td>
<td>130</td>
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<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
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<tr>
<td>Bromodichloromethane</td>
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<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>1,2-Dichloropropene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
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<tr>
<td>Trichloroethene</td>
<td>2500</td>
<td>72000</td>
<td>5.4</td>
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<td>Dibromoethane</td>
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<td>1,1,2-Trichloroethene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
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<tr>
<td>2-Chloroethylvinyl ether</td>
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<td>1800</td>
<td>2.0</td>
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<td>Bromoform</td>
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<td>3500</td>
<td>4.0</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
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<td>1800</td>
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<td>Tetrachloroethene</td>
<td>520</td>
<td>5000</td>
<td>2.0</td>
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<tr>
<td>2-Butanone</td>
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<td>Benzene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
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<tr>
<td>Toluene</td>
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<td>1800</td>
<td>2.0</td>
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<tr>
<td>Chlorobenzene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>m-Xylene</td>
<td>1700</td>
<td>1800</td>
<td>2.0</td>
</tr>
<tr>
<td>o,p-Xylene</td>
<td>1300</td>
<td>3200</td>
<td>4.0</td>
</tr>
</tbody>
</table>

### Surrogate Recoveries

<table>
<thead>
<tr>
<th>Analyte</th>
<th>% REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromochloromethane</td>
<td>73.6%</td>
</tr>
<tr>
<td>o,a,a-Trifluorotoluene</td>
<td>137.3%</td>
</tr>
</tbody>
</table>

---

Text page 2
### Test 1 (continued)

<table>
<thead>
<tr>
<th>Sample Information</th>
<th>Cust ID: PURGE MIX</th>
<th>BLANK</th>
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<tr>
<td>RFM Batch No:</td>
<td>B9TKD01</td>
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</tr>
<tr>
<td>Sample No:</td>
<td>MB-3</td>
<td>MB-1</td>
</tr>
<tr>
<td>Matrix:</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>D.F.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Units:</td>
<td>% REC</td>
<td>µg/L</td>
</tr>
</tbody>
</table>

### Analytes

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Dichloromethane
- Trichlorofluoromethane
- 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
- Bromofore
- 1,1,2,2-Tetrachloroethene
- Tetrachloroethylene

### Surrogate Recoveries

- Bromochloromethane 136 %
- a,a,a-Trifluorotoluene 97 %
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: [Signature] Date: 12/01/89
WESTON ANALYTICS
GC/MS DATA SUMMARY
SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

<table>
<thead>
<tr>
<th>AFN Batch Number: 8907K01</th>
<th>Client: TEST 9</th>
<th>Pages: 1</th>
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<tbody>
<tr>
<td>Cust ID: FeED</td>
<td>PROCESS</td>
<td>LEACHATE</td>
</tr>
<tr>
<td>RFN: 8907K0101</td>
<td>8907K0102</td>
<td>8907K0103</td>
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<tr>
<td>Matrix: Soil</td>
<td>Soil</td>
<td>Water</td>
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<tr>
<td>D.F.:</td>
<td>330</td>
<td>320</td>
</tr>
<tr>
<td>Units: ug/kg</td>
<td>ug/kg</td>
<td>ug/l</td>
</tr>
<tr>
<td>Nitrobenzene-d5:</td>
<td>54 %</td>
<td>12 %</td>
</tr>
<tr>
<td>Surrogate</td>
<td>2-Fluorobiphenyl:</td>
<td>57 %</td>
</tr>
<tr>
<td>Recovery (%)</td>
<td>p-Terphenyl-d14:</td>
<td>83 %</td>
</tr>
<tr>
<td>Phenol-d5:</td>
<td>31 %</td>
<td>19 %</td>
</tr>
<tr>
<td>2,4,6-Fluorobiphenyl:</td>
<td>28 %</td>
<td>22 %</td>
</tr>
<tr>
<td>2,4,6-Br3-phenol:</td>
<td>30 %</td>
<td>26 %</td>
</tr>
</tbody>
</table>

| 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 U | 100 U | 10 U | 200 U |
| Fluoranthen | 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)Fluoranthen | 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 | 10 U | 1000 U |
| Phenanthrene | 790 | 3200 | 10 U | 200 U |
| Pyrene | 260 | 310 | 10 U | 200 U |
| Benzo(k)Fluoranthen | 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.
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: [Signature]

Date: 8/30/89
## Test 2

<table>
<thead>
<tr>
<th>Sample Information</th>
<th>Cust ID: FEED</th>
<th>FEED</th>
<th>PROCESS</th>
<th>PURGE</th>
<th>RFM Batch #: 8907TK02 6907TK02 8907TK02 69TKD01</th>
</tr>
</thead>
</table>
|                    | SOIL SOIL SOIL B/C/6S | Sample No: 01 01R 02 MB-3 | Matrix: Soil Soil Soil Water | D.F.1 182 182 1 1 | Units: ug/kg ug/kg ug/kg % REC |}

### Analytes

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroethane</td>
<td>3600 U</td>
<td>3600 U</td>
</tr>
<tr>
<td>Bromoethane</td>
<td>3600 U</td>
<td>3600 U</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>3600 U</td>
<td>3600 U</td>
</tr>
<tr>
<td>Chloroethene</td>
<td>3600 U</td>
<td>3600 U</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>360 J</td>
<td>360 J</td>
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<tr>
<td>1,1-Dichloroethylene</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>1800 U</td>
<td>1800 U</td>
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<td>trans-1,2-Dichloroethene</td>
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<td>Chloroform</td>
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<tr>
<td>1,2-Dichloroethane</td>
<td>1800 U</td>
<td>1800 U</td>
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<tr>
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<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene</td>
<td>1800 U</td>
<td>1800 U</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>1800 U</td>
</tr>
<tr>
<td>2-Chloroethylvinlylister</td>
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<td>1800 U</td>
</tr>
<tr>
<td>Bromoform</td>
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<td>3600 U</td>
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<tr>
<td>1,1,2,2-Tetrachloroethane</td>
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<td>1800 U</td>
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<tr>
<td>Tetrachloroethylene</td>
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<td>Acetone</td>
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<tr>
<td>2-Butanone</td>
<td>11000 U</td>
<td>11000 U</td>
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<tr>
<td>Benzene</td>
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<tr>
<td>Chlorobenzene</td>
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<td>a-Xylene</td>
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<td>a,p-Xylene</td>
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### Surrogate Recoveries

<table>
<thead>
<tr>
<th>Surrogate</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Bromochloroethane</td>
<td>69.1 %</td>
</tr>
<tr>
<td>a,a,a-Trifluorotoluene</td>
<td>188.5 %</td>
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</table>

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H-7
<table>
<thead>
<tr>
<th>Analytes</th>
<th>% REC</th>
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<tbody>
<tr>
<td>Chloromethane</td>
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</tr>
<tr>
<td>Bromomethane</td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
</tr>
<tr>
<td>Chloroethane</td>
<td></td>
</tr>
<tr>
<td>Dichloromethane</td>
<td></td>
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<td>Trichlorofluoromethane</td>
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<td>1,1-Dichloroethylene</td>
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<td>1,1-Dichloroethane</td>
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<td>trans-1,2-Dichloroethene</td>
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<td>Chloroform</td>
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<td>1,1,1-Trichloroethane</td>
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<td>Carbon Tetrachloride</td>
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<td>1,2-Dichloropropane</td>
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<td>cis-1,3-Dichloropropene</td>
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<tr>
<td>trans-1,3-Dichloropropene</td>
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<tr>
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<td>2-Butanone</td>
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<td>Benzene</td>
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<td>m-Xylene</td>
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<tr>
<td>o,p-Xylene</td>
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<td>Surrogate Recoveries</td>
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<tr>
<td>Bromochloromethane</td>
<td>156</td>
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<tr>
<td>a,a,a-Trifluorotoluene</td>
<td>97</td>
</tr>
</tbody>
</table>

H-8
1. This set of samples consisted of 2 soil samples collected on 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: [Signature] Date: 7/25/89
### GC/MS DATA SUMMARY

**SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS**

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>FF</th>
<th>LEACHATE</th>
<th>BK LEACHATE</th>
<th>D.F.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFW: 8907K0201</td>
<td>Soil</td>
<td>Soil</td>
<td>Water</td>
<td>Water</td>
<td>ug/kg</td>
</tr>
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<td>112 %</td>
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**Test 2 (continued)**

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<td>3400 U</td>
<td>500 U</td>
<td>1000 U</td>
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<td>820 J</td>
<td>670 J</td>
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<td>200 U</td>
<td>3800 U</td>
<td>3400 U</td>
<td>100 U</td>
<td>200 U</td>
</tr>
</tbody>
</table>

**Note:** U = Analyzed, not detected. J = Present at less than detection limit. NR = Not requested.
This set of samples consisted of 6 soil samples collected on 8/1/89.

These samples were analyzed on 8/2/89.

All required holding times for these samples were met.

All blanks analyzed were below allowable limits of detection.

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.

Surrogate recoveries were between 7-140%.

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: 8/6/89
### Test 4

<table>
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<th>Sample Information</th>
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### Analytes

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<td>4.0 U</td>
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<td>4.0 U</td>
<td>4.0 U</td>
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<td>4.0 U</td>
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### Surrogate Recoveries

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H-12
Test 4
(continued)

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Surrogate Recoveries

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H-13
Test 4
(continued)

---
VOA Prep Batch No: 89TKD07  Date Analyzed: 02 Aug 89  page 3
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Surrogate Recoveries

| Brooocloroethane          | 120 |
| 4,4,4-Trifluorotoluene    | 85  |

---

H-14
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: [Signature] Date: 13 Jul 89
WESTON ANALYTICS
GC/MS DATA SUMMARY

SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

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<th>Cust Ids</th>
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1,2-Dichlorobenzene........................................ 24000                      600 J        4500 U        23 J        82000 J      530 J
1,4-Dichlorobenzene........................................ 6500                      180 J        4500 U        4 J        23000 J      130 J
2-Methylnaphthalene........................................ 2100 J                      310 J        4500 U        8 J        6300 J      500 J
1,3-Dichlorobenzene........................................ 2800 J                      3400 U    4500 U        1 J        10000 J     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 J      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
Dibenzo(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)pyrene......................................... 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................................................ 320 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.
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Note: U= Analyzed, not detected.
J= Present at less than detection limit.
NR= Not requested.
This set of samples consisted of 4 soil samples collected on 8/9/89.

These samples were analyzed on 8/11/89.

All required holding times for these samples were met.

All blanks analyzed were below allowable limits of detection for all compounds with the exception of Trichloroethene due to high background concentrations.

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.

Surrogate recoveries were between 30-161%.

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: 3/6/89

H-18
Test B

Additional Information

Sample Information
RFM 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 2.0 U 20 U
1,1-Dichloroethylene 800 U 800 U 2.0 U 20 U
trans-1,2-Dichloroethylene 380 J 380 J 8.0 J 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 J 20 U
Trichloroethene 8700 8300 46 J 3500
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 13 J 20 J 0.9 J 5.0
Chlorobenzene 800 U 800 U 2.0 U 20 U
Ethylbenzene 800.0 U 800.0 U 2.1 70
o-Xylene 1600.0 U 800 U 0.3 J 3.2 J
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 &
(continued)

<table>
<thead>
<tr>
<th>Sample Information</th>
<th>Cust ID</th>
<th>FIELD</th>
<th>METHOD</th>
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<td>VOA Prep Batch No: 89TKD09 Date Analyzed: 11 AUG 89 page 2</td>
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<td>RFN Batch No</td>
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<td>04 05 06 07</td>
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<tr>
<td>Matrix</td>
<td>Water Water Water Water</td>
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<td>D.F.</td>
<td>1 1 1 1</td>
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<tr>
<td>Units</td>
<td>ug/L ug/L % REC % REC</td>
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### Analytes

<table>
<thead>
<tr>
<th>Analyte</th>
<th>FIELD</th>
<th>METHOD</th>
<th>BLANK</th>
<th>SPIKE</th>
<th>% REC</th>
<th>% REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloromethane</td>
<td>4.0 U</td>
<td>4.0 U</td>
<td>89 %</td>
<td>82 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromoform</td>
<td>4.0 U</td>
<td>4.0 U</td>
<td>78 %</td>
<td>82 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>4.0 U</td>
<td>4.0 U</td>
<td>79 %</td>
<td>72 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>4.0 U</td>
<td>4.0 U</td>
<td>61 %</td>
<td>75 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>160 %</td>
<td>135 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroform</td>
<td>0.7 J</td>
<td>2.0 U</td>
<td>91 %</td>
<td>95 %</td>
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<td></td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>87 %</td>
<td>85 %</td>
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<td></td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>45 %</td>
<td>48 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>3.8</td>
<td>2.0 U</td>
<td>63 %</td>
<td>62 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>75 %</td>
<td>78 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>79 %</td>
<td>93 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>98 %</td>
<td>81 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>80 %</td>
<td>92 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>82 %</td>
<td>79 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>80 %</td>
<td>78 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>32 %</td>
<td>45 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>42 %</td>
<td>45 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>42</td>
<td>18</td>
<td>42 %</td>
<td>39 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dibromoform</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>56 %</td>
<td>62 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>58 %</td>
<td>65 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Chloroethylvinyl ether</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>81 %</td>
<td>83 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromoform</td>
<td>4.0 U</td>
<td>4.0 U</td>
<td>83 %</td>
<td>83 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>87 %</td>
<td>83 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>0.9 J</td>
<td>1.1 J</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>12 U</td>
<td>12 U</td>
<td>5 %</td>
<td>7 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Butanone</td>
<td>12 U</td>
<td>12 U</td>
<td>3 %</td>
<td>7 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>5.5</td>
<td>1.1 J</td>
<td>86 %</td>
<td>80 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td>2.0 U</td>
<td>0.3 J</td>
<td>86 %</td>
<td>92 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>77 %</td>
<td>71 %</td>
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<td></td>
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<tr>
<td>Ethylbenzene</td>
<td>2.0 U</td>
<td>2.0 U</td>
<td>62 %</td>
<td>85 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m-Xylene</td>
<td>9.4</td>
<td>4.0 U</td>
<td>76 %</td>
<td>91 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o,p-Xylene</td>
<td>7.7</td>
<td>4.0 U</td>
<td>82 %</td>
<td>75 %</td>
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</tr>
</tbody>
</table>

### Surrogate Recoveries

<table>
<thead>
<tr>
<th>Surrogate</th>
<th>% REC</th>
<th>% REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromochloromethane</td>
<td>112.9 %</td>
<td>124.9 %</td>
</tr>
<tr>
<td>a,a,a-Trifluorotoluene</td>
<td>88.8 %</td>
<td>76.1 %</td>
</tr>
</tbody>
</table>

---

H-20
Test 8  
(continued)

VGA Prep Batch No: 89TKD09  Date Analyzed: 11 AUG 89  page 3

Sample Information
Cust ID: BLANK  RFW Batch No: 8908TKD04
Sample No: 08  Matris: Water
D.F.: 1  Units: % REC

Analytes
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Dichloromethane
Trichlorofluoromethane
1,1-Dichloroethylene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethene
1,1,1-Trimchloroethane
Carbon Tetrachloride
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Trichloroethylene
Dibromochloromethane
1,1,2-Trichloroethane
2-Chloroethylvinyl ether
Bromoform
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Acetone
2-Butanone
Benzene
Toluene
Chlorobenzene
Ethylbenzene
e-Xylene
o,p-Xylene

Surrogate Recoveries
Bromochloromethane  97 %
4,4,4-Trifluorotoluene  130 %
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: [Signature] Date: 13 Nov 89
<table>
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<tr>
<th>RFM Batch Number</th>
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<td>B9087004</td>
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<td>Soil</td>
<td>Soils</td>
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**Surrogate Recovery (%)**

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<tr>
<th>Compound</th>
<th>Recovered</th>
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<tbody>
<tr>
<td>Chlorobenzene</td>
<td>14%</td>
</tr>
<tr>
<td>Phenol</td>
<td>14%</td>
</tr>
<tr>
<td>2,4,6-Tris-Phenol</td>
<td>24%</td>
</tr>
<tr>
<td>2,4-Dichlorobenzene</td>
<td>24%</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>11%</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>11%</td>
</tr>
<tr>
<td>Toluene</td>
<td>11%</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>11%</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>11%</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>11%</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>11%</td>
</tr>
<tr>
<td>Pyrene</td>
<td>11%</td>
</tr>
<tr>
<td>Benz[a]anthracene</td>
<td>11%</td>
</tr>
<tr>
<td>Benz[b]fluoranthene</td>
<td>11%</td>
</tr>
<tr>
<td>Benz[k]fluoranthene</td>
<td>11%</td>
</tr>
<tr>
<td>Benz[a]pyrene</td>
<td>11%</td>
</tr>
<tr>
<td>Benzo[ghi]perylene</td>
<td>11%</td>
</tr>
</tbody>
</table>

**Note:**
- u/g indicates less than detection limit.
- ng/g indicates that the compound is greater than 100ng on column.
- "E" indicates the compound is not detected.
- "N" indicates the compound is not requested.

*Sample processed on 8/10/04*  
*Reported on 9/08/04"
### GC/MS DATA SUMMARY

**SEMI-VOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>RFW Batch Numbers</th>
<th>Client</th>
<th>Page 2</th>
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<td>8908TK046 89TK05MB1 89TK06MB1</td>
<td>Water</td>
<td>Soil</td>
</tr>
<tr>
<td>D.F.</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Units</td>
<td>ug/L</td>
<td>ug/kg</td>
<td>ug/kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surrogate</th>
<th>Recovery (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrobenzene-d5</td>
<td>62 %</td>
<td>75 %</td>
</tr>
<tr>
<td>2-Fluorobiphenyl</td>
<td>70 %</td>
<td>81 %</td>
</tr>
<tr>
<td>p-Terphenyl-d14</td>
<td>96 %</td>
<td>105 %</td>
</tr>
<tr>
<td>Phenol-d5</td>
<td>16 %</td>
<td>18 %</td>
</tr>
<tr>
<td>2-Fluorophenol</td>
<td>21 %</td>
<td>26 %</td>
</tr>
<tr>
<td>2,4,6-Trisphenol</td>
<td>70 %</td>
<td>58 %</td>
</tr>
</tbody>
</table>

**List of Compounds**

<table>
<thead>
<tr>
<th>Compound</th>
<th>J</th>
<th>10 U</th>
<th>10 U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-Dichlorobenzene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td></td>
<td>1 J</td>
<td>10 U</td>
</tr>
<tr>
<td>2-Methylnaphthalene</td>
<td></td>
<td>2 J</td>
<td>10 U</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Naphthalene</td>
<td></td>
<td>1 J</td>
<td>10 U</td>
</tr>
<tr>
<td>Benz(a) anthracene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Benzo(a)Pyrene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Benzo(b)Fluoranthene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Chrysene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Dibenz(a,h) Anthracene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Anthracene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Benzo(g,h,i) Perylene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Fluorene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd) Pyrene</td>
<td></td>
<td>20 U</td>
<td>30 U</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td></td>
<td>1 J</td>
<td>10 U</td>
</tr>
<tr>
<td>Pyrene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>Benzo(k) Fluoranthene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>4-Chloroaniline</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
<tr>
<td>2-Chloronaphthalene</td>
<td></td>
<td>20 U</td>
<td>10 U</td>
</tr>
</tbody>
</table>

**Note:**

- **U** = Analyzed, not detected.
- **J** = Present at less than detection limit.
- **NR** = Not requested.

---

**Test 8**

---

**Test 8**
APPENDIX I

PERMIT DOCUMENTS
Dear Mr. Layton

Per direction in your letter dated 25 Jan 89, we will formally submit an application for a "Hazardous and Solid Waste" memorandum of \( \text{M} \) (HSMWA), "Research, Development, and Demonstration Test Plan" for the hazardous waste project entitled "Thermal Stripping of JP-4 and other VOCs from soils at Tinker Air Force Base." We propose that the demonstration test plan, title 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 Darrell Cornell, CC-ALC/EMR at extension (405)-734-3058.

Ray D. Reeves, Col. USAF
Director, Environmental Management

1 Attach
Health & Safety Plan

cc Al Davis
Damon Wingfield
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,

[Signature]

Allyn H. Davis  
Director  
Hazardous Waste Management Division (6H)

Enclosures

cc: Damon Wingfield,  
Oklahoma State Department of Health
Permittee: TINKER AIR FORCE BASE  
Number: OK157124331  
Location of RUW 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 11, 1988 and referenced in the Permittee's 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.
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.

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 continuously 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.
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 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.

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 LT3 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\textsubscript{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\degree 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:

   \[ \text{DRE} = \left( \frac{W_{\text{in}} - W_{\text{out}}}{W_{\text{in}}} \right) \times 100 \]

   Where:

   \( W_{\text{in}} \) = Mass feed rate of one POHC in waste stream feeding the incinerator, and

   \( W_{\text{out}} \) = Mass emission rate of the same POHC present in exhaust emissions prior to release to the atmosphere.
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 bearings and cleanup objectives

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Organic Concentration (ug/kg)</th>
<th>Goal Cleanup Level in Extract (ug/L)</th>
</tr>
</thead>
<tbody>
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<td>Trichloroethene</td>
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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>
<thead>
<tr>
<th>Contaminant</th>
<th>Concentration (ug/kg)</th>
<th>Goal Cleanup Level in Extract (ug/L)</th>
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<td>avg.</td>
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<td>Benzenes</td>
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</tbody>
</table>

- Remedial Design Bog Creek Farm Site, Superfund Project, Howell Township, New Jersey, U.S. Army Corps of Engineers, DACW 41-88-8-0162.
- California List, 40 CFR Part 268, Subpart D.
- Substances Toxic to Aquatic Life, Support B: General Use Waters Quality Standards of Illinois (February, 1986).
- N.D. - None detected.
- N.A. - Not assigned.