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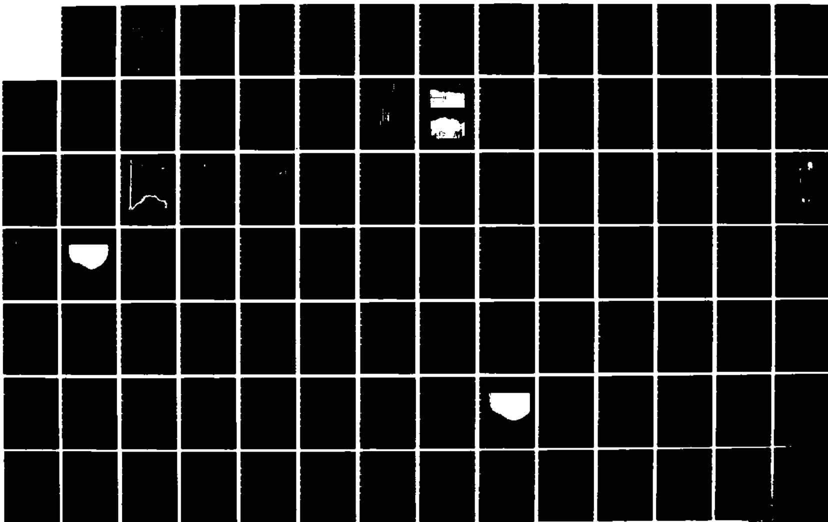

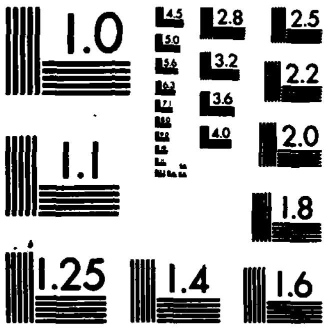

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Installation Restoration General Environmental Technology Development

FINAL REPORT

Task 2. Incineration Test of Explosives Contaminated Soils At Savanna Army Depot Activity, Savanna, Illinois

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April 1984

Prepared for:
U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
Aberdeen Proving Ground (Edgewood Area), Maryland 21010

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

This report presents the results of a comprehensive study which successfully demonstrates the effectiveness of incineration as a decontamination method for explosives contaminated soils. The project included: incineration equipment and test site selection, soil characterization and reactivity testing, development of a detailed test plan and site plan safety submission, environmental permitting, evaluation of materials handling procedures, incineration testing, and evaluation of results.

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Principal Organic Hazardous Constituent (POHC)
Destruction and Removal Efficiency (DRE)

CONTENTS

CONTENTS

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CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

TABLES

TABLES

WESTON

TABLE i. ACRONYMS AND ABBREVIATIONS

ABL	-	Allegany Ballistics Laboratory
acf(m)	-	actual cubic feet (per minute)
2-Amino	-	2-Amino-4,6 Dinitrotoluene
ANOVA	-	analysis of variance
APE	-	Ammunition Peculiar Equipment
As	-	arsenic
Ba	-	barium
Btu	-	British thermal unit
C	-	carbon
cd	-	cadmium
Cl	-	chlorine
CFR	-	Code of Federal Regulations
CO	-	carbon monoxide
CO_2	-	carbon dioxide
Cr	-	chromium
Cu	-	copper
dBA	-	decibels, A scale
DNB	-	1,3-Dinitrobenzene
DNT	-	2,6- or 2,4-Dinitrotoluene
DRE	-	Destruction and Removal Efficiency
dscf(m)	-	dry standard cubic feet (per minute)
EPA	-	Environmental Protection Agency
EP Toxicity	-	Extraction Procedure Toxicity
F	-	Fahrenheit
ft^3	-	cubic feet
g	-	gram
GEP	-	Good Engineering Practice
H	-	Hydrogen
HC	-	hydrocarbon
HCl	-	hydrogen chloride
Hg	-	mercury
HHV	-	Higher Heating Value
HMX	-	1,3,5,7-Tetranitro-Octahydro-1,3,5,7-Tetracyclo-octane
IECS	-	Incineration of Explosives Contaminated Soils

TABLE i. (continued)

LAAP	-	Louisiana Army Ammunition Plant
lb	-	pound (mass)
L	-	liter
mg	-	milligram
min	-	minute
N	-	nitrogen
NB	-	nitrobenzene
NO_x	-	oxides of nitrogen
Pb	-	lead
POHC	-	Principal Organic Hazardous Constituent
pph	-	pounds per hour
ppm	-	parts per million (volume, weight)
RCRA	-	Resource Conservation and Recovery Act
RDX	-	1,3,5-Trinitro-Hexahydro-1,3,5-Triazine
S	-	sulfur
SADA	-	Savanna Army Depot Activity
scf(m)	-	standard cubic feet (per minute)
SCR	-	Silicon Controlled Rectifier
Se	-	selenium
sec	-	second
SO_2	-	sulfur dioxide
tetryl	-	tetranitromethylaniline
TNB	-	1,3,5-Trinitrobenzene
TNT	-	2,4,6-Trinitrotoluene
ug	-	microgram
USATHAMA	-	U.S. Army Toxic and Hazardous Materials Agency
Zn	-	zinc

1. INTRODUCTION

1.1 Background. Large quantities of wastewater are generated during the manufacturing of explosives and propellants; the loading, assembly, and packing of munitions; as well as demilitarization and washout operations. These wastewaters (referred to as "red water" or "pink water" due to their characteristic color) contain varying concentrations of explosives. Standard practice in the past has been to dispose of these wastewaters in settling lagoons at various U.S. Army installations. Although current practice provides for in-plant treatment of these wastewaters, the inactive settling lagoons at numerous U.S. Army installations are a source of potential groundwater contamination.

The U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) is currently evaluating a number of potential remedial action options for future implementation. One option has emerged as the most promising in the near term (i.e., for installations requiring remedial action within the next five years). This option is excavation of the soils, followed by thermal processing in a rotary kiln incinerator. The U.S. Army routinely incinerates pure explosives and propellants; however, previous to this project this technology was undemonstrated on explosives contaminated soils.

1.2 Project objectives. The objectives of the Incineration of Explosives Contaminated Soils (IECS) project were as follows:

(a) The primary objective of these tests was to demonstrate the effectiveness of incineration as a decontamination method for explosives contaminated soils.

(b) The secondary objectives of the project were to:
- Develop a data base and appropriate correlations for designing and predicting the performance of the incinerator as a decontamination method.
- Determine the fate of the explosives and metals in the contaminated soils during/after incineration.
- Measure pollutant levels in the stack gas to determine the air pollution control devices that would be required for incinerators that may be used in the future to incinerate explosives contaminated soils.

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1.3 Criteria for a successful project. The primary objective of the project is to demonstrate the effectiveness of incineration as a decontamination method for soils which potentially contain concentrations of explosives and associated products of decomposition. Successful demonstration of this goal requires demonstration of the following:

(a) Destruction removal efficiency (DRE) of greater than 99.99 percent of explosives in the stack emissions based on the explosives concentrations in the feed soil.

(b) Thermal treatment of the contaminated soils such that the ash residues are not hazardous due to the characteristic of reactivity (as defined in Title 40 CFR, Part 261, Section 261.23).

(c) Thermal treatment of the contaminated soils such that the ash residues are not hazardous due to the characteristic of EP toxicity (as defined in Title 40 CFR, Part 261, Section 261.24).

1.4 Report organization. The information contained within this report is organized into 11 sections as follows:

Section	Title
1	Introduction
2	Executive Summary
3	Test Site
4	Characteristics of Explosives Contaminated Soils
5	Description of the Incineration Test Equipment
6	Experimental Variables
7	Presentation of Test Burn Data
8	Comparison of Test Burn Results to Regulatory Criteria
9	Analysis of Results and Development of Incinerator Design Criteria
10	Conclusions/Recommendations
11	References

The appendices provide additional data and analysis. Appendix A provides a detailed summary of the data collected during each of the 19 incineration test burns in a mass balance format. Appendix B provides a detailed description of the analytical approach utilized to evaluate the test burn results and to develop simple linear equations for designing and predicting the performance of the incinerator as a full-scale remedial action alternative. Appendix C provides referenced sections from the Federal Register regarding hazardous waste regulations. Appendix D provides the molecular structure, preferred nomenclature, and chemical formula for each of the explosives discussed in this report.

2. EXECUTIVE SUMMARY

In August 1982, USATHAMA commissioned Roy F. Weston, Inc. (WESTON) to develop and implement a program to demonstrate the effectiveness of rotary kiln incineration in decontaminating explosives contaminated soils. This program was an unqualified success as demonstrated by the following results:

(a) It was demonstrated that a "transportable" incineration system could be disassembled, transported approximately 1,000 miles, be reassembled, and fully operational within two weeks.

(b) Nineteen days of formal trial burn testing were completed within 20 consecutive calendar days with no lost time due to equipment failure.

(c) An additional six days of operation were performed at steady-state conditions with no downtime due to equipment failure or malfunction.

(d) Comparing the mass of explosives measured in the ash residues and the stack gas to the mass of explosives in the soil feed, the following destruction and removal efficiences were demonstrated:
- Greater than 99.99 percent destruction efficiency in the kiln ash.
- Greater than 99.9999 percent destruction efficiency in the fabric filter ash.
- No explosives detected in the stack gas which results in an overall destruction and removal efficiency (DRE) of 100 percent.

(e) Stack emissions were in compliance with all Federal, state, and local regulations including:
- Sulfur dioxide (SO_2)
- Hydrogen chloride (HCl)
- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)
- Particulates

(f) Ash residues were not hazardous from the standpoint of EP toxicity or reactivity. Application has been filed[1] with the Illinois EPA to allow land application of the ash residues at the Savanna Army Depot Activity.

Simply stated, the IECS program demonstrated that explosives contaminated soils can be excavated, thermally decontaminated, and the ash residues landfilled on-site in a safe and environmentally acceptable manner.

The IECS program consisted of seven tasks:

(a) Task 1 - Incineration Equipment/Test Site Selection
(b) Task 2 - Soil Characterization/Reactivity Testing
(c) Task 3 - Development of Detailed Test Plan/Safety Plan
(d) Task 4 - Environmental Permitting
(e) Task 5 - Evaluation of Materials Handling Procedures
(f) Task 6 - Incineration Testing
(g) Task 7 - Evaluation of Results

The IECS Project Schedule is presented in Figure 1. The following subsections summarize the objectives and results of the first six tasks.

2.1 Incineration equipment/test site selection. After a comprehensive survey of rotary kiln manufacturers to determine the availability of appropriately sized test units, ThermAll, Inc. of Peapack, New Jersey was selected as the incinerator subcontractor for the project. A major innovation of this project was the decision to use a "transportable" incinerator (i.e., equipment disassembled, loaded on trucks, shipped to the test site, and reassembled) as opposed to a "mobile" incinerator (i.e., truck mounted) or shipment of the contaminated soils to a commercial facility.

The test site selected was Savanna Army Depot Activity in Savanna, Illinois which provided the following advantages:

(a) Remote location well isolated from populated areas.
(b) Close proximity to contaminated soils.
(c) Well controlled access and security.

Figure 2 provides an overall view of the installed incineration system at the Savanna Army Depot Activity. Figure 3 is a photograph of the front of the ThermAll, Inc. rotary kiln incinerator showing the soil feed system in the foreground.

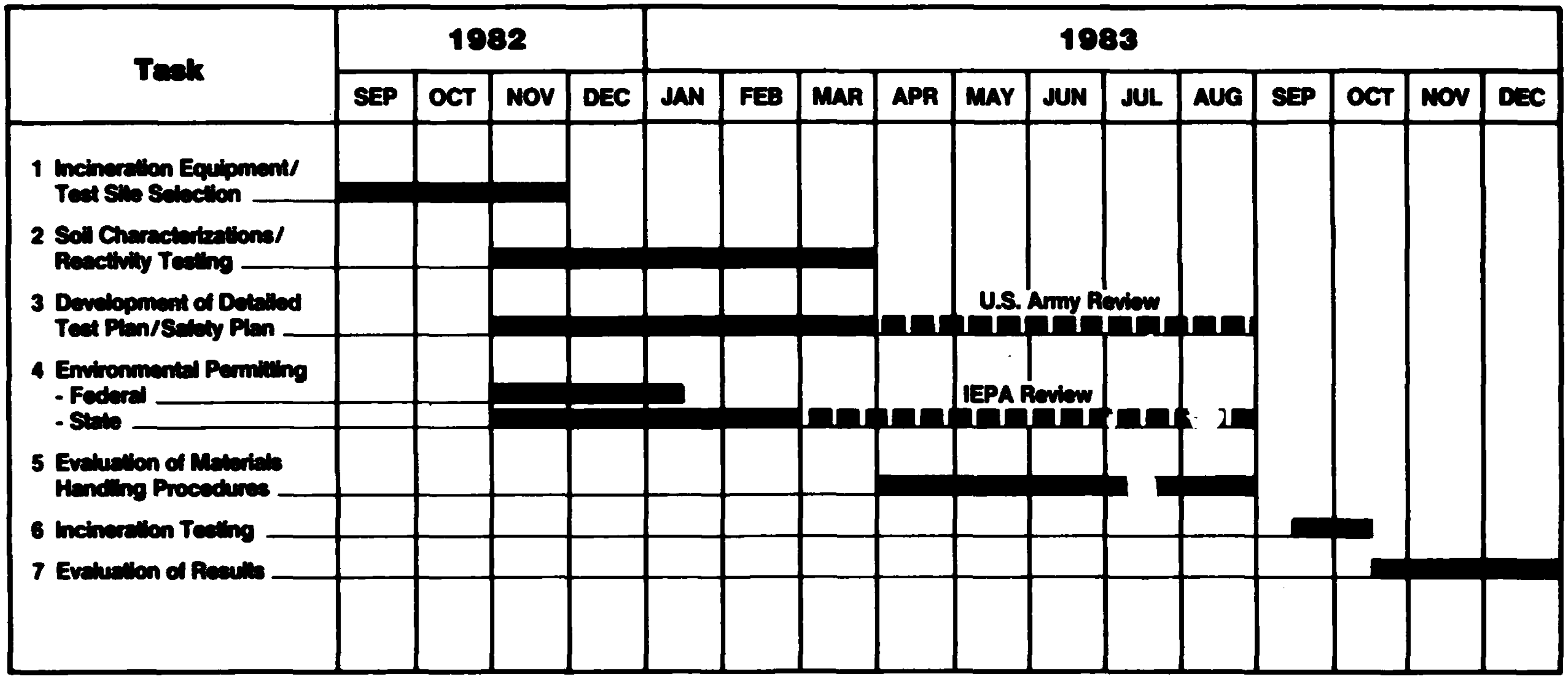

FIGURE 1 PROJECT SCHEDULE

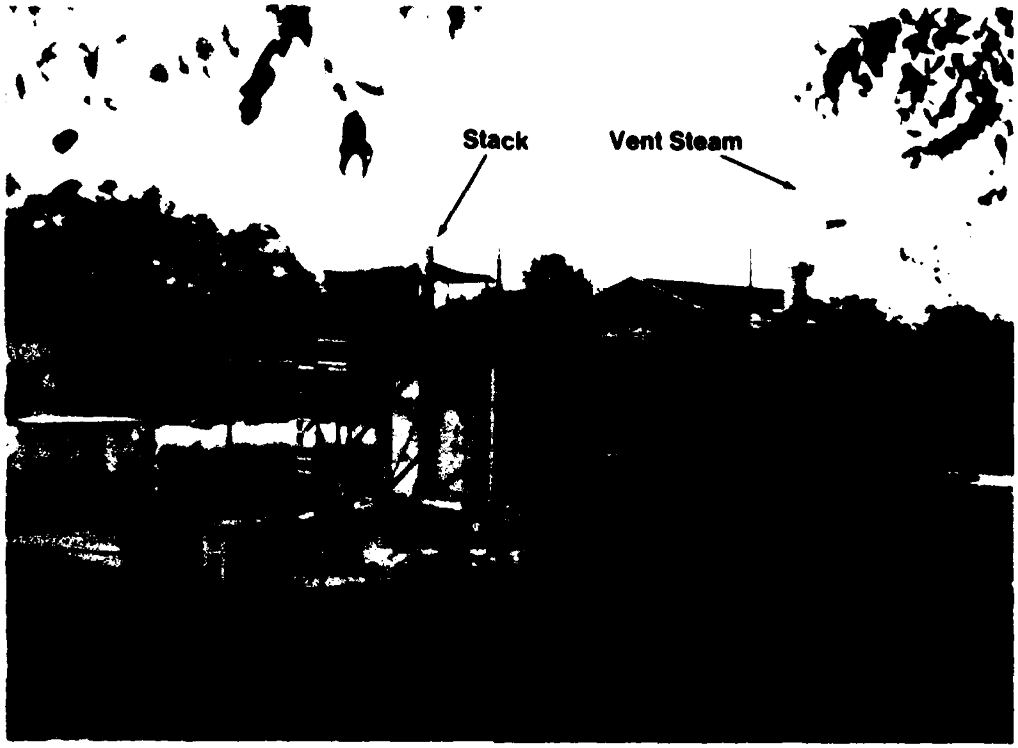

FIGURE 2 OVERALL VIEW OF THE IECS INCINERATION TEST EQUIPMENT INSTALLED AT THE SAVANNA ARMY DEPOT ACTIVITY

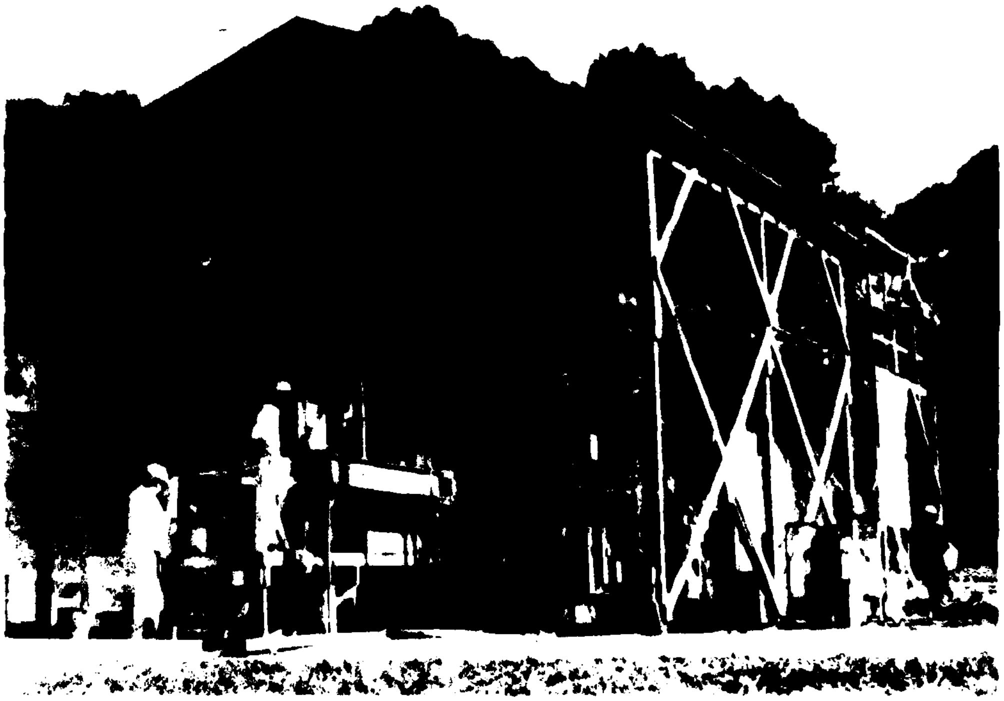

FIGURE 3 FRONT VIEW OF THE THERMALL, INC. ROTARY KILN INCINERATOR

2.2 Soil characterization/reactivity testing. In order to maximize the usefulness of the results of the project, USATHAMA decided to test contaminated lagoon soils from two separate installations with widely varying characteristics (see Table 1). The two installations selected provided ranges of soil characteristics typical of most other U.S. Army installations.

The contaminated lagoon soils are hazardous because they exhibit the characteristic of reactivity (i.e., potential for detonation or explosion). Testing conducted at Allegany Ballistics Laboratory (ABL) in Cumberland, Maryland confirmed that the lagoon soils are reactive and that special precautions must be taken in developing materials handling procedures and equipment design.

2.3 Development of detailed test plan/safety plan. In order to provide for meaningful evaluation of the incineration test results, a test plan[2] was developed which included a systematic analytical approach to the defined problem. The approach WESTON followed throughout the completion of the program is depicted on Figure 4. The nine steps of the analytical approach can be categorized as pre-experimental (steps 1 through 5), experimental (step 6), and the analysis and conclusions. The pre-experimental and experimental steps are addressed in Sections 3 through 6, while the remaining steps are addressed in Sections 7 through 10.

An important activity in the development of the test plan was the selection of key parameters (input variables) to be controlled and held at various levels during testing. These key parameters were:

(a) Soil feed rate.
(b) Temperature in the primary combustion chamber.
(c) Temperature in the secondary combustion chamber.

These key parameters were selected since they directly relate to the economics of incineration (i.e., how much can be burned, how quickly can it be burned, and how much fuel is required?).

Other test variables were held constant to the extent possible. Test variables that could not be held constant were measured during the test as illustrated in the test plan schematic diagram (Figure 5).

TABLE 1. CHARACTERISTICS OF EXPLOSIVES CONTAMINATED SOILS

Description	Savanna Army Depot Activity (SADA)	Louisiana Army Ammunition Plant (LAAP)
Soil Matrix	Sand	Clay
Moisture Content[2]	12 - 26%	25 - 30%
Ash Content (as received)	44 - 83%	54 - 66%
Explosives Content[1] (dry basis)		
- TNT	9 - 41%	5 - 14%
- RDX	<0.02%	3 - 10%
- HMX	Not Detected	0.6 - 1.4%
- Other	<0.03	<0.06%
- Total Explosives	9 - 41%	10 - 22%
Heating Value (as received)	50 - 2,400 Btu/lb	600 - 1,200 Btu/lb

[1]Molecular structure of TNT, RDX, HMX, and other relevant explosives are provided in Appendix D.

[2]Moisture content for soils are based on samples taken from the soil prior to feeding into the incinerator.

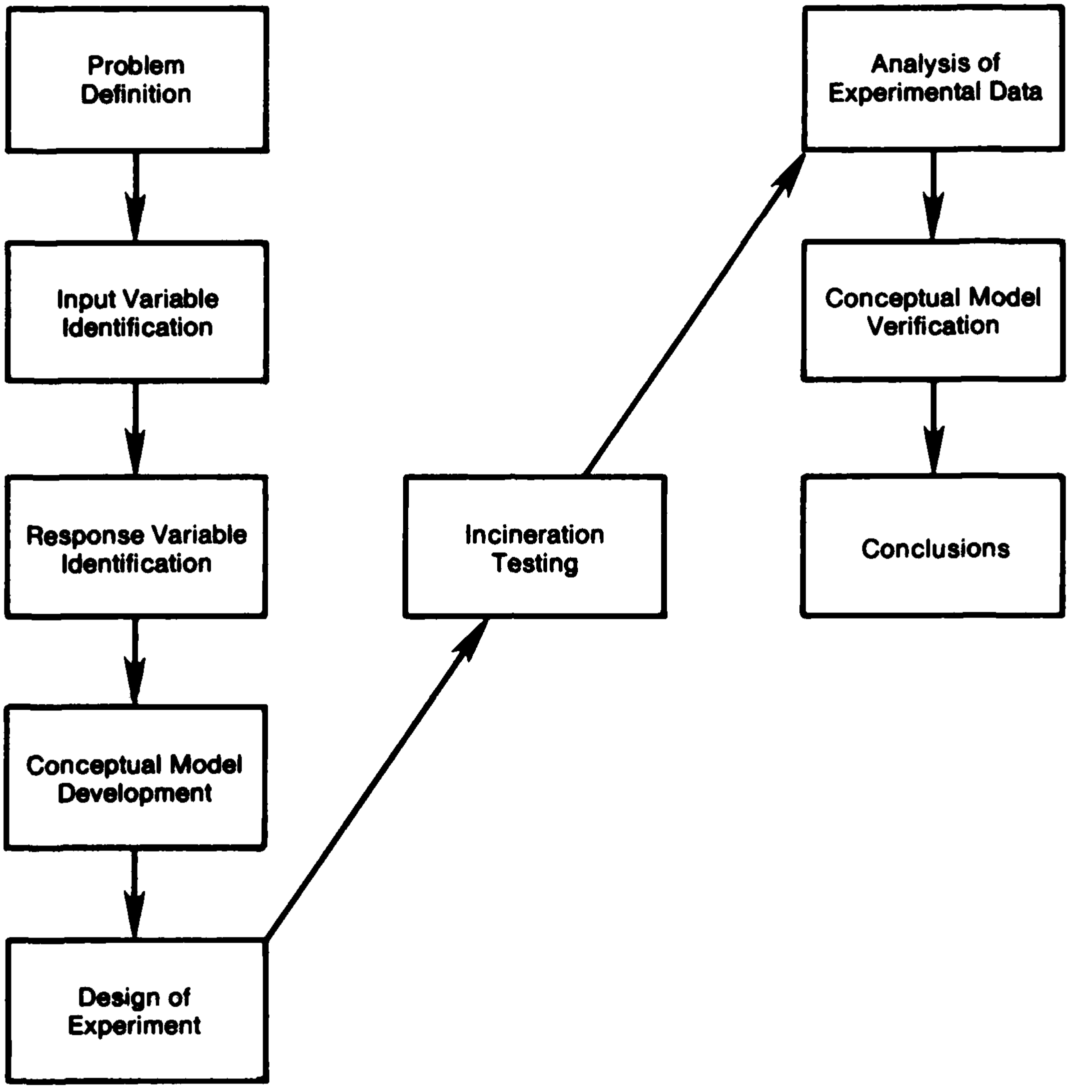

FIGURE 4 TEST PLAN ANALYTICAL APPROACH

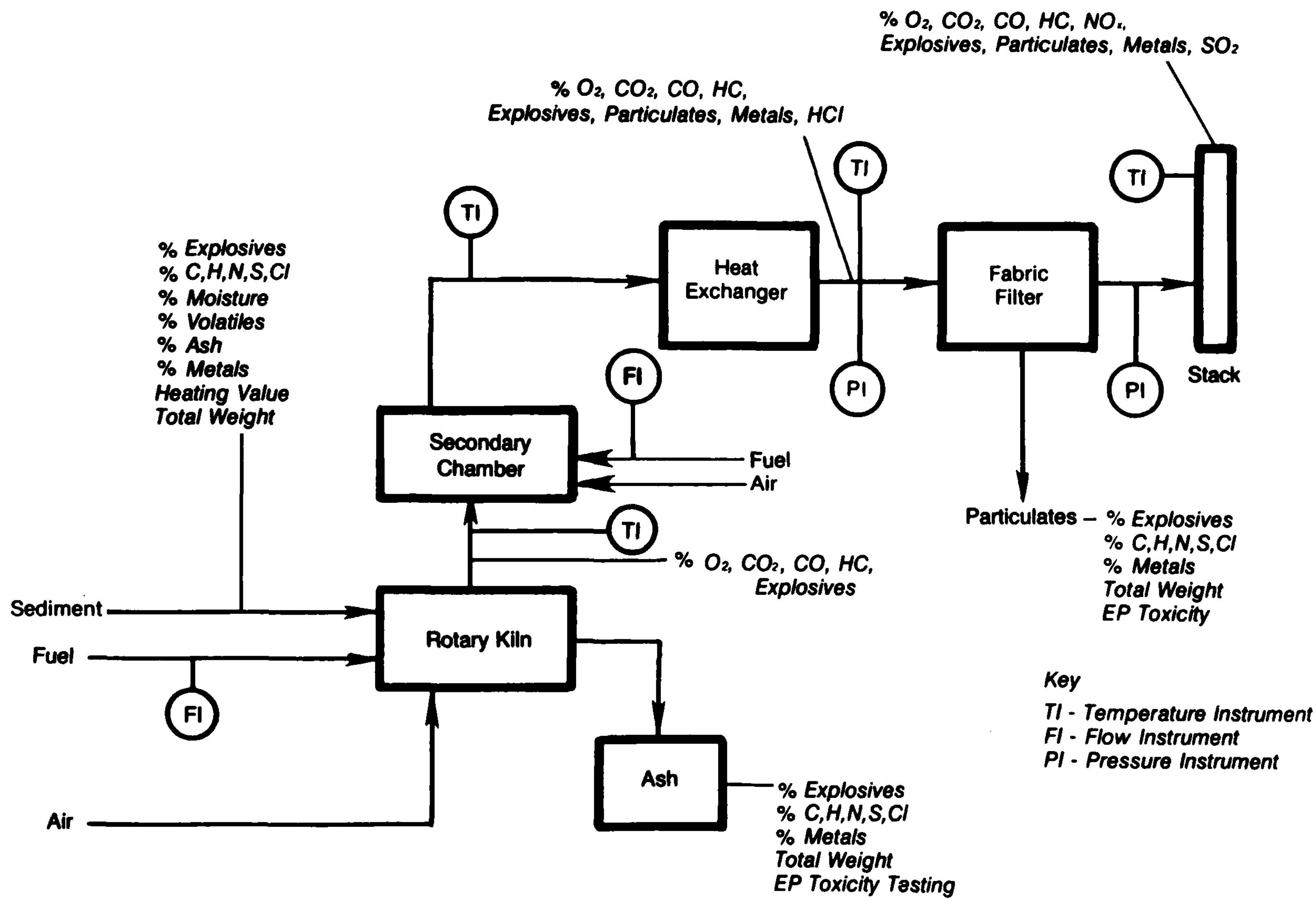

FIGURE 5 INCINERATION TEST SCHEMATIC DIAGRAM

From the outset, USATHAMA assigned personnel safety the highest priority for this project. In this regard, a detailed site plan and safety submission[3] were developed and reviewed and approved by the Department of Defense Explosives Safety Board.

2.4 Environmental permitting. Recognizing the importance of Federal and state environmental concerns, the IECS project was structured to be fully responsive to the requirements of the Resource Conservation and Recovery Act (RCRA) of 1976 and the Illinois Air Pollution and Hazardous Waste Management Regulations. As shown in the project schedule, the environmental permitting[4] was an extremely rigorous and time-consuming process.

2.5 Evaluation of materials handling procedures. The primary objective of this task was to evaluate, design, and implement materials handling procedures that emphasized personnel and environmental safety. There were four major goals:

(a) Minimize personnel contact with the lagoon soils.
(b) Avoid confining the lagoon soils (which could lead to detonation).
(c) Avoid any initiating forces (i.e., friction, heating under confinement, etc.).
(d) Contain any spills and minimize contamination of clean areas.

The test plan[2] was developed assuming the use of a screw conveyor to feed the contaminated soils into the incinerator. However, subsequent soil reactivity testing at ABL led to cancellation of the screw conveyor due to safety considerations.

A soils handling protocol and a bucket feed system were designed specifically for this test program which met all of the test objectives and safety requirements. During the course of the test program, the feed system cycled over 4,000 times without a single failure.

2.6 Incineration testing. The incineration testing commenced on 19 September 1983. Nineteen daily tests were completed in 20 consecutive calendar days with no time lost due either to incineration or sampling equipment failure. Table 2 provides a summary of the test dates and controlled process variables for each of the 19 test runs. Since explosives contaminated soils had never been incinerated previously, a preliminary test run (Test Run No. 1) was conducted at the proposed maximum soil feed rate (500 pounds per hour) and the proposed minimum primary kiln

TABLE 2. DEFINITION OF TEST MATRICES AND SUMMARY OF CONTROLLED PROCESS VARIABLES

Test run number	Test date	Matrix number	Soil feed rate (lb/hr)	Primary kiln temperature (°F)	Secondary chamber temperature (°F)	Soil type (A or B)[1]
1	9/19	0-1	500	800	1,400	A
3	9/21	1-1	300	1,200	1,600	A
15	10/4	1-2	350	1,200	1,600	A
2	9/20	1-3	400	1,200	1,600	A
5	9/23	1-4	300	1,400	1,800	A
8	9/27	1-5	350	1,400	1,800	A
4	9/22	1-6	400	1,400	1,800	A
10	9/29	1-7	300	1,600	2,000	A
14	10/3	1-8	350	1,600	2,000	A
12	10/1	1-9	400	1,600	2,000	A
7	9/26	2-1	300	1,200	1,600	B
19	10/8	2-2	350	1,200	1,600	B
17	10/6	2-3	400	1,200	1,600	B
13	10/2	2-4	300	1,400	1,800	B
16	10/5	2-5	350	1,400	1,800	B
6	9/24	2-6	400	1,400	1,800	B
9	9/28	2-7	300	1,600	2,000	B
11	9/30	2-8	350	1,600	2,000	B
18	10/7	2-9	400	1,600	2,000	B

[1]Soil Type 'A' is SADA lagoon soil.
Soil Type 'B' is LAAP lagoon soil.

temperature ($800^{o}F$) to determine whether explosives breakthrough would be detectable in the stack gas. Explosives were not detected in the stack gas; however, low concentrations of explosives were detected in the primary kiln ash (6.48 ppm), in the fabric filter ash (26.27 ppm), and in the flue gas entering the secondary chamber (195.9 ppm). Therefore, all subsequent tests were run at lower soil feed rates and higher primary kiln temperatures to ensure that no explosives would be released to the environment.

After the formal testing was completed on 8 October 1983, an additional 25,000 pounds of lagoon soils were incinerated from 10 to 15 October 1983 (64 actual hours of processing soil). The objectives of burning the additional lagoon soils were twofold:

(a) Thermally treat all lagoon soils that had been excavated but not required during the formal testing.
(b) Determine the operational characteristics of the incinerator system under a longer term, steady-state production mode of operation.

3. TEST SITE

The incineration test was conducted at the Savanna Army Depot Activity (SADA) which is located near Savanna, Illinois. The location of SADA is identified on the map represented in Figure 6. The incinerator test site is shown in Figure 7. The relationship between the lagoons from which the soil was excavated and the incinerator test site is shown in Figure 8.

The selection of the test site was somewhat predicated by the selection of contaminated soils that were to be incinerated. The options evaluated included:

(a) Testing at SADA which would require manifesting the LAAP soils.
(b) Testing at LAAP which would require manifesting the SADA soils.
(c) Testing at another U.S. Army installation which would require manifesting both soils.
(d) Testing at a commercial incineration facility which would also require manifesting both soils.

Performing the incineration test burn at SADA using a temporary, transportable incinerator was the selected option for the following reasons:

(a) Based on discussions with the Illinois EPA and EPA, Region V, both agencies indicated that they would be more receptive to approving a temporary, short-term trial burn on-site rather than revising the permit for an existing facility to allow burning of explosives contaminated lagoon soils.
(b) There was less probability of adverse public reaction/ public hearings if the material was burned on-site in a temporary incinerator rather than at a commercial facility.
(c) The government would potentially be exposed to a higher degree of liability by performing the test off-site at a subcontractor's facility.
(d) The government would have less control of the safety procedures by performing the test off-site.
(e) Additional handling, transportation, and storage of the lagoon soils would be required by performing the test off-site which increases the potential risk regarding safety of personnel and equipment.

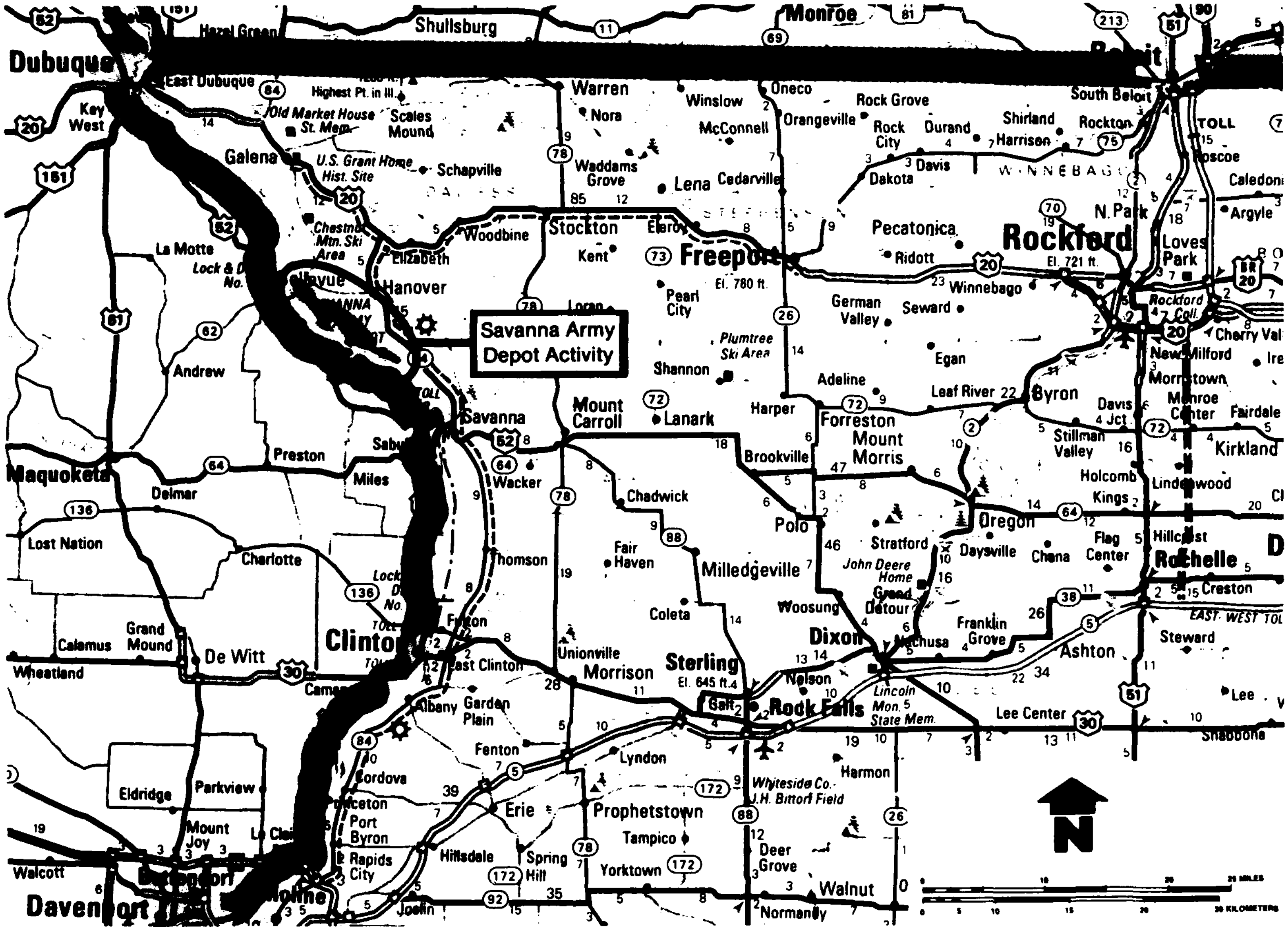

FIGURE 6 LOCATION MAP OF SAVANNA ARMY DEPOT ACTIVITY

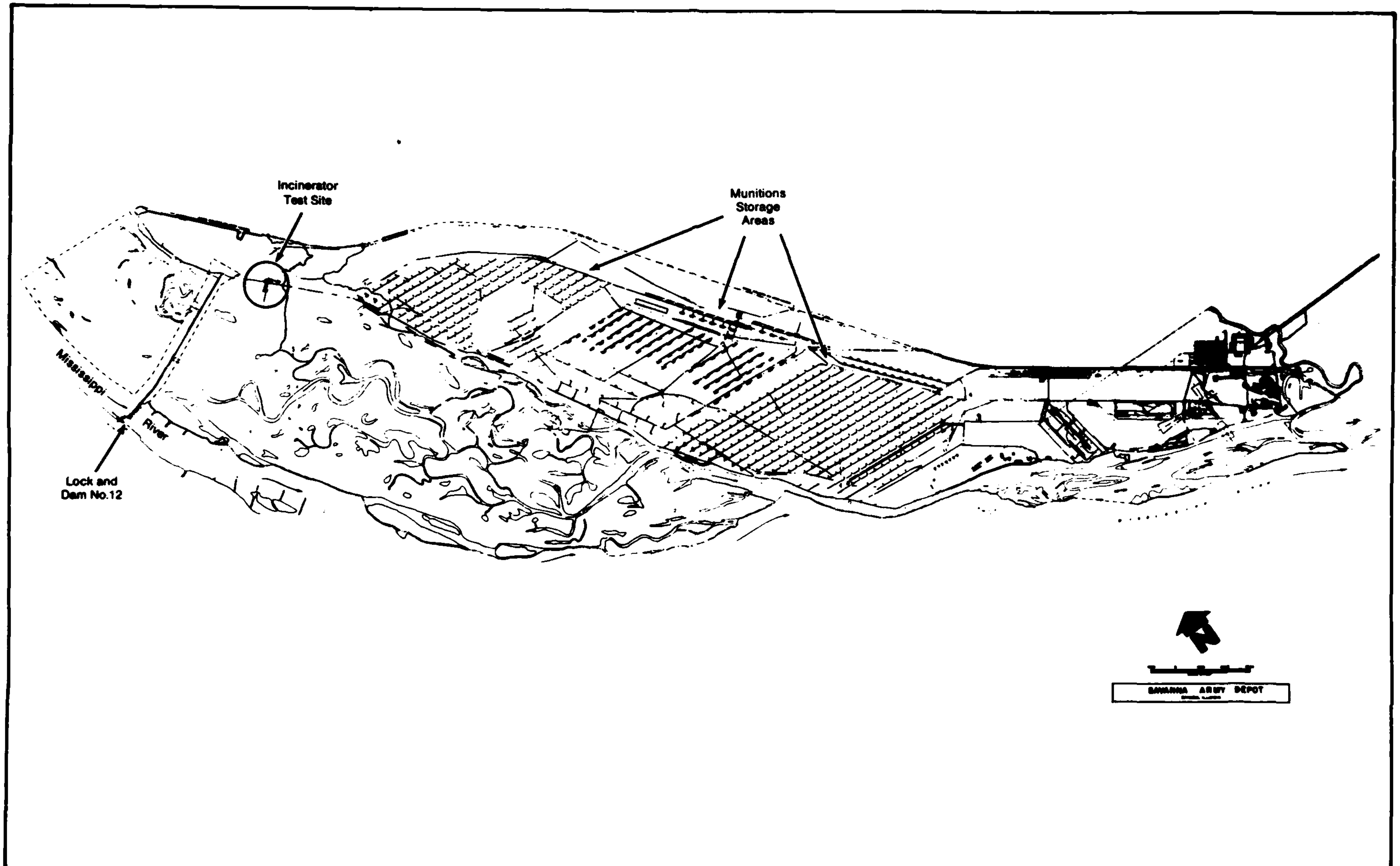

FIGURE 7 PLOT PLAN OF SAVANNA ARMY DEPOT ACTIVITY WITH INCINERATOR TEST SITE IDENTIFIED

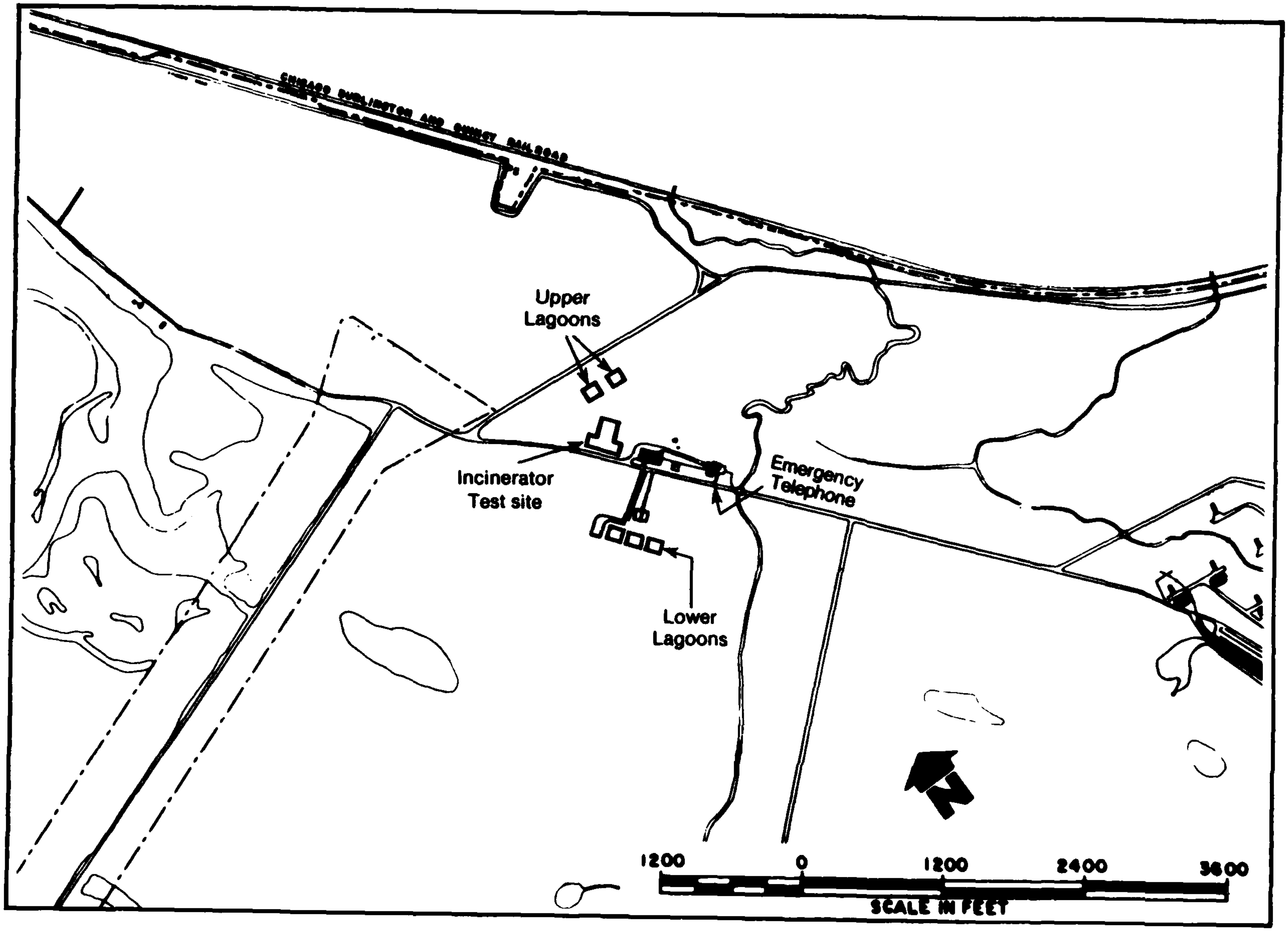

FIGURE 8 LOCATION MAP OF LAGOONS AND INCINERATOR TEST SITE

(f) Performing the test burn on-site with a transportable unit more closely simulates the full-scale remedial incineration option and minimizes future environmental permitting if this remedial action option is implemented.

4. CHARACTERISTICS OF EXPLOSIVES CONTAMINATED SOIL

In the 19 May 1980 Federal Register, page 33123, K044 (wastewater treatment sludges from the manufacturing and processing of explosives) is listed as a hazardous waste because it exhibits the characteristic of reactivity. The characteristic of reactivity is defined in 40 CFR 261.23 as exhibiting any of the following properties:

(a) Normally unstable and readily undergoes violent change without detonating.
(b) Reacts violently with water.
(c) Forms potentially explosive mixtures with water.
(d) When mixed with water, generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
(e) A cyanide- or sulfide-bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
(f) Capable of detonation or explosive reaction if subjected to a strong initiating source or if heated under confinement.
(g) Readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
(h) A forbidden explosive as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53, or a Class B explosive as defined in 49 CFR 173.88.

The lagoon soils also contain explosives and products of explosives decomposition that are specifically listed in 40 CFR 261, Appendix VIII, as hazardous constituents. These Appendix VIII hazardous constituents could potentially include the following:

(a) Dinitrobenzene (DNB)
(b) 2,4-Dinitrotoluene (2,4-DNT)
(c) 2,6-Dinitrotoluene (2,6-DNT)
(d) Nitrobenzene (NB)
(e) Trinitrobenzene (TNB)

In order to gain as much meaningful information from the IECS testing program as is practical and to allow proper statistical interpretation of the results, it was decided that the entire series of test runs would be replicated using a soil from another U.S. Army installation with properties and characteristics widely varying from those of the SADA soil. The Louisiana Army Ammunition Plant (LAAP) was selected as the second source of contaminated soils. Table 3 provides the SADA soil analyses based on composite sampling conducted during 10 separate incinerator test burns. Table 4 provides comparative data for the LAAP soil based on composite sampling conducted during nine separate incinerator test burns. Data for the individual test burns are provided in Appendix A.

As shown in Tables 3 and 4 these two soils provide widely varying ranges of properties. Typically, the SADA soil is a drier, sandy soil with higher TNT concentrations but little or no HMX or RDX, whereas the LAAP soil is typically a more consistent, moist, clay-based soil with relatively higher HMX and RDX concentrations, and slightly higher metals content.

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TABLE 3. SAVANNA ARMY DEPOT ACTIVITY SOIL ANALYSIS

Total Analysis

Parameter	Range of values	Detection limit[1]
Moisture, %	11.7 - 26.3	---
Ash, % as received	44.5 - 82.5	---
Ash, % dry basis	60.5 - 95.6	---
Heating Value, Btu/lb as received	ND[2] - 2,364	50

Elemental Analysis (Dry Weight Basis)

Parameter	Range of values	Detection limit
Sulfur, %	ND	0.01
Carbon, %	2.68 - 12.70	---
Hydrogen, %	0.28 - 0.79	---
Nitrogen, %	1.01 - 6.03	---
Total Chlorine, %	ND - 0.12	0.01

Heavy Metals Content (Dry Weight Basis)

Parameter	Range of values	Detection limit
Barium (Ba), ppm	17 - 29	---
Cadmium (Cd), ppm	ND	3.9
Chromium (Cr), ppm	ND - 13	5.9
Copper (Cu), ppm	ND - 30	10.4
Lead (Pb), ppm	16 - 100	---
Zinc (Zn), ppm	32 - 160	---
Arsenic (As), ppm	ND	5.7
Selenium (Se), ppm	ND	5.0
Mercury (Hg), ppm	ND	0.5

4523A

TABLE 3. (CONTINUED)

Explosives Analysis (Dry Weight Basis)

Parameter	Range of values	Detection limit
2,4,6-Trinitrotoluene (TNT), ppm	88,100 - 406,000	---
HMX[3], ppm	ND	15.9
RDX[3], ppm	28.6 - 145	---
1,3,5-Trinitrobenzene (TNB), ppm	90.7 - 256	---
1,3-Dinitrobenzene (DNB), ppm	ND - 35.1	7.39
Nitrobenzene (NB), ppm	ND	5.26
2-Amino-4,6-Dinitrotoluene (2-Amino), ppm	ND - 27.9	3.64
2,6-Dinitrotoluene (2,6-DNT), ppm	ND	5.03
2,4-Dinitrotoluene (2,4-DNT), ppm	ND	5.20

[1]Detection limit listed only for parameters not detected.

[2]ND - Not detected (i.e., sample concentration below the detection limit).

[3]Refer to Appendix D for the structures of HMX and RDX.

TABLE 4. LOUISIANA ARMY AMMUNITION PLANT SOIL ANALYSIS

Total Analysis

Parameter	Range of values	Detection limit[1]
Moisture, %	25.1 - 29.5	---
Ash, % as received	54.3 - 66.0	---
Ash, % dry basis	77.1 - 88.1	---
Heating Value, Btu/lb as received	582 - 1,172	---

Elemental Analysis (Dry Weight Basis)

Parameter	Range of values	Detection limit
Sulfur, %	ND[2] - 0.01	0.01
Carbon, %	5.08 - 7.66	---
Hydrogen, %	0.66 - 1.05	---
Nitrogen, %	2.52 - 6.72	---
Total Chlorine, %	ND - 0.37	0.01

Heavy Metals Content (Dry Weight Basis)

Parameter	Range of values	Detection limit
Barium (Ba), ppm	98 - 150	---
Cadmium (Cd), ppm	ND - 13	3.9
Chromium (Cr), ppm	17 - 23	---
Copper (Cu), ppm	42 - 65	---
Lead (Pb), ppm	100 - 160	---
Zinc (Zn), ppm	140 - 310	---
Arsenic (As), ppm	ND	5.7
Selenium (Se), ppm	ND	5.0
Mercury (Hg), ppm	2.2 - 3.4	---

TABLE 4. (CONTINUED)

Explosives Analysis (Dry Weight Basis)

Parameter	Range of values	Detection limit
2,4,6-Trinitrotoluene (TNT), ppm	55,100 - 142,000	---
HMX[3], ppm	5,740 - 13,500	---
RDX[3], ppm	33,100 - 96,500	---
1,3,5-Trinitrobenzene (TNB), ppm	57.0 - 139	---
1,3-Dinitrobenzene (DNB), ppm	ND - 22.4	7.39
Nitrobenzene (NB), ppm	ND	5.26
2-Amino-4,6-Dinitrotoluene (2-Amino), ppm	ND - 588	3.64
2,6-Dinitrotoluene (2,6-DNT), ppm	ND	5.03
2,4-Dinitrotoluene (2,4-DNT), ppm	ND	5.20

[1]Detection limit listed only for parameters not detected.

[2]ND - Not detected (i.e., sample concentration below the detection limit).

[3]Refer to Appendix D for the structures of HMX and RDX.

WESTON

5. DESCRIPTION OF THE INCINERATION TEST EQUIPMENT

WESTON evaluated 44 potential incinerator equipment suppliers located in 16 states, and selected ThermAll, Inc. of Peapack, New Jersey as the recommended incineration equipment subcontractor. A layout of the ThermAll incineration equipment is illustrated in Figures 9 and 10. As shown in Figure 10, the system components include the following:

(a) Soil Feed System
(b) Primary Combustion Chamber (Rotary Kiln)
(c) Secondary Combustion Chamber (Afterburner)
(d) Heat Exchanger
(e) Fabric Filter Collector
(f) Induced Draft Fan and Stack

5.1 Soil feed system. The soil feed system selected and designed for this test consisted of a pneumatic ram feeder utilizing a standard 12 quart galvanized steel mop pail to contain the contaminated soil (see Figure 9). This system was selected for the following reasons:

(a) Traditional feed systems (e.g., screw feeders, ram feeders, etc.) would expose the contaminated soil to frictional forces and/or confinement which was unacceptable from an explosives safety perspective.
(b) The mop pail provided a convenient container for excavating the soils, transporting the soils to the site, and loading into and unloading from the feed system with minimum potential for personnel contact or spillage resulting in contamination of clean areas.

Figure 11 is a photograph taken inside of the primary chamber showing the feed system in operation. The design of materials handling and incinerator feed systems for a full-scale remedial action project is the subject of other on-going USATHAMA studies and will not be addressed in this report.

5.2 Primary combustion chamber (rotary kiln). The primary combustion chamber is a rotatable refractory-lined cylinder which is mounted at a slight incline to the horizontal. The chamber size is approximately 4.5 feet outside diameter by 8.5 feet in length. The rotation of the chamber was variable via a Silicon Controlled Rectifier (SCR) drive between 0 and 4 rpm. Facing the feed end of the primary chamber, the kiln rotated in a counter-clockwise direction so that the freshly fed soil rotated directly into the flame (see Figure 11).

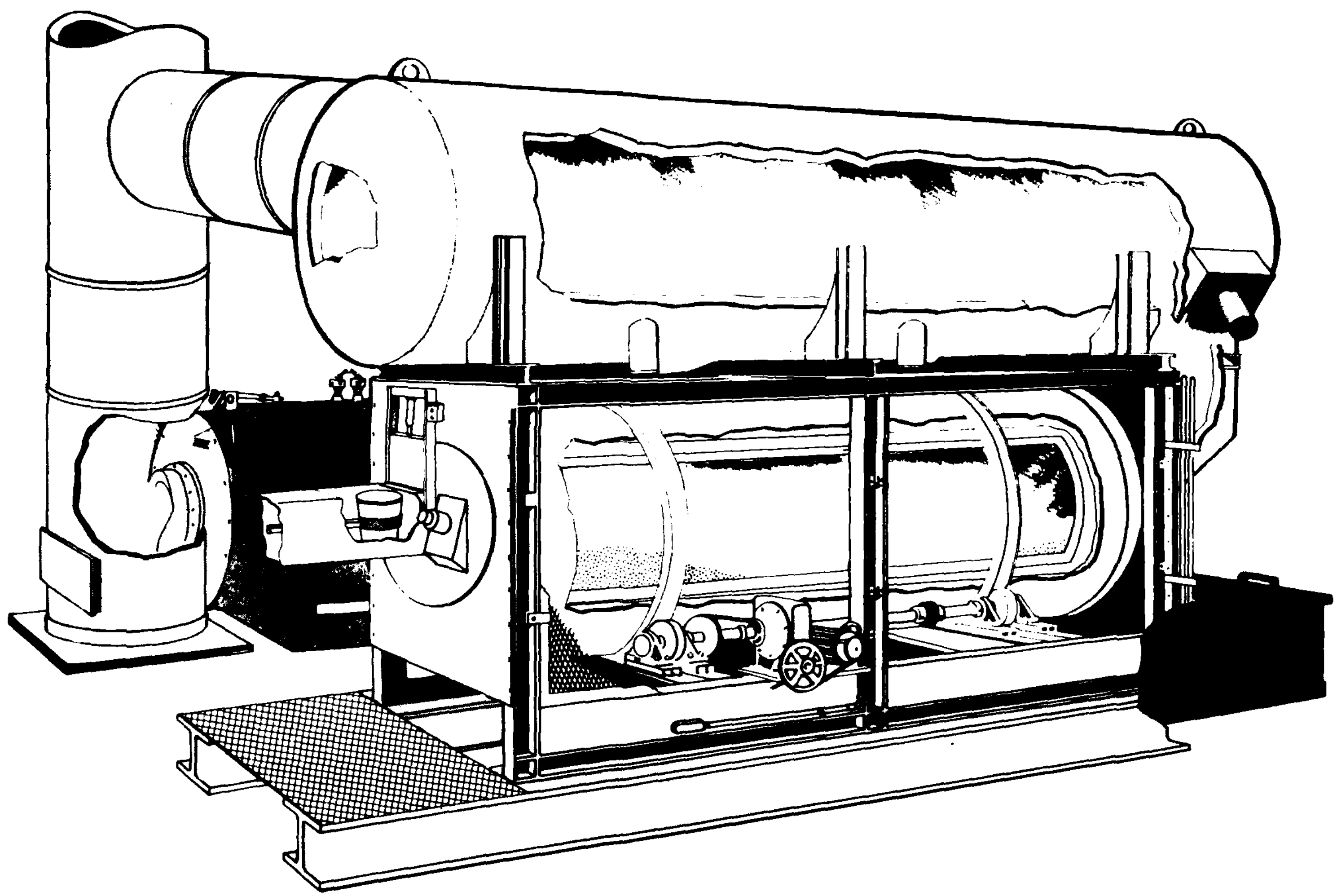
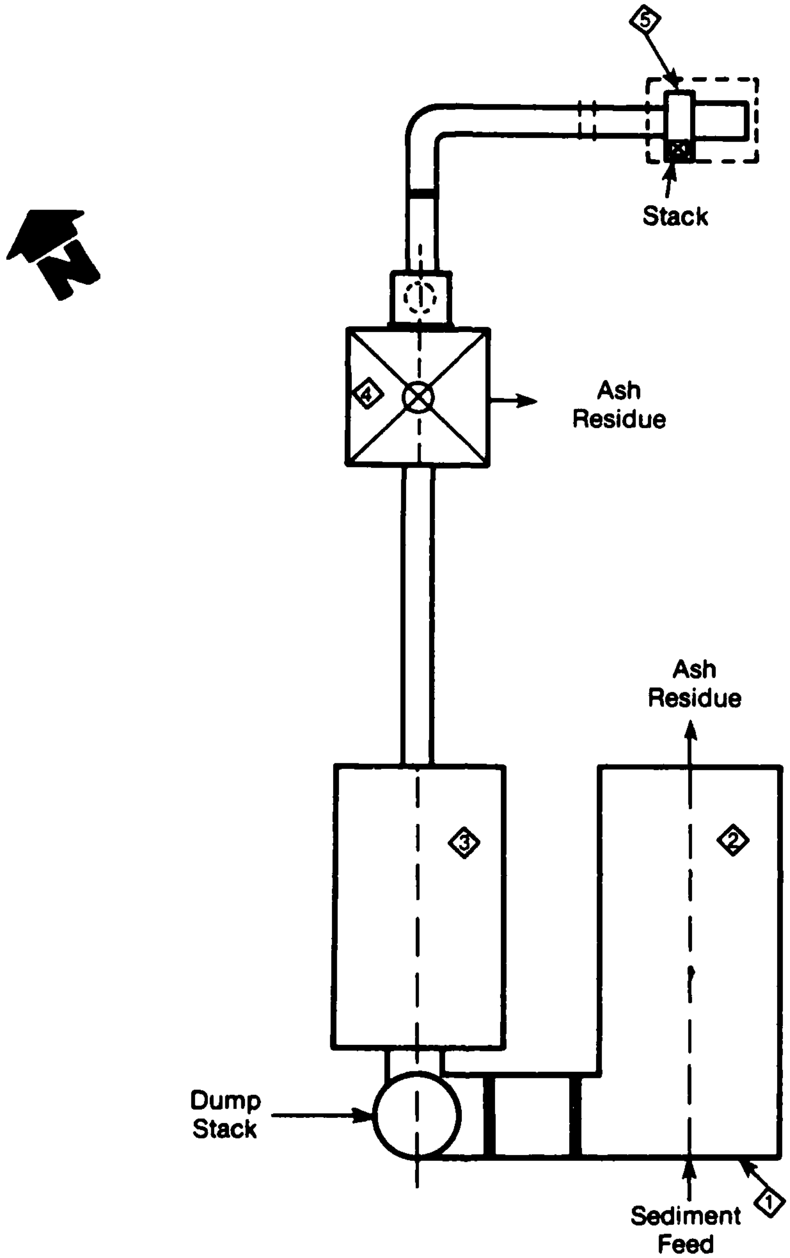


FIGURE 9 CUTAWAY SECTIONAL VIEW OF THE THERMALL INCINERATOR



Item	Equipment	W	L	H
1	Primary Combustion Chamber	4'-6"	8'-6"	5'-6"
2	Secondary Combustion Chamber	4'-6"	14'-0"	4'-6"
3	Heat Exchanger	5'-5"	9'-0"	6'-6"
4	Fabric Filter Collector	5'-0"	5'-0"	20'-0"
5	Induced Draft Fan	2'-6"	2'-6"	3'-6"

FIGURE 10 EQUIPMENT LAYOUT

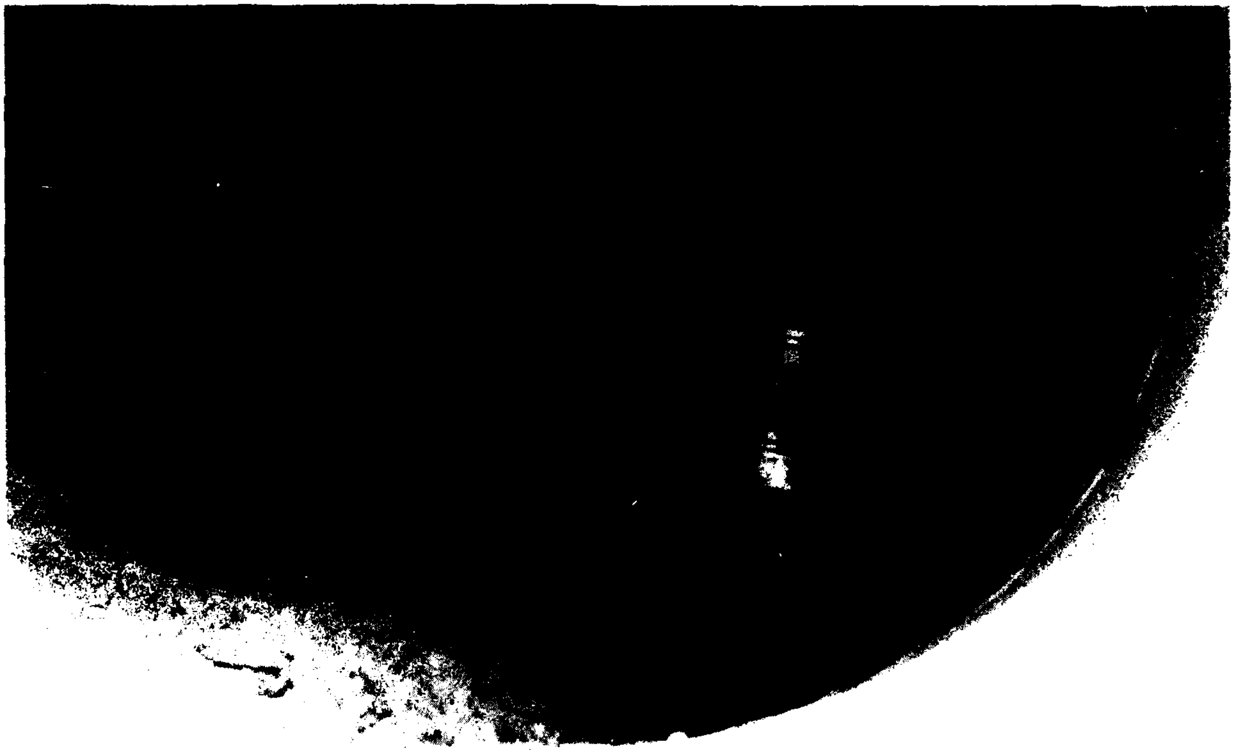


FIGURE 11 PHOTOGRAPH OF THE FEED SYSTEM IN OPERATION

The chamber volume of 75 cubic feet is further complemented by the end panel volume of 15 cubic feet for an actual combustion volume of 90 cubic feet. Primary combustion chamber temperatures were variable and determined by the heat content of the soil as well as a modulating propane-fired burner mounted on the front panel of the kiln.

In order to maintain a specific processing temperature, the burner automatically fired or remained in low-fire mode if the temperature could be maintained by the soil alone. The burner is rated at 1.5 million Btu per hour. Air seals are permanently fixed on the rear of the kiln and are variable on the front of the kiln so that a wide range of excess air capability was available. Normal kiln temperature ranges are between 800°F and 1,900°F.

The end panel is a stationary refractory-lined structure which connects the primary combustion chamber (rotary kiln) to both the ash discharge and the secondary combustion chamber. The lower section of the panel has an 18-inch by 25-inch opening which allows the ash generated in the kiln to automatically discharge to a DOT-approved 55-gallon drum ash receptacle. Ash drum removal occurred periodically during the test runs and allowed continuous feeding of the system without stopping for ash removal. The upper section of the end panel connects to the secondary combustion chamber.

5.3 <u>Secondary combustion chamber (afterburner)</u>. The secondary combustion chamber is a stationary refractory-lined cylinder connected to the primary combustion chamber via the end panel. The chamber houses a second modulating propane-fired burner which was controlled by a thermocouple located in the discharge duct of the chamber. The burner is positioned in the entry to the chamber in a tangential arrangement so that the waste gases discharged from the end panel passed through the flame and provided additional turbulence to these gases. The chamber is lined with high alumina refractory, allowing temperatures of up to 3,000°F. The chamber volume is approximately 90 cubic feet, and residence time, depending on gas temperatures, varied between 1.0 and 2.0 seconds. As with the primary combustion chamber, the burner provided 1.5 million Btu per hour at full fire.

5.4 Heat exchanger (waste heat boiler). The flue gases discharged from the secondary combustion chamber were directed, via refractory-lined duct work, to a heat exchanger. The heat exchanger was utilized to recover the waste heat in the flue gas in the form of low-pressure steam and, more importantly, in so doing reduced the flue gas temperature to 300 to 350°F. Thus, the flue gas was cooled without the use of dilution air and/or quench water. The lowering of flue gas temperature and corresponding flue gas volume protected the fabric filter bags and allowed the downstream ductwork and equipment to be of reduced size and capital cost. The waste heat boiler is of the three-pass fire tube design.

5.5 Fabric filter collector. Particulate matter was controlled by a fabric filter manufactured by Micro Pulse. It contains 64 "Huyglas" (glass and Teflon) bags 10 feet long by 4.5 inches in diameter. The bags were precoated with $CaCO_3$, pulse jet cleaned, and designed for 99-percent control down to a particle diameter of 0.5 um. The bag material was capable of withstanding 500°F peak temperature and a sustained maximum temperature of 425°F. The inlet temperature was maintained at a minimum of 300°F to avoid acid dew-point problems.

5.6 Induced draft fan and stack. Following the fabric filter, the gas passed through an induced draft fan (with a maximum flow rate of 2,800 acfm), a damper, and then to a 24-foot tall by 12-inch diameter unlined stack. The duct work leaving the heat exchanger contained a motorized damper which was electrically driven from the draft signal generated in the end panel. Thus, draft was automatically maintained throughout the system operation.

A dump stack was provided immediately upstream of the heat exchanger in case emergency bypass was required. Upon loss of system electrical power, the dump stack opened to provide natural draft to evacuate the hot gases from the incinerator. This is not a normal mode of operation and incinerator shutdown procedures would commence immediately.

6. EXPERIMENTAL VARIABLES

In order to properly design and implement any field test, important questions must be answered so that the data obtained during the experiment can be evaluated and meaningful results obtained. These questions are:

(a) What are the experimental variables for the test?
(b) Which test variables can be easily controlled and held constant throughout the tests?
(c) Which test variables are most critical to the analysis and can be controlled and held constant at various levels throughout the tests?
(d) Which test variables are impractical to control and must be allowed to vary randomly throughout the tests?
(e) What are the response variables (i.e., the measurements that will be made throughout the tests)?

This section of the report provides a summary of the approach taken to answer these questions. Table 5 provides a summary of the experimental variables for the IECS test burn program. The following subsections describe each of the experimental variables listed in Table 5.

6.1 Test variables to be controlled and held constant.

6.1.1 Soil preparation. It was important to establish a consistent soil preparation procedure so that variability in the manner in which the soil was removed from the lagoons and handled prior to introduction into the feed system did not bias the results of the incineration tests.

6.1.1.1 Preparation of the SADA soils. There are six lagoons located at SADA (four lower lagoons and two upper lagoons). The SADA soil for the IECS test burns was excavated from the upper lagoons (specifically Lagoon No. 5) for the following reasons:

(a) The explosives concentrations are higher in the upper lagoons.
(b) There is less susceptibility for standing water in the upper lagoons, a condition which would impede excavation of the soils.
(c) There is less debris (i.e., leaves, sticks, rocks, etc.) in the soil from the upper lagoons, which improves the materials handling characteristics.

TABLE 5. SUMMARY OF THE EXPERIMENTAL VARIABLES FOR THE IECS TEST BURN

- Test Variables to be Controlled and Held Constant

  Soil Preparation
  Kiln Rotation Rate
  Fuel Composition

- Test Variables Held Constant at Various Levels

  Incinerator Feed Rate
  Primary Chamber Temperature
  Secondary Chamber Temperature

- Test Variables Allowed to Vary Randomly

  Soil Feed Composition
  Kiln Ash Residence Time
  Flue Gas Residence Time
  Percent Excess Air
  Fuel Input Rate

- Response Variable Measurements to be Made

  Ash Residue Analyses

  - Primary Chamber
  - Fabric Filter

  Flue Gas Analyses

  - Before Secondary Chamber
  - Before Fabric Filter
  - Stack

The SADA soil was excavated manually using plastic shovels. Prior to excavation, the soil was surveyed with a magnetometer to detect any metal objects/unexploded ordnance. The soil was loaded directly into the 12-quart mop pails and transported to the incineration test site in the back of a pick-up truck that had a specially designed "egg crate" wooden frame that held 30 buckets securely. At the incineration test site, the buckets were stored on plastic sheeting and covered with plastic until loaded into the feed system. The soil was excavated daily for the following day's test.

The soil feed rate was determined by weighing each individual bucket before and after feeding to obtain an actual net weight of soil fed. A sample was taken from each individual bucket prior to weighing. The feed samples were then combined to form a composite sample for each run.

6.1.1.2 Preparation of the LAAP soils. The LAAP soils were excavated by LAAP personnel, manifested, and transported to the incineration test site in DOT-approved, 55-gallon drums with plastic liners. Fifty drums of soils were manifested and shipped simultaneously and were unloaded on wooden pallets in the upper lagoon area.

The LAAP drums were individually dumped into a galvanized steel tank by a fork lift with a specially designed lifting harness. The LAAP soils were manually loaded into 12-quart mop pails using aluminum scoops. All metal objects (i.e., ammunition box hinges, flashlight batteries, etc.) were removed. The LAAP soils were transported to the incineration test site and fed to the incinerator in the same manner described for the SADA soils.

6.1.2 Kiln rotation rate. The kiln rotation rate was an important factor in establishing the soils residence time within the primary combustion chamber. This parameter was held at a constant value of approximately four revolutions per hour for all of the test runs. This corresponded to an ash residence time in the primary chamber of approximately 50 minutes to 2 hours.

6.1.3 Fuel composition. The fuel for the burners in the primary and secondary combustion chambers was propane. The propane was stored at the test site in four propane storage tanks provided by Thermogas. The propane had a heating value of 21,560 Btu per pound or approximately 2,500 Btu per cubic foot.

6.2 Test variables held constant at various levels. Three variables were selected as the most important factors in evaluating the economic feasibility of incineration of explosives contaminated soils. These variables were incinerator feed rate and primary and secondary chamber temperatuers. These factors directly related to the length of time necessary to decontaminate a fixed quantity of soil and the projected fuel consumption. Therefore, the test runs included three separate levels for each of these three variables. A summary of the test dates and controlled process variables for each of the 19 test runs was provided in Table 2. The following subsections discuss the level and operating ranges for these three variables.

6.2.1 Incinerator feed rate. The test plan[2] was developed assuming the use of a screw conveyor to feed the contaminated soils into the incinerator. However, subsequent soil reactivity/sensitivity testing at ABL led to cancellation of the screw conveyor due to safety considerations. Feed rates of up to 800 pounds per hour were proposed for the screw conveyor feed system since it would meter the soil into the primary chamber in a consistent fashion. However, with the bucket feed system used for the IECS test runs, the feed rate had to be reduced since the material was bulk loaded at 2- to 3-minute intervals. A maximum of 500 pounds per hour was proposed.

Since explosives contaminated soils had never been incinerated previously, a preliminary test run (Test Run No.0-1) was conducted on 19 September 1983 at the proposed maximum soil feed rate (500 pounds per hour) and the proposed minimum primary kiln temperature (800°F) to determine whether explosives breakthrough would be detectable in the stack gas. No explosives were detected in the stack gas; however, the following adverse results did occur:

(a) Explosives were detected in the kiln ash (6.48 ppm).
(b) Explosives were detected in the fabric filter ash (26.27 ppm).
(c) Explosives were detected in the flue gas entering the secondary chamber (195.9 ppm).
(d) Based on physical observations the soil did not appear to burn well (see Subsection 7.5.3).
(e) The kiln ash was black with large "clinkers" up to 6 inches in diameter.
(f) The ash had a strong ammonia smell.

For these reasons it was decided that all subsequent runs would be conducted at feed rates no higher than 400 pounds per hour and primary chamber temperatures no lower than 1,200°F to ensure that further contamination of downstream equipment (i.e., waste heat boiler, fabric filter, etc.) would be minimized and to ensure that no explosives would be released to the atmosphere. Therefore, the feed rates selected for evaluation were 300, 350, and 400 pounds per hour.

6.2.2 Primary chamber temperature. Primary chamber temperatures could be varied between 800°F and 1,900°F. However, due to the discussion presented in Subsection 6.2.1, the potentially high moisture content of the soil, the fact that previous studies have shown that explosives volatilize at relatively low temperatures, and the presence of the afterburner downstream, the kiln temperatures selected for evaluation were 1,200°F, 1,400°F, and 1,600°F. Additionally, these temperatures would be practical for future full-scale remedial action projects.

6.2.3 Secondary chamber temperature. The secondary chamber burner limited operation to a maximum of 2,200°F. The secondary chamber temperatures selected for evaluation were 1,600°F, 1,800°F, and 2,000°F. For the IECS test program it was established that for all test runs the secondary chamber would be operated at 400°F above the primary chamber temperature. This decision was made for the following reasons:

(a) Introduction of a fourth controlled variable would increase the number of matrix runs required from 18 (i.e., kiln temperature - three levels, soil feed rate - three levels, and soil type - two levels) to 54 which would be impractical.

(b) Variation of the secondary chamber temperature independent of the kiln temperature is not practical since the afterburner cannot be operated at a lower temperature than the kiln without cooling the gas, and the maximum amount of incremental temperature increase is limited by the capacity of the secondary burner.

(c) Industrial practice with rotary kiln incinerators has shown that operation of the secondary chamber at approximately 200 to 400°F above the kiln temperature provides for cost-effective supplementary fuel utilization consistent with effective destruction of flue gas contaminants (i.e., carbon monoxide and hydrocarbons).

6.3 Test variables allowed to vary randomly.

6.3.1 Soil feed composition. The explosives, moisture, and metals concentrations in the soils were the "as received" levels and no attempt was made to adjust these variables. Two distinctively different types of soils were tested from two separate Army installations. The characteristics of the soils were presented in Section 4.

6.3.2 Kiln ash residence time. The kiln ash residence time was a function of incinerator feed rate, kiln rotation rate, the ash density, and the angle of repose of the material. Since the kiln rotation rate was held relatively constant at four revolutions per hour, the primary factors affecting kiln ash residence time was ash characteristics (i.e., density and angle of repose) and feed rate. As shown in Subsection 7.2.3, the kiln ash residence time varied from 54 to 114 minutes for the SADA test runs and from 49 to 120 minutes for the LAAP test runs.

6.3.3 Flue gas residence time. The flue gas residence time within the secondary chamber was a function of fuel burn rate, amount of organics oxidized from the soil, the soil moisture content, the amount of excess air, and the secondary combustion chamber temperature and volume. As shown in Subsection 7.2.4, the flue gas residence times in the secondary combustion chamber varied from 1.0 to 2.0 seconds.

6.3.4 Percent excess air. The percent excess air is a measure of the amount of additional oxygen available above and beyond the amount required for stoichiometric combustion of the fuel and oxidation of the organics in the sediment. Due to the high degree of variability of organics content of the soil (i.e., explosives concentration), no attempt was made to maintain constant excess air levels. However, to ensure an adequate supply of combustion air to oxidize the explosives in the soil and the flue gas, excess air rates of 100 to over 200 percent were provided in the primary combustion chamber. Excess flow rates in the flue gas leaving the secondary combustion chamber were approximately 100 percent.

6.3.5 Fuel input rate. The fuel input rate was a function of the heat content of the soil (i.e., explosives concentration), the moisture content of the soil, the air flowrate, heat losses, and the selected primary and secondary combustion chamber temperatures. Once the incinerator reached steady-state conditions, the primary and secondary chamber burners modulated, as required, to automatically maintain the temperature set points. Total fuel input rates varied from 500 to 1,300 cubic feet per hour of propane during the test runs.

6.4 Response variables. The response variables are the various ash residue and flue gas analyses as shown in Figure 5. The detailed sampling and analysis techniques employed were presented in a previous document[5] and will not be repeated in this report.

There was only one deviation from the referenced sampling and analysis plan[5]. The on-site total hydrocarbon analyses were performed on aliquots of the integrated gas samples collected in the EPA Method 3 sampling trains rather than on the explosives/hydrocarbon train bag samples as originally planned. This procedure change was necessitated because the bag samples from the explosives/hydrocarbon trains picked-up acetonitrile vapors (from sample recovery activities) which interferred with the determination of total hydrocarbons.

Acetonitrile was confirmed in the bag samples from the explosives/hydrocarbons trains which were sent to WESTON's West Chester, Pennsylvania laboratories. No other deviations from the sampling/testing and analysis plan were necessary.

7. PRESENTATION OF TEST BURN DATA

7.1 Summary of test burn data. The test burn dates and controlled process variables (i.e., soil feed rate and primary and secondary chamber temperatures) were summarized in Table 2. Figures 12 and 13 provide the average data for the nine test burns on SADA soil (Test Matrix Nos. 1-1 to 1-9) and the nine test burns on LAAP soil (Test Matrix Nos. 2-1 to 2-9), respectively. These figures summarize the data in a material balance format and provide a complete summary of the composition of the feed and waste streams and the flue gas sampling results. An individual material balance diagram for each of the 18 test burns summarized in Figures 12 and 13, as well as the preliminary test burn (Test Matrix No. 0-1) is provided in Appendix A.

7.2 Presentation of data and calculation procedures.

7.2.1 Emission testing periods. Table 6 summarizes the actual emission testing periods and propane fuel consumption of the primary and secondary burners. The emission testing periods shown on Table 6 do not include the pre-test warm-up and post-test cool-down time. The pre-test warm-up took up to 3 hours depending on the required kiln temperature. Once the desired operating conditions were achieved and soil feed commenced, equilibrium conditions were maintained for 60 minutes prior to starting the emission testing. As shown in Table 6, the duration of the actual emission testing ranged from approximately 2 to 3 hours. After the emission testing was completed, the soil feed was discontinued and equilibrium conditions were maintained for an additional 60 minutes to ensure that the ash in the kiln was properly processed. The post-test cool-down took up to 3 hours to ensure that the temperature of the refractory was reduced gradually.

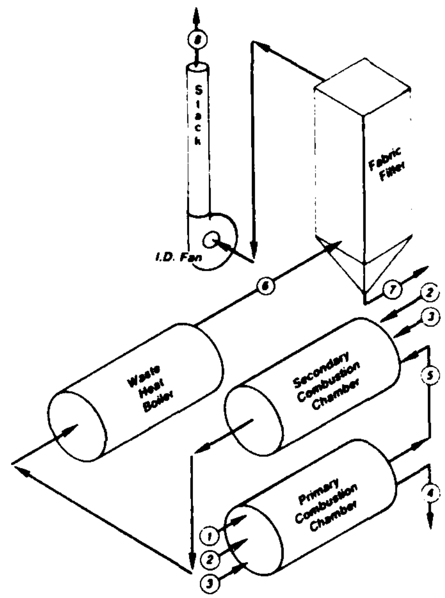
The propane burn rate data presented in Table 6 was calculated based on the gas meter readings at the start and finish of the emission test period. The propane burn rate is for both the primary and secondary burners combined. The heating value of the propane was 21,560 Btu per pound or approximately 2,500 Btu per standard cubic foot.

7.2.2 Actual soil feed rate and ash production data. The actual soil feed weights and the respective total kiln and fabric filter ash weights are listed in Table 7 for each of the test burns. The average soil feed rate for each test was calculated by dividing the total soil fed by the total time soil was fed. Although these average feed rates do not account for instantaneous feeding surges (i.e., one bucket of soil every 2 to

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	21.4	1.22	-	-	0.031	-
Hydrogen	(lb/hr)	-	-	1.48	0.063	-	-	0.0027	-
Oxygen	(lb/hr)	-	-	-	-	13%*	539.6	-	673.5
Nitrogen	(lb/hr)	-	-	9.40	0.34	81.5%*	3,434.8	0.018	3,856.3
Sulfur	(lb/hr)	-	-	ND	0.042	-	-	0.0030	-
Chlorine	(lb/hr)	-	-	0.089	0.042	-	-	0.0023	-
Moisture	(lb/hr)	-	-	59.5		-	-	-	-
Ash	(lb/hr)	-	-	206.9	208.2	-	-	4.22	-
Explosives - TNT	(lb/hr)	-	-	57.2	4.1×10^{-4}	ND	ND	7.8×10^{-5}	ND
RDX	(lb/hr)	-	-	0.019	1.2×10^{-4}	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	3.0×10^{-5}	ND
Other	(lb/hr)	-	-	0.050	ND	ND	ND	9.9×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	7.1×10^{-3}	2.9×10^{-3}	NM	3.8×10^{-4}	3.5×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	4.1×10^{-5}	2.4×10^{-5}	NM
Cr	(lb/hr)	-	-	1.4×10^{-3}	ND	NM	7.9×10^{-5}	6.8×10^{-5}	NM
Cu	(lb/hr)	-	-	2.5×10^{-3}	ND	NM	1.9×10^{-4}	1.7×10^{-4}	NM
Pb	(lb/hr)	-	-	0.013	3.2×10^{-3}	NM	2.3×10^{-3}	9.5×10^{-4}	NM
Zn	(lb/hr)	-	-	0.021	4.0×10^{-3}	NM	2.1×10^{-3}	1.1×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	4.8×10^{-5}	4.0×10^{-4}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	3.9×10^{-5}	8.6×10^{-5}	1.8×10^{-5}
Air	(lb/hr)	4,367.2	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.5%*	426.8	-	422.3
Water Vapor	(lb/hr)	57.5	-	-	-	10.0%*	274.0	-	272.8
Propane	(lb/hr)	-	106.6	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	2.08	-	4.9×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	80.1ppmv*	0.077	-	0.75
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	3.00
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.039
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	7.2×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	6.4ppmv*	0.14	-	2.7×10^{-3}
Total Mass Flow Rate	(lb/hr)		106.6	356.1	209.9	NM*	4,677.5	4.28	5,228.0
Average Temperature	(°F)	4,424	60	60	1,453	1,453	302	192	192
Average Volumetric Flow Rate	(dscfm)	60	15.6	-	-	NM*	978	-	1,100
Heating Value	(Btu/lb)	370 F	21,560	846	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. *Values are presented as volumetric percentages or ppm's on a volume or weight basis*



For IECS Incineration Test Burn
At Savanna Army Depot Activity (SADA)
Savanna, Illinois

WESTON DESIGNERS CONSULTANTS
WESTON WAY
WEST CHESTER, PENNSYLVANIA 19380
PHONE 215 692 3030
TELEX 83 5348

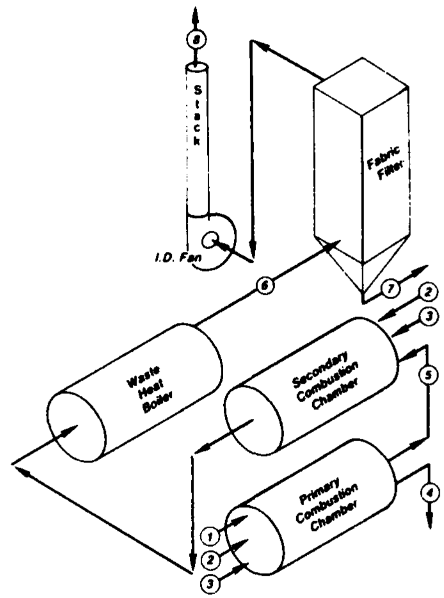
FIGURE 12 AVERAGE MATERIAL BALANCE FOR NINE TEST BURNS ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0001
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	15.7	0.96	-	-	0.020	-
Hydrogen	(lb/hr)	-	-	2.06	0.085	-	-	0.0018	-
Oxygen	(lb/hr)	-	-	-	-	13.2%*	527.4	-	665.0
Nitrogen	(lb/hr)	-	-	10.1	0.49	82.0%*	3,425.6	0.0062	3,852.8
Sulfur	(lb/hr)	-	-	0.015	ND	-	-	0.0018	-
Chlorine	(lb/hr)	-	-	0.18	0.47	-	-	0.0009	-
Moisture	(lb/hr)	-	-	96.5		-	-	-	-
Ash	(lb/hr)	-	-	189.5	210.9	-	-	4.39	-
Explosives - TNT	(lb/hr)	-	-	21.4	2.3×10^{-3}	ND	ND	ND	ND
RDX	(lb/hr)	-	-	13.1	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	2.1	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.096	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.029	0.026	NM	1.6×10^{-4}	3.3×10^{-4}	NM
Cd	(lb/hr)	-	-	8.4×10^{-4}	4.7×10^{-4}	NM	6.1×10^{-5}	2.8×10^{-5}	NM
Cr	(lb/hr)	-	-	5.3×10^{-3}	2.3×10^{-3}	NM	4.4×10^{-5}	5.7×10^{-5}	NM
Cu	(lb/hr)	-	-	0.013	7.0×10^{-3}	NM	1.2×10^{-4}	1.4×10^{-4}	NM
Pb	(lb/hr)	-	-	0.034	0.019	NM	9.8×10^{-4}	1.1×10^{-3}	NM
Zn	(lb/hr)	-	-	0.058	0.028	NM	1.2×10^{-3}	1.2×10^{-3}	NM
As	(lb/hr)	-	-	ND	1.1×10^{-3}	NM	3.6×10^{-5}	6.4×10^{-5}	ND
Hg	(lb/hr)	-	-	7.4×10^{-4}	8.5×10^{-5}	NM	1.4×10^{-5}	2.4×10^{-5}	2.1×10^{-4}
Air	(lb/hr)	4,390.3	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	4.8%*	424.6	-	405.6
Water Vapor	(lb/hr)	57.8	-	-	-	12.6%*	328.7	-	322.8
Propane	(lb/hr)	-	121.7	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.37	-	4.0×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	68.8ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.6
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.069
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.016	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	0.6ppmv*	0.040	-	8.0×10^{-4}
Total Mass Flow Rate	(lb/hr)	4,448.1	121.7	350.9	213.0	NM*	4,707.7	4.42	5,247.9
Average Temperature	(°F)	60	60	60	1,451	1,451	301	194	194
Average Volumetric Flow Rate	(dscfm)	976	17.8	-	-	NM*	973	-	1,095
Heating Value	(Btu/lb)	-	21,560	890	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

WESTON
DESIGNERS CONSULTANTS
WESTON WAY
WEST CHESTER, PENNSYLVANIA 19380
PHONE 215 692 3030
TELEX 83 5348

FIGURE 13 AVERAGE MATERIAL BALANCE FOR NINE TEST BURNS ON LAAP SOIL

Scale	Project Number	Drawing Number
None		
Date 1/3/84	2281-01-02	MB-0002

TABLE 6. SUMMARY OF ACTUAL EMISSION TESTING PERIODS AND PROPANE FUEL CONSUMPTION (EXCLUDES PRE-TEST WARM-UP AND POST-TEST COOL-DOWN)

Matrix number	Test date	Emission testing start time	Emission testing stop time	Emission test duration (hr)	Propane burn rate during emission testing (ft^3/hr)
0-1	9/19	13:15	16:30	3.25	481.6
1-1	9/21	10:45	13:10	2.42	904.7
1-2	10/4	9:30	11:45	2.25	941.3
1-3	9/20	10:45	13:30	2.75	714.3
1-4	9/23	12:50	15:06	2.27	982.4
1-5	9/27	10:15	12:42	2.45	723.2
1-6	9/22	10:15	12:44	2.48	924.8
1-7	9/29	10:50	13:15	2.42	986.9
1-8	10/3	11:29	13:59	2.50	1151.6
1-9	10/1	10:15	12:35	2.33	1083.4
2-1	9/26	11:31	13:57	2.43	846.2
2-2	10/8	8:45	11:00	2.25	944.1
2-3	10/6	9:45	12:00	2.25	997.2
2-4	10/2	9:04	11:15	2.18	1130.1
2-5	10/5	9:45	12:00	2.25	1156.7
2-6	9/24	11:42	14:15	2.55	954.8
2-7	9/28	11:00	13:27	2.45	1086.3
2-8	9/30	10:15	12:30	2.25	1211.9
2-9	10/7	10:30	12:34	2.07	1282.6

TABLE 7. SUMMARY OF ACTUAL SOIL FEED RATES AND ASH PRODUCTION DATA

MATRIX NUMBER	TOTAL AMOUNT OF SOIL FED (lbs)	TOTAL TIME SOIL FED (hrs)	AVERAGE SOIL FEED RATE (lbs/hr)	TOTAL PRIMARY CHAMBER ASH (lbs)	TOTAL FABRIC FILTER ASH[1] (lbs)	TOTAL AVERAGE PERCENT ASH BY WEIGHT (%)
0-1	2,338.5	4.53	515.9	743	18.0	32.5
1-1	1,015.5	3.17	320.7	680	10.5	68.0
1-2	1,156.5	3.30	350.5	902	18.5	79.6
1-3	1,533.5	3.60	426.0	1,050	13.5	69.4
1-4	1,129.0	3.75	301.1	754	14.5	68.1
1-5	1,128.5	3.17	356.3	392	11.0	35.7
1-6	1,367.0	3.37	406.0	880	16.5	65.6
1-7	1,011.5	3.47	291.8	345	14.0	35.5
1-8	1,182.5	3.35	353.0	733	16.0	63.3
1-9	1,249.0	3.08	405.1	615	15.0	50.4
2-1	968.5	3.17	305.8	438	14.5	46.7
2-2	1,127.0	3.65	308.8	700	17.5	63.7
2-3	1,362.5	3.40	400.7	961	16.0	71.7
2-4	969.5	3.20	303.0	560	14.0	59.2
2-5	1,134.0	3.25	348.9	817	21.0	73.9
2-6	1,413.0	3.40	415.6	787	14.5	56.7
2-7	961.0	3.17	303.4	495	12.0	52.8
2-8	1,419.5	4.03	352.0	792	12.0	56.6
2-9	1,640.5	4.07	403.4	1,125	17.0	69.6

(1) On the final day of testing an additional 116 lbs of ash was removed from the fabric filter. This ash was distributed equally among all of the daily total fabric filter ash weights.

3 minutes), they are representative due to the relatively long residence time of the ash in the kiln. The calculated average feed rates are used in Section 9 to analyze the data, as well as similarly calculated kiln and fabric filter ash discharge rates.

The inconsistency of ash removal from the fabric filter is evidenced by the amount of ash (116 pounds or 10 times the actual daily fabric filter ash discharged) removed during the dismanteling of the system. This ash was distributed equally among all of the daily fabric filter ash weights. Due to the potential error associated with this assumption, fabric filter ash weights were not used in the computerized analysis in Section 9. Instead, the particulate loadings (in grains per standard cubic foot) from the gas sampling location upstream of the fabric filter were used.

7.2.3 Estimated primary chamber ash residence times. The estimated primary chamber ash residence times for each of the test burns on SADA soils are presented in Table 8 and similarly for the test burns on LAAP soils in Table 9. Ash residence time could not be directly measured in the field. Therefore, the following procedure was established to estimate ash residence time.

(a) The time that the first ash drum was removed (t_i) was recorded, as well as the time that soil feed commenced (t_o).

(b) The empty ash drum was weighed before the test and the filled ash drum was weighed again after it was removed to determine the net ash weight (m_i).

(c) The height of the ash in the drum was measured to determine the volume of ash in the drum (V_i).

(d) The ash density was estimated by dividing the net weight of ash in the drum by the volume of ash in the drum (m_i/V_i).

(e) The volumetric ash production rate was determined by the following equation:

$$\dot{V} = (m_T) + \left[(t_T) \times \left(\frac{m_i}{V_i}\right)\right]$$

Where: M_T = total primary chamber ash, lb (Table 7)
t_T = total time soil fed, hr (Table 7)

(f) The volume of ash in the kiln (V_k) was determined by the following equation:

$$V_k = \left[(\dot{V}) \times (t_i - t_o)\right] - (V_i)$$

TABLE 8. SUMMARY OF ESTIMATED PRIMARY CHAMBER ASH RESIDENCE TIMES FOR THE SADA RUNS

Matrix number	Time start feed t_o	Time first drum removed t_i	Total time $t_i - t_o$ (hr)	First drum weight M_i (lb)	First drum volume V_i (ft^3)	Ash density $\frac{M_i}{V_i}$ ($\frac{lb}{ft^3}$)	Ash production rate $\dot{V}$ ($\frac{ft^3}{hr}$)	Ash in kiln[2] V_k (ft^3)	Ash residence time[3] T_R (min)
0-1	12:05	15:15	3.17	290	3.30	87.9	1.86	2.6	84
1-1	10:00	14:10	4.17	487	5.50	88.5	2.43	4.6	114
1-2	08:40	11:10	2.50	442	5.06	87.4	3.13	2.8	54
1-3	09:33	12:05	2.53	445	5.28	84.3	3.46	3.5	61
1-4	11:23	14:45	3.37	427	4.84	88.2	2.28	2.8	74
1-5	09:32	13:30	3.97	317	3.96	80.1	1.55	2.2	85
1-6	09:20	12:50	3.50	600	6.82	88.0	2.97	3.6	73
1-7	09:30	13:00	3.50	162	1.76	92.3	1.08	2.0	111
1-8	10:25	13:30	3.08	350	3.96	88.4	2.48	3.7	90
1-9	09:02[4]	12:45	3.72	470	5.94	79.1[4]	2.52	3.4	81

1. $\dot{V} = (M_T) \div \left[(t_T) \times (\frac{M_i}{V_i})\right]$, where: M_T = total primary chamber ash, lb (Table A-1)
t_T = total time soil fed, hr (Table A-1)

2. $V_k = (\dot{V}) \times (t_i - t_o) - (V_i)$

3. $T_R = \left(\frac{V_k}{\dot{V}}\right) \times (60 \frac{min}{hr})$

4. Test 1-9 includes 28 minutes of feeding background sand (132 lb total) which effects ash density.

TABLE 9. SUMMARY OF ESTIMATED PRIMARY CHAMBER ASH RESIDENCE TIMES FOR THE LAAP RUNS

Matrix number	Time start feed t_o	Time first drum removed t_i	Total time $t_i - t_o$ (hr)	First drum weight M_i (lb)	First drum volume V_i (ft^3)	Ash density $\frac{M_i}{V_i}$ ($\frac{lb}{ft^3}$)	Ash production rate $\dot{V}$ ($\frac{ft^3}{hr}$)	Ash in kiln[2] V_k (ft^3)	Ash residence time[3] T_R (min)
2-1	10:45	13:35	2.83	150	3.30	45.5	3.04	5.3	105
2-2	07:35[4]	10:00	2.42	290	4.84	59.9[4]	3.20	2.9	54
2-3	08:44[4]	11:30[5]	2.77	506[5]	10.34[5]	48.9[4,5]	5.78	5.7	59
2-4	08:20	11:45	3.42	247	5.72	43.2	4.05	8.1	120
2-5	08:44[4]	11:26[5]	2.70	472[5]	10.56[5]	44.7[4,5]	5.62	4.6	49
2-6	10:58	13:10	2.20	223	4.62	48.3	4.79	5.9	74
2-7	10:16	13:05	2.82	245	5.06	48.4	3.23	4.0	74
2-8	09:30	14:05	2.58	310	7.04	44.0	4.46	4.5	61
2-9	09:30[4]	13:00[6]	3.50	720[6]	15.84[6]	45.5[6]	6.08	5.4	53

1.
$V = (M_T) \div \left[(t_T) \times \left(\frac{M_i}{V_i}\right)\right]$, where: M_T = total primary chamber ash, lb (Table A-1)
t_T = total time soil fed, hr (Table A-1)

2 $V_k = (\dot{V}) \times (t_i - t_o) - (V_i)$

3
$T_R = \left(\frac{V_k}{\dot{V}}\right) \times \left(60 \frac{min}{hr}\right)$

4 Test 1-9 includes 28 minutes of feeding background sand (132 lb total) which effects ash density.

(g) The ash residence time in the kiln (T_R) was determined by the following equation:

$$T_R = \left(\frac{V_k}{\bar{V}}\right) \times \left(60\ \frac{min}{hr}\right)$$

As shown in Tables 8 and 9, the kiln ash densities were quite different for the two types of soil. The SADA primary kiln ash density was generally in the range of 80 to 90 pounds per cubic foot, whereas the LAAP primary kiln ash density was generally in the range of 40 to 50 pounds per cubic foot. The footnotes in Tables 8 and 9 point out specific test runs in which uncontaminated background sand was fed during the pre-test warm-up to minimize the adherence of ash to the kiln refractory. This is discussed more thoroughly in Subsection 7.3.

The volume of ash in the kiln was also quite different for the two types of soil. Since the kiln rotation was held constant for all tests at approximately four revolutions per hour and since the feed rates and kiln temperatures were essentially replicated for the two soils, the differences in the volume of ash in the kiln (i.e., generally 2 to 4 cubic feet for the SADA kiln ash compared to 4 to 8 cubic feet for the LAAP kiln ash) is most likely due to the difference in the "angle of repose" of the two types of ash. The differences between the two types of kiln ash are discussed more thoroughly in Subsection 7.3.1.

The kiln ash residence times, on the other hand, were comparable for the two types of ash. The residence times varied from 54 minutes to 114 minutes for the SADA kiln ash and from 53 minutes to 120 minutes for the LAAP kiln ash.

7.2.4 Estimated secondary chamber flue gas residence time. The estimated secondary chamber flue gas residence times for each of the test burns are summarized in Table 10. As shown in Table 10, the secondary chamber flue gas residence times ranged from 1.1 to 2.0 seconds. These estimated flue gas residences times are based on the secondary chamber volume of 90 cubic feet, and do not include any credit for the flue gas residence time in the primary chamber, the end panel, or the refractory-lined ductwork upstream of the waste heat boiler.

7.2.5 Explosives concentrations in the soil feed, ash residues, and stack gas. Prior to development of the test plan[2], soil core samples and grab samples had been taken from each of the six SADA lagoons as part of the Task Order 1 effort. The core samples were either 5 or 1.5 feet in depth and explosives concentration analyses were performed on samples taken at 6-inch intervals throughout the depth of each core sample.

TABLE 10. SUMMARY OF ESTIMATED SECONDARY CHAMBER FLUE GAS RESIDENCE TIMES

Matrix number	Secondary temperature (set point)	Chamber (°F) (average actual)	Flue gas flowrate at secondary chamber outlet (scfm)	Flue gas flowrate at secondary chamber outlet (acfm)	Secondary chamber residence time (sec)
0-1	1,400	1,390	783	2,733	2.0
1-1	1,600	1,700[1]	883	3,599	1.5
1-2	1,600	1,575	1,192	4,577	1.2
1-3	1,600	1,600	875	3,401	1.6
1-4	1,800	1,800	908	3,872	1.4
1-5	1,800	1,790	825	3,502	1.5
1-6	1,800	1,730	875	3,616	1.5
1-7	2,000	1,980	1,017	4,682	1.2
1-8	2,000	1,980	1,015	4,673	1.2
1-9	2,000	1,980	1,075	4,949	1.1
2-1	1,600	1,580	850	3,272	1.7
2-2	1,600	1,580	1,000	3,849	1.4
2-3	1,600	1,580	1,083	4,168	1.3
2-4	1,800	1,800	1,042	4,443	1.2
2-5	1,800	1,780	1,058	4,472	1.2
2-6	1,800	1,780	867	3,664	1.5
2-7	2,000	1,960	858	3,918	1.4
2-8	2,000	1,980	958	4,410	1.2
2-9	2,000	1,980	1,042	4,797	1.1

The TNT concentrations found in the core samples ranged from 200,000 ppm (20 percent) to less than 24 ppm (the detection limit). The core and grab samples demonstrated in general that:

(a) The explosives concentrations tended to be highest in the top 6 inches of soil.
(b) The explosive concentrations in the top 6 inches diminished with distance from the point where the wastewater had entered the lagoon.

For these reasons, it was decided that the SADA soil would be excavated from lagoon No. 5 in the vicinity where the wastewater had entered the lagoon and to a depth not to exceed approximately 4 to 6 inches. This decision was made to maximize the explosive concentrations in the feed soil so that an explosives DRE of 99.99 percent could potentially be demonstrated within the detection limits of the stack sampling equipment. As a result, the TNT concentrations in the composite feed samples from the SADA runs were much higher than those found in the core samples. As shown in Table 11, they ranged from 406,000 ppm (40.6 percent) to 88,100 ppm (8.81 percent). Other explosives in the SADA soil were negligible by comparison.

The LAAP soil, on the other hand, had quite substantial concentrations of RDX and HMX, as well as TNT as shown in Table 11. Other explosives in the LAAP soil were negligible by comparison.

Table 12 summarizes the concentrations of explosives in the kiln ash. In general, the only explosives detected in the kiln ash were very low concentrations of TNT ranging from not detected to less than 30 ppm.

Table 13 summarizes the concentrations of explosives in the fabric filter ash. The data in Table 13 should not be analyzed on a run-by-run basis. A compressed air, pulse-jet cleaning cycle was performed on the fabric filter bags before and after each test run, and the ash that was dislodged from the bags was removed from the collection hopper, weighed, and analyzed. However, there was no assurance that the ash removed from the hopper directly corresponded to the respective test run. As described previously in Subsection 6.2.1, explosives breakthrough occurred during the preliminary Test Run No. 0-1 which is supported by the data in Table 13. Chronologically, the next three test runs were matrix Nos. 1-3, 1-1, and 1-6. Each of these runs had similar, gradually decreasing levels of explosives which indicate that the fabric filter bags were most likely contaminated

TABLE 11. EXPLOSIVES CONCENTRATIONS IN THE FEED SOIL

Explosives concentrations[1] (ppm, dry weight basis)

Matrix number	HMX	RDX	TNB	DNB	NB	2-Amino	TNT	2,6-DNT	2,4-DNT
0-1	ND[2]	64.6	113	ND	ND	ND	136,000	ND	ND
1-1	ND	28.6	94.8	ND	ND	ND	99,500	ND	ND
1-2	ND	60.9	131	11.2	ND	ND	150,000	ND	ND
1-3	ND	49.1	117	ND	ND	ND	115,000	ND	ND
1-4	ND	37.8	90.7	5.50	ND	4.95	88,100	ND	ND
1-5	ND	84.2	256	35.1	ND	ND	264,000	ND	ND
1-6	ND	46.9	110	14.3	ND	ND	121,000	ND	ND
1-7	ND	145	253	32.4	ND	27.9	406,000	ND	ND
1-8	ND	58.2	128	8.42	ND	ND	228,000	ND	ND
1-9	ND	69.8	156	29.2	ND	ND	263,000	ND	ND
2-1	11,000	67,300	155	16.0	ND	ND	142,000	ND	ND
2-2	13,500	96,500	90.1	9.78	ND	588	108,000	ND	ND
2-3	6,180	43,600	94.3	ND	ND	142	59,700	ND	ND
2-4	7,210	45,400	67.7	22.4	ND	411	98,500	ND	ND
2-5	7,060	40,000	57.0	16.8	ND	189	60,600	ND	ND
2-6	6,790	35,400	88.2	12.9	ND	173	81,100	ND	ND
2-7	8,300	51,700	139	ND	ND	265	92,500	ND	ND
2-8	5,740	33,100	72.8	12.2	ND	459	61,200	ND	ND
2-9	8,260	51,800	99.1	21.7	ND	208	55,100	ND	ND
Detection limits	15.9	12.2	26.1	7.39	5.26	3.64	24.0	5.03	5.20

[1]Molecular structure of explosives is presented in Appendix D.
[2]ND - Not detected.

TABLE 12. EXPLOSIVES CONCENTRATIONS IN THE KILN ASH

Explosives concentrations[1] (ppm, dry weight basis)

Matrix number	HMX	RDX	TNB	DNB	NB	2-Amino	TNT	2,6-DNT	2,4-DNT
0-1	ND[2]	ND	ND	ND	ND	ND	6.48	ND	ND
1-1	ND	5.21	ND	ND	ND	ND	ND	ND	ND
1-2	ND	ND	ND	ND	ND	ND	2.65	ND	ND
1-3	ND	ND	ND	ND	ND	ND	8.78	ND	ND
1-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-5	ND	ND	ND	ND	ND	ND	3.44	ND	ND
1-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-7	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-8	ND	ND	ND	ND	ND	ND	2.55	ND	ND
1-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-1	ND	ND	2.47	ND	ND	ND	6.58	ND	ND
2-2	ND	ND	ND	ND	ND	ND	19.3	ND	ND
2-3	ND	ND	ND	ND	ND	ND	26.9	ND	ND
2-4	ND	ND	ND	ND	ND	ND	17.6	ND	ND
2-5	ND	ND	ND	ND	ND	ND	4.88	ND	ND
2-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-7	ND	ND	ND	ND	ND	ND	8.78	ND	ND
2-8	ND	ND	ND	ND	ND	ND	13.1	ND	ND
2-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Detection limits	1.27	0997	2.09	0.591	0.421	0.291	1.92	0.402	0.416

[1] Molecular structure of explosives is presented in Appendix D.

[2] ND - Not detected.

TABLE 13. EXPLOSIVES CONCENTRATIONS IN THE FABRIC FILTER ASH

Explosives concentrations[1] (ppm, dry weight basis)

Matrix number	HMX	RDX	TNB	DNB	NB	2-Amino	TNT	2,6-DNT	2,4-DNT
0-1	4.30	1.22	11.1	0.896	3.55	ND[2]	5.20	ND	ND
1-1	1.30	ND	4.07	0.832	ND	ND	2.08	ND	ND
1-2	ND	ND	ND	ND	ND	ND	2.65	ND	ND
1-3	ND	1.57	5.17	ND	ND	ND	2.62	ND	ND
1-4	ND	ND	2.52	ND	ND	ND	ND	ND	ND
1-5	5.02	ND	2.25	ND	ND	ND	ND	ND	ND
1-6	ND	ND	4.32	0.854	ND	ND	1.94	ND	ND
1-7	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-8	ND	ND	2.43	ND	ND	ND	155	ND	ND
1-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-1	1.61	ND	3.66	0.726	ND	ND	ND	ND	ND
2-2	ND	ND	ND	ND	ND	ND	4.24	ND	ND
2-3	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-4	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-5	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-6	ND	ND	2.37	ND	ND	ND	ND	ND	ND
2-7	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-8	ND	ND	2.27	ND	ND	ND	ND	ND	ND
2-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Detection limits	1.27	0977	2.09	0.591	0.421	0.291	1.92	0.402	0.416

[1]Molecular structure of explosives is presented in Appendix D.
[2]ND - Not detected.

with explosives during Test Run No. 0-1 and may have continued to contaminate subsequent test run ash samples.

No explosives were detected in the stack gas during any of the test burns, including the preliminary Test Run No. 0-1. The estimation of explosives destruction and removal efficiency is presented in Subsection 8.2.4.2.

7.2.6 Fabric filter particulate loadings, control efficiencies, and particle size distribution data. The fabric filter particulate loadings and control efficiencies are summarized in Table 14 for each test run. The fabric filter control efficiencies ranged from 99.1 to 99.9 percent with an average efficiency of 99.6 percent. The consistently high removal efficiency was further evidenced by the lack of a visible stack plume.

The fabric filter particulate size distributions for the SADA and LAAP test runs are presented in Figures 14 and 15, respectively. As shown in Figures 14 and 15, the size distributions for the two types of fabric filter ash are almost identical. The general size distribution data applicable to both ash types are summarized below.

Particle diameter, microns	Weight percent within range
0 - 5	Negligible
5 - 10	2 percent
10 - 50	8 percent
50 - 100	20 percent
>100	70 percent

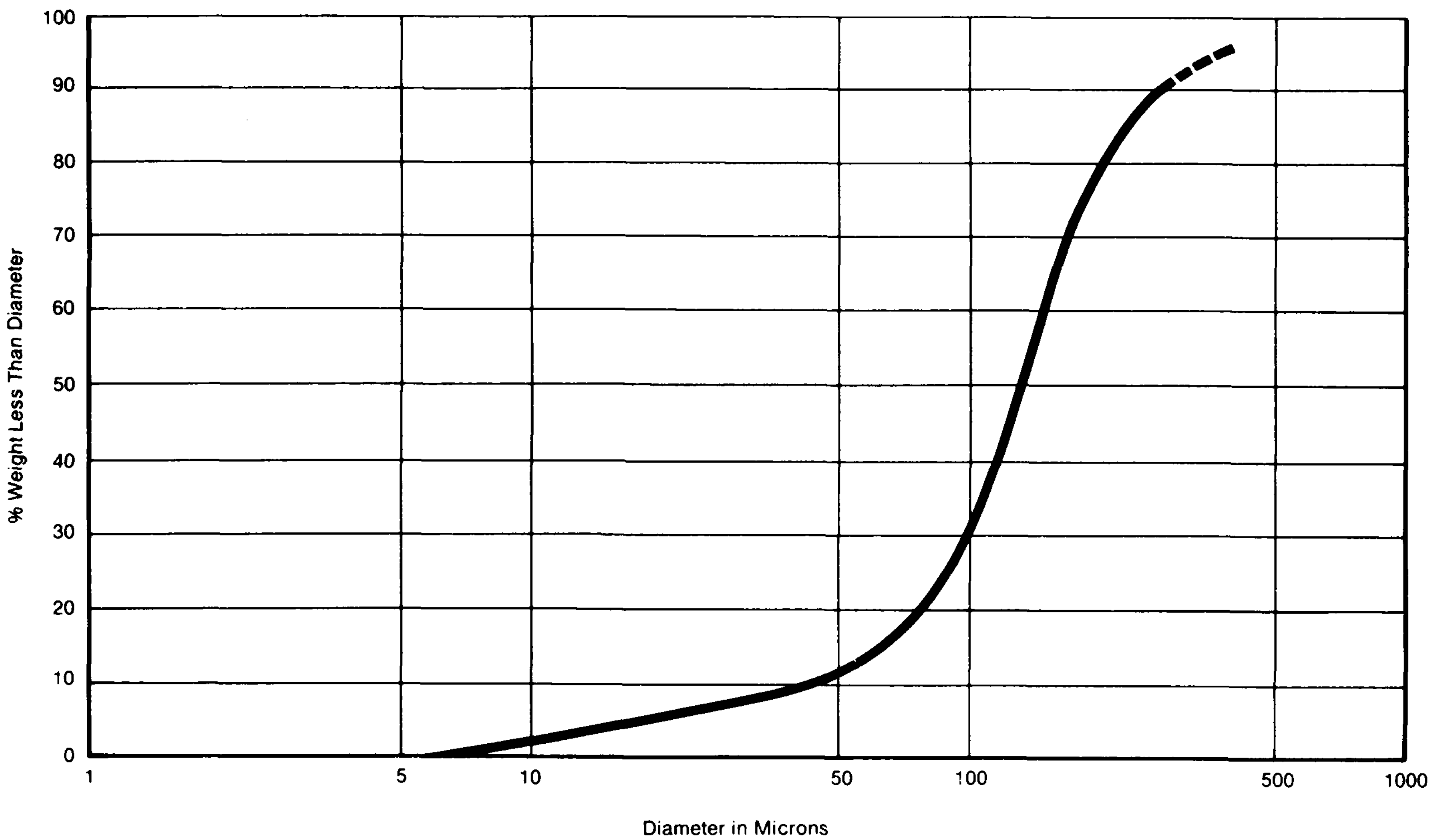
7.2.7 Stack emissions data for gaseous pollutants. The stack emissions data for hydrogen chloride (HCl), sulfur dioxide (SO_2), and oxides of nitrogen (NO_x) are summarized in Table 15. The stack emissions data for hydrocarbons and carbon monoxide (CO) are summarized in Table 16. No significant differences are apparent between the two soil types in the magnitude of the values. No stack emissions of heavy metals were detected except for mercury which did not exceed 5×10^{-4} pounds per hour for any of the test burns.

7.2.8 EP toxicity testing data for the ash residues. The results of the extraction procedure (EP) toxicity testing data for the kiln ash and the fabric filter ash are presented in Tables 17 and 18, respectively. In most instances, either no heavy metals were detected or the maximum possible metal concentration (in the ash) was below the EP toxicity threshold limit and the test was not conducted. Regardless of soil type or the levels of other test variables, the EP toxicity threshold limits were not exceeded.

TABLE 14. SUMMARY OF FABRIC FILTER PARTICULATE LOADINGS AND CONTROL EFFICIENCIES

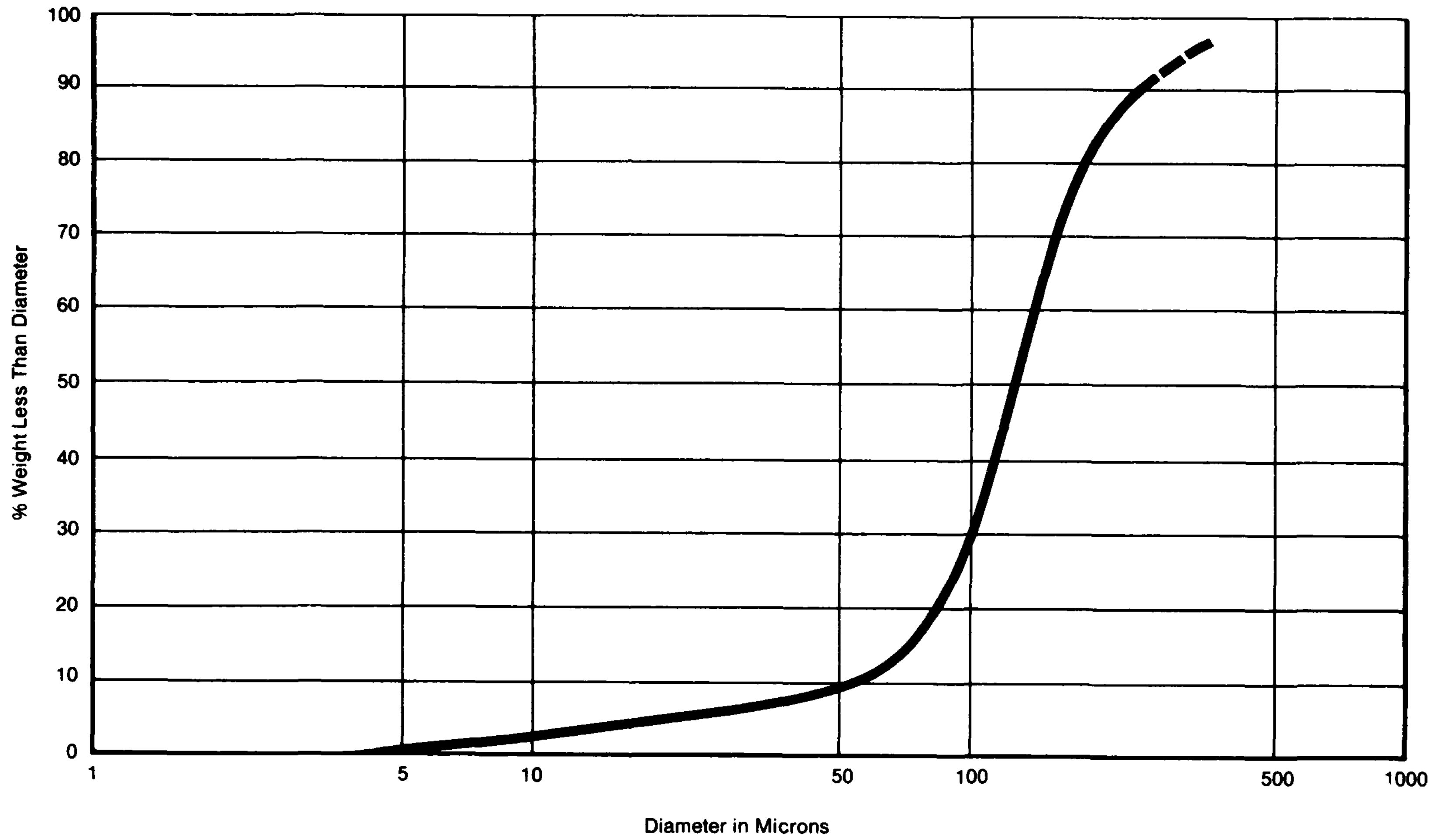
	Fabric Filter Particulate Loadings				
MATRIX NUMBER	INLET (grains/dscf)	OUTLET (grains/dscf)	INLET (lb/hr)	OUTLET (lb/hr)	FABRIC FILTER CONTROL EFFICIENCY[1] (%)
0-1	0.080	0.00054	0.54	0.0045	99.2
1-1	0.170	0.00048	1.30	0.0045	99.7
1-2	0.420	0.00053	4.30	0.0058	99.9
1-3	0.170	0.00042	1.30	0.0037	99.7
1-4	0.290	0.00067	2.30	0.0061	99.7
1-5	0.085	0.00069	0.60	0.0056	99.1
1-6	0.360	0.00044	2.70	0.0040	99.9
1-7	0.190	0.00051	1.70	0.0048	99.7
1-8	0.260	0.00066	2.60	0.0067	99.7
1-9	0.200	0.00026	1.90	0.0026	99.9
2-1	0.091	0.00071	0.66	0.0060	99.1
2-2	0.260	0.00018	2.20	0.0018	99.9
2-3	0.240	0.00035	2.20	0.0035	99.8
2-4	0.130	0.00024	1.20	0.0024	99.8
2-5	0.140	0.00066	1.30	0.0063	99.5
2-6	0.220	0.00072	1.60	0.0063	99.6
2-7	0.160	0.00063	1.20	0.0055	99.5
2-8	0.091	0.00033	0.77	0.0031	99.6
2-9	0.130	0.00014	1.20	0.0014	99.9

(1) Fabric filter control efficiency is calculated based upon inlet and outlet particulate loadings expressed in lb/hr.



Note: Assumed Ash Specific Gravity = 1.0

FIGURE 14 PARTICULATE SIZE DISTRIBUTION FOR SADA FABRIC FILTER ASH COMPOSITE SAMPLE FOR ALL RUNS



Note: Assumed Ash Specific Gravity = 1.0

FIGURE 15 PARTICULATE SIZE DISTRIBUTION FOR LAAP FABRIC FILTER ASH COMPOSITE SAMPLE FOR ALL RUNS

TABLE 15. SUMMARY OF STACK EMISSION DATA FOR HCl, SO_2, AND NO_X

MATRIX NUMBER	GASEOUS STACK EMISSIONS					
	HCL		SO_2		NO_X	
	ppm/v	lb/hr	ppm/v	lb/hr	ppm/v	lb/hr
0-1	7.2	0.0320	1.3	0.013	530	3.6
1-1	1.3	0.0064	2.3	0.025	220	1.7
1-2	0.86	0.0058	2.7	0.034	300	2.7
1-3	1.2	0.0059	1.6	0.017	240	1.8
1-4	1.1	0.0057	3.3	0.034	270	2.0
1-5	1.4	0.0065	5.3	0.050	450	3.1
1-6	1.2	0.0061	2.7	0.028	380	2.9
1-7	1.6	0.0094	4.2	0.046	600	4.8
1-8	1.7	0.0110	4.5	0.053	390	3.4
1-9	1.3	0.0078	5.2	0.060	500	4.2
2-1	1.6	0.0077	3.9	0.039	190	1.3
2-2	2.9	0.0160	3.3	0.037	240	1.9
2-3	3.3	0.0210	6.2	0.070	140	1.1
2-4	2.2	0.0130	6.4	0.075	180	1.4
2-5	2.8	0.0170	7.2	0.080	200	1.6
2-6	1.8	0.0088	7.5	0.076	230	1.7
2-7	3.4	0.0170	6.9	0.069	210	2.3
2-8	3.3	0.0190	6.3	0.069	220	1.7
2-9	4.2	0.0250	10.0	0.110	130	1.0

TABLE 16. SUMMARY OF STACK EMISSION DATA FOR HYDROCARBONS AND CARBON MONOXIDE

	Hydrocarbons (ppm as CH_4)			Carbon Monoxide (ppm)		
MATRIX	SECONDARY CHAMBER INLET	FABRIC FILTER INLET	STACK	SECONDARY CHAMBER INLET	FABRIC FILTER OUTLET	STACK
0-1	4	ND(1)	ND	1050	75	83
1-1	46	525	6	122	ND	ND
1-2	ND	ND	ND	126	5	5
1-3	ND	ND	ND	240	ND	ND
1-4	ND	ND	ND	16	ND	ND
1-5	7	3	3	140	46	41
1-6	5	16	ND	5	ND	ND
1-7	ND	ND	ND	13	7	7
1-8	ND	ND	ND	20	18	14
1-9	ND	ND	ND	39	90	77
2-1	ND	2	ND	174	ND	ND
2-2	ND	ND	ND	160	ND	ND
2-3	5	ND	ND	220	ND	ND
2-4	NE	128	3	5	ND	ND
2-5	ND	20	ND	14	ND	ND
2-6	ND	ND	ND	31	ND	ND
2-7	ND	ND	ND	5	5	ND
2-8	ND	ND	ND	5	ND	ND
2-9	ND	ND	ND	5	ND	ND
Detection Limits:	2	2	2	5	5	5

(1) ND - Not Detected

TABLE 17. SUMMARY OF EP TOXICITY TESTING DATA FOR THE PRIMARY CHAMBER ASH

MATRIX	METALS IN PRIMARY CHAMBER ASH EP TOXICITY LEACHATE (mg/L)[1]						
NUMBER	Ba	Cd	Cr	Pb	As	Se	Hg
0-1	0.28	ND[2]	ND	ND	ND	ND	ND
1-1	0.21	ND	ND	ND	ND	ND	ND
1-2	--	--	--	--	--	--	--
1-3	0.21	ND	ND	ND	ND	ND	ND
1-4	0.26	0.05	ND	ND	ND	ND	ND
1-5	0.22	ND	ND	ND	ND	ND	ND
1-6	0.38	ND	ND	ND	ND	ND	ND
1-7	--	--	--	--	--	--	--
1-8	--	--	--	--	--	--	--
1-9	--	--	--	--	--	--	--
2-1	0.47	ND	ND	ND	ND	ND	ND
2-2	--	--	--	--	--	--	--
2-3	0.31	ND	ND	ND	0.014	ND	ND
2-4	--	--	--	--	--	--	--
2-5	0.22	ND	ND	ND	ND	ND	ND
2-6	1.10	ND	ND	ND	ND	ND	ND
2-7	0.28	ND	ND	ND	0.033	ND	ND
2-8	0.27	0.14	ND	ND	0.019	ND	0.004
2-9	--	--	--	--	--	--	--
Detection Limits:	0.02	0.05	0.05	0.5	0.010	0.010	0.0005
EP Toxicity Threshold Limits:	100	1.0	5.0	5.0	5.0	1.0	0.2

[1] -- Indicates that sample was not analyzed for metals in the leachate because the contaminant limits could not be exceeded based upon the analysis of total metals in the sample.

[2] ND-Not Detected

TABLE 18. SUMMARY OF EP TOXICITY TESTING DATA FOR THE FABRIC FILTER ASH

MATRIX NUMBER	METALS IN FABRIC FILTER ASH EP TOXICITY LEACHATE (mg/L)[1]						
	Ba	Cd	Cr	Pb	As	Se	Hg
0-1	0.22	ND[2]	ND	ND	ND	ND	ND
1-1	0.22	ND	ND	ND	ND	ND	0.002
1-2	0.23	0.11	ND	ND	0.054	ND	0.002
1-3	0.24	ND	ND	ND	ND	ND	0.004
1-4	0.25	ND	ND	ND	ND	ND	0.002
1-5	0.25	0.06	ND	ND	ND	ND	0.005
1-6	0.24	ND	ND	ND	ND	ND	ND
1-7	0.27	0.07	ND	ND	0.034	ND	0.003
1-8	--	--	--	--	--	--	--
1-9	0.23	0.10	ND	ND	0.019	ND	0.003
2-1	0.21	0.05	ND	ND	0.020	ND	0.006
2-2	0.22	0.12	ND	ND	0.042	0.012	0.003
2-3	0.24	0.12	ND	ND	0.041	0.010	0.002
2-4	0.22	0.12	ND	ND	0.019	0.030	0.004
2-5	0.23	0.16	ND	ND	0.110	0.014	0.002
2-6	0.23	ND	ND	ND	ND	ND	0.004
2-7	0.28	0.10	ND	ND	0.016	ND	0.003
2-8	--	--	--	--	--	--	--
2-9	0.20	0.14	ND	ND	0.031	0.011	0.003
Detection Limits:	0.02	0.05	0.05	0.5	0.010	0.010	0.0005
EP Toxicity Threshold Limits:	100	1.0	5.0	5.0	5.0	1.0	0.2

(1)--Indicates that sample was not analyzed for metals in the leachate because the contaminant limits could not be exceeded based upon the analysis of total metals in the sample.

(2) ND - Not Detected

7.3 Physical observations. The objective of this section is to provide firsthand observations regarding parameters that are somewhat difficult to quantify and reduce to numerical terms. These physical observations include the following:

(a) Soil/ash appearance and density.
(b) Combustion observations.
(c) Steady-state production run.
(d) Industrial hygiene observations.
(e) Miscellaneous observations.

7.3.1 Soil/ash appearance and density. The SADA soil, although excavated as the top 4 to 6 inches of an approximately 300-square foot area of a single lagoon, was widely variable in appearance. The soil was excavated from the area immediately adjacent to the influent stand pipe which was identified as having the highest explosives concentrations within the lagoon. The soil ranged from light tan to dark reddish-brown in color. The texture ranged from loose sand to packed silt. One area of the lagoon had a subsurface layer of soil that was somewhat unique. The soil was a light tan dry powder (like talcum) that would not wet (floats on water) and when exposed to sunlight for approximately 10 minutes changed color to light yellow. Once disturbed, the soil again appeared light tan. The soil seemed to be sensitive to sunlight (perhaps ultraviolet).

The LAAP soil, by comparison, was much more consistent in appearance. The soil in the drums varied from densely packed clay to clay mixed with sand and free water. The soil was dark reddish-brown in color and was very tightly compacted within the drums.

The density of the SADA and LAAP soils and respective primary kiln ashes was estimated in the field by weighing fixed volumes of each material. The SADA soil ranged from 80 to 120 pounds per cubic foot and the LAAP soil ranged from 90 to 105 pounds per cubic foot. A representative density for either soil is approximately 100 pounds per cubic foot. It is suspected that if the LAAP soil were freshly excavated the density would be lower due to a higher moisture content.

The SADA primary kiln ash was also quite variable. The ash ranged from "salt and pepper" colored sand, to a mixture of sand and small "clinkers" (friable clumps less than 2 inches in diameter), to one test run in which the ash was black with large clinkers up to 6 inches in diameter (Test Run 0-1). The SADA ash density averaged approximately 85 pounds per cubic foot.

The LAAP primary kiln ash was again more consistent by comparison. The ash was light reddish-brown to black in color and was composed almost exclusively of small friable clinkers 1 to 4 inches in diameter. The clinkers were extremely porous and the resulting ash density averaged approximately 45 pounds per cubic foot.

7.3.2 Combustion observations. The following comments relate to observations made during the various test burns relative to the combustion process within the primary chamber.

(a) On 16 September 1983 a preliminary test run was performed on SADA soil at the following conditions:

Feed Rate	=	400 lb/hr
Primary Chamber Temperature	=	1,600°F
Secondary Chamber Temperature	=	2,000°F

During this preliminary run (i.e., gas sampling was not conducted) the soil appeared to burn very well. There was no noticeable increase in primary kiln temperature once feeding commenced, which suggests that the heat content of the soil was sufficient to offset the increased heat load to evaporate the moisture in the soil. The flame was bright orange with no detectable smoke. At one point the unit shut down due to a high boiler feed-water level which resulted in a temporary loss of the induced draft fan. Under this condition, black smoke was emitted from the combustion air ports at the front of the incinerator. Upon start-up and with the burners off but with the induced draft fan on, the soil burned with a violent flame. This suggests that some of the combustibles in the soil require sufficient oxygen to properly combust. The ash from this run was fine sand, light in color, and with no noticeable odor. This observation led to a basic change in approach. Prior to this it was anticipated that the incinerator would most appropriately be operated as a dryer to first drive off the high moisture content of the soil and then to "roast" the soil to volatilize and destroy the explosives. Under these conditions, high excess air rates in the primary chamber would not be critical. However, this observation supported the fact that the unit should be operated as an incinerator with high excess air rates to ensure complete combustion of the organics.

(b) On 19 September 1983 Test Run Matrix No. 0-1 was performed on SADA soil at the following conditions:

Feed Rate	=	500 lb/hr
Primary Chamber Temperature	=	800°F
Secondary Chamber Temperature	=	1,200°F

As described previously, this run was conducted at the proposed "worst-case" conditions of maximum feed rate and minimum temperature to basically challenge the system and determine if explosives breakthrough would occur. During this run the soil did not appear to burn well. The soil contributed significantly to the heat input and as a result the burners modulated at a very "low-fire" position during this burn. The ash was black with large clinkers up to 6 inches in diameter. The ash had a strong ammonia smell.

(c) On 21 September 1983 a "doughnut" of feed soil/ash started accumulating in the front of the primary chamber as shown in Figure 16. This circumferential ring of friable material recurred periodically throughout the testing program (most predominantly with the LAAP soil). This buildup of material did not impede the combustion process; however, it was of concern due to mass balance considerations and was periodically removed during incinerator cool down. The material was easily removed and could easily be remedied by installing a scraper bar for future applications. It was also found that feeding background sand prior to feeding the LAAP soil minimized formation of the doughnut.

(d) As observed through the combustion air ports in the front of the incinerator, the LAAP soil had a tendency to expand as the moisture and combustibles were vaporized from the soil. This "popcorn" effect resulted in the relatively low density ash discussed earlier and, instead of the typical 50 percent volume reduction experienced with the SADA soil, no volume reduction, and up to a 40 percent volume increase was experienced with the LAAP soil.

FIGURE 16 INSIDE VIEW OF THE PRIMARY CHAMBER
MIDWAY THROUGH THE IECS PROGRAM (NOTE THE FORMATION OF THE "DOUGHNUT" AT THE FRONT OF THE KILN)

(e) In general, for the system tested, the following observations can be made for processing both SADA and LAAP soils:

- Operation of the primary kiln at 1,400°F seemed to be an optimum condition. At 1,600°F there were more problems with smoking/flaming buckets coming out of the feed system. At 1,200°F there seemed to be a higher propensity for doughnut formation. However, both of the problems could be easily remedied in a future full-scale system.
- Operation above 400 pounds per hour soil feed rate appeared to be a problem due to material fall-back into the front-end panel (which could be remedied by slight redesign or a continuous versus a bulk feed system) and due to shorter ash residence time (which could be remedied by a longer primary chamber or alternative kiln rotation rates).

7.3.3 Steady-state production run. After the formal testing was completed on 8 October 1983, an additional 25,000 pounds of LAAP soils were incinerated from 10 to 15 October 1983 (64 actual hours of incinerating soils). The objectives of burning the additional soils were twofold:

(a) Thermally treat all LAAP soil that had been excavated and manifested to the Savanna Army Depot Activity but not required during the formal testing.
(b) Determine the operational characteristics of the incinerator system under a longer term, steady-state production mode of operation.

The operational parameters during this steady-state run were as follows:

Feed Rate	=	400 lb/hr
Primary Chamber Temperature	=	1,400°F
Secondary Chamber Temperature	=	1,800°F

Complete destruction of explosives had been consistently demonstrated in the stack gas, as well as in the kiln ash residues at these conditions. For this reason these conditions were proposed to and approved by the Illinois EPA for continuation of the test burn program without any further requirement for stack testing.

During this 5.5 day run, two shifts of operators allowed an operating span of up to 20 hours including warm-up and cool down and an actual processing time of up to 15 hours per day.

The incineration equipment performed flawlessly during this extended run with no downtime due to mechanical failure. Two instances did occur that required reprocessing of primary kiln ash drums collected:

(a) On 10 October 1983 the second ash drum pulled was smoking (purple/pink smoke). One of the smoldering clinkers was broken open and there was red clay inside which started smoking heavily when exposed to the air. Further investigation revealed that the feed soil bucket weights were too heavy resulting in an average feed rate of 540 pounds per hour rather than 400 pounds per hour. The bucket weights were corrected and the first two drums of ash were reprocessed. Subsequent ash drums were normal (i.e., no smoke).

(b) On 11 October 1983 the second ash drum pulled was again smoking. The smoke was generally white in color with traces of pink and purple. The ammonia smell was strong enough to break through the respirator cartridges. Further investigation revealed that the kiln rotation was improperly set. The kiln was making one revolution every 8 minutes rather than every 15 minutes. The kiln rotation rate was reset and the first two ash drums were reprocessed. Subsequent ash drums were normal.

These two incidents, both of which effectively reduced the ash residence time within the primary chamber, appeared to have resulted in incomplete combustion of the explosives in the soil. This suggests a strong correlation between ash residence time and explosives destruction efficiency in the primary chamber ash.

7.3.4 Industrial hygiene observations. The purpose of this subsection is not to detail all the safety precautions that were taken on this project. These precautions were discussed thoroughly in the site plan and safety submission.[3] This subsection will address additional safety precautions instituted in the field in response to observations made during the IECS testing program. These observations and precautions are as follows:

(a) A noise survey of the incineration test site revealed that the noise levels in the vicinity of the incinerator and the induced draft fan exceeded 85 dbA with a maximum reading on the stack sampling platform (directly above the induced draft fan) of 98 dbA. The 85 dbA contour line very closely paralleled the perimeter of the concrete pad. Therefore, hearing protection was required for all personnel on the concrete pad.

(b) During the initial pretest burn (16 September 1983), the incinerator operator detected a strong odor (like burnt matches or fireworks) from the buckets he removed from the feeder access hatch. He further noticed an irritation in his throat. At this point a full-face respirator* was established as standard operating practice for the incinerator operator on the feed platform. This operator subsequently had symptoms similar to sunburn (i.e., dry skin, irritation) on his entire face. He has fair skin and to some extent this may have been due to irritation from the full-face respirator. He also developed a small open sore below his lower lip the following day. The sunburn feeling and open sore persisted for the next four days although no additional exposure occurred. On the fourth day he developed a severe headache accompanied by stomach upset (which is very atypical for this individual).

(c) Another incinerator operator complained of experiencing nausea at night and headaches that persisted throughout the day. He further explained that he had a cold and symptoms may not be directly related to his exposure.

(d) One member of the soil excavation team complained of a rash ("sunburn-like") under his hat band. He was wearing a baseball cap. He threw the hat away and the rash subsided.

(e) One of the operators (who was relatively fair skinned) reported that his skin had a yellowish cast, that his lips were noticeably purple, and that he frequently had a bitter taste in his mouth.

*Respirator Model No.: MSA Ultra Twin Respirator Face Piece (471286). Cartridge Model No.: GMC-H (464027). Designed for acids, dust, fumes, organics, radionuclides.

(f) One of the individuals who handed the buckets to the operators complained of a skin rash/irritation on his forearms. The sores appear like mosquito bites, scab over, and eventually dry up. One of the operators complained of a similar irritation. Subsequently, all individuals handling the feed soil and empty buckets were instructed to wear full-length disposable coveralls, gauntlet style plastic gloves with disposable liners, and respirators.

It should be pointed out that all of the above observations took place during the first week of operations and no subsequent incidences occurred during the remaining three weeks of the test program.

7.3.5 Miscellaneous observations. One additional observation was noteworthy and does not readily fit into any of the previous categories. It was observed that the moisture which collected on the clean underside of the plastic sheeting covering the buckets of feed soil was "pinkish" in color. This pink coloration is a direct indication of the presence of TNT in the water droplets. It appears that a portion of the TNT in the feed soil vaporized and condensed on the plastic along with the moisture that vaporized and condensed.

8. COMPARISON OF TEST BURN RESULTS TO REGULATORY CRITERIA

8.1 Federal regulatory issues.* The objective of this section of the report is to address three critical questions regarding Federal regulatory issues based on the characteristics of explosives contaminated soils (Section 4) and the test burn results (Section 7). These three key questions are:

(a) Is the incineration of explosives contaminated soils subject to regulation under 40 CFR Part 264, Subpart O - Incinerators?

(b) If exempted from all requirements of 40 CFR Part 264, Subpart O, except Sections 264.341 (Waste Analysis) and 264.351 (Closure), what are the implications?

(c) If not exempt from regulation under 40 CFR Part 264, Subpart O, what are the implications?

8.1.1 Background. The solid waste disposal act, as amended by the Resource Conservation and Recovery Act of 1976, requires EPA to establish a national regulatory program to ensure that hazardous wastes are managed in a manner which does not endanger human health or the environment from the time they are created until their eventual destruction or final disposition (i.e., "cradle-to-grave"). To this end, EPA published initial regulations governing hazardous waste incineration on 19 May 1980 and subsequently amended those regulations on 23 January 1981 and 24 June 1982.

The initial 19 May 1980 regulations provided a first step in meeting the requirements of RCRA. Appendix VIII of those regulations specified certain chemical substances, when present in a waste, could serve as a basis for designating the waste as hazardous. Part 261 of the regulations identified four characteristics of hazardous waste to be used by persons handling solid waste to determine if that waste is hazardous (i.e., ignitability, corrosivity, reactivity, and EP toxicity). In addition, it lists 85 process wastes (e.g., K044 - wastewater treatment sludges from the manufacturing and processing of explosives; and K047 - pink/red water from TNT operations), as hazardous wastes and approximately 400 chemicals as hazardous wastes if they are discarded. The 19 May 1980 regulations (Part 265) also included some general requirements for the operation of existing incineration facilities during interim status (the period after an owner or operator originally applies for a permit, but prior to final approval).

*Appendix C provides referenced sections from the Federal Register.

EPA 23 January 1981 regulations specifically identified the information necessary to complete a Part B application for an incinerator including test burn requirements. These regulations also specified three requirements regarding incinerator performance:

(a) Principal organic hazardous constituents (POHC's) designated in each waste must be destroyed and/or removed to an efficiency (DRE) of 99.99 percent.
(b) Particulate emissions must not exceed 180 milligrams per dry standard cubic meter corrected to 12 percent carbon dioxide in the stack gas.
(c) Gaseous hydrogen chloride (HCl) resulting from combustion of wastes containing more than 0.5 percent chlorine must be reduced by 99 percent.

In addition to the incinerator performance standards (Section 264.3), this regulation also addressed the following:

(a) Applicability (Section 264.340).
(b) Waste analysis (Section 264.341).
(c) Principal organic hazardous constituents (Section 264.342).
(d) New wastes: trial burns or permit modifications (Section 264.344).
(e) Operating requirements (Section 264.345).
(f) Monitoring and inspections (Section 264.347).
(g) Closure (Section 264.351).

In response to public comment and a public hearing and technical assistance conference in Cincinnati, Ohio on 21 and 22 April 1981, EPA determined that modification of certain Subpart O regulations would enhance their technical feasibility and reduce the cost of compliance, while maintaining adequate protection of human health and the environment. The EPA formally promulgated the amended regulations on 24 June 1982. The significant amendments to the 23 January 1981 regulation are summarized in Table 19. The 24 June 1982 regulations specifically addressed the issue of incineration of reactive wastes and the applicability of the regulation as discussed in the following section.

TABLE 19. SUMMARY OF SIGNIFICANT AMENDMENTS TO THE REGULATIONS FOR HAZARDOUS WASTE INCINERATORS

Section	23 January 1981 regulation	Amended regulation
264.340*	Exempted wastes: 1) listed ignitables and 2) those failing the test for ignitability, when shown to contain no Appendix VIII substances.	Exempted wastes: 1) listed ignitables, corrosives, and/or selected reactives and 2) those failing the tests for ignitability, corrosivity, and/or selected reactivity characteristics, when shown to contain no or insignificant levels of Appendix VIII substances.
264.343(b)	Performance standard for HCl emissions: if waste input exceeds 0.5 percent chloride, then remove 99 percent of stack gas HCl.	Performance standard for HCl emissions: if stack emissions exceed 1.8 kg HCl/hr, then control emissions so that they do not exceed the larger of the following: 1) 1.8 kg HCl/hr, or 2) 1 percent of the HCl in the stack gas.
264.343(c)	Performance standard for particulate emissions: emissions may not exceed 180 mg/DSCM when corrected to 12 percent carbon dioxide.	Performance standard for particulate emissions: emissions may not exceed 180 mg/DSCM when corrected to 50 percent excess air or as otherwise specified in the permit.
264.344	No provisions for permits to new incinerators.	Allows for four-phase permit for new incinerators: Phase 1: "Shake-down" phase; Phase 2: Trial burn; Phase 3: "Follow-up" phase; Phase 4: Permanent operation phase.
264.345	Air feed rate to be designated as an operating requirement.	Indicator of combustion gas velocity to be designated as an operating requirement.
122.27	1. New facilities must have final RCRA permit prior to construction.	1. New facilities submit Part B of the permit application and required information for trial burn plan simultaneously. Permit is issued after opportunity for public hearing.
	2. Requirement to monitor hazardous combustion byproducts during trial burn.	2. Deleted.
	3. Waste analysis requirements for trial burn plan.	3. Language clarification.

*Equivalent changes have been made in the corresponding section of Part 265 (Interim Status Standards).

8.1.2 Applicability of the incineration standards to the incineration of explosives contaminated soils. A solid waste becomes a "hazardous waste" subject to regulation under Subtitle C of RCRA in one of two ways:

(a) The waste fails one or more of EPA's characteristic tests for ignitability, corrosivity, reactivity, or Extraction Procedure (EP) toxicity.
(b) The waste contains hazardous constituents listed in Appendix VIII and has been specifically listed as hazardous by EPA.

In the 24 June 1982 regulations 40 CFR Part 264, Section 264.340, EPA decided to automatically exempt all wastes which are hazardous solely due to the characteristic of reactivity as described by Secton 261.23 (a)(1), (2), (3), (6), (7), and (8) (see Section 4, page 20). Wastes having the reactivity characteristics described by Section 261.23 (a)(4) and (5) are not exempted since they may emit toxic gases and vapors (such as cyanide) upon reaction. The amendment specifies that reactive wastes, if exempted, must not be burned in the presence of any other hazardous waste, since the reactive wastes (by definition) are capable of explosion or violent reaction that could potentially disperse other toxic substances present into the environment. Therefore, if the reactive waste in question contains detectable concentrations of Appendix VIII constituents it cannot be automatically exempted. However, the regulation does provide that qualified reactive wastes that contain low concentrations (i.e., less than 100 to 1,000 ppm) of some Appendix VIII constituents may be exempted if the Regional Administrator finds that the exemption will not result in a potential threat to human health and the environment.

TNT, RDX, and HMX, which were the major organic contaminants in the SADA and LAAP soils, are not listed in Appendix VIII as hazardous constituents. The Appendix VIII constituents that were detected in the soils were in extremely low concentrations as shown in Table 20. Therefore, it appears that applicability of the incineration standards to the incineration of explosives contaminated soil will be based on the judgment of the respective EPA Regional Administrator. Four factors combine to make an extremely strong case that the Regional Administrator would exempt explosives contaminated soils from regulation under all except Sections 264.341 (Waste Analysis) and 264.351 (Closure). These four factors are:

(a) The explosives contaminated soils, when mixed with water, do not generate toxic gases and they are not cyanide- or sulfide-bearing wastes.

TABLE 20. SUMMARY OF CONCENTRATIONS OF APPENDIX VIII HAZARDOUS CONSTITUENTS IN THE SADA AND LAAP SOILS

Appendix VIII hazardous constituent	Concentration (ppm - dry weight basis)				
	SADA soil		LAAP soil		Detection limits
	Mean	Range	Mean	Range	
1,3,5-Trinitrobenzene (TNB)	148.5	90.7 - 256	95.9	57.0 - 139	26.1
1,3-Dinitrobenzene (DNB)	15.1	ND[1] - 35.1	12.4	ND - 22.4	7.39
Nitrobenzene (NB)	ND	ND	ND	ND	5.26
2,6-Dinitrotoluene (2,6-DNT)	ND	ND	ND	ND	5.03
2,4-Dinitrotoluene (2,4-DNT)	ND	ND	ND	ND	5.20

[1]ND - Not detected.

(b) The concentrations of Appendix VIII constituents are extremely low.
(c) No other hazardous wastes would be incinerated simultaneously with the explosives contaminated soils.
(d) The incineration site would most likely be at a remote U.S. Army location which would further limit potential hazards to the general public.

8.1.3 Implications of exemption from the incineration standards. Applicants seeking exemption under Section 264.340 must submit sufficient waste analysis data with Part B of the permit application to document levels of all hazardous constituents listed in Appendix VIII which would reasonably be found in the waste. When setting the conditions of the permit, the Regional Administrator will determine whether an exemption should be granted for incineration of the reactive waste based on a review of the waste analysis data. If the exemption is granted, the applicant will be exempt from the following sections:

Section No.	Title
264.342	Principal organic hazardous constituents (POHC's).
264.343	Performance standards.
264.344	New wastes: trial burns or permit modifications.
264.345	Operating requirements.
264.347	Monitoring and inspections.

The implications of exemption from these regulations are explained in Subsection 8.1.4.

The only remaining applicable regulation is Section 264.251 (Closure). At closure, the owner or operator must remove all hazardous waste and hazardous waste residues (i.e., kiln and fabric filter ash) from the incineration site. All ash residues from the incineration of hazardous wastes are classified as hazardous wastes unless it is demonstrated in accordance with 40 CFR Part 261, Section 261.3(d) that the residue is not a hazardous waste.

The implications of Section 264.251 (Closure) could be substantial since every pound of explosive contaminated soil which is incinerated generates approximately 0.3 to 0.7 pounds of ash residue. Generally over 96 to 98 percent of the residue is discharged in the form of kiln ash, while the remaining ash is collected in the fabric filter. Further, due to the lower relative density of the kiln ash compared to the feed soil (particularly for the LAAP soil), the actual volume reduction ranges from approximately 50 percent to a slight volume increase. Should the ashes be classified as hazardous waste, then costly additional treatment techniques or special disposal methods will be necessary. Otherwise, the ash residues would be permanently landfilled in an area preferably near the incineration site.

The results of the ash analyses conducted during the IECS test program indicate a strong case for delisting the ash since, in accordance with 40 CFR Part 261, Section 261.3(d)(1), the ash residues do not exhibit any of the characteristics of a hazardous waste identified in 40 CFR Part 261, Subpart C (i.e., ignitability, corrosivity, reactivity, or EP toxicity). The following subsections compare the results of the ash analyses to criteria for each of these characteristics of hazardous waste.

8.1.3.1 Ignitability. A solid waste exhibits the characteristic of ignitability if, when ignited, it burns so vigorously and persistently that it creates a hazard. It is reasonable to expect the ash residues to not be ignitable by virtue of:

(a) The thermal processing conditions that the ashes were subjected to during the incineration process.
(b) The undetectable heating value of the ashes.

8.1.3.2 Corrosivity. A solid waste exhibits the characteristic of corrosivity if, as an aqueous solution, it has a pH less than or equal to 2.0 or greater than or equal to 12.5. Composite samples of the SADA and LAAP kiln ash and fabric filter ash residues had pH values that ranged from 7.4 to 7.7. Therefore, the ash residues do not exhibit the characteristic of corrosivity.

8.1.3.3 Reactivity. The eight criteria for designating a solid waste as hazardous were presented previously in Section 4.

Based on the data generated during the testing program, it is reasonable to assume that the ash residues are not reactive and exhibit none of the eight criteria as explained below:

Criteria	Observations
(1) Instability	The ash residues were handled throughout the testing and were physically and chemically stable when subjected to the recommended operating conditions.
(2) and (3) Reaction with Water	The residues were in contact with water during sample preparation and analysis and showed no signs of adverse reaction.
(4) and (5) Generation of Toxic Gases	The ash residues are not cyanide- or sulfide-bearing wastes, and when mixed with water do not generate toxic gases, vapors, or fumes.
(6) and (7) Explosive Reaction	The extremely low levels of total explosives in the ash residues (i.e., not detected to less than 30 ppm) are insufficient to support combustion or promulgation of detonation when subjected to initiating sources or if heated under confinement.
(8) Forbidden Explosives	The ash residues are not classified as forbidden explosives as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53, or a Class B explosive as defined in 49 CFR 173.88.

8.1.3.4 EP toxicity. The results of the EP toxicity testing for the kiln ash and fabric filter ash for each test run are presented in Tables A-9 and A-10, respectively. As shown in these tables, concentrations of all contaminants in the leachate were far below the maximum threshold concentrations. Therefore, the ash residues clearly do not exhibit the characteristic of EP toxicity.

8.1.4 Implications of not being exempted from the incineration standards. If the respective EPA Regional Administrator does not grant exemption under 40 CFR Part 264, Section 264.340, additional requirements must be met above and beyond those discussed in Subsection 8.1.3. These additional requirements are discussed in the following subsections.

8.1.4.1 Principal organic hazardous constituents (section 264.342). As specified in 40 CFR Part 264, Section 264.342(b)(1), one or more POHC's must be specified from the list of hazardous constituents listed in Part 261, Appendix VIII, for each waste to be burned. The selection of POHC is based on the relative degree of difficulty of incineration and on the concentration or mass in the soil feed.

The explosives that are in the soils in relatively high concentrations (i.e., TNT, RDX, HMX) are not listed in Part 261, Appendix VIII and, therefore, cannot be designated as POHC's. The hazardous constituents that are present in the soils (i.e., TNB and DNB) are only present in extremely low concentrations (i.e., not detected to less than 300 ppm as shown in Table 20). The preamble to the 24 June 1982 amendments (Federal Register Vol. 47, No. 122, page 27530) provides guidelines for selecting POHC's. These guidelines establish 100 ppm as an absolute lower limit beyond which determination of a 99.99 percent destruction removal efficiency (DRE) will be difficult to verify, and further recommends 1,000 ppm as a more reasonable minimum concentration in the waste feed. Therefore, short of artificially spiking the feed soils with higher concentrations of TNB and DNB, selection of a POHC may pose a significant obstacle.

8.1.4.2 Performance standards (section 264.343). An incinerator burning hazardous waste must be designed and operated to meet the following three performance standards:

- Destruction Removal Efficiency (DRE)

The incinerator must achieve a DRE of 99.99 percent for each POHC designated in its permit for each waste feed. DRE is determined for each POHC from the following equation:

$$DRE = \frac{(W_{in} - W_{out})}{W_{in}} \times 100\%$$

Where:

W_{in} = mass feed rate of one POHC in the waste stream feeding the incinerator

W_{out} = mass emission rate of the same POHC present in the exhaust emissions prior to release to the atmosphere

In other words, credit is given for removal of the POHC in the kiln and fabric filter ash residues, as well as destruction of the POHC in the incineration process.

During the IECS test programs, no explosives (i.e., TNT, RDX, HMX, as well as the Appendix VIII constituents) were detected in the stack exhaust emissions to the atmosphere. Therefore, in accordance with the guidelines provided in the previously referenced preamble to the 24 June 1982 amendments (page 27350), if the POHC is not detected in the stack exhaust, attainment of 100 percent destruction and removal will be assumed for that POHC. However, taking a much more conservative approach (i.e., assuming that explosives concentrations might be at or just below the detection limits) the calculated DRE's for each test run are presented in Tables 21 and 22. However, these DRE's are for TNT, RDX, and HMX since these were the only contaminants in sufficient concentration in the feed to allow estimation of DRE. As shown in Tables 21 and 22, even using this overly conservative approach, DRE's of 99.99 percent were achieved in most cases. Failure to achieve 99.99 percent only resulted from lower explosive concentration in the waste feed relative to the detection limit in the stack exhaust.

TABLE 21. SUMMARY OF EXPLOSIVE CONCENTRATIONS IN THE SAVANNA FEED SOIL, DETECTION LIMITS OF EXPLOSIVE IN STACK GAS AND THE RESPECTIVE DRE'S

Matrix number	TNT concentration, lb/hr		Worst case DRE[2]
	In soil feed	In stack gas[1]	
0-1	58.285	ND	> 99.996
1-1	27.028	ND	> 99.995
1-2	45.490	ND	> 99.995
1-3	41.309	ND	> 99.996
1-4	23.424	ND	> 99.992
1-5	71.770	ND	> 99.997
1-6	43.084	ND	> 99.994
1-7	87.224	ND	> 99.997
1-8	68.170	ND	> 99.996
1-9	88.429	ND	> 99.997

[1]ND - Not detected. Detection limits ranged from 0.0018 and 0.0028 for the various runs.

[2]Worst case DRE - No explosives were detected in the stack gases. Percent destruction and removal efficiency (DRE) is based on the detection limit of TNT in the stack gas. Actual DRE's will be higher than the values shown.

TABLE 22. SUMMARY OF EXPLOSIVES CONCENTRATIONS IN THE LOUISIANA FEED SOIL, DETECTION LIMITS OF EXPLOSIVES IN THE STACK GAS AND THE RESPECTIVE DRE'S

	TNT concentration (lb/hr)			RDX concentration (lb/hr)			HMX concentration (lb/hr)		
Matrix number	In soil feed	In stack gas[1]	Worst case DRE[2]	In soil feed	In stack gas[1]	Worst case DRE[2]	In soil feed	In stack gas[1]	Worst case DRE[2]
2-1	30.614	ND	> 99.993	14.509	ND	> 99.993	2.372	ND	> 99.941
2-2	24.213	ND	> 99.993	21.635	ND	> 99.996	3.026	ND	> 99.964
2-3	17.917	ND	> 99.988	13.086	ND	> 99.992	1.855	ND	> 99.925
2-4	21.310	ND	> 99.991	9.822	ND	> 99.989	1.559	ND	> 99.917
2-5	15.519	ND	> 99.986	10.244	ND	> 99.988	1.808	ND	> 99.917
2-6	14.605	ND	> 99.993	10.740	ND	> 99.992	2.060	ND	> 99.942
2-7	19.814	ND	> 99.989	11.074	ND	> 99.990	1.778	ND	> 99.921
2-8	15.619	ND	> 99.985	8.447	ND	> 99.986	1.465	ND	> 99.898
2-9	16.248	ND	> 99.986	15.275	ND	> 99.992	2.436	ND	> 99.938

[1]ND - Not detected. Detection limits ranged from 0.00082 to 0.0024 for the various runs.

[2]Worst case DRE - No explosives were detected in the stack gases. Percent destruction and removal efficiency (DRE) is based on detection limits of explosives in stack gas. Actual DRE's will be higher than the values shown.

- Hydrogen Chloride Control

Since analysis of all feed samples for both SADA and LAAP soils indicated total chlorine concentrations of less than 0.5 percent and since total hydrogen chloride (HCl) emissions were substantially below 1.8 kilograms per hour (4 pounds per hour), HCl control was not required.

- Particulate Control

Particulate emissions are limited to 180 milligrams per dry standard cubic meter (0.08 grains per dry standard cubic foot) when corrected for proper excess air levels. The results of all test runs were at least two orders of magnitude lower than the permissible emission limits due to the excellent control efficiency of the fabric filter.

In summary, the trial burns demonstrated consistent compliance with the performance standards.

8.1.4.3 New wastes: trial burns or permit modifications (section 264.344). Clearly, the results of the IECS Test Program should exempt the U.S. Army from any further trial burn requirements unless the waste analysis of the explosives contaminated soils is significantly different than the SADA or LAAP soils.

8.1.4.4 Operating requirements (section 264.345) and monitoring and inspections (section 264.347). In order to comply with the operating and monitoring requirements specified, it appears that only two additional pieces of instrumentation would be required to supplement the incineration equipment and controls supplied by ThermAll, Inc. for the IECS test program:

(a) A device for continuously measuring combustion gas velocity.
(b) A device for continuously measuring carbon monoxide at the stack.

The 23 January 1981 amendments specified the continuous measurement of combustion air flow rate. However, it is impractical to measure air feed rate for a rotary kiln which does not employ a forced draft system (which lends itself to measurement of air feed rate). Instead, air is drawn into the kiln at many points, and actual air feed rate is impossible to monitor. The 24 June 1982 amendments address this problem and allow the use of other appropriate indicators of combustion gas flow rate for rotary kilns. Suitable indicators such as induced draft fan amperage or exhaust gas velocity are specified.

The continuous monitoring of carbon monoxide will provide an excellent indicator of combustion efficiency and will ensure complete destruction of all detectable explosives in the exhaust gases. It is well documented that the oxidation of carbon monoxide to carbon dioxide is the rate limiting step in most afterburners.[7] Generally, the time required for all of the steps involved in the oxidation of hydrocarbons to carbon monoxide is less than one-tenth of that which is required for the carbon monoxide to carbon dioxide conversion. Since explosives exhibit no reluctance to oxidize, it is reasonable to assume that the carbon monoxide-to-carbon dioxide step will be the key criteria for proper design of the secondary chamber.

Review of the raw sampling data for Test Run No. 0-1 reveals supporting evidence that the known relationship between carbon monoxide and hydrocarbons can be applied to the incineration of explosives contaminated soils. As the combustion gases entered the secondary chamber the DRE for TNT was in excess of 99 percent although the CO concentration was over 1,000 ppm. At the inlet to the fabric filter, no TNT was detected in the flue gas (i.e. DRE = 100 percent) and the CO was reduced to 75 ppm. The oxidation rate of the explosives, therefore, was significantly higher than the oxidation rate for CO. During subsequent runs at higher combustion chamber temperatures and lower feed rates, no explosives were detected in the flue gas at any sampling locations, including the inlet to the secondary chamber. CO levels were consistently lower also, but always detectable at the secondary chamber inlet. As a result, two observations can be made:

(a) It appears that destruction of CO and not explosives will be the limiting criteria for design and operation of the secondary combustion chamber.

(b) It appears that monitoring CO will provide a dependable and cost-effective way to ensure proper combustion of explosives as well as CO.

8.2 <u>State and local regulatory issues</u>. State and local regulations must be evaluated on a site-specific basis. However, some general comments can be made. Most states have directly adopted the Federal hazardous waste management regulations into their statutes. Therefore, if their program is Federally approved, the requirements discussed in Subsection 8.1 may be administered either jointly between the state and the Regional

EPA office or exclusively by the state agency. Concerning criteria (nonhazardous) pollutants, the typical areas of concern are:

(a) Particulates
(b) Carbon monoxide
(c) Oxides of nitrogen
(d) Oxides of sulfur
(e) Halogenated compounds

8.2.1 Particulates. Typically, the state would require meeting the hazardous waste incinerator performance standard of 180 milligrams per dry standard cubic meter (0.08 grains per dry standard cubic foot) unless other state or local regulations were more stringent. However, with fabric filter control of particulate emissions, any state or local regulation could be met.

8.2.2 Carbon monoxide. Typical state emission limits for carbon monoxide emissions from combustion processes are approximately 500 ppm on a volume basis. For the IECS test program no stack measurements of CO exceeded 85 ppm.

8.2.3 Oxides of nitrogen. Few if any states have specific mass emission limitations that would be applicable to this type of source. However, all states have ambient air quality standards for the maximum allowable concentrations of oxides of nitrogen measured at offsite locations (i.e., outside of the property boundaries) due to source operations. Most states will require a modeling analysis to demonstrate that the NO_x, as well as other applicable ambient air quality standards, will not be exceeded. Assuming the installation of a GEP (good engineering practice) height stack, this should not pose any problem.

8.2.4 Oxides of sulfur and halogenated compounds. Although regulated, due to the low concentrations of sulfur and chlorine, mass emissions of oxides of sulfur or halogenated compounds are not anticipated to pose any problems.

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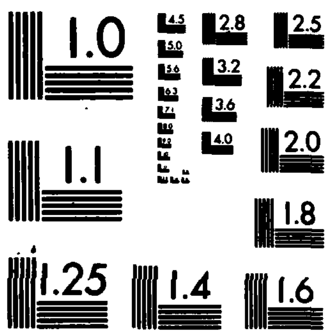

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9. ANALYSIS OF RESULTS AND DEVELOPMENT OF INCINERATOR DESIGN CRITERIA

9.1 Analytical technique. In the early stages of the IECS project a test plan[2] was developed which identified key process variables and established a matrix of test conditions (replicated for two different soil types). This experimental design was selected to allow statistical evaluation of the test burn data. Two statistical analyses of variance (ANOVA) techniques were utilized in the analysis of the test burn data:

(a) Forward and backward stepping multiple regression analyses.[8]
(b) Two-way balanced factorial analysis.[9]

The analytical approach is detailed in Appendix B. The objective of the analytical approach was to apply the two techniques listed above to combinations of the data base input and response variables listed in Table 23 to develop simple linear equations[10] of the type:

$$y = b_o + b_i x_i + \ldots + b_n x_n + E$$

Where:
y = response variable
b_o = intercept
b_i = regression coefficient
x_i = input or controlled variables
E = residuals

The key response variables of interest are:

(a) Destruction and removal efficiency (DRE) of explosives.
(b) Environmental impact of incineration of explosives contaminated soils (i.e., CO, NO_x, and particulates).
(c) Incinerator design variables affecting system economics (i.e., kiln ash production rate, soil heating value, and auxiliary fuel burn rate).

9.2 Destruction and removal efficiency of explosives. No explosives were detected in the stack gas for any of the 19 test burns. Therefore, statistical analysis is not required to deduce that for the range of incinerator operating variables tested (i.e., soil feed rates as high as 500 pounds per hour and primary and secondary chamber temperatures as low as 800°F and 1,200°F, respectively) a DRE of 100 percent can be expected based on stack emissions. Since no explosives were detected,

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TABLE 23. EVALUATED INPUT AND RESPONSE VARIABLES USING STATISTICAL TECHNIQUES

Soil Input Variables

- Soil type (SADA or LAAP)
- Moisture content (ppm_w and lb/hr[1])
- Ash content (ppm_w and lb/hr[1])
- Volatiles (ppm_w and lb/hr[1])
- Explosives (ppm_w and lb/hr, dry basis)
  - HMX
  - RDX
  - TNT
  - TNB
  - DNB
  - 2-Amino[2]
  - Total explosives
- Elemental analysis (ppm_w, dry basis)
  - Sulfur
  - Carbon
  - Hydrogen
  - Nitrogen
  - Chlorine
- Metals analysis (ppm_w, dry basis)
  - Barium
  - Cadmium
  - Chromium
  - Copper
  - Lead
  - Zinc
  - Mercury
- Soil heating value (Btu/lb)[1]

TABLE 23. (Continued)

System Operating Input Variables

- Kiln temperature (°F)
- After burner temperature (°F)
- Soil feed rate (lb/hr)
- Excess air (%)
- Afterburner residence time (seconds)
- Kiln ash residence time (minutes)
- Combustion gas flow rate (scfh and lb/hr)
- Fuel burn rate (scfh)

System Response Variables

- Ash production rates
  - Kiln ash (lb/hr)
  - Fabric filter ash (lb/hr)
- Particulate loadings
  - Fabric filter inlet (grains/scf)
  - Fabric filter inlet (lb/hr)
- Explosives
  - TNT in kiln ash (ppm_w)
  - Total explosives in kiln ash (ppm_w)
  - Total explosives in kiln ash (lb/hr)
  - Total explosives in fabric filter ash (ppm_w)
  - Total explosives in fabric filter ash (lb/hr)
- Metals in kiln ash (ppm_w, dry basis)
  - Barium
  - Copper
  - Lead
  - Zinc

TABLE 23. (Continued)

- Metals in fabric filter ash (ppm_w, dry basis)
  - Barium
  - Copper
  - Lead
  - Zinc
- CO at inlet to after burner
- Stack gas air pollutants
  - HCl (ppm_v)
  - HCl (lb/hr)
  - SO_2 (ppm_v)
  - SO_2 (lb/hr)
  - NO_x (ppm_v)
  - NO_x (lb/hr)
- Destruction and removal efficiencies of explosives
- Soil heating value (Btu/lb)
- Fuel burn rate (scfh)

[1] As received basis.

[2] Includes tetryl, since tetryl and 2-amino are indistinguishable on chromatographs.

it is impossible to develop correlations to predict estimated DRE's at soil feed rates higher than 500 pounds per hour or at kiln temperatures below 800°F and afterburner temperatures below 1,200°F.

Explosives were detected in the combustion gases leaving the primary chamber for one test burn (i.e., 195.9 ppm for Test Run No. 0-1). Explosives were not detected at this sampling location for any other test runs. Therefore, it can be deduced that as long as the kiln is operated at 1,200°F or higher and soil feed rates 400 pounds per hour or lower, an afterburner is not required to destroy explosives in the combustion gases.

No significant correlations could be found to predict the low-level concentrations of explosives in the kiln ash. It is suspected that the reason for this is the fact that the explosives concentrations in the kiln ash were below or close to the detection limits.

The fabric filter ash explosives concentration data were not analyzed since the fabric filter was obviously contaminated during Test Run No. 0-1 and subsequent test run ash samples continued to reflect this initial contamination.

9.3 Environmental impact of the incineration of explosives contaminated soils.

9.3.1 Carbon monoxide (CO). No attempt was made to develop correlations to predict the CO concentrations measured at the stack or at the fabric filter inlet since 14 of the 19 test runs had CO concentrations at or below the detection limit of 5 ppm for each of the two sampling locations. The CO concentrations for the other five test runs ranged from only 7 to 90 ppm compared to the Illinois EPA limitation of 500 ppm.

The CO concentrations measured at the kiln outlet were analyzed. The relationship between carbon monoxide concentration and the destruction and removal of explosives in the primary kiln exhaust gas has previously been established in Subsection 8.1.4.4. It has also been stated that the CO level in the kiln gas may be a critical system design parameter in terms of indicating the DRE of explosives, meeting stack emissions standards, and the requirement of auxiliary thermal treatment of the primary kiln exhaust gas. Statistical evaluation and the literature[7] indicate that a relationship exists between the kiln operating temperature and soil feed rate in predicting the CO concentration in the kiln exhaust gas. Of course, these two variables are not the only parameters which affect the system's response of CO. However, they do represent a major contribution. The kiln exhaust gas flow rate (i.e., flue gas residence time) would be another logical contributor, but was not available for analysis since isokinetic conditions could not be achieved in the short duct between the primary and secondary chambers. Since the gas flow rate at the fabric filter inlet (which should be proportional to kiln exhaust gas flow rate) was available, and was included in the analysis and did not contribute significantly, it was assumed that the kiln exhaust gas flow rate was not a significant contributor within the range evaluated.

Figure 17 shows that based on the mean values of each set of raw data points for soil feed rate and kiln temperature (Test Run Nos. 0-1 and 1-5 excluded as data outliers), the CO concentration is constant and very low above kiln temperatures of 1,400^{o}F regardless of feed rate. This leads to the expansion of the statistical equation to values outside of the tested range as shown by Figure 18. These curves are based on the equation:

$$CO = 1{,}252 - 1.22\,(T_k) + 1.26\,(M_s)$$

Where: CO = CO concentration in kiln exhaust gas (ppm_v)
T_k = kiln temperature (^{o}F)
M_s = soil feed rate (lb/hr)

The equation is significant both in terms of contribution and probability of correctness. (Refer to Appendix B for an explanation of statistical analyses and terminology.) Curiously, the concentration of explosives and elemental carbon in the soil did not seem to be response-related variables in the model. Therefore, the accuracy of the model is questionable at very low concentrations of these constituents.

The probability of residuals in the equation is depicted by Figure 19. For the range of variables on which the equation is based, it is 90 percent probable that the predicted value will be within the range of $\pm$ 150 ppm. At the higher kiln temperatures the margin of error is drastically reduced since the raw data are within those levels.

9.3.2 Oxides of nitrogen (NO_X). The NO_X concentration in the stack gas is also an important criteria since the explosives in the soils are nitrogen-based compounds and considerable

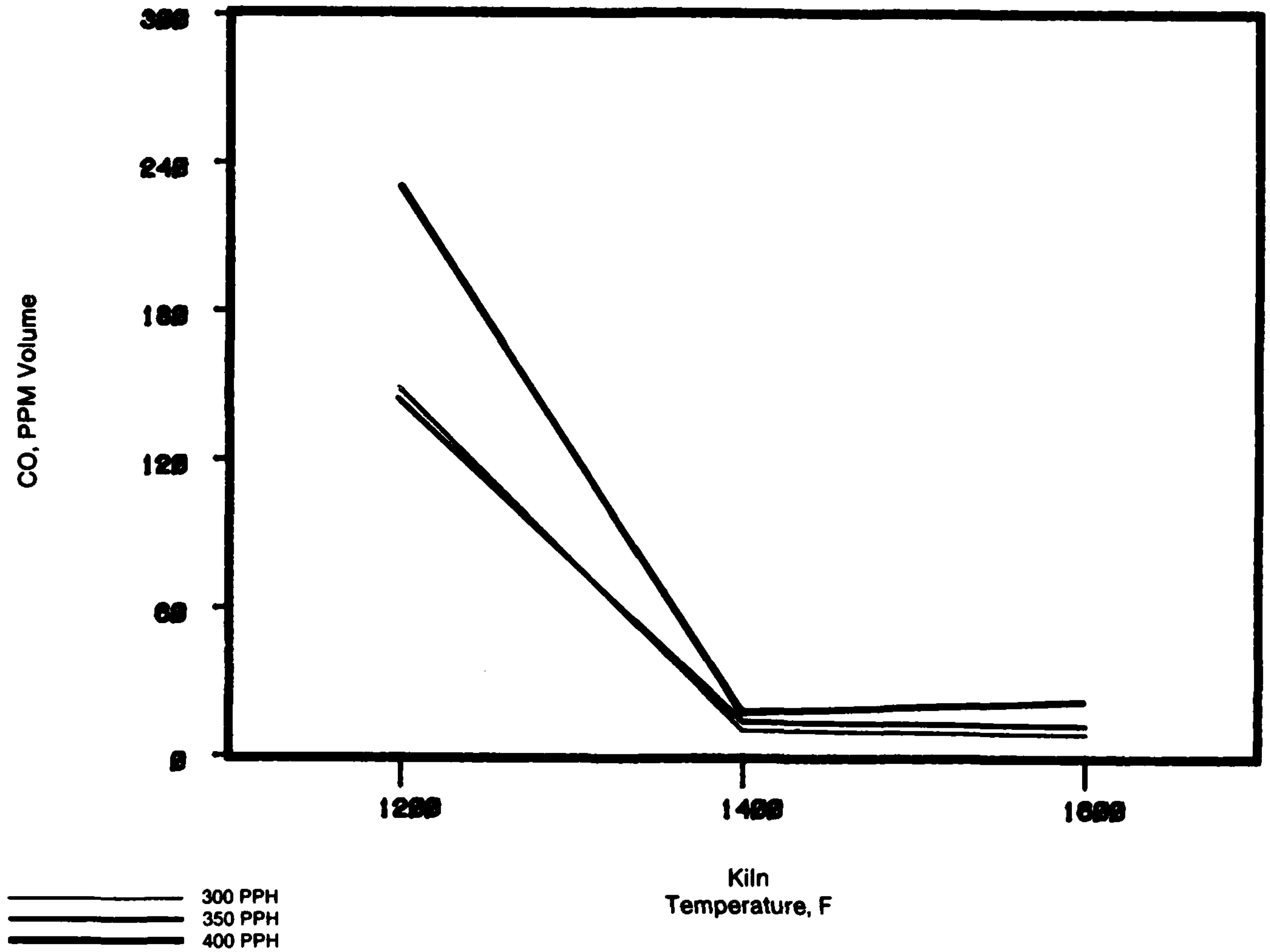


FIGURE 17 CARBON MONOXIDE CONCENTRATION IN KILN EXHAUST BASED ON SOIL FEEDRATE

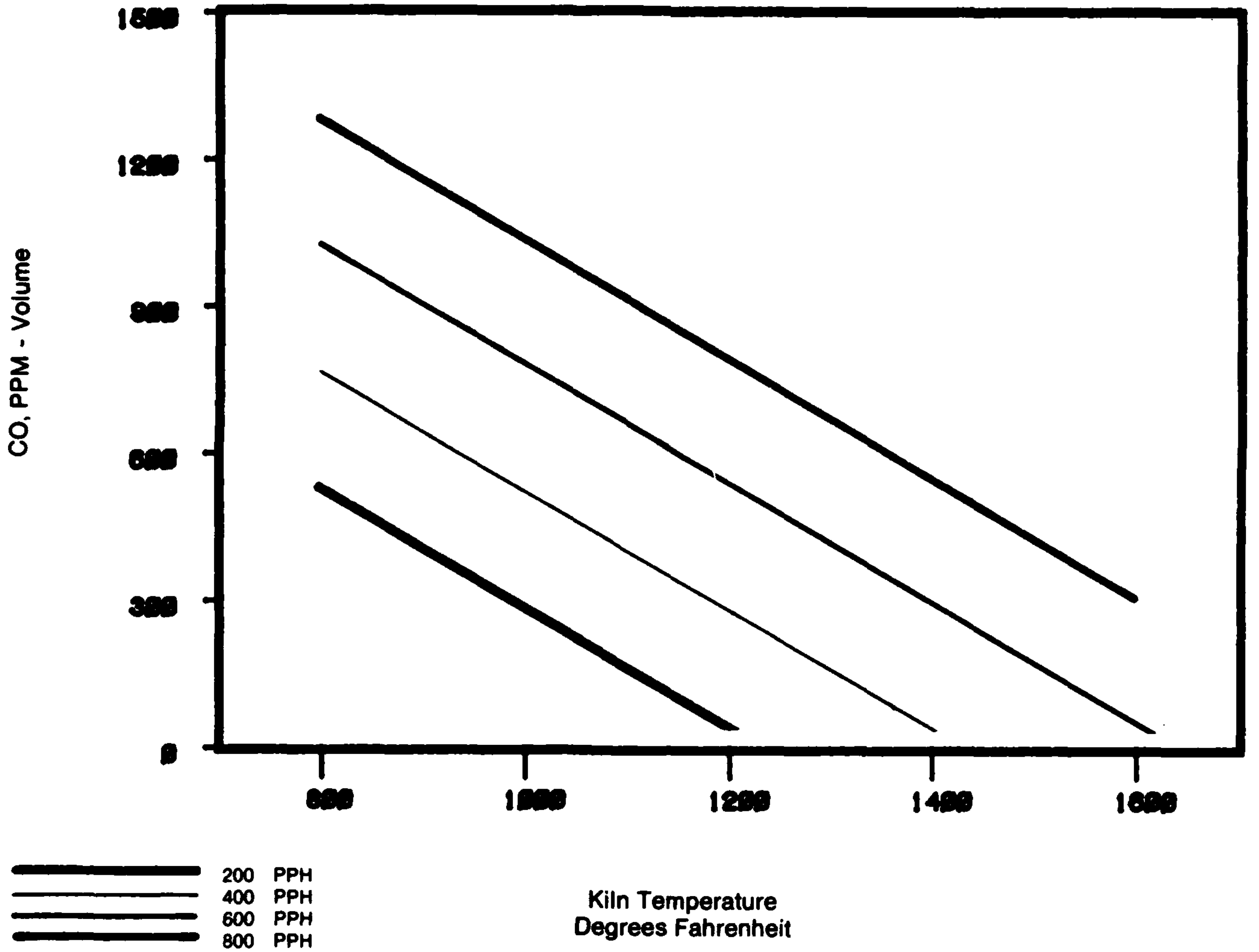


FIGURE 18 CARBON MONOXIDE CONCENTRATION IN KILN EXHAUST BASED ON SOIL FEED RATE

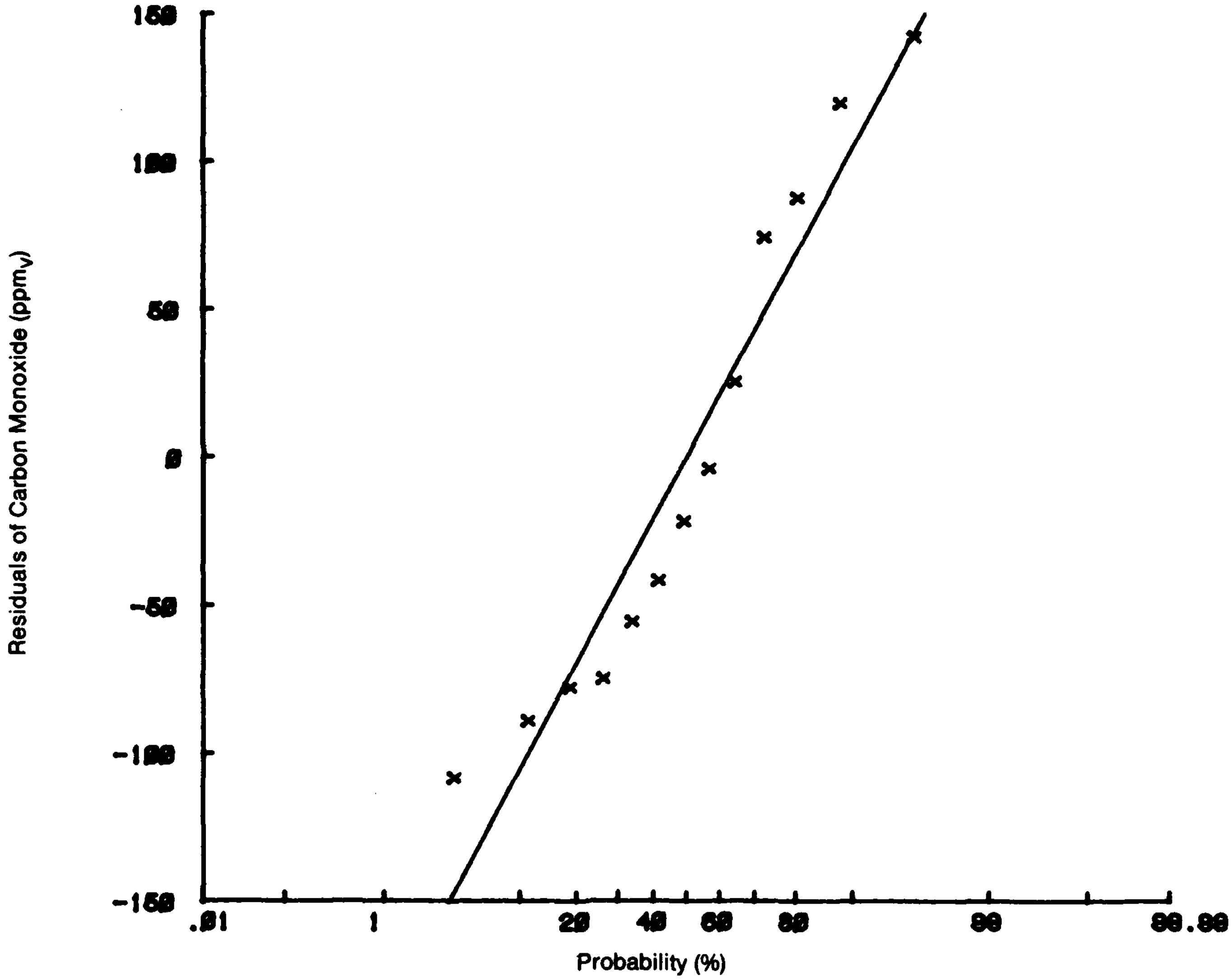


FIGURE 19 PROBABILITY OF RESIDUALS BASED ON THE SYSTEM MODEL EQUATION FOR CARBON MONOXIDE IN THE KILN EXHAUST GAS

regulatory focus from the state perspective will be directed at evaluating the potential increases in ambient NO_x concentrations at surrounding off-site locations. The system equation very closely correlated NO_x mass emission rates in the stack gas to two parameters.

(a) Explosive (TNT) concentration in the feed soil.
(b) Soil feed rate.

Intuitively, one might expect a strong correlation between thermal NO_x formation and kiln and afterburner operating temperatures. However, the key factor affecting thermal NO_x formation is flame temperature, not combustion chamber temperature. Thermal NO_x was controlled to low levels for all runs by controlling the excess air supplied to the burner nozzles. A stoichiometric propane flame (i.e., "zero" excess air) temperature is approximately 3,000°F resulting in relatively high thermal NO_x formation. Whereas, by providing 10 percent excess air to the burner nozzles, (the set point for the IECS test program) flame temperatures are decreased to approximately 2,200°F, thereby substantially reducing thermal NO_x formation.

Figure 20 illustrates the relationship between NO_x mass emissions in the stack gas and feed soil TNT content and feed rate. The curves in Figure 20 are described by the following equation:

$$M_{NO_x} = 0.74 + 0.0004\ (TNT)(M_s)$$

Where: M_{NO_x} = NO_x mass rate in the stack gas (lb/hr)
TNT = TNT concentration in percent (i.e., for 20% enter "20")
M_s = soil feed rate (lb/hr)

As shown in Figure 20, NO_x emissions increase with increasing soil feed rate and increasing TNT concentration. Figure 21 presents the probability of residuals in the above equation. Figure 21 illustrates that for the range of variables on which the model is based, it is 90 percent probable that the predicted value will be within the range of ± 0.5 pounds per hour.

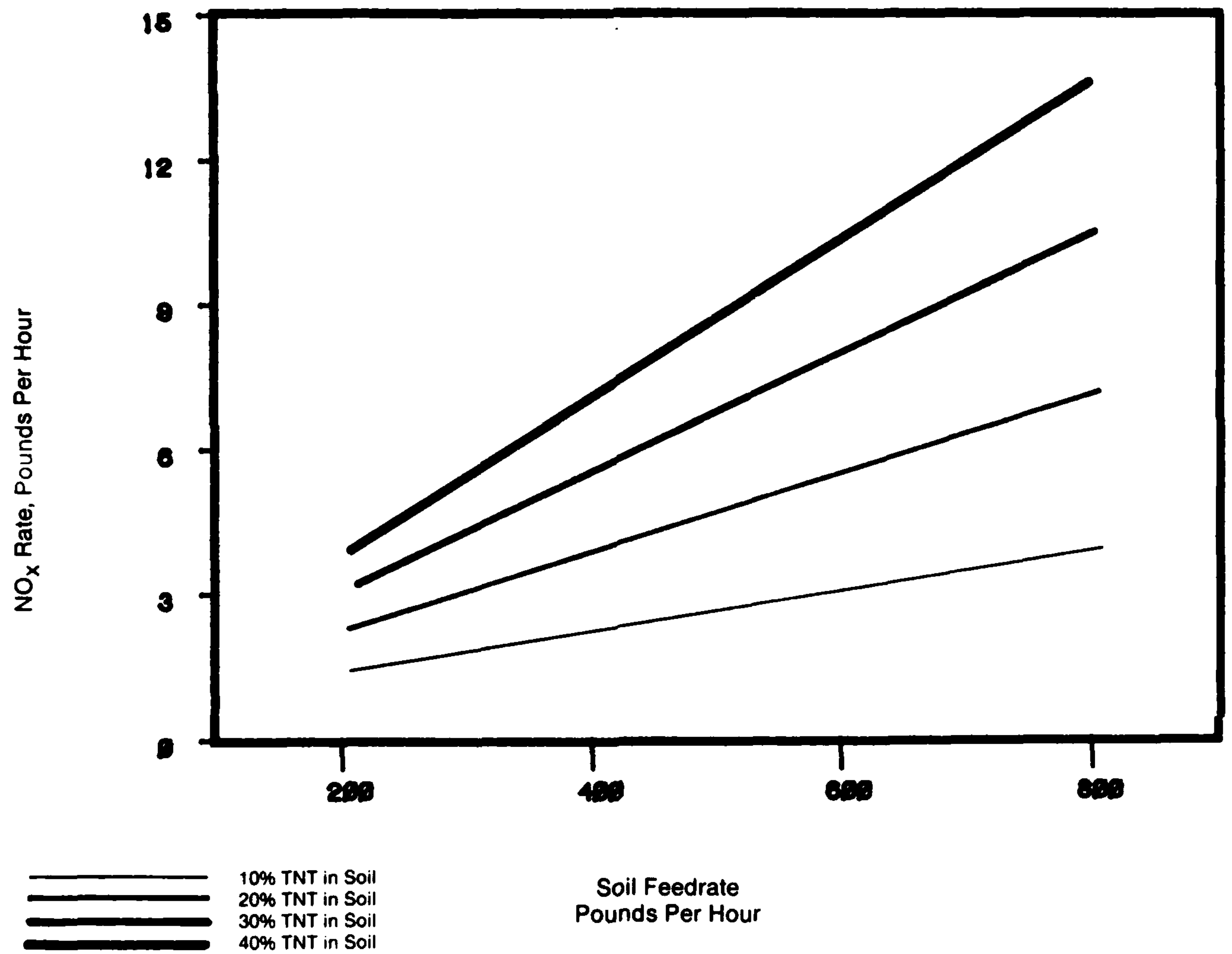


FIGURE 20 NO$_x$ MASS EMISSION RATE IN STACK GAS BASED ON TNT CONCENTRATION IN THE SOIL FEED

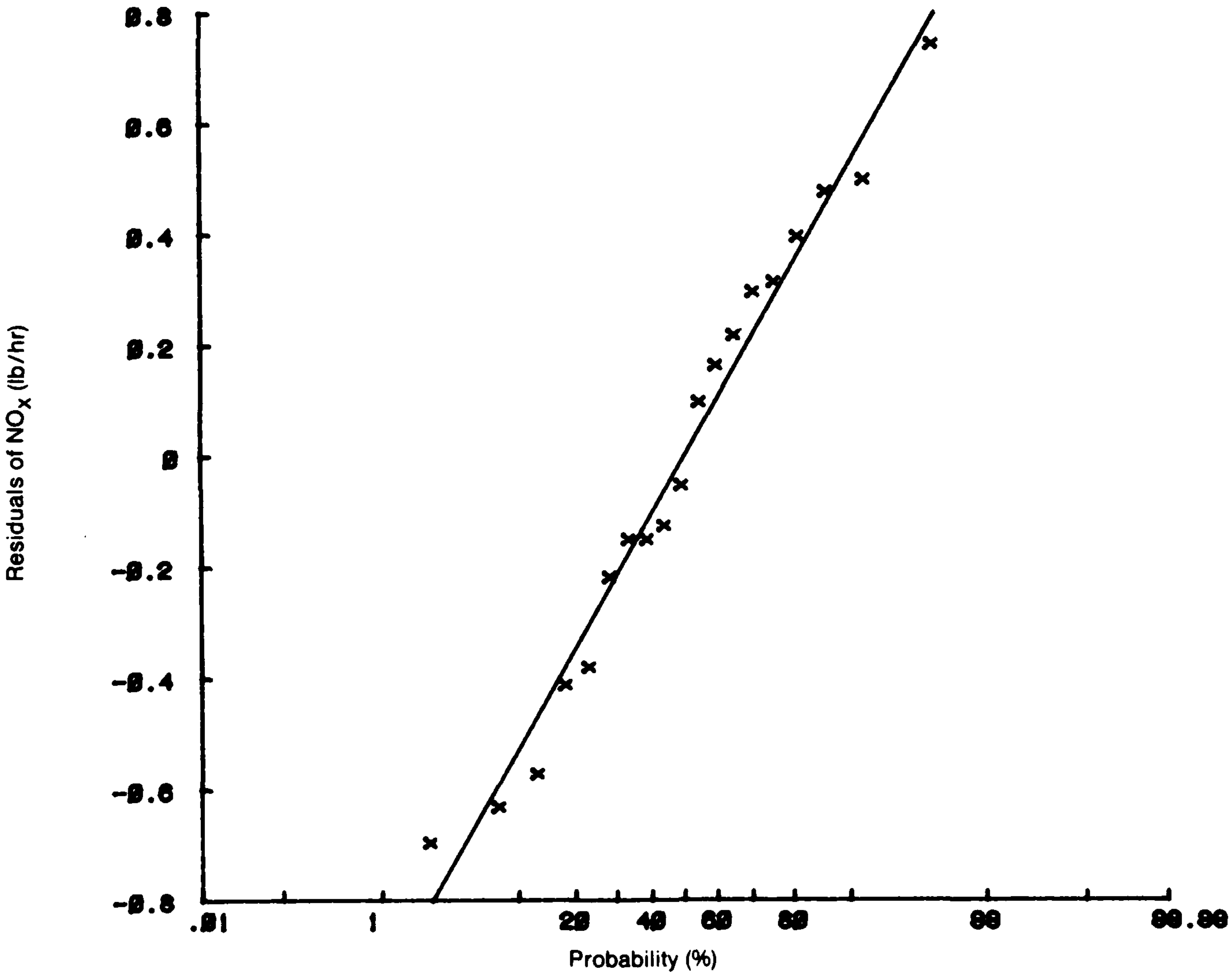


FIGURE 21 PROBABILITY OF RESIDUALS BASED ON THE SYSTEM MODEL EQUATION FOR NO_x IN THE STACK GAS

WESTON

9.3.3 Particulates. No attempt was made to develop correlations to predict particulate loading in the stack gas since the fabric filter consistently reduced particulate emissions two orders of magnitude lower than required to meet the Illinois EPA regulations or the Federal hazardous waste incinerator regulations. However, if the particulate loading at the inlet of the fabric filter is known in conjunction with the particulate sizing distribution, key sizing parameters for the fabric filter (i.e., air-to-cloth ratio, frequency of cleaning, pressure drop, etc.) can be optimized. The particulate size distributions for the SADA and LAAP fabric filter ash were presented in Figures 14 and 15, respectively. Figure 22 presents the relationship between the fabric filter inlet particulate loading and the kiln ash production rate based on a least-squares analysis. Figure 22 includes a "scatter plot" of 18 test runs (Test Run No. 0-1 was excluded), and shows a general trend of increasing particulate loading at the fabric filter inlet with increasing kiln ash production rate. Although the data are not strongly correlated and, as shown in the scatter plot, variations of ± 10 to 50 percent are common, it can be stated that the kiln ash-to-fly ash ratio is within the range of 25:1 to 60:1.

9.4 Incinerator design variables affecting system economics.

9.4.1 Kiln ash production rate. The total ash production rate is an important variable in estimating the ash residue disposal costs. The kiln ash production rate is an important variable in establishing the design basis for ash removal, heat recovery, storage, and disposal systems.

No attempt was made to develop correlations to predict kiln ash production rate since total ash production rate is equivalent to the amount of ash in the feed soil. The kiln ash can be estimated by simply subtracting the estimated fly ash (i.e., ash in combustion gases going to the fabric filter) from the total ash in the soil feed. As shown in Subsection 9.3.3, the fly ash ranges from approximately 2 to 4 percent of the total ash, resulting in kiln ash values ranging from 98 to 96 percent.

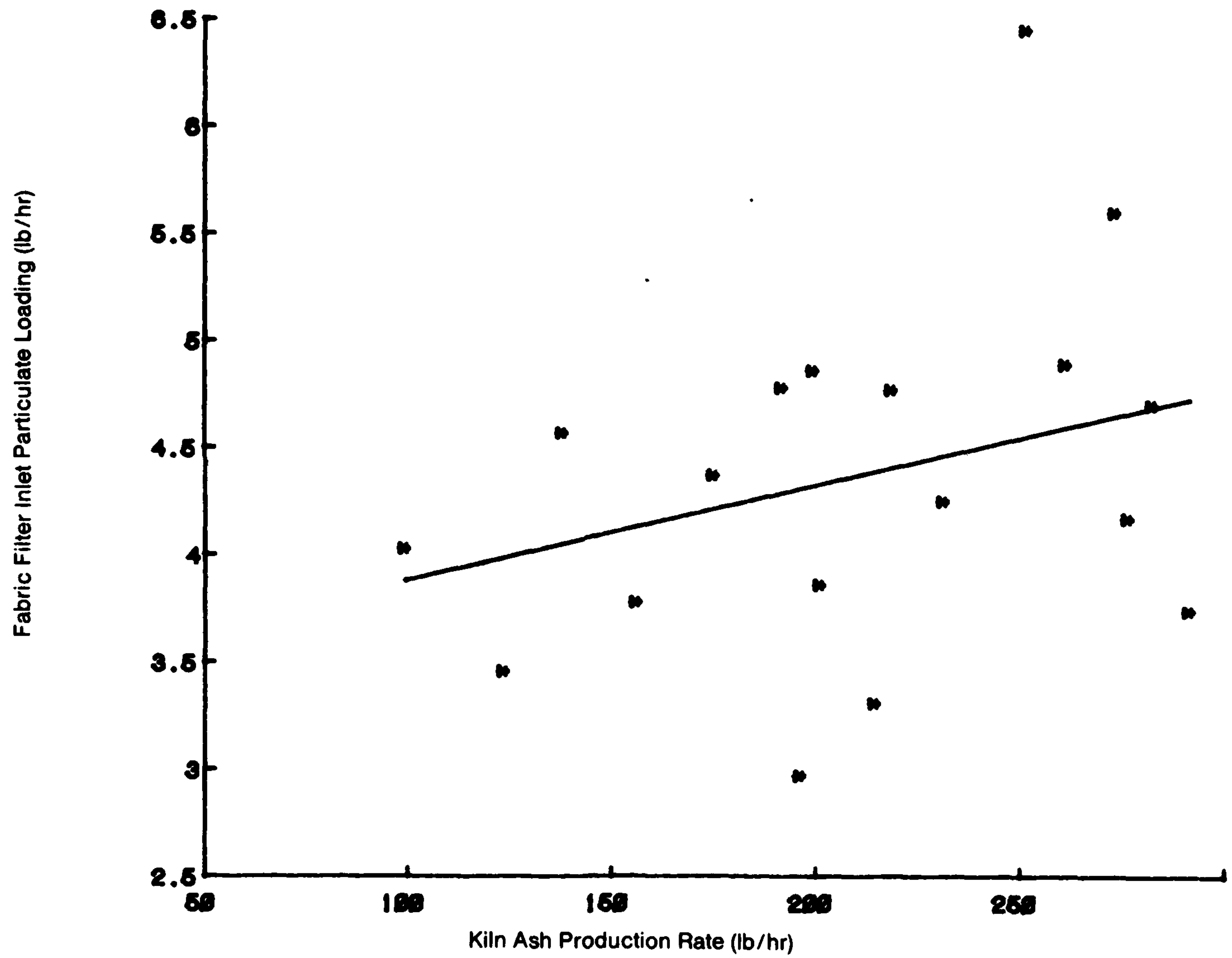


FIGURE 22 PROJECTION OF PARTICULATE MASS LOADING AT THE FABRIC FILTER INLET BASED ON KILN ASH PRODUCTION RATE

9.4.2 Soil heating value. The heating value of the soil is an important variable in estimating fuel consumption, burner design, and heat release rates within the primary chamber. Figure 23 presents the projected soil heating value based on the percent elemental carbon and percent volatiles in the feed soil. The curves in Figure 23 are described by the following equation:

$$HHV_S = -554 + 126\ (\%\ C) + 47\ (\%\ VM)$$

Where: HHV_S = higher heating value of the soil (Btu/lb, dry basis)
% C = elemental carbon in the soil in percent
% VM = volatile matter in the soil in percent

Figure 24 presents the probability of residuals in the above equation. Figure 24 illustrates that for the range of variables on which the model is based, it is 90 percent probable that the predicted value will be within the range of $\pm$ 200 Btu per pound.

9.4.3 Fuel burn rate. Figure 25 closely correlates overall propane fuel consumption for the test burns based on the kiln temperature (assuming the afterburner temperature is 400°F higher), the soil heating value, the soil feed rate, total system air flowrate, and the percent ash in the soil. As shown in Figure 25, the propane burn rate decreases as kiln temperature decreases and as soil feed rate increases. The curves in Figure 25 are given by the following equation:

$$Q_{C_3H_8} = 0.21\ (M_A) + 0.77\ (400 + T_k) - 0.24\ (HHV_S) - 0.52\ (M_S) - 9.0\ (\%\ ash) - 303$$

Where: $Q_{C_3H_8}$ = propane burn rate (scfh)
M_A = total system air flow rate (assumed 4,692 lb/hr)*
T_k = kiln temperature (°F; assumes afterburner is 400°F higher)
HHV_S = higher heating value of the soil (assumed 868 Btu/lb, dry basis)*
M_S = soil feed rate (lb/hr)
% ash = ash in the soil in percent (assumed 55.9%)*

Figure 26 presents the probability of residuals in the above equation. Figure 26 illustrates that for the range of variables on which the model is based, it is 90 percent probable that the predicted value will be within the range of $\pm$ 70 scfh of propane.

*Based on the average air flow rate, heating value, and percent ash in the soil for the 18 SADA and LAAP test runs summarized in Figures 13 and 14.

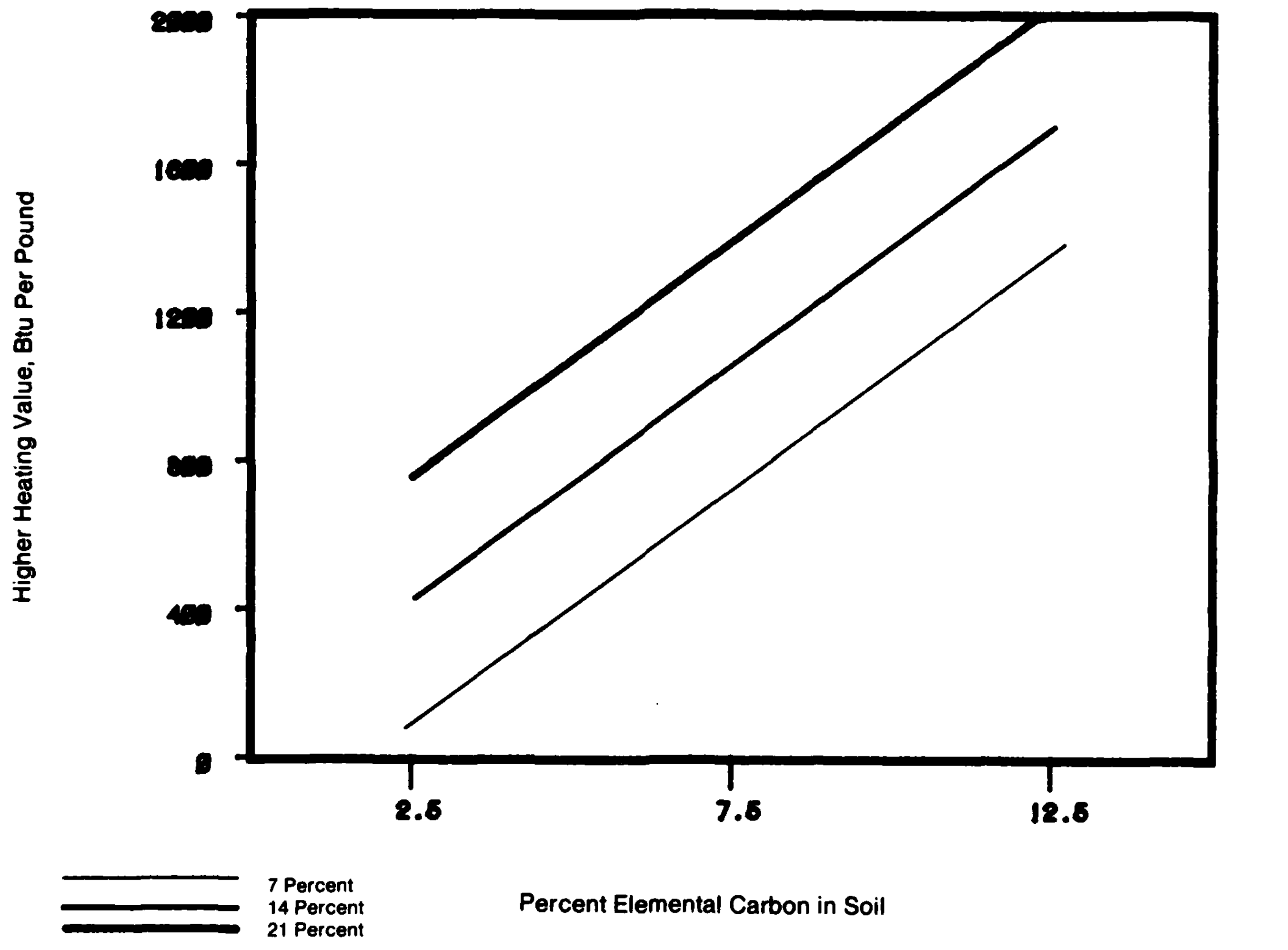


FIGURE 23 SOIL HEATING VALUE BASED ON VOLATILE CONCENTRATION

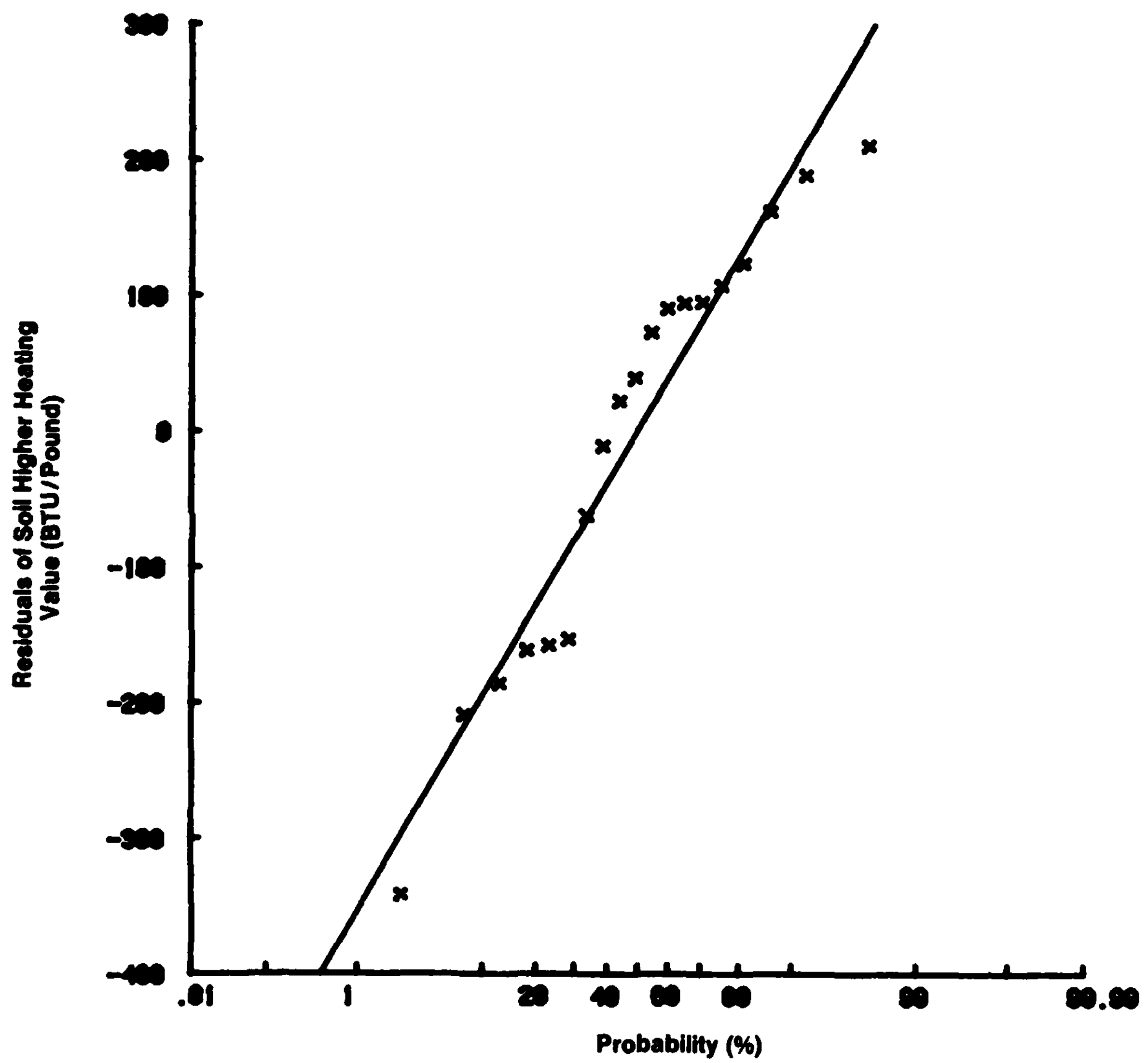


FIGURE 24 PROBABILITY OF RESIDUALS BASED ON THE SYSTEM MODEL EQUATION FOR SOIL HIGHER HEATING VALUE

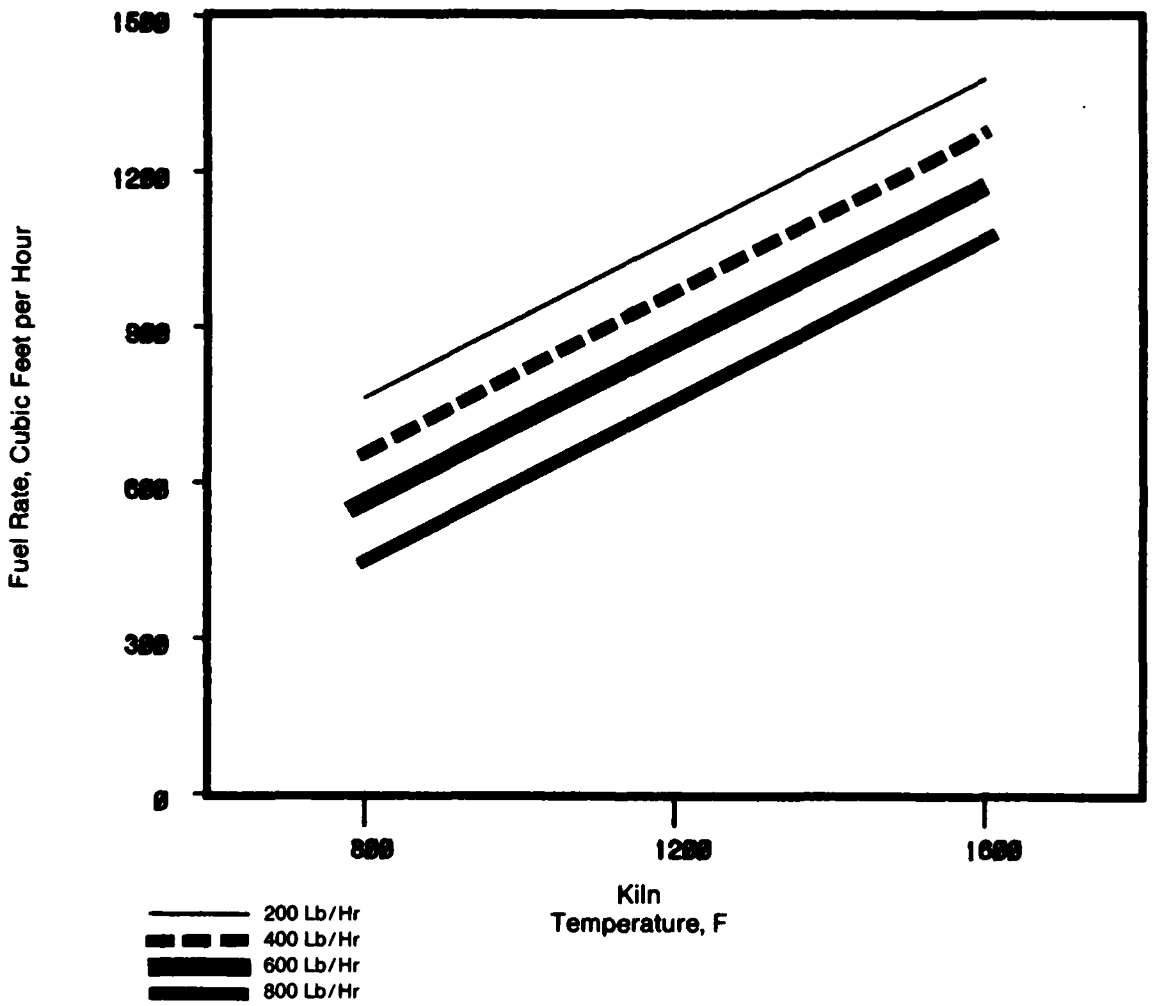


FIGURE 25 PROPANE BURN RATE BASED ON KILN TEMPERATURE AND SOIL HEATING VALUE

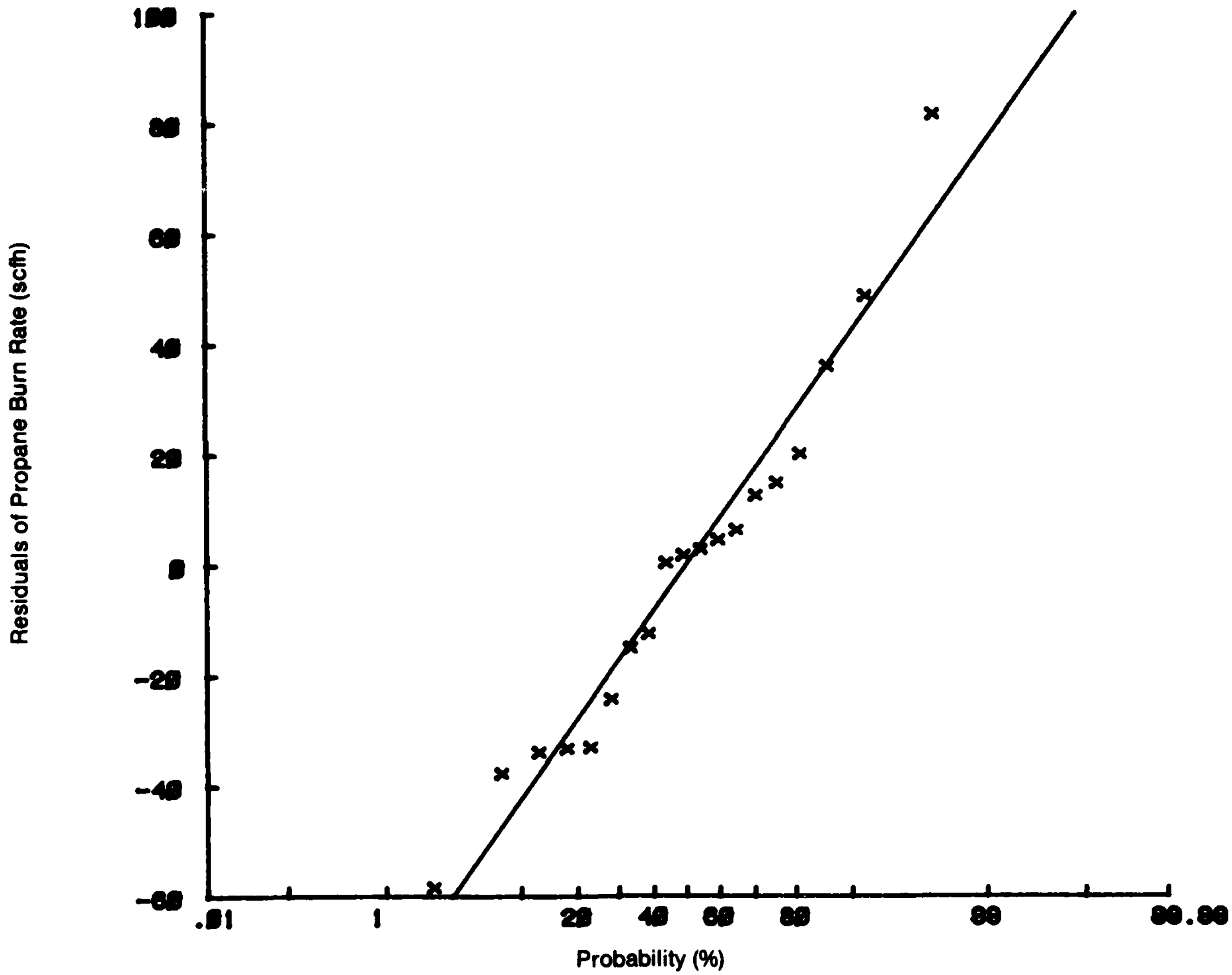


FIGURE 26 PROBABILITY OF RESIDUALS BASED ON THE SYSTEM MODEL EQUATION FOR PROPANE BURN RATE

9.5 Summary of optimum incinerator design criteria. As a result of the analysis of the data generated during the IECS testing program, the following guidelines for optimum incinerator design have been developed:

(a) Soil feed rate. Based on the feed system tested and the physical dimensions of the kiln, soil feed rates above 400 pounds per hour cannot be recommended. Higher feed rates appear to be practical as long as the kiln design (i.e., kiln diameter, length, slope, and speed of rotation) provides kiln ash residence times in the range of 1 to 2 hours. For larger units a "continuous" rather than "bulk" feed system would be preferable due to lower instantaneous heat release rates when the soil is fed. Soil moisture content should be minimized to reduce fuel consumption.

(b) Kiln temperature. Based strictly on explosives destruction, kiln temperatures as low as 800°F are acceptable as long as an afterburner temperature of at least 1,200°F is maintained. However, operation of the kiln below 1,200°F cannot be recommended because of poor kiln ash quality (i.e., large clinkers and ammonia smell). If the kiln temperature is maintained at a minimum of 1,400°F, an afterburner is not required for the control of any pollutants including explosives and CO. There is no justification for operating the kiln above 1,400°F with or without an afterburner.

(c) Afterburner temperature. If an afterburner is provided, there is no justification for operation above 1,400°F and combustion gas residence times in excess of 1 to 2 seconds. Destruction of CO in the combustion gases and not explosives is the most limiting criteria for design of the afterburner.

(d) Burner design. Location of the kiln burner such that the soil rotates directly into the flame after being fed was a positive feature of the incinerator design. Co-current firing (i.e., burner and soil feed at the same end of the kiln) was also a positive feature which essentially eliminates the requirement for an afterburner.

The kiln burner heat input rate and turndown ratio should be designed to accommodate a feed soil with a heating value of 0 to 2,500 Btu per pound with moisture contents as high as 30 percent. The secondary burner (if required) should not be required to provide more than 200°F temperature increase above the kiln temperature. However, a higher design heat input rate may be practical to allow timely preheat of the refractory.

(e) Excess air. The induced draft fan and combustion air inlet ports should be designed to provide 100 to 200 percent excess air in the primary chamber and up to 100 percent excess air in the secondary chamber.

(f) Kiln ash collection/heat recovery. During the IECS testing program, the kiln ash samples were collected from four separate depths within each ash drum immediately after the drum was removed from the ashpit. The hot ash sample was composited, placed in a metal can, and cooled by placing in a water bath. Therefore, this sampling technique did not take credit for further degradation of explosives that would most likely have resulted due to long residence times of the kiln ash in the drums at elevated temperatures during gradual cool down. This sampling technique closely approximates a full-scale kiln ash removal system incorporating a planetary cooler (or similar heat tranfer method) to preheat the combustion air or waste heat boiler feed water.

(g) Heat recovery. A heat recovery system (i.e., heat exchanger or waste heat boiler) with a design heat recovery efficiency of approximately 80 percent is required to cool the incinerator combustion gases prior to entering the fabric filter.

(h) Particulate control. A fabric filter is required for particulate control. Based on the inlet loading and particle size distribution, a pulse-jet cleaned outside collector is recommended with a design air-to-cloth ratio of 5:1.

(i) Equipment size limitations. The use of a "transportable" incinerator appears to be extremely advantageous for future remedial action projects. Therefore, individual component design (e.g., rotary kiln) should take into consideration size limitations for truck and/or rail shipment.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions. The IECS project demonstrated the following:

(a) A "transportable" incineration system can be disassembled, loaded on trucks, transported approximately 1,000 miles, and be reassembled and fully operational within 2 weeks.

(b) The explosives contaminated soils can be excavated, transported to the incineration site, fed into the incinerator, and thermally decontaminated in a safe and environmentally acceptable manner.

(c) Comparing the mass of explosives measured in the ash residues and the stack gas to the mass of explosives in the soil feed, the following destruction and removal efficiencies were demonstrated:
- Greater than 99.99 percent destruction efficiency in the kiln ash.
- Greater than 99.9999 percent destruction efficiency in the fabric filter ash.
- No explosives detected in the stack gas, which results in an overall destruction and removal efficiency (DRE) of 100 percent.

(d) Stack emissions were in compliance with all Federal, state, and local regulations including:
- Sulfur dioxide (SO_2)
- Hydrogen chloride (HCl)
- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)
- Particulates

(e) Ash residues were not hazardous due to the characteristics of EP toxicity or reactivity. Application has been filed[1] with the Illinois EPA to allow land application of the ash residues at the Savanna Army Depot Activity.

(f) The incineration system demonstrated the capability of safe and reliable operation over a wide range of operating conditions, including a longer-term, steady-state production mode of operation.

Comparison of the IECS project results to the applicable Federal regulatory criteria demonstrated the following:

(a) It appears that the explosives contaminated soils are exempt from selected sections of the Federal hazardous waste incineration standards (40 CFR, Part 264). However, final judgment on this exemption will rest with the respective EPA Regional Administrator. Four factors combine to make an extremely strong case that the EPA regional administrators would approve this exemption:
  - The explosives contaminated soils, when mixed with water, do not generate toxic gases and they are not cyanide- or sulfide-bearing wastes.
  - The concentrations of 40 CFR, Part 261 - Appendix VIII hazardous constituents are extremely low.
  - No other hazardous wastes would be incinerated simultaneously with the explosives contaminated soils.
  - The incineration site would most likely be a remote U.S. Army location which would further limit potential hazards to the general public.

(b) For future full-scale remedial action projects waste analysis data must be submitted with the Part B permit application for the project. If the above-described exemption is granted, the implications would be as follows:
  - A formal trial burn would not be required.
  - The incinerator would not be required to meet incinerator performance standards (including the 99.99 percent DRE requirement).
  - The incinerator would be exempt from all Federal operating, monitoring, and inspection requirements.

  All ash residues would be classified as hazardous wastes; however, the IECS project results clearly demonstrate that delisting of the ash residues should be a straightforward process, assuming the ash passes the EP toxicity test.

(c) If the above exemption is not granted, the implications would be as follows:
  - Clearly, the results of the IECS test program should exempt the U.S. Army from any further trial burn requirements unless the waste analysis of the explosives contaminated soils is significantly different than the SADA or LAAP soils.

- The IECS test results demonstrated consistent compliance with all incinerator performance standards.
- It appears that only two additional pieces of instrumentation would be required to supplement the incineration equipment and controls supplied by ThermAll, Inc. for the IECS test program: 1) a device for continuously measuring combustion gas velocity, and 2) a device for continuously measuring carbon monoxide at the stack.*

In summary, if the exemption is not granted the permitting and reporting requirements will most likely be more rigorous and time consuming; however, compliance with the regulations would not be problematic.

In the early stages of the IECS project a test plan[2] was developed which identified key process variables and established a matrix of test conditions (replicated for two different soil types). This experimental design was selected to allow statistical evaluation of the test burn data. As a result, significant simple linear models were developed which accurately predict incinerator air pollutant emission criteria, as well as important incinerator design parameters (e.g., ash production rates, soil heating value, and supplemental fuel burn rate).

A pneumatic ram feeder utilizing a standard 12-quart galvanized mop pail to contain the contaminated soil was selected and designed specifically for this testing program. Traditional feed systems (e.g., screw conveyors, ram feeders, etc.) were unacceptable due to the potential explosive hazards associated with frictional forces and/or confinement. The bucket feed system met all of the test objectives and proved to be very safe and reliable. During the course of the testing program, the feed system cycled over 4,000 times without a single failure. However, it is anticipated that the bucket feed system will not be suitable for full-scale remedial action projects due to the disadvantages of limited feed rates (due to the required cycle times) and of being relatively labor intensive.

10.2 Recommendations. The success of the IECS testing program (i.e., no explosives detected in the combustion gases entering the secondary chamber and stack CO and particulate emissions orders of magnitude below the regulatory limits) suggests that certain system/process modifications should be evaluated to

*This device may serve a dual role since the IECS test data indicate that CO monitoring will provide a dependable and cost-effective way to ensure proper combustion of explosives, as well as CO.

optimize cost effectiveness, while at the same time meeting all environmental goals. The evaluation of system/process modifications should include:

(a) Reduce the temperature of the secondary chamber to reduce fuel usage.
(b) Reduce the secondary chamber volume (i.e., flue gas residence time) to reduce capital costs.
(c) Reduce the excess air supplied to both the primary and secondary chambers to reduce fuel costs and fan power costs.
(d) Potentially eliminate the secondary chamber and:
    - Monitor CO at the kiln outlet.
    - Increase the kiln flue gas residence time.
    - Increase the kiln temperature.
(e) Increase the soil feed rate to the kiln to improve overall economics and potentially increase the kiln volume to provide adequate ash residence time.
(f) Increase the air-to-cloth ratio in the fabric filter (i.e., reduce size of unit) to reduce capital costs.
(g) Evaluate the feasibility of retrofitting the U.S. Army APE-1236 deactivation furnaces for thermally treating explosives contaminated soils.
(h) Evaluate the feasibility of transporting the explosives contaminated soils to a commercial incineration facility for thermal treatment.

The evaluation of the above system/process modifications will be the objective of Phase II of the IECS project (Task Order No. 7).

11. REFERENCES

1. Letter from Mr. Arlen J. Dahlman to Mr. Bharat Mathur in reference to results of the IECS Testing Program, dated 12 January 1984.

2. Roy F. Weston, Inc., Test Plan for an Incineration Test of Explosives Contaminated Sediments at Savanna, Illinois, USATHAMA Contract No. DAAK11-82-C-0017, Task Order No. 2, March 1983.

3. Roy F. Weston, Inc., Safety Plan for an Incineration Test of Explosives Contaminated Sediments at The Savanna Army Depot Activity, USATHAMA Contract No. DAAK11-82-C-0017, Task Order No. 2, March 1983.

4. Roy F. Weston, Inc., Permit Application for an Incineration Test of Explosives Contaminated Sediments at Savanna, Illinois, USATHAMA Contract No. DAAK11-82-C-0017, Task Order No. 2, February 1983.

5. Roy F. Weston, Inc., Sampling and Analysis Plan for an Incineration Test of Explosives Contaminated Sediments at the Savanna Army Depot Activity, USATHAMA Contract No. DAAK11-82-C-0017, Task Order No. 2, March 1983.

6. Robert C. Weast, Ph.D., CRC Handbook of Chemistry and Physics, 58th Edition, CRC Press, Inc., Cleveland, Ohio, 1977.

7. R.W. Rocke, et al., Afterburner Systems Study, Shell Development Company, Emeryville, California, August 1972.

8. Users Manual, Statistics: Multiple Linear Regression, Plot 50 - 4050D04, Tektronix, Inc., Beaverton, Oregon, July 1982.

9. Users Manual, Statistics: Analysis of Variance, Plot 50 - 4050D03, Tektronix, Inc. Beaverton, Oregon, August 1982.

APPENDIX A

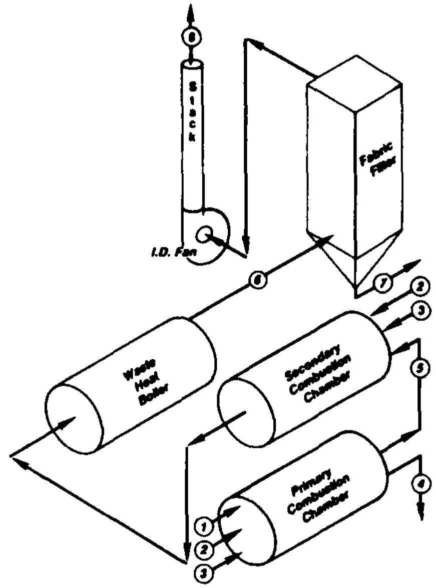
INCINERATION TEST BURN DATA SUMMARY TABLES

WESTON

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	18.47	5.71	-	-	0.23	-
Hydrogen	(lb/hr)	-	-	1.54	0.15	-	-	0.01	-
Oxygen	(lb/hr)	-	-	-	-	15.6%*	581.2	-	702.6
Nitrogen	(lb/hr)	-	-	7.28	1.8	80.2%*	2,686.8	0.09	3,281.4
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.02	-
Chlorine	(lb/hr)	-	-	0.09	ND	-	-	0.01	-
Moisture	(lb/hr)	-	-	87.4	-	-	-	-	-
Ash	(lb/hr)	-	-	342.7	156.3	-	-	3.61	-
Explosives - TNT	(lb/hr)	-	-	58.3	0.001	182.4ppmw*	ND	2.1×10^{-5}	ND
RDX	(lb/hr)	-	-	0.03	ND	5.7ppmw*	ND	4.8×10^{-6}	ND
HMX	(lb/hr)	-	-	ND	ND	5.2ppmw*	ND	1.7×10^{-5}	ND
Other	(lb/hr)	-	-	0.05	ND	2.6ppmw*	ND	6.2×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.009	0.004	NM	6.1×10^{-5}	7.1×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	5.5×10^{-6}	4.0×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	ND	NM	2.9×10^{-5}	2.2×10^{-4}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	5.6×10^{-5}	3.9×10^{-4}	NM
Pb	(lb/hr)	-	-	0.008	0.004	NM	2.4×10^{-4}	2.4×10^{-3}	NM
Zn	(lb/hr)	-	-	0.017	0.007	NM	3.9×10^{-4}	2.2×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	9.1×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	2.1×10^{-6}	5.5×10^{-6}
Air	(lb/hr)	3,274.9	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	4.2%*	236.6	-	275.1
Water Vapor	(lb/hr)	43.1	-	-	-	9.3%*	219.4	-	234.2
Propane	(lb/hr)	-	54.9	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	0.54	-	4.5×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	1,050ppmv*	0.251	-	0.338
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	3.6
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.013
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.032	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	4.0ppmv*	ND	-	ND
Total Mass Flow Rate	(lb/hr)	3,318.0	54.9	515.9	164.0	NM*	3,724.8	3.97	4,497.3
Average Temperature	(°F)	60	60	60	883	883	287	185	185
Average Volumetric Flow Rate	(dscfm)	737.3	8.0	-	-	NM*	783	-	950
Heating Value	(Btu/lb)	-	21,560	95	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

WESTON DESIGNERS CONSULTANTS
WESTON WAY
WEST CHESTER, PENNSYLVANIA 19380
PHONE 215-692-3030
TELEX 83-5348

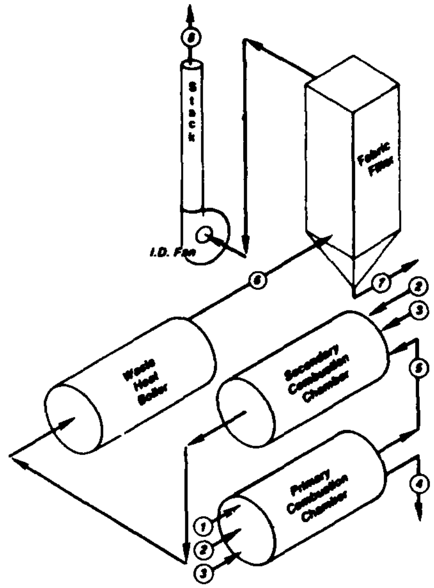
FIGURE A-1 MATERIAL BALANCE FOR 0-1 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0003
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	12.53	1.05	-	-	0.05	-
Hydrogen	(lb/hr)	-	-	0.98	0.09	-	-	3.6×10^{-3}	-
Oxygen	(lb/hr)	-	-	-	-	13.8%*	495.7	-	674.1
Nitrogen	(lb/hr)	-	-	5.05	0.62	82.0%*	3,119.1	0.016	3,726.5
Sulfur	(lb/hr)	-	-	ND	ND	-	-	5.3×10^{-3}	-
Chlorine	(lb/hr)	-	-	0.054	0.09	-	-	2.6×10^{-3}	-
Moisture	(lb/hr)	-	-	49.4	-	-	-	-	-
Ash	(lb/hr)	-	-	225.6	213.1	-	-	3.24	-
Explosives - TNT	(lb/hr)	-	-	26.99	ND	ND	ND	6.9×10^{-6}	ND
RDX	(lb/hr)	-	-	0.008	0.001	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	4.3×10^{-6}	ND
Other	(lb/hr)	-	-	0.026	ND	ND	ND	1.6×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.007	0.004	NM	2.7×10^{-4}	4.3×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	1.3×10^{-5}	2.0×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	0.002	NM	5.9×10^{-5}	8.6×10^{-5}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	1.1×10^{-4}	1.9×10^{-4}	NM
Pb	(lb/hr)	-	-	0.005	0.005	NM	3.1×10^{-4}	9.6×10^{-4}	NM
Zn	(lb/hr)	-	-	0.010	0.008	NM	5.9×10^{-4}	1.2×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	2.0×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	3.6×10^{-6}	7.9×10^{-7}
Air	(lb/hr)		-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	4.2%*	343.8	-	402.4
Water Vapor	(lb/hr)	3,921.2	-	-	-	7.6%*	220.6	-	244.0
Propane	(lb/hr)	-	103.1	-	-	-	-	-	-
Particulate	(lb/hr)	51.6	-	-	-	NM	1.3	-	4.5×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	122ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.7
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.025
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	6.4×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	46ppmv*	1.13	-	0.016
Total Mass Flow Rate	(lb/hr)	3,972.8	103.1	320.7	215.0	NM*	4,181.6	3.31	5,048.7
Average Temperature	(°F)	60	60	60	1,278	1,278	293	172	172
Average Volumetric Flow Rate	(dscfm)	882.8	15.1	-	-	NM*	883	-	1,067
Heating Value	(Btu/lb)	-	21,560	<50	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

WESTON DESIGNERS CONSULTANTS
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WEST CHESTER, PENNSYLVANIA 19380
PHONE 215-692-3030
TELEX 83-5348

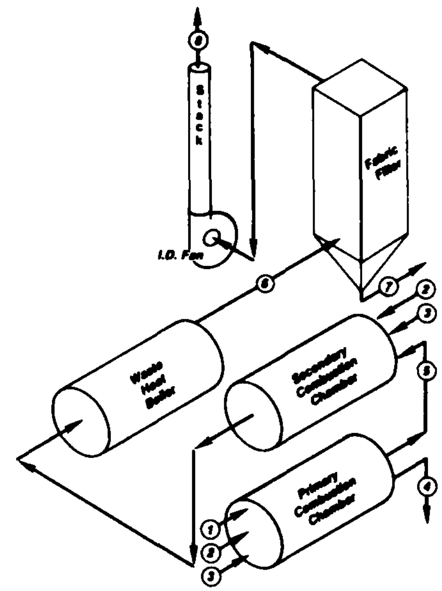
FIGURE A-2 MATERIAL BALANCE FOR 1-1 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0004
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	16.91	1.72	-	-	0.017	-
Hydrogen	(lb/hr)	-	-	1.24	0.11	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	15.1%*	779.6	-	835.9
Nitrogen	(lb/hr)	-	-	7.94	ND	81.2%*	4,148.7	0.040	4,514.8
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	0.061	ND	-	-	0.002	-
Moisture	(lb/hr)	-	-	47.4	-	-	-	-	-
Ash	(lb/hr)	-	-	231.4	271.2	-	-	5.55	-
Explosives - TNT	(lb/hr)	-	-	45.47	0.001	ND	ND	1.1×10^{-5}	ND
RDX	(lb/hr)	-	-	0.018	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.043	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.008	0.005	NM	6.9×10^{-4}	3.1×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	5.1×10^{-5}	3.4×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	ND	NM	1.5×10^{-4}	5.6×10^{-5}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	2.7×10^{-4}	1.5×10^{-4}	NM
Pb	(lb/hr)	-	-	0.007	0.004	NM	1.5×10^{-3}	1.7×10^{-3}	NM
Zn	(lb/hr)	-	-	0.012	0.007	NM	2.1×10^{-3}	1.2×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	7.8×10^{-5}	7.9×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	3.4×10^{-6}	1.1×10^{-5}	1.6×10^{-5}
Air	(lb/hr)	5,371.4	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	3.7%*	408.0	-	397.5
Water Vapor	(lb/hr)	70.7	-	-	-	7.1%*	286.3	-	259.8
Propane	(lb/hr)	-	107.3	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	4.3	-	5.8×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	126ppmv*	0.025	-	0.027
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	2.7
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.034
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	5.8×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	5,442.1	107.3	350.5	273.0	NM*	5,626.9	5.61	6,010.8
Average Temperature	(°F)	60	60	60	1,178	1,178	306	208	208
Average Volumetric Flow Rate	(dscfm)	1,209.4	15.7	-	-	NM*	1,192	-	1,283
Heating Value	(Btu/lb)	-	21,560	573	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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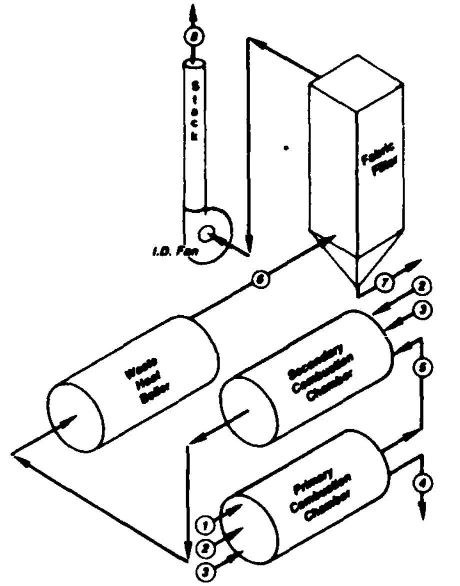
FIGURE A-3 MATERIAL BALANCE FOR 1-2 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0005
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	15.32	0.79	-	-	0.017	-
Hydrogen	(lb/hr)	-	-	1.19	ND	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	12.6%*	499.8	-	678.4
Nitrogen	(lb/hr)	-	-	6.54	0.61	81.8%*	3,068.9	0.016	3,633.0
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.002	-
Chlorine	(lb/hr)	-	-	0.036	ND	-	-	0.001	-
Moisture	(lb/hr)	-	-	66.5	-	-	-	-	-
Ash	(lb/hr)	-	-	295.0	290.6	-	-	3.71	-
Explosives - TNT	(lb/hr)	-	-	41.34	0.003	ND	ND	9.8×10^{-6}	ND
RDX	(lb/hr)	-	-	0.018	ND	ND	ND	5.9×10^{-6}	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.042	ND	ND	ND	1.9×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.008	0.006	NM	3.2×10^{-4}	5.3×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	1.8×10^{-6}	2.6×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	ND	NM	7.3×10^{-5}	1.2×10^{-4}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	1.5×10^{-4}	2.4×10^{-4}	NM
Pb	(lb/hr)	-	-	0.006	0.005	NM	3.8×10^{-4}	1.3×10^{-3}	NM
Zn	(lb/hr)	-	-	0.013	0.011	NM	8.4×10^{-4}	1.5×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	2.3×10^{-6}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	4.6×10^{-6}	5.6×10^{-6}	1.5×10^{-6}
Air	(lb/hr)	3,880.4	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.6%*	364.2	-	364.7
Water Vapor	(lb/hr)	51.1	-	-	-	9.6%*	212.7	-	229.5
Propane	(lb/hr)	-	81.4	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.3	-	3.7×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	240ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.8
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.017
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	5.9×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	3,931.5	81.4	426.0	292.0	NM*	4,146.9	3.75	4,907.4
Average Temperature	(°F)	60	60	60	1,263	1,263	284	162	162
Average Volumetric Flow Rate	(dscfm)	873.7	11.9	-	-	NM*	875	-	1,042
Heating Value	(Btu/lb)	-	21,560	112	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



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At: Savanna Army Depot Activity (SADA)
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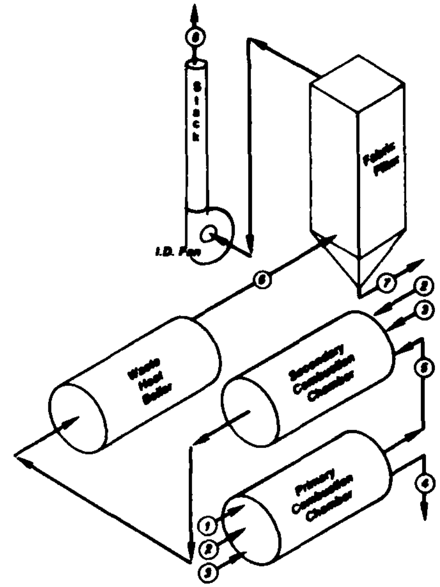
FIGURE A-4 MATERIAL BALANCE FOR 1-3 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0006
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	7.12	2.63	-	-	0.029	-
Hydrogen	(lb/hr)	-	-	0.74	0.12	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	12.7%*	505.6	-	658.0
Nitrogen	(lb/hr)	-	-	2.68	1.09	82.0%*	3,209.4	0.014	3,677.7
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.003	-
Chlorine	(lb/hr)	-	-	0.32	0.06	-	-	3.9×10^{-4}	-
Moisture	(lb/hr)	-	-	35.3	-	-	-	-	-
Ash	(lb/hr)	-	-	231.5	197.1	-	-	3.82	-
Explosives - TNT	(lb/hr)	-	-	23.42	ND	ND	ND	ND	ND
RDX	(lb/hr)	-	-	0.010	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.027	ND	ND	ND	9.8×10^{-6}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.008	0.004	NM	3.5×10^{-4}	3.8×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	1.5×10^{-5}	1.5×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	ND	NM	6.0×10^{-5}	6.2×10^{-5}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	9.3×10^{-6}	1.2×10^{-4}	NM
Pb	(lb/hr)	-	-	0.004	ND	NM	3.1×10^{-4}	5.0×10^{-4}	NM
Zn	(lb/hr)	-	-	0.009	ND	NM	5.3×10^{-4}	6.6×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	5.4×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	2.7×10^{-6}	1.3×10^{-6}
Air	(lb/hr)	4,024.1	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.3%*	359.8	-	329.6
Water Vapor	(lb/hr)	53.0	-	-	-	9.5%*	212.1	-	220.9
Propane	(lb/hr)	-	112.0	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	2.3	-	6.1×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	16ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	2.0
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.034
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	5.7×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,077.1	112.0	301.1	201.0	NM*	4,289.2	3.87	4,888.2
Average Temperature	(°F)	60	60	60	1,488	1,488	296	184	184
Average Volumetric Flow Rate	(dscfm)	906.0	16.4	-	-	NM*	908	-	1,042
Heating Value	(Btu/lb)	-	21,560	< 50	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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FIGURE A-5 MATERIAL BALANCE FOR 1-4 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0007
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	32.62	1.28	-	-	0.056	-
Hydrogen	(lb/hr)	-	-	2.06	0.01	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	12.6%*	462.9	-	571.8
Nitrogen	(lb/hr)	-	-	14.21	0.09	81.6%*	2,863.7	0.018	3,284.3
Sulfur	(lb/hr)	-	-	ND	0.01	-	-	0.007	-
Chlorine	(lb/hr)	-	-	0.109	ND	-	-	0.007	-
Moisture	(lb/hr)	-	-	84.7	-	-	-	-	-
Ash	(lb/hr)	-	-	150.8	122.6	-	-	3.38	-
Explosives - TNT	(lb/hr)	-	-	71.70	4.3×10^{-4}	ND	ND	ND	ND
RDX	(lb/hr)	-	-	0.023	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	1.7×10^{-5}	ND
Other	(lb/hr)	-	-	0.079	ND	ND	ND	7.8×10^{-6}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.005	0.002	NM	7.0×10^{-4}	2.9×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	3.8×10^{-5}	2.2×10^{-5}	NM
Cr	(lb/hr)	-	-	0.002	ND	NM	4.3×10^{-5}	5.9×10^{-5}	NM
Cu	(lb/hr)	-	-	0.004	0.001	NM	1.8×10^{-4}	1.7×10^{-4}	NM
Pb	(lb/hr)	-	-	0.018	0.008	NM	2.4×10^{-3}	8.7×10^{-4}	NM
Zn	(lb/hr)	-	-	0.019	0.006	NM	1.6×10^{-3}	1.0×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	2.7×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	9.5×10^{-6}	2.4×10^{-5}	2.9×10^{-5}
Air	(lb/hr)	3,655.2	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.8%*	398.5	-	393.1
Water Vapor	(lb/hr)	48.1	-	-	-	11.8%*	292.1	-	273.6
Propane	(lb/hr)	-	82.4	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	0.60	-	5.6×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	140ppmv*	0.162	-	0.165
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	3.1
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.050
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	6.5×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	7.0ppmv	0.006	-	0.007
Total Mass Flow Rate	(lb/hr)	3,703.3	82.4	356.3	124.0	NM*	4,018.0	3.47	4,526.1
Average Temperature	(°F)	60	60	60	1,435	1,435	289	186	186
Average Volumetric Flow Rate	(dscfm)	823.0	12.1	-	-	NM*	825	-	942
Heating Value	(Btu/lb)	-	21,560	1,602	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.

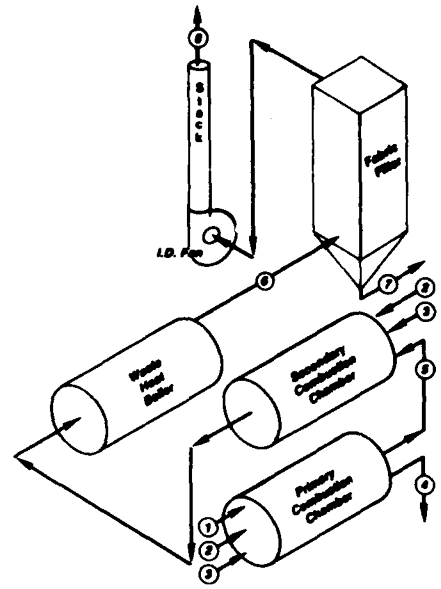

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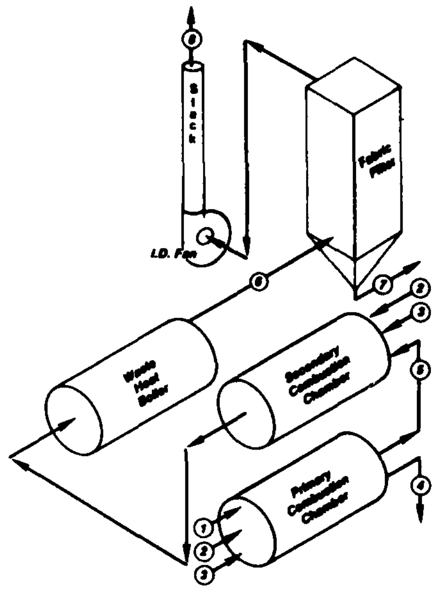
FIGURE A-6 MATERIAL BALANCE FOR 1-5 TEST BURN ON SADA SOIL

Scale	None	Project Number	Drawing Number
Date	1/3/84	2281-01-02	MB-0006

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	12.49	2.04	-	-	0.043	-
Hydrogen	(lb/hr)	-	-	1.10	0.23	-	-	0.004	-
Oxygen	(lb/hr)	-	-	-	-	12.3%*	465.6	-	642.8
Nitrogen	(lb/hr)	-	-	5.16	0.70	81.7%*	3,102.5	4.9×10^{-4}	3,703.2
Sulfur	(lb/hr)	-	-	ND	0.42	-	-	0.004	-
Chlorine	(lb/hr)	-	-	ND	0.10	-	-	0.002	-
Moisture	(lb/hr)	-	-	50.3	-	-	-	-	-
Ash	(lb/hr)	-	-	293.8	257.5	-	-	4.85	-
Explosives - TNT	(lb/hr)	-	-	43.04	ND	ND	ND	9.5×10^{-6}	ND
RDX	(lb/hr)	-	-	0.017	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.044	ND	ND	ND	2.5×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.009	0.006	NM	3.8×10^{-4}	4.8×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	1.6×10^{-5}	2.0×10^{-5}	NM
Cr	(lb/hr)	-	-	ND	ND	NM	6.1×10^{-5}	7.8×10^{-5}	NM
Cu	(lb/hr)	-	-	ND	ND	NM	1.1×10^{-4}	1.9×10^{-4}	NM
Pb	(lb/hr)	-	-	0.006	0.003	NM	3.0×10^{-4}	7.4×10^{-4}	NM
Zn	(lb/hr)	-	-	0.011	0.006	NM	5.4×10^{-4}	9.3×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	2.9×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	ND	1.1×10^{-6}
Air	(lb/hr)		-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.0%*	358.3	-	374.8
Water Vapor	(lb/hr)	3,866.9	-	-	-	10.7%*	239.1	-	257.4
Propane	(lb/hr)			-	-	-	-	-	-
Particulate	(lb/hr)	50.9	-	-	-	NM	2.7	-	4.0×10^{-3}
Carbon Monoxide	(lb/hr)	-	105.4	-	-	5.0ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	2.9
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.028
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	6.1×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	5.0ppmv*	0.034	-	ND
Total Mass Flow Rate	(lb/hr)	3,917.8	105.4	406.0	261.0	NM*	4,168.2	4.90	4,981.1
Average Temperature	(°F)	60	60	60	1,498	1,498	294	173	173
Average Volumetric Flow Rate	(dscfm)	870.6	15.4	-	-	NM*	875	-	1,050
Heating Value	(Btu/lb)	-	21,560	<50	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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PHONE 215-692-3030
TELEX 83-5348

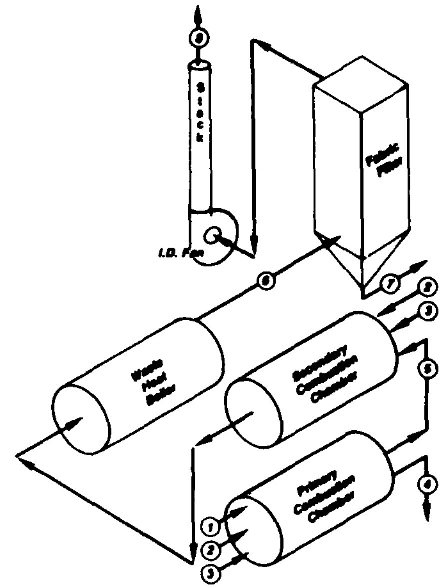
FIGURE A-7 MATERIAL BALANCE FOR 1-6 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0009
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	27.28	0.37	-	-	0.017	-
Hydrogen	(lb/hr)	-	-	1.70	0.07	-	-	0.003	-
Oxygen	(lb/hr)	-	-	-	-	12.0%*	526.1	-	645.3
Nitrogen	(lb/hr)	-	-	12.95	ND	81.2%*	3,569.8	0.037	3,904.7
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.002	-
Chlorine	(lb/hr)	-	-	0.04	ND	-	-	0.002	-
Moisture	(lb/hr)	-	-	77.0	-	-	-	-	-
Ash	(lb/hr)	-	-	85.45	98.56	-	-	3.97	-
Explosives - TNT	(lb/hr)	-	-	87.21	ND	ND	ND	ND	ND
RDX	(lb/hr)	-	-	0.031	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.067	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.005	ND	NM	2.0×10^{-4}	2.1×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	4.8×10^{-5}	2.1×10^{-5}	NM
Cr	(lb/hr)	-	-	0.003	ND	NM	7.1×10^{-5}	4.0×10^{-5}	NM
Cu	(lb/hr)	-	-	0.006	ND	NM	2.4×10^{-4}	1.2×10^{-4}	NM
Pb	(lb/hr)	-	-	0.021	ND	NM	4.0×10^{-3}	1.1×10^{-3}	NM
Zn	(lb/hr)	-	-	0.034	ND	NM	3.3×10^{-3}	8.5×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	8.1×10^{-5}	3.2×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	1.3×10^{-5}	5.2×10^{-5}
Air	(lb/hr)	4,568.3	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.8%*	491.4	-	496.3
Water Vapor	(lb/hr)	60.2	-	-	-	12.4%*	344.8	-	323.0
Propane	(lb/hr)	-	112.5	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.7	-	4.8×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	13ppmv*	0.030	-	0.033
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	4.8
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.046
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	9.4×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,628.5	112.5	291.8	99.0	NM*	4,933.8	4.03	5,374.2
Average Temperature	(°F)	60	60	60	1,643	1,643	316	212	212
Average Volumetric Flow Rate	(dscfm)	1,028.6	16.4	-	-	NM*	1,017	-	1,117
Heating Value	(Btu/lb)	-	21,560	2,364	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



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At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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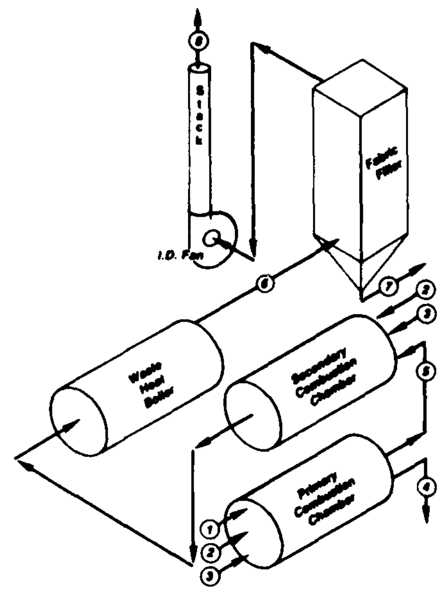
FIGURE A-8 MATERIAL BALANCE FOR 1-7 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0010
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	25.33	0.22	-	-	0.18	-
Hydrogen	(lb/hr)	-	-	1.61	ND	-	-	0.003	-
Oxygen	(lb/hr)	-	-	-	-	12.1%*	583.7	-	710.0
Nitrogen	(lb/hr)	-	-	10.49	0.04	81.6%*	4,046.8	0.003	4,234.9
Sulfur	(lb/hr)	-	-	ND	ND	-	-	ND	-
Chlorine	(lb/hr)	-	-	ND	0.07	-	-	0.001	-
Moisture	(lb/hr)	-	-	54.0	-	-	-	-	-
Ash	(lb/hr)	-	-	193.3	218.7	-	-	4.76	-
Explosives - TNT	(lb/hr)	-	-	68.17	5.6×10^{-4}	ND	ND	7.4×10^{-4}	ND
RDX	(lb/hr)	-	-	0.017	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.041	ND	ND	ND	1.2×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.007	ND	NM	2.7×10^{-4}	1.7×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	8.4×10^{-5}	3.0×10^{-5}	NM
Cr	(lb/hr)	-	-	0.004	ND	NM	9.9×10^{-5}	4.2×10^{-5}	NM
Cu	(lb/hr)	-	-	0.004	ND	NM	2.9×10^{-4}	1.3×10^{-4}	NM
Pb	(lb/hr)	-	-	0.022	ND	NM	5.2×10^{-3}	ND	NM
Zn	(lb/hr)	-	-	0.030	ND	NM	4.6×10^{-3}	1.3×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	1.3×10^{-4}	4.8×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	6.4×10^{-6}	7.2×10^{-6}	2.1×10^{-5}
Air	(lb/hr)	5,202.4	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.3%*	555.7	-	504.4
Water Vapor	(lb/hr)	68.5	-	-	-	10.9%*	347.3	-	322.8
Propane	(lb/hr)	-	131.3	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	2.6	-	6.7×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	20ppmv*	0.088	-	0.072
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	3.4
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.053
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.011	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	5,270.9	131.3	353.0	219.0	NM*	5,536.2	4.78	5,775.6
Average Temperature	(°F)	60	60	60	1,653	1,653	322	215	215
Average Volumetric Flow Rate	(dscfm)	1,171.3	19.2	-	-	NM*	1,015	-	1,208
Heating Value	(Btu/lb)	-	21,560	1,088	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



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At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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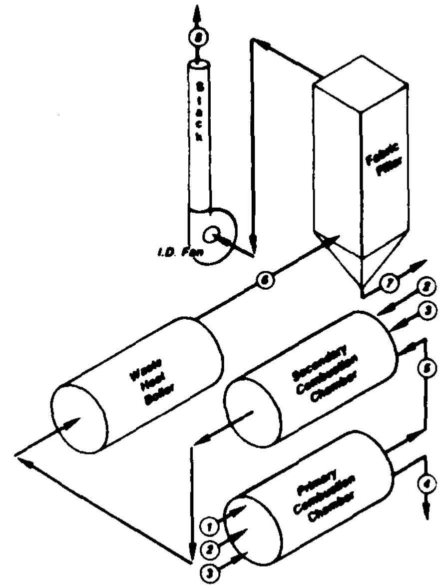
FIGURE A-9 MATERIAL BALANCE FOR 1-8 TEST BURN ON SADA SOIL

Scale	Project Number	Drawing Number
None		
Date 1/3/84	2281-01-02	MB-0011

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	37.33	0.52	-	-	0.017	-
Hydrogen	(lb/hr)	-	-	2.32	ND	-	-	0.001	-
Oxygen	(lb/hr)	-	-	-	-	13.4%*	556.3	-	683.8
Nitrogen	(lb/hr)	-	-	16.86	0.12	80.6%*	3,756.3	0.017	4,127.6
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	ND	ND	-	-	ND	-
Moisture	(lb/hr)	-	-	68.5	-	-	-	-	-
Ash	(lb/hr)	-	-	191.4	198.4	-	-	4.83	-
Explosives - TNT	(lb/hr)	-	-	88.53	ND	ND	ND	ND	ND
RDX	(lb/hr)	-	-	0.023	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	ND	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.062	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.009	ND	NM	2.2×10^{-4}	1.7×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	8.9×10^{-5}	2.6×10^{-5}	NM
Cr	(lb/hr)	-	-	0.003	ND	NM	9.1×10^{-5}	3.7×10^{-5}	NM
Cu	(lb/hr)	-	-	0.006	ND	NM	2.8×10^{-4}	1.2×10^{-4}	NM
Pb	(lb/hr)	-	-	0.024	ND	NM	5.9×10^{-3}	1.3×10^{-3}	NM
Zn	(lb/hr)	-	-	0.040	ND	NM	5.2×10^{-3}	1.3×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	1.4×10^{-4}	5.8×10^{-5}	ND
Hg	(lb/hr)	-	-	ND	ND	NM	ND	5.8×10^{-6}	3.7×10^{-5}
Air	(lb/hr)	4,789.4	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.0%*	548.4	-	541.9
Water Vapor	(lb/hr)	63.1	-	-	-	10.4%*	318.8	-	311.3
Propane	(lb/hr)	-	123.5	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.9	-	2.6×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	39ppmv*	0.413	-	0.390
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	4.2
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.06
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	7.8×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,852.5	123.5	405.1	199.0	NM*	5,182.1	4.87	5,669.3
Average Temperature	(°F)	60	60	60	1,644	1,644	318	214	214
Average Volumetric Flow Rate	(dscfm)	1,078.3	18.1	-	-	NM*	1,075	-	1,183
Heating Value	(Btu/lb)	-	21,560	1,874	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For IECS Incineration Test Burn
At Savanna Army Depot Activity (SADA)
Savanna, Illinois

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WEST CHESTER, PENNSYLVANIA 1938C
PHONE 215-692-3030
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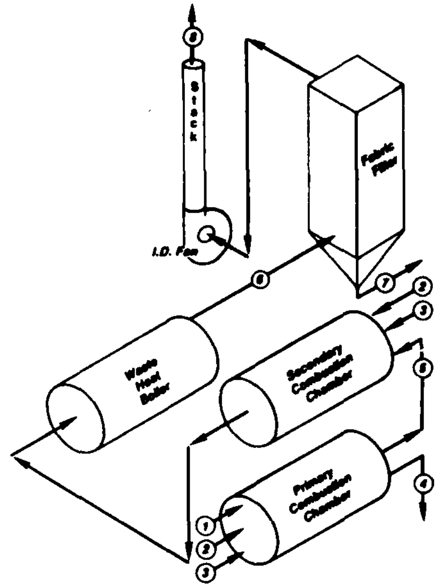
FIGURE A-10 MATERIAL BALANCE FOR 1-9 TEST BURN ON SADA SOIL

Scale	None	Project Number	Drawing Number
Date	1/3/84	2281-01-02	MB-0012

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	13.70	0.83	-	-	0.056	-
Hydrogen	(lb/hr)	-	-	1.74	0.08	-	-	0.003	-
Oxygen	(lb/hr)	-	-	-	-	13.5%*	485.6	-	655.8
Nitrogen	(lb/hr)	-	-	10.86	0.22	81.5%*	2,985.2	0.013	3.464.1
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.007	-
Chlorine	(lb/hr)	-	-	0.04	0.06	-	-	ND	-
Moisture	(lb/hr)	-	-	90.4	-	-	-	-	-
Ash	(lb/hr)	-	-	141.4	136.7	-	-	4.49	-
Explosives - TNT	(lb/hr)	-	-	30.59	9.1×10^{-4}	ND	ND	ND	ND
RDX	(lb/hr)	-	-	14.50	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	2.37	ND	ND	ND	7.4×10^{-6}	ND
Other	(lb/hr)	-	-	0.037	3.4×10^{-4}	ND	ND	2.0×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.026	0.019	NM	8.5×10^{-5}	1.1×10^{-3}	NM
Cd	(lb/hr)	-	-	ND	0.001	NM	2.9×10^{-5}	6.4×10^{-5}	NM
Cr	(lb/hr)	-	-	0.004	0.003	NM	2.3×10^{-5}	1.7×10^{-4}	NM
Cu	(lb/hr)	-	-	0.014	0.007	NM	7.5×10^{-5}	2.8×10^{-4}	NM
Pb	(lb/hr)	-	-	0.034	0.022	NM	3.1×10^{-4}	2.1×10^{-3}	NM
Zn	(lb/hr)	-	-	0.067	0.044	NM	5.2×10^{-4}	2.7×10^{-3}	NM
As	(lb/hr)	-	-	ND	0.001	NM	ND	1.1×10^{-4}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	ND	1.0×10^{-4}	7.1×10^{-5}
Air	(lb/hr)	3,781.0	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.0%*	348.1	-	334.0
Water Vapor	(lb/hr)	49.8	-	-	-	12.2%*	275.5	-	284.2
Propane	(lb/hr)	-	96.5	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	0.66	-	6.0×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	174ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.3
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.039
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	7.7×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	0.004	-	ND
Total Mass Flow Rate	(lb/hr)	3,830.8	96.5	305.8	138.0	NM*	4,095.1	4.57	4,739.4
Average Temperature	(°F)	60	60	60	1,266	1,266	285	183	183
Average Volumetric Flow Rate	(dscfm)	851.3	14.1	-	-	NM*	850	-	992
Heating Value	(Btu/lb)	-	21,560	1,138	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



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Savanna, Illinois

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FIGURE A-11 MATERIAL BALANCE FOR 2-1 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0013
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	17.17	1.40	-	-	0.015	-
Hydrogen	(lb/hr)	-	-	2.35	0.13	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	15.2%*	614.9*	-	782.8
Nitrogen	(lb/hr)	-	-	15.07	0.65	81.4%*	3,492.9	0.020	3,954.4
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	ND	0.06	-	-	0.001	-
Moisture	(lb/hr)	-	-	84.6	-	-	-	-	-
Ash	(lb/hr)	-	-	140.4	189.6	-	-	4.75	-
Explosives - TNT	(lb/hr)	-	-	24.21	0.004	ND	ND	2.0×10^{-5}	ND
RDX	(lb/hr)	-	-	21.64	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	3.03	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.154	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.022	0.031	NM	4.5×10^{-4}	2.2×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	0.001	NM	6.5×10^{-5}	2.7×10^{-5}	NM
Cr	(lb/hr)	-	-	0.004	0.004	NM	9.5×10^{-5}	2.9×10^{-5}	NM
Cu	(lb/hr)	-	-	0.011	0.007	NM	2.6×10^{-4}	1.0×10^{-4}	NM
Pb	(lb/hr)	-	-	0.029	0.029	NM	7.5×10^{-4}	8.1×10^{-4}	NM
Zn	(lb/hr)	-	-	0.063	0.036	NM	1.2×10^{-3}	8.1×10^{-4}	NM
As	(lb/hr)	-	-	ND	0.003	NM	ND	5.7×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	2.6×10^{-5}	4.5×10^{-6}	2.1×10^{-4}
Air	(lb/hr)	4,481.0	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	3.4%*	375.8	-	343.5
Water Vapor	(lb/hr)	59.0	-	-	-	9.8%*	278.6	-	276.4
Propane	(lb/hr)	-	107.6	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	2.2	-	1.8×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	160ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.9
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.037
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.016	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,540.0	107.6	308.8	192.0	NM*	4,764.4	4.79	5,359.0
Average Temperature	(°F)	60	60	60	1,233	1,233	292	183	183
Average Volumetric Flow Rate	(dscfm)	1,008.9	15.7	-	-	NM*	1,000	-	1,133
Heating Value	(Btu/lb)	-	21,560	964	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.

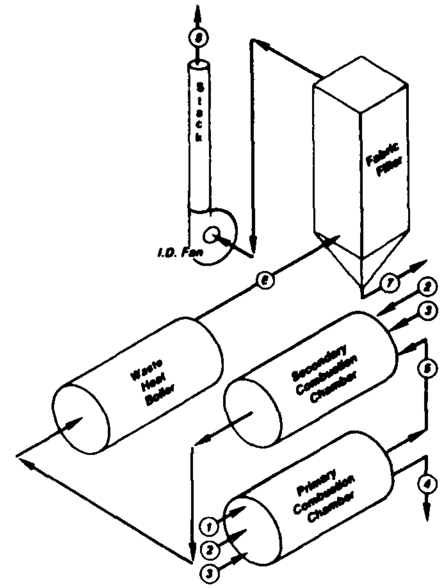

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FIGURE A-12 MATERIAL BALANCE FOR 2-2 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0014
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	15.25	2.07	-	-	0.021	-
Hydrogen	(lb/hr)	-	-	2.13	0.14	-	-	0.003	-
Oxygen	(lb/hr)	-	-	-	-	15.5%*	661.2	-	771.0
Nitrogen	(lb/hr)	-	-	8.8	1.53	81.5%*	3,795.3	ND	4,128.2
Sulfur	(lb/hr)	-	-	0.03	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	0.06	ND	-	-	0.001	-
Moisture	(lb/hr)	-	-	100.5	-	-	-	-	-
Ash	(lb/hr)	-	-	240.8	279.1	-	-	4.68	-
Explosives - TNT	(lb/hr)	-	-	17.92	0.008	ND	ND	ND	ND
RDX	(lb/hr)	-	-	13.09	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	1.86	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.071	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.033	0.027	NM	3.5×10^{-4}	2.4×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	0.002	NM	5.6×10^{-5}	2.8×10^{-5}	NM
Cr	(lb/hr)	-	-	0.006	0.006	NM	9.2×10^{-5}	4.1×10^{-5}	NM
Cu	(lb/hr)	-	-	0.014	0.008	NM	2.3×10^{-4}	1.1×10^{-4}	NM
Pb	(lb/hr)	-	-	0.048	0.037	NM	8.8×10^{-4}	9.9×10^{-4}	NM
Zn	(lb/hr)	-	-	0.054	0.037	NM	1.1×10^{-3}	9.4×10^{-4}	NM
As	(lb/hr)	-	-	ND	0.005	NM	6.5×10^{-5}	7.5×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	0.001	NM	7.4×10^{-5}	ND	3.0×10^{-4}
Air	(lb/hr)	4,890.2	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	3.0%*	400.0	-	363.9
Water Vapor	(lb/hr)	64.4	-	-	-	11.5%*	327.3	-	310.7
Propane	(lb/hr)	-	113.7	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	2.2	-	3.5×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	220ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.1
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.070
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.021	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	5.0ppmv*	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,954.6	113.7	400.7	283.0	NM*	5,186.0	4.71	5,575.0
Average Temperature	(°F)	60	60	60	1,241	1,241	300	193	193
Average Volumetric Flow Rate	(dscfm)	1,101.0	16.6	-	-	NM*	1,083	-	1,175
Heating Value	(Btu/lb)	-	21,560	582	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.

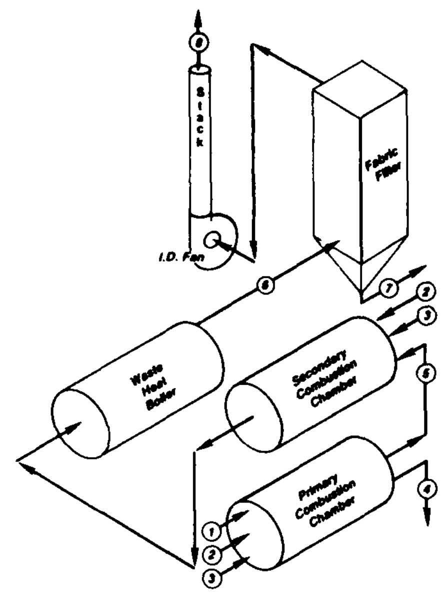

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FIGURE A-13 MATERIAL BALANCE FOR 2-3 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0015
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	15.25	0.67	-	-	0.018	-
Hydrogen	(lb/hr)	-	-	1.88	0.09	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	12.1%*	554.2	-	691.5
Nitrogen	(lb/hr)	-	-	7.25	ND	82.8%*	3,661.7	0.003	4,120.7
Sulfur	(lb/hr)	-	-	0.02	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	0.04	2.10	-	-	0.001	-
Moisture	(lb/hr)	-	-	86.7	-	-	-	-	-
Ash	(lb/hr)	-	-	158.9	172.1	-	-	4.36	-
Explosives - TNT	(lb/hr)	-	-	21.31	0.003	ND	ND	ND	ND
RDX	(lb/hr)	-	-	9.82	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	1.56	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.108	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.032	0.007	NM	9.1×10^{-5}	1.3×10^{-4}	NM
Cd	(lb/hr)	-	-	0.001	ND	NM	7.9×10^{-5}	ND	NM
Cr	(lb/hr)	-	-	0.005	ND	NM	2.9×10^{-5}	2.7×10^{-5}	NM
Cu	(lb/hr)	-	-	0.013	0.005	NM	1.1×10^{-4}	1.1×10^{-4}	NM
Pb	(lb/hr)	-	-	0.026	0.005	NM	9.6×10^{-4}	7.4×10^{-4}	NM
Zn	(lb/hr)	-	-	0.058	0.005	NM	1.7×10^{-3}	8.3×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	6.3×10^{-5}	4.2×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	4.5×10^{-6}	8.8×10^{-6}	1.8×10^{-4}
Air	(lb/hr)	4,712.8	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.1%*	475.4	-	432.2
Water Vapor	(lb/hr)	62.1	-	-	-	12.0%*	338.9	-	331.1
Propane	(lb/hr)	-	128.8	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.2	-	2.4×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	5ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.4
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.075
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.013	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	0.325	-	0.009
Total Mass Flow Rate	(lb/hr)	4,774.9	128.8	303.0	175.0	NM*	5,031.7	4.38	5,577.0
Average Temperature	(°F)	60	60	60	1,473	1,473	308	207	207
Average Volumetric Flow Rate	(dscfm)	1,061.1	18.8	-	-	NM*	1,042	-	1,167
Heating Value	(Btu/lb)	-	21,560	1,013	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.

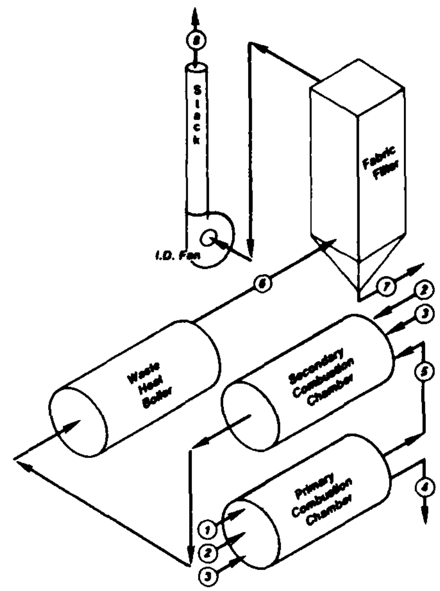

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FIGURE A-14 MATERIAL BALANCE FOR 2-4 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0016
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	13.86	1.48	-	-	0.024	-
Hydrogen	(lb/hr)	-	-	1.92	0.15	-	-	0.001	-
Oxygen	(lb/hr)	-	-	-	-	13.6%*	563.0	-	670.8
Nitrogen	(lb/hr)	-	-	7.32	0.28	82.3%*	3,728.3	0.016	4,020.9
Sulfur	(lb/hr)	-	-	0.03	ND	-	-	0.003	-
Chlorine	(lb/hr)	-	-	0.102	ND	-	-	0.002	-
Moisture	(lb/hr)	-	-	92.8	-	-	-	-	-
Ash	(lb/hr)	-	-	205.1	248.9	-	-	6.41	-
Explosives - TNT	(lb/hr)	-	-	15.52	0.001	ND	ND	ND	ND
RDX	(lb/hr)	-	-	10.24	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	1.81	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.067	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.025	0.105	NM	7.2×10^{-5}	4.6×10^{-4}	NM
Cd	(lb/hr)	-	-	0.001	ND	NM	4.5×10^{-5}	6.2×10^{-5}	NM
Cr	(lb/hr)	-	-	0.006	0.004	NM	2.4×10^{-5}	9.0×10^{-5}	NM
Cu	(lb/hr)	-	-	0.012	0.009	NM	6.9×10^{-5}	2.2×10^{-4}	NM
Pb	(lb/hr)	-	-	0.031	0.025	NM	5.5×10^{-4}	2.7×10^{-3}	NM
Zn	(lb/hr)	-	-	0.049	0.068	NM	8.0×10^{-4}	2.5×10^{-3}	NM
As	(lb/hr)	-	-	ND	0.002	NM	ND	1.5×10^{-4}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	1.2×10^{-5}	3.6×10^{-5}	2.3×10^{-4}
Air	(lb/hr)	4,816.8	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	4.1%*	468.7	-	445.8
Water Vapor	(lb/hr)	63.4	-	-	-	12.4%*	348.6	-	336.5
Propane	(lb/hr)	-	131.9	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.3	-	6.3×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	14ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.6
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.080
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.017	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	0.052	-	ND
Total Mass Flow Rate	(lb/hr)	4,880.2	131.9	348.9	251.0	NM*	5,110.0	6.46	5,475.7
Average Temperature	(°F)	60	60	60	1,451	1,451	308	201	201
Average Volumetric Flow Rate	(dscfm)	1,084.5	19.3	-	-	NM*	1,058	-	1,142
Heating Value	(Btu/lb)	-	21,560	729	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis

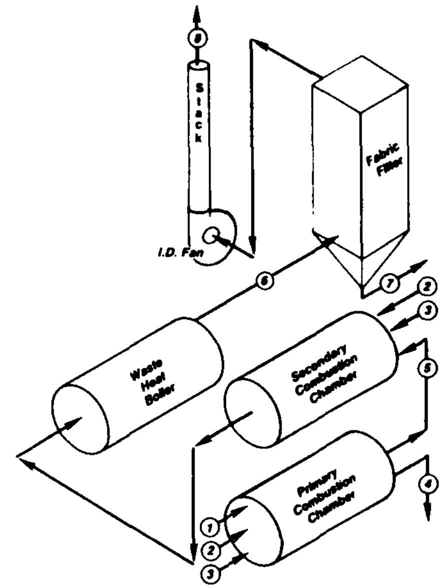

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FIGURE A-15 MATERIAL BALANCE FOR 2-5 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0017
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	16.02	0.60	-	-	0.023	-
Hydrogen	(lb/hr)	-	-	2.0	0.02	-	-	0.004	-
Oxygen	(lb/hr)	-	-	-	-	12.0%*	537.3	-	657.7
Nitrogen	(lb/hr)	-	-	7.65	0.51	82.2%*	3,039.0	0.006	3,611.2
Sulfur	(lb/hr)	-	-	0.03	ND	-	-	0.003	-
Chlorine	(lb/hr)	-	-	1.12	0.05	-	-	0.002	-
Moisture	(lb/hr)	-	-	112.2	-	-	-	-	-
Ash	(lb/hr)	-	-	238.9	229.7	-	-	4.22	-
Explosives - TNT	(lb/hr)	-	-	24.61	ND	ND	ND	ND	ND
RDX	(lb/hr)	-	-	10.74	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	2.06	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.083	ND	ND	ND	1.0×10^{-5}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.036	0.030	NM	2.4×10^{-4}	3.1×10^{-4}	NM
Cd	(lb/hr)	-	-	0.001	0.001	NM	4.2×10^{-5}	1.7×10^{-5}	NM
Cr	(lb/hr)	-	-	0.007	0.004	NM	5.2×10^{-5}	4.7×10^{-5}	NM
Cu	(lb/hr)	-	-	0.018	0.013	NM	1.1×10^{-4}	1.1×10^{-4}	NM
Pb	(lb/hr)	-	-	0.049	0.035	NM	6.3×10^{-4}	5.1×10^{-4}	NM
Zn	(lb/hr)	-	-	0.064	0.039	NM	1.1×10^{-3}	6.8×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	ND	3.0×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	5.6×10^{-6}	2.4×10^{-5}	6.4×10^{-5}
Air	(lb/hr)	3,823.3	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	5.8%*	302.5	-	324.5
Water Vapor	(lb/hr)	50.4	-	-	-	13.5*	286.7	-	300.8
Propane	(lb/hr)	-	108.8	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.6	-	6.3×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	31ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.7
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.076
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	8.8×10^{-3}	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	3,873.7	108.8	415.6	231.0	NM*	4,167.1	4.26	4,896.0
Average Temperature	(°F)	60	60	60	1,454	1,454	296	179	179
Average Volumetric Flow Rate	(dscfm)	860.8	15.9	-	-	NM*	867	-	1,025
Heating Value	(Btu/lb)	-	21,560	750	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis

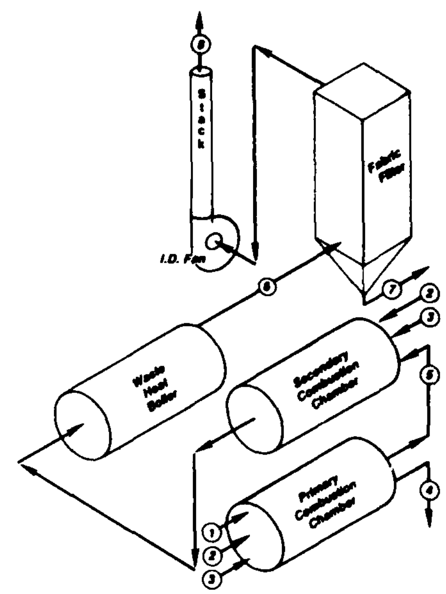

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FIGURE A-16 MATERIAL BALANCE FOR 2-6 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0018
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	15.13	0.48	-	-	0.020	-
Hydrogen	(lb/hr)	-	-	1.88	ND	-	-	0.002	-
Oxygen	(lb/hr)	-	-	-	-	11.8%*	410.5	-	557.9
Nitrogen	(lb/hr)	-	-	9.99	ND	82.2%*	3,027.5	0.002	3,555.7
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.002	-
Chlorine	(lb/hr)	-	-	0.19	1.01	-	-	0.002	-
Moisture	(lb/hr)	-	-	89.4	-	-	-	-	-
Ash	(lb/hr)	-	-	154.0	154.5	-	-	3.76	-
Explosives - TNT	(lb/hr)	-	-	19.80	0.001	ND	ND	ND	ND
RDX	(lb/hr)	-	-	11.06	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	1.78	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.086	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.026	0.008	NM	1.1×10^{-4}	2.8×10^{-4}	NM
Cd	(lb/hr)	-	-	ND	ND	NM	5.1×10^{-5}	2.6×10^{-5}	NM
Cr	(lb/hr)	-	-	0.005	ND	NM	3.4×10^{-5}	5.7×10^{-5}	NM
Cu	(lb/hr)	-	-	0.013	0.004	NM	9.7×10^{-5}	1.4×10^{-4}	NM
Pb	(lb/hr)	-	-	0.028	0.007	NM	1.8×10^{-3}	1.1×10^{-3}	NM
Zn	(lb/hr)	-	-	0.056	0.006	NM	1.1×10^{-3}	1.1×10^{-3}	NM
As	(lb/hr)	-	-	ND	ND	NM	2.5×10^{-6}	4.5×10^{-5}	ND
Hg	(lb/hr)	-	-	4.7×10^{-4}	ND	NM	ND	2.5×10^{-5}	1.2×10^{-4}
Air	(lb/hr)	3,893.7	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.0%*	437.7	-	434.5
Water Vapor	(lb/hr)	51.3	-	-	-	13.5%*	339.3	-	341.6
Propane	(lb/hr)	-	123.8	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.2	-	5.5×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	5.0ppmv*	0.018	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	2.3
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.069
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.017	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	3,945.0	123.8	303.4	156.0	NM*	4,216.2	3.79	4,892.1
Average Temperature	(°F)	60	60	60	1,656	1,656	298	194	194
Average Volumetric Flow Rate	(dscfm)	876.7	18.1	-	-	NM*	858	-	1,008
Heating Value	(Btu/lb)	-	21,560	1,172	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.

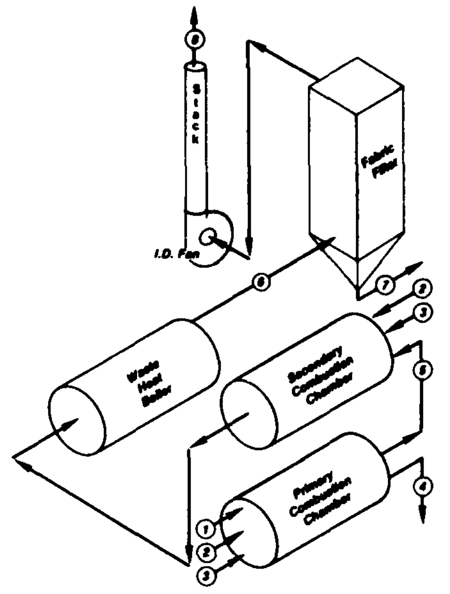

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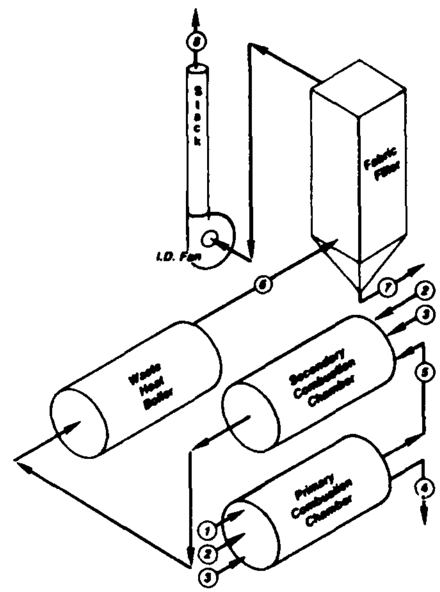
FIGURE A-17 MATERIAL BALANCE FOR 2-7 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0019
Date 1/3/84		

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	14.02	0.28	-	-	0.007	-
Hydrogen	(lb/hr)	-	-	1.92	0.08	-	-	0.001	-
Oxygen	(lb/hr)	-	-	-	-	11.8%*	435.1	-	567.7
Nitrogen	(lb/hr)	-	-	7.46	0.26	82.2*	3,401.8	0.003	3,830.0
Sulfur	(lb/hr)	-	-	ND	ND	-	-	0.001	-
Chlorine	(lb/hr)	-	-	0.10	0.04	-	-	ND	-
Moisture	(lb/hr)	-	-	96.6	-	-	-	-	-
Ash	(lb/hr)	-	-	206.1	196.3	-	-	2.97	-
Explosives - TNT	(lb/hr)	-	-	15.63	0.003	ND	ND	ND	ND
RDX	(lb/hr)	-	-	8.45	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	1.47	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.139	ND	ND	ND	6.8×10^{-6}	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.027	0.006	NM	1.2×10^{-6}	1.4×10^{-4}	NM
Cd	(lb/hr)	-	-	0.003	ND	NM	6.0×10^{-5}	2.0×10^{-5}	NM
Cr	(lb/hr)	-	-	0.005	ND	NM	1.9×10^{-6}	3.3×10^{-5}	NM
Cu	(lb/hr)	-	-	0.011	0.004	NM	6.8×10^{-5}	9.5×10^{-5}	NM
Pb	(lb/hr)	-	-	0.026	ND	NM	1.3×10^{-3}	8.9×10^{-4}	NM
Zn	(lb/hr)	-	-	0.036	0.005	NM	1.2×10^{-3}	8.3×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	6.9×10^{-6}	3.6×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	ND	1.0×10^{-5}	1.8×10^{-4}
Air	(lb/hr)	4,325.1	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	6.0%*	488.9	-	496.1
Water Vapor	(lb/hr)	57.0	-	-	-	14.0%*	348.7	-	353.7
Propane	(lb/hr)	-	138.2	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	0.77	-	3.1×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	5.0ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.7
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.069
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.019	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,382.1	138.2	352.0	197.0	NM*	4,675.3	2.98	5,249.3
Average Temperature	(°F)	60	60	60	1,642	1,642	308	203	203
Average Volumetric Flow Rate	(dscfm)	973.8	20.2	-	-	NM*	958	-	1,083
Heating Value	(Btu/lb)	-	21,560	807	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

WESTON DESIGNERS CONSULTANTS
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WEST CHESTER, PENNSYLVANIA 19380
PHONE 215-692-3030
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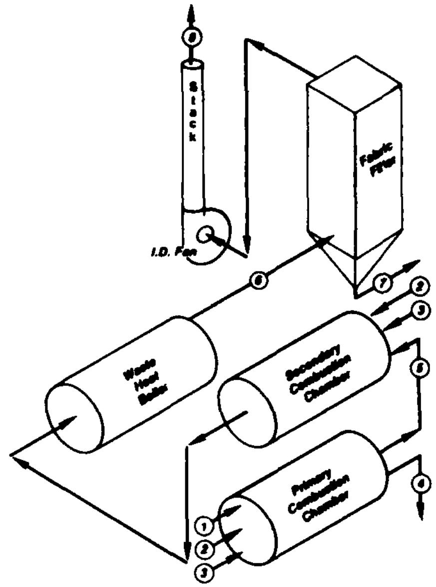
FIGURE A-18 MATERIAL BALANCE FOR 2-8 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None		
Date 1/3/84	2281-01-02	MB-0020

Stream Number		1	2	3	4	5	6	7	8
Description		Combustion Air (Total)	Fuel (Total)	Soil Feed	Kiln Ash	Secondary Chamber Inlet	Fabric Filter Inlet	Fabric Filter Ash	Stack Exhaust
Carbon	(lb/hr)	-	-	18.24	0.86	-	-	-	-
Hydrogen	(lb/hr)	-	-	2.47	0.17	-	-	-	-
Oxygen	(lb/hr)	-	-	-	-	13.2%*	488.1	-	628.2
Nitrogen	(lb/hr)	-	-	14.26	1.49	82.0%*	3,692.8	-	3,973.0
Sulfur	(lb/hr)	-	-	0.03	ND	-	-	-	-
Chlorine	(lb/hr)	-	-	ND	ND	-	-	-	-
Moisture	(lb/hr)	-	-	108.8	-	-	-	-	-
Ash	(lb/hr)	-	-	225.4	273.4	-	-	-	-
Explosives - TNT	(lb/hr)	-	-	16.23	ND	ND	ND	ND	ND
RDX	(lb/hr)	-	-	15.26	ND	ND	ND	ND	ND
HMX	(lb/hr)	-	-	2.43	ND	ND	ND	ND	ND
Other	(lb/hr)	-	-	0.097	ND	ND	ND	ND	ND
Heavy Metals - Ba	(lb/hr)	-	-	0.030	0.009	NM	2.4×10^{-5}	1.6×10^{-4}	NM
Cd	(lb/hr)	-	-	0.001	ND	NM	1.2×10^{-4}	2.6×10^{-5}	NM
Cr	(lb/hr)	-	-	0.007	ND	NM	2.6×10^{-5}	3.3×10^{-5}	NM
Cu	(lb/hr)	-	-	0.015	0.005	NM	8.4×10^{-5}	9.2×10^{-5}	NM
Pb	(lb/hr)	-	-	0.038	0.010	NM	1.6×10^{-3}	7.5×10^{-4}	NM
Zn	(lb/hr)	-	-	0.059	0.008	NM	1.9×10^{-3}	7.5×10^{-4}	NM
As	(lb/hr)	-	-	ND	ND	NM	9.8×10^{-5}	6.3×10^{-5}	ND
Hg	(lb/hr)	-	-	0.001	ND	NM	3.2×10^{-6}	1.3×10^{-5}	4.9×10^{-4}
Air	(lb/hr)	4,759.3	-	-	-	-	-	-	-
CO_2	(lb/hr)	-	-	-	-	4.8%*	517.4	-	469.8
Water Vapor	(lb/hr)	62.7	-	-	-	14.8%*	396.1	-	376.6
Propane	(lb/hr)	-	146.2	-	-	-	-	-	-
Particulate	(lb/hr)	-	-	-	-	NM	1.2	-	1.4×10^{-3}
Carbon Monoxide	(lb/hr)	-	-	-	-	5.0ppmv*	ND	-	ND
Oxides of Nitrogen	(lb/hr)	-	-	-	-	NM	NM	-	1.0
Sulfur Dioxide	(lb/hr)	-	-	-	-	NM	NM	-	0.11
Hydrogen Chloride	(lb/hr)	-	-	-	-	NM	0.025	-	NM
Hydrocarbons	(lb/hr)	-	-	-	-	ND	ND	-	ND
Total Mass Flow Rate	(lb/hr)	4,822.0	146.2	403.4	276.0	NM*	5,095.6	4.18	5,448.7
Average Temperature	(°F)	60	60	60	1,641	1641	315	204	204
Average Volumetric Flow Rate	(dscfm)	1,071.6	21.4	-	-	NM*	1,042	-	1,125
Heating Value	(Btu/lb)	-	21,560	858	0	-	-	0	-

Notes:
ND - Not Detected
NM - Not Measured

* - Flue gas volumetric flow rate was not measured at the secondary chamber inlet since isokinetic conditions could not be achieved. Values are presented as volumetric percentages or ppm's on a volume or weight basis.



For: IECS Incineration Test Burn
At: Savanna Army Depot Activity (SADA)
Savanna, Illinois

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FIGURE A-19 MATERIAL BALANCE FOR 2-9 TEST BURN ON LAAP SOIL

Scale	Project Number	Drawing Number
None	2281-01-02	MB-0021
Date 1/3/84		

APPENDIX B

ANALYSIS TECHNIQUES

WESTON

APPENDIX B

ANALYSIS TECHNIQUES

The two analysis techniques applied to the raw data base were multiple linear regression and balanced two-way factorial.

B.1 Two-way factorial. The balanced two-way factorial requires a balanced matrix of the controlled variables, in this case soil feed rate and kiln temperature (afterburner temperature was controlled, but was directly related to kiln temperature), and equal observations in each cell. A 3 by 3 matrix was developed for the trial burns with two observations in each cell - the SADA soil and the LAAP soil. The raw test data were analyzed using a Tektronix 4054 microcomputer and associated plot-50 analysis software.[8,9] The critical result of this analysis was the relationship of CO, soil feed rate, and kiln temperature. Additionally, the system software allowed the identification of data outliers.

An important consideration of any data set is the repeatability of the data and the identification of outliers. A common means of designating repeatability is fitting the data into a "box and whisker" plot which graphically shows the median, interquartile range*, extremes and symmetry of variable values. Refer to Figures B-1 through B-23 at the end of this appendix.

The program categorized the data values at the ends of the distribution into three groups:

(a) Those values within 1.5 Q-spreads of the upper or lower quartile. The two outermost of these values define the ends of the whiskers and are called adjacent values.

(b) Those values between 1.5 and 3 Q-spreads from the upper or lower quartile, called outside values. Each outside value is represented on the plot by a cross.

(c) Those values more than 3 Q-spreads from the upper or lower quartile, called far outside values. Each far outside value is represented on the plot by a square.

*The length of the box - the interquartile range - is called the Q-spread.

The relatively few identified outside and far outside values demonstrate:

(a) Consistency of soil preparation.
(b) Even distribution of constituents in the soil in the areas from which the feed was collected.
(c) High confidence in the sampling and analysis.

B.2 Multiple regression. The multiple regression analysis reduces the data to a linear equation as discussed in Section 9, which can be used to predict important response variables. The use of stepwise analysis allows the determination of regression coefficients, while interactively specifying the system equations via addition or deletion of singular variables.

As with any statistical tool, there are limitations of the multiple regression technique; however, these limitations can be overcome as discussed in the following subsections.

In the case of a nonlinear relationship between the input variables and the response variable, the alternative procedures include:

(a) Reduce the span of the analysis of the response variable until an acceptable correlation is found.
(b) Transform the response variable, e.g.,
$$LN(Y) = a + b_n X_n$$
(c) Weigh each of the input variables, e.g.,
$$Y = a + b_1 w_1 x_1 + b_2 w_2 x_2 + \ldots + b_n w_n x_n$$
(d) Use multiple regression as the initial iterative step followed by analysis by a different technique to finalize the correlation.
(e) Utilize the linear relationship in an estimation capacity recognizing there may be variance from the true relationship.

In order to determine the exact relationship between the variables over a useful span, the second, third, and fourth procedures would have to be employed following each of a series of trial operations similar to the test recently completed. This would be very costly and time consuming, and is impractical for this analysis.

A correlation which minimizes the variance from the true relationship could be developed using the second, third, and fourth procedures to analyze the data recorded from the completed test. Although this procedure could extract some otherwise indistinguishable relationships from the data, it would be very time consuming and is also not within the scope of this project.

The method generally accepted as the initial iterative step is a combination of the first and fifth procedures, whereby a basic correlation would be developed followed by the determination of its useful span. This data analysis is based on this method.

One advantage of multiple regression is the ability to simultaneously analyze unlimited numbers of input variables. When computers are used to perform the analysis the number of input variables may be limited by the software or hardware of the computer. WESTON has utilized software and hardware which can analyze all of the test variables simultaneously. A Tektronix 4054 microcomputer and its associated plot-50 statistics: Multiple Linear Regression software package[8] was utilized to perform the computations necessary for the iterative steps.

It should be noted, however, that the number of calculations required to solve the equations used in the analysis increases factorially as each additional variable is included in the analysis. Computer time should be a consideration when deciding the number of input variables to be analyzed.

As the number of input variables increases, so does the probability of coincidence (i.e., an input variable may not actually be correlated to the response variable other than by coincidence). While only additional testing can prove correlation by coincidence, this factor can be discounted based on scientific judgment and adjustment to the response parameters.

B.3 <u>Final solution</u>. Application of both the two-way factorial and multiple regression packages yielded identification of outliers, ANOVA tables, regression tables, plots of residuals, and summary of successive significance of input variables.

The ANOVA table includes the following information*:

(a) SS - The sum of squares of the deviations.
(b) MS - The mean square, which is SS/df.
(c) df - Degress of freedom.
(d) F - The value of the F statistic, such that F = (Regression SS/df)/(Residual SS/dt).

*A glossary of statistical terms is provided in Table B-1 at the end of this appendix.

(e) Pr > F - The probability that a value of a random variable having the F-distribution takes on a value greater than the value of F. A value less than 0.1 indicates significance of the F statistic and, consequently, the overall system equations. Statisticians normally associate a Pr > F value of less than 0.05 with a very significant hypothesis.

(f) R-square - The coefficient of determination, which gives a measure of the linear association between the dependent variable and the set of independent variables. The R-square value indicates the significance of the model (or variable) where 1.0 equals 100 percent.

(g) Rbar-square - An adjustment to R-square for its tendency to increase as the number of independent variables increases. The adjustment is

$$1 - ((\Sigma res^2/(n-p))/(\Sigma(Y_j-\bar{Y})^2/(n-1))$$

(h) Root of Residual MS - The square root of the residual mean square.

The regression table includes the following information for each variable coefficient in the regression equation:

(a) Estimate - The estimated value of the coefficient.

(b) Standard Error - The standard error of the regression coefficient estimates.

(c) t - The value of the t-statistic, which is, for each estimate:

Estimate/Standard Error.

(d) Pr > ABS(t) - The probability that the absolute value of a random variable having the t-distribution takes on a value greater than the absolute value of t. A value of Pr > ABS(t) of less than 0.1 indicates significance of the t-static and, consequently, the estimated value of the coefficient. Statisticians normally associate a Pr > ABS(t) value of less than 0.05 with a very significant hypothesis.

The value of the Durbin-Watson statistic can be used to test whether the residuals are uncorrelated.

The plot of residuals indicates the difference between the measured values and the fitted values in graphical form, observations for which the residual is greater than one standard deviation are labeled on the plot.

For each iterative step, both the forward and backward stepping techniques are applied. The forward stepping analysis allows the statistician to select a variable to be added to the model, or the Tektronix 4054 will automatically select the variable which is most significant of those remaining, and add it to the model. The forward stepping technique determines the marginal contribution of each variable added. The backward stepping technique includes all of the selected variables to determine interrelationships between the input variables and to calculate an overall system equation.

The iteration process was continued until significant and practical system equations were developed. System equations were rejected if:

(a) The probability that the hypothesized equation was not correct exceeded 10 percent ($Pr > F$ was not less than 0.1).
(b) The significance of the equation did not approach 90 percent (R-square did not approach 0.9) or too many variables were required to reach this level.
(c) Separation of observations by soil type was required.
(d) The range of response variables for which a correlation could be developed was too small.
(e) Transformation of the data was required.

Input variables were eliminated from the system equations based on:

(a) Insignificant marginal contribution to the model determined by the R-squared value computed during the forward stepping process.
(b) A high probability that the hypothesized variable coefficient was not correct as determined by the analysis of the t statistic of the regression table ($Pr > ABS(t)$).
(c) Scientific and intuitive reasoning suggesting alternative correlations between the input variable in question and the response variable.
(d) The coefficient of the input variable was corrective.

The system model is a set of simple linear equations which describe certain system parameters and enable the projection of responses to be calculated based on measureable input data. The use of the system model can vary from a basis for an environmental permit application to becoming an aid for system design or ultimately a dynamic model. The intended use of the system equations for the purposes of this report is the projection of system requirements to aid in future technical and economic feasibility analyses of incineration as a decontamination method for explosives contaminated soils as well as system design.

TABLE B-1. GLOSSARY OF STATISTICAL TERMINOLOGY

Adjacent value - The furthest data value from the median that is still within 1.5 Q-spreads of the upper or lower quartile.

ANOVA table - Analysis of Variance table. The ANOVA table provides a useful summary of calculations about variability. It contains sums of squares and mean square estimates of the two sources of variability (regression and residuals) and their respective degrees of freedom, the value of the F-statistic, R-square, Rbar-square, and Pr F.

Censored data - Data falling outside the interval of measurement.

Dependent variable - The variable to be described in terms of others in the regression model.

Far outside value - A data value lying more than 3 Q-spreads beyond the upper or lower quartile.

Fitted values - Values of the dependent variable calculated from the regression equation and existing values of the independent variables in the model.

Independent variable - A variable used, possibly in conjunction with other variables, to describe a given dependent variable.

Least squares - The least-squares method is a method of line-fitting that determines parameter values to minimize the sum of squares of the deviations (lengths of the vertical line segments) from the observed data points to the line.

Mean - The arithmetic average of a column of data.

Median - The middle value in an ordered column of data; that is, the data value half way between the top and bottom.

Missing-data value - A numeric constant used as a place holder for data missing from the data set.

Mode - The value that occurs most often in a data set.

Model - A statistical equation that expresses the supposed (often only approximate) functional relation between variables.

TABLE B-1. (Continued)

Observation - A row of data in a data file.

Outliers - A pair of values being plotted is an outlier if the value for one of the variables falls outside a specified number of standard deviations from its mean. (Outliers for an index plot are defined only on the variable for the y axis.) More generally, any discrepant value.

Outside value - A data value lying between 1.5 and 3 Q-spreads beyond the upper or lower quartile.

Pr>ABS(t) - The probability that the absolute value of a random variable having the the t distribution takes on a value greater than the value of the t statistic calculated as part of the regression table.

Pr>F - The probability that a random variable having the F distribution takes on a value greater than the value of the F statistic calculated as part of the ANOVA table.

Predicted value - The value of the dependent variable calculated from the regression equation and new values of the independent variables in the model.

Probability plot - Values of a variable plotted on a probability scale. The horizontal scale refers to percentages of the probability distribution. The vertical scale, an ordinary arithmetic scale, is for the variable. The degree to which the data lies on a straight line indicates the closeness of fit of the sample distribution to the theoretical distribution.

Q-spread - The distance between the quartiles.

Raw data - The set of data values read from a data file and used directly by an algorithm, as opposed to a set of data read from a data file and manipulated by transformations before being used.

Regression coefficient - The coefficients of the equation used in a regression model.

Regression table - A table that provides a summary of regression calculations. It contains parameter estimates, the standard error of the estimates, the value of the t statistic, the t probability, and the mean and standard deviation of the dependent variable.

TABLE B-1. (Continued)

Residuals - The difference between the actual values and the fitted values of the dependent variable (see definition for e).

Resistant line - A line fitted through the data by resistant techniques rather than by least squares. The resistant line is less sensitive to the effects of outliers, especially when the outliers are near the extremes of the data.

Response variable - Another name for a dependent variable.

Scatter plot - A scatter plot is a graphical display showing how two variables are related to each other.

Standard deviation - The square root of the variance.

Standard error of the mean - The standard deviation of a set of sample means.

Variance - The average of the sum of the squares of the deviation of each observation from the mean of the variable.

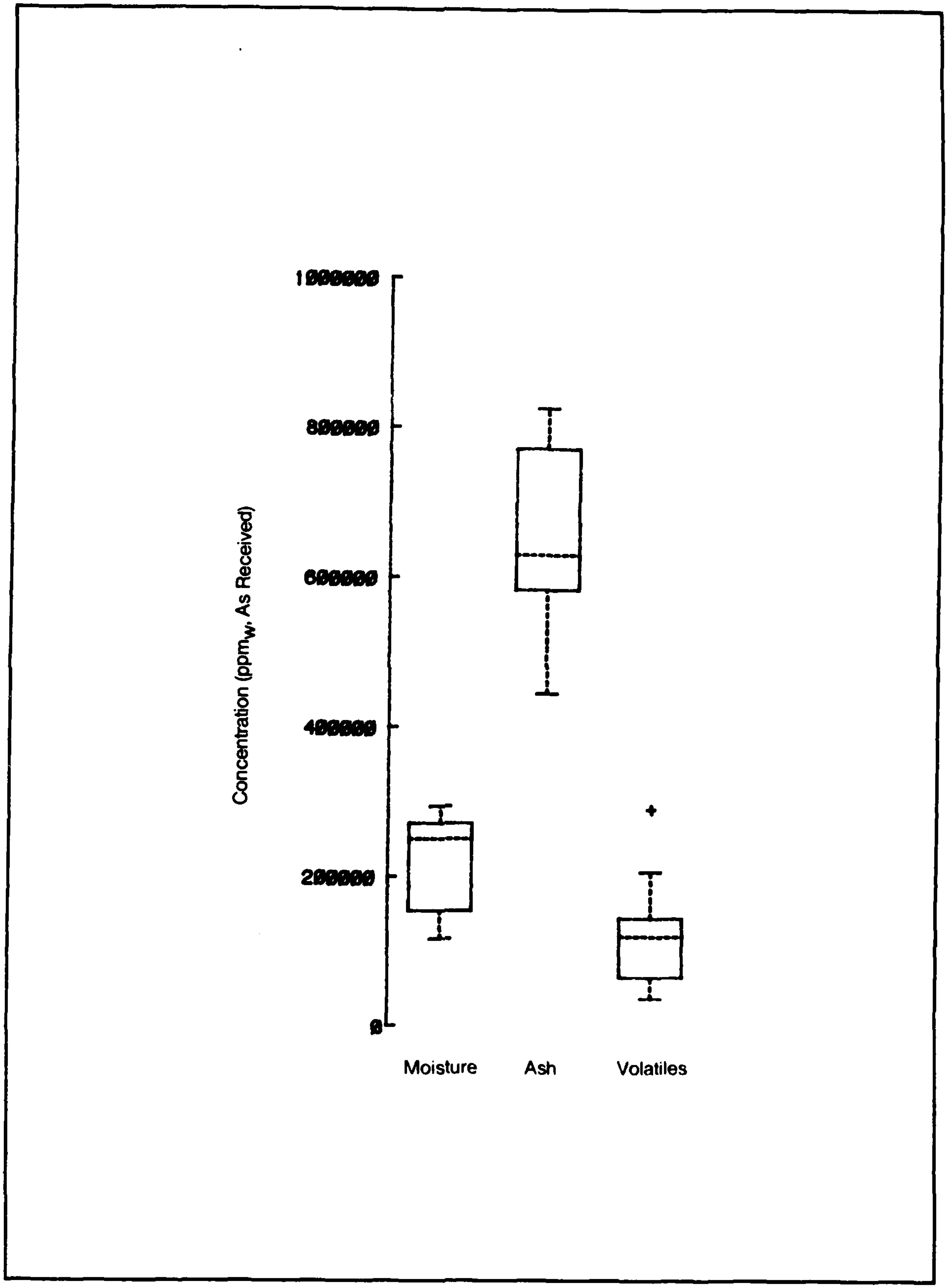

FIGURE B-1 SOIL MOISTURE, ASH, AND VOLATILES CONCENTRATION

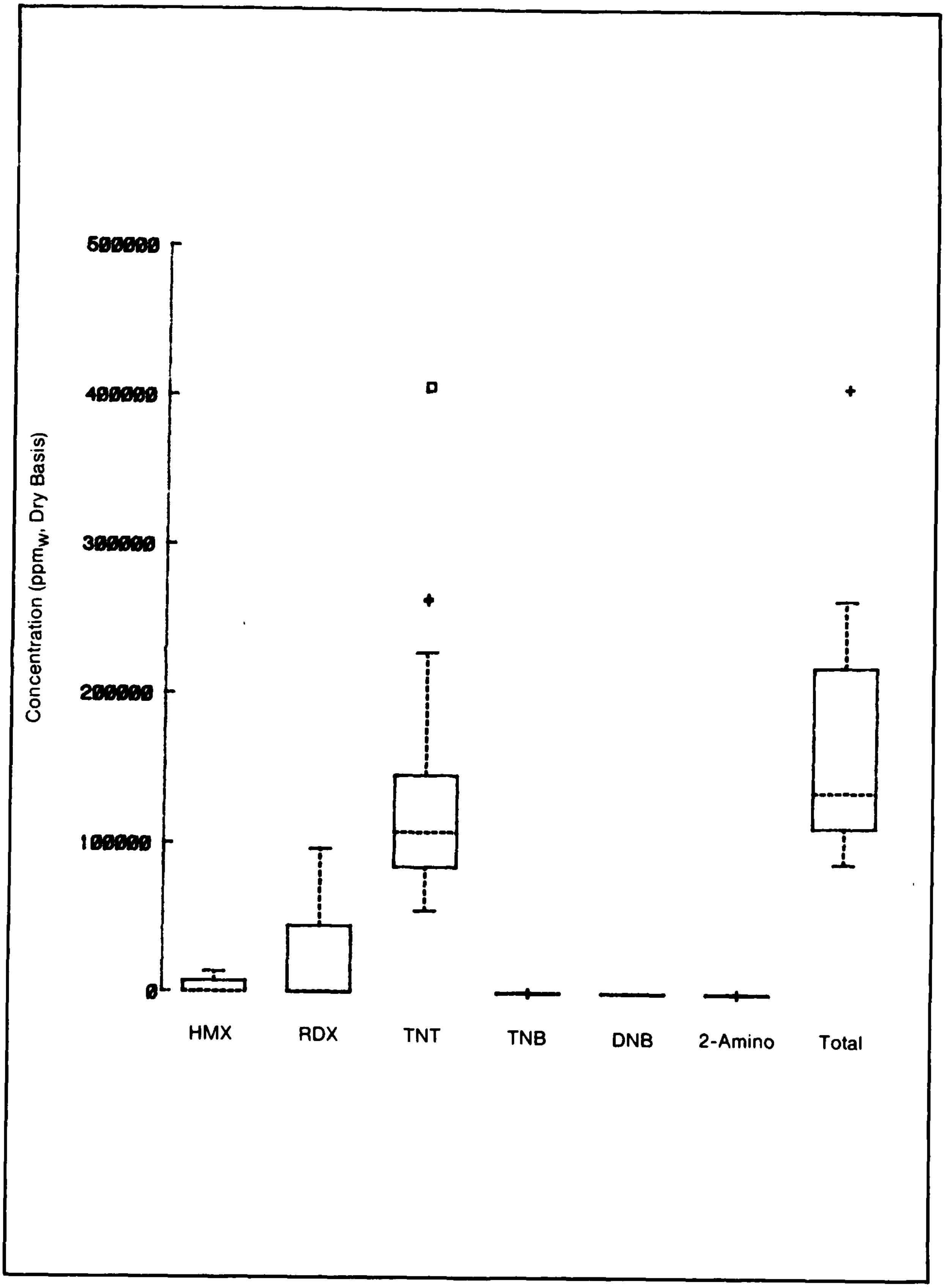

FIGURE B-2 EXPLOSIVE CONCENTRATIONS IN SOIL FEED

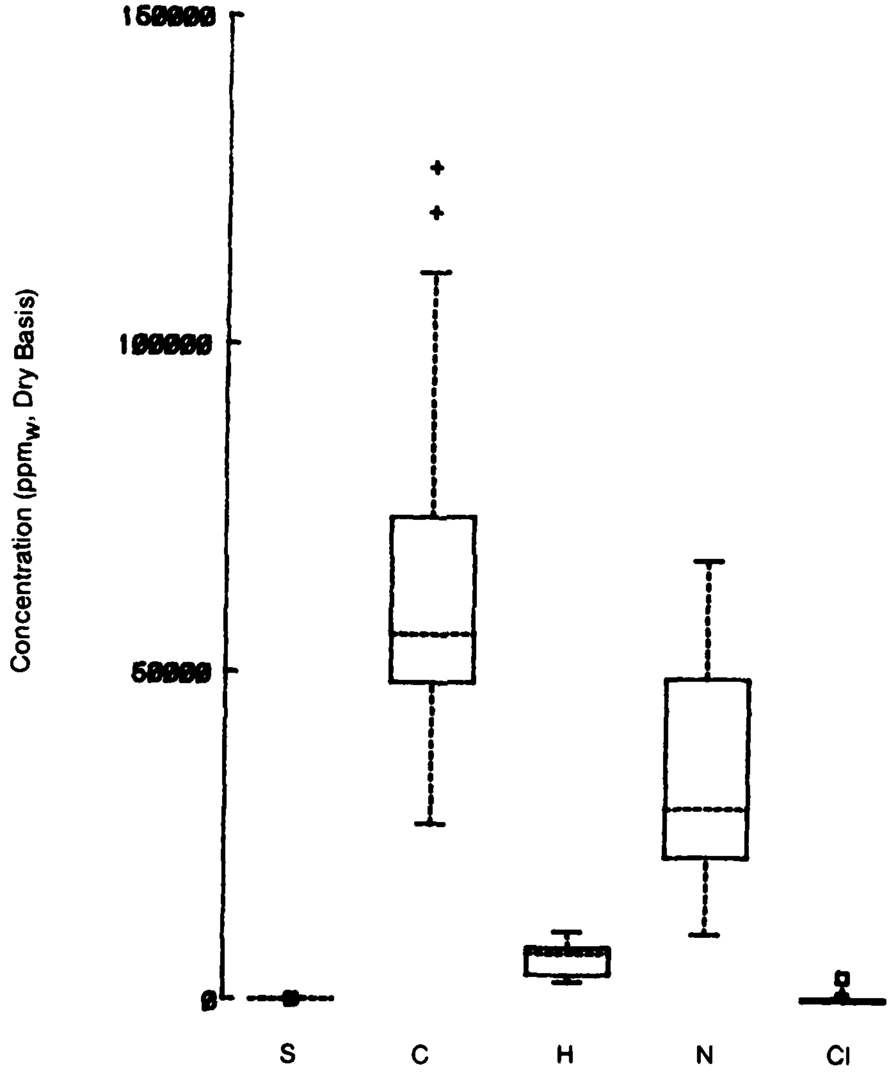

FIGURE B-3 SOIL FEED ELEMENTAL CONCENTRATIONS

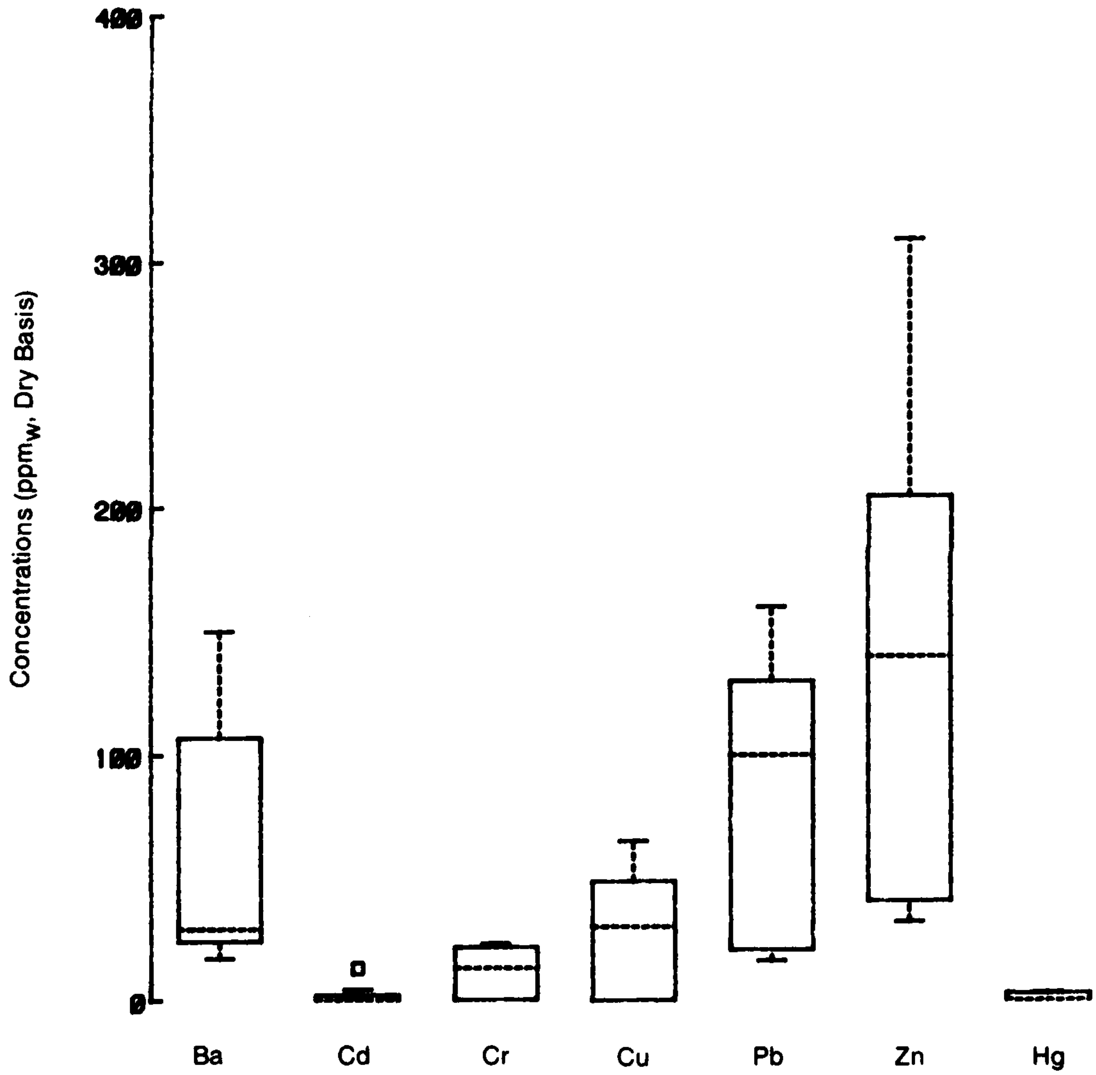

FIGURE B-4 SOIL FEED HEAVY METAL CONCENTRATIONS

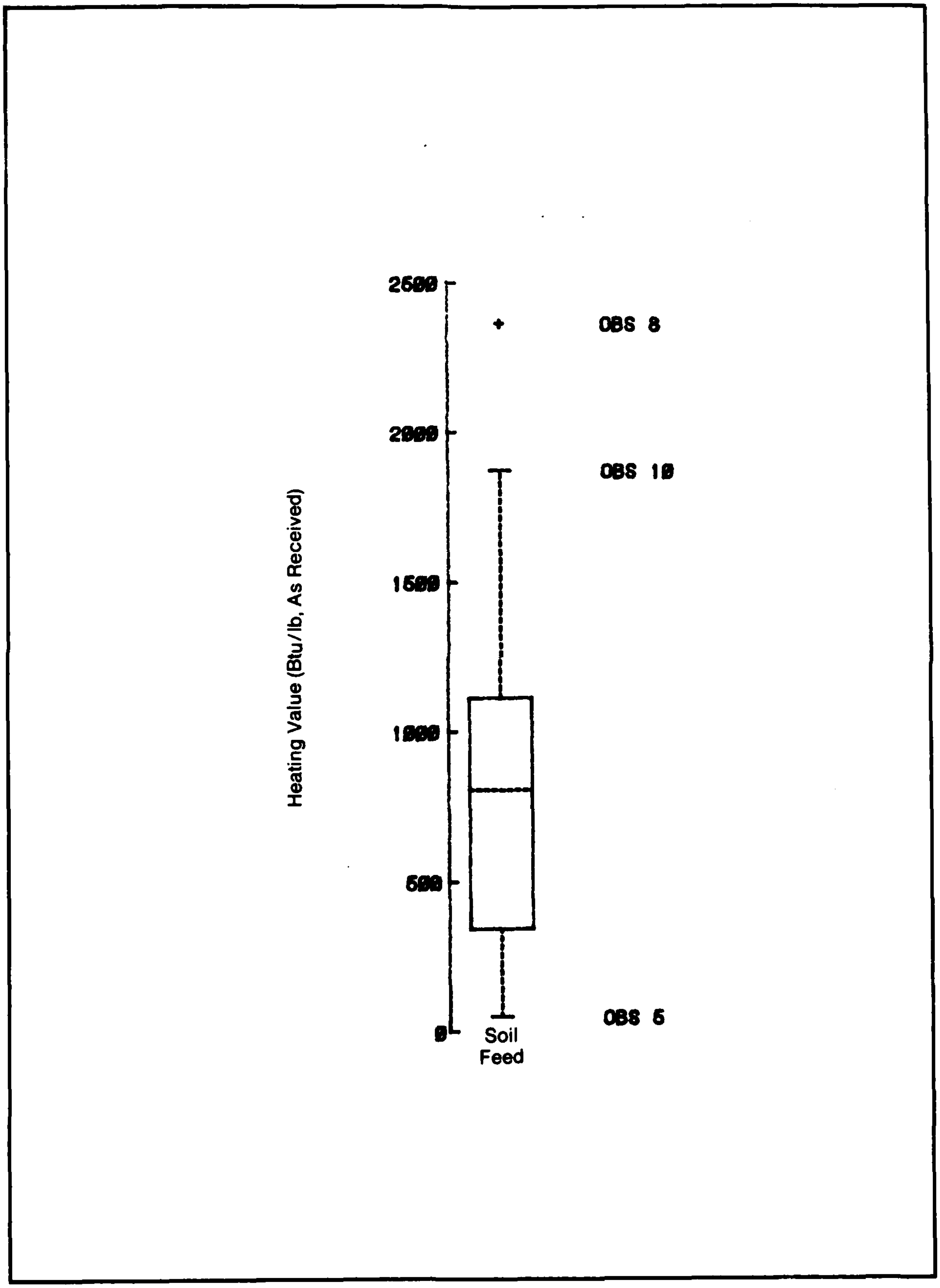

FIGURE B-5 SOIL HEATING VALUE

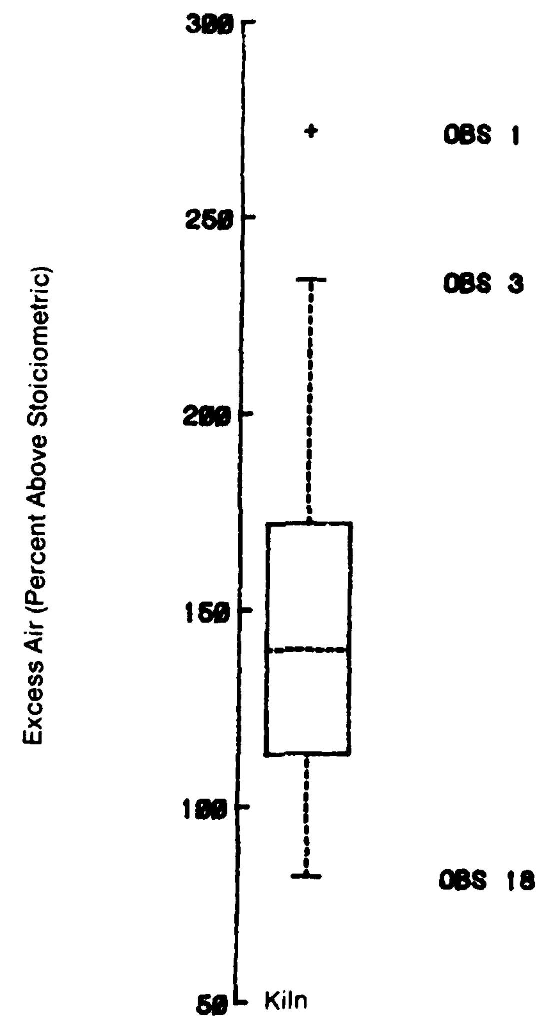

FIGURE B-6 PRIMARY CHAMBER EXCESS AIR

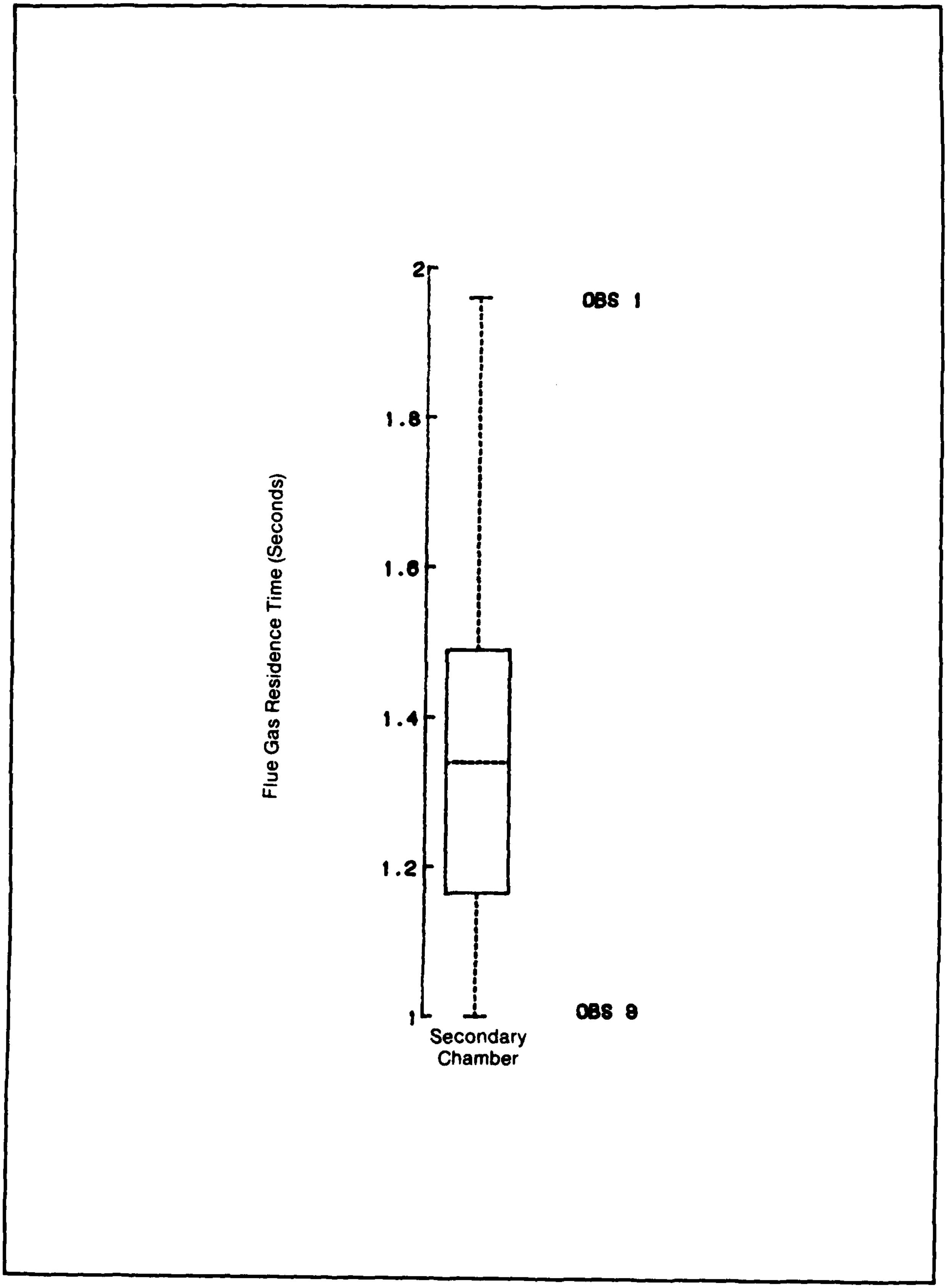

FIGURE B-7 FLUE GAS RESIDENCE TIME IN THE SECONDARY CHAMBER

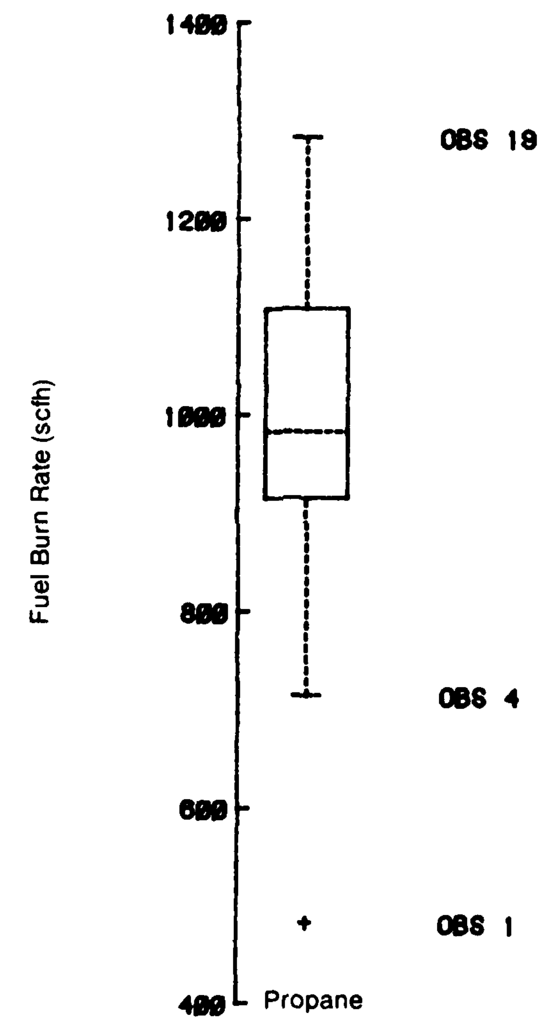

FIGURE B-8 PROPANE FUEL CONSUMPTION

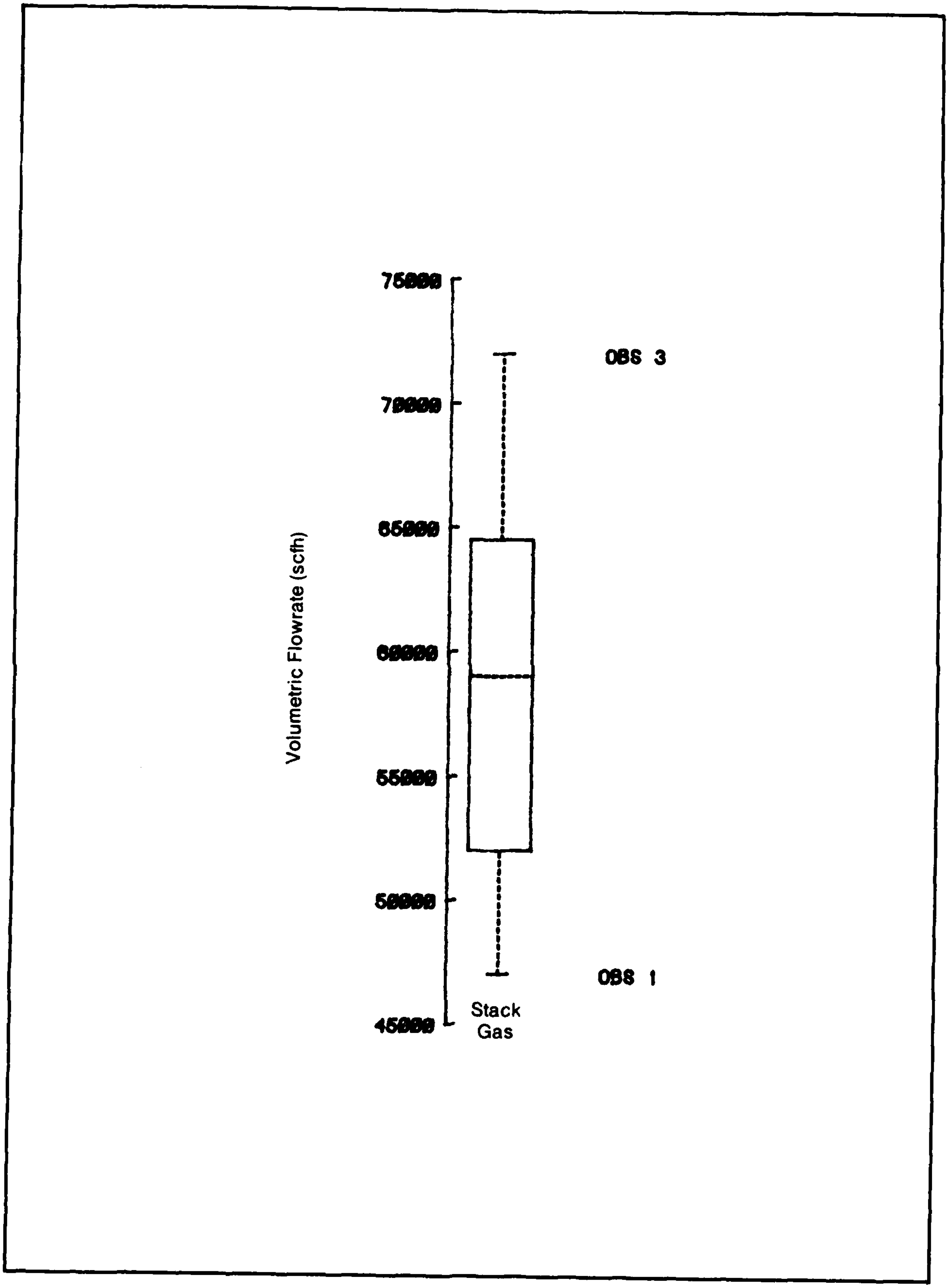

FIGURE B-9 STACK GAS VOLUMETRIC FLOW RATE

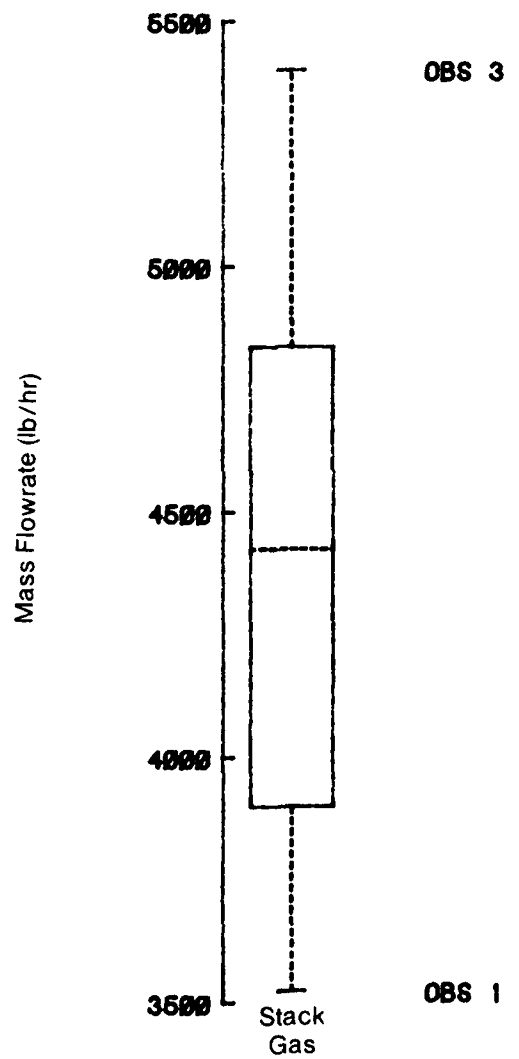

FIGURE B-10 STACK GAS MASS FLOWRATE

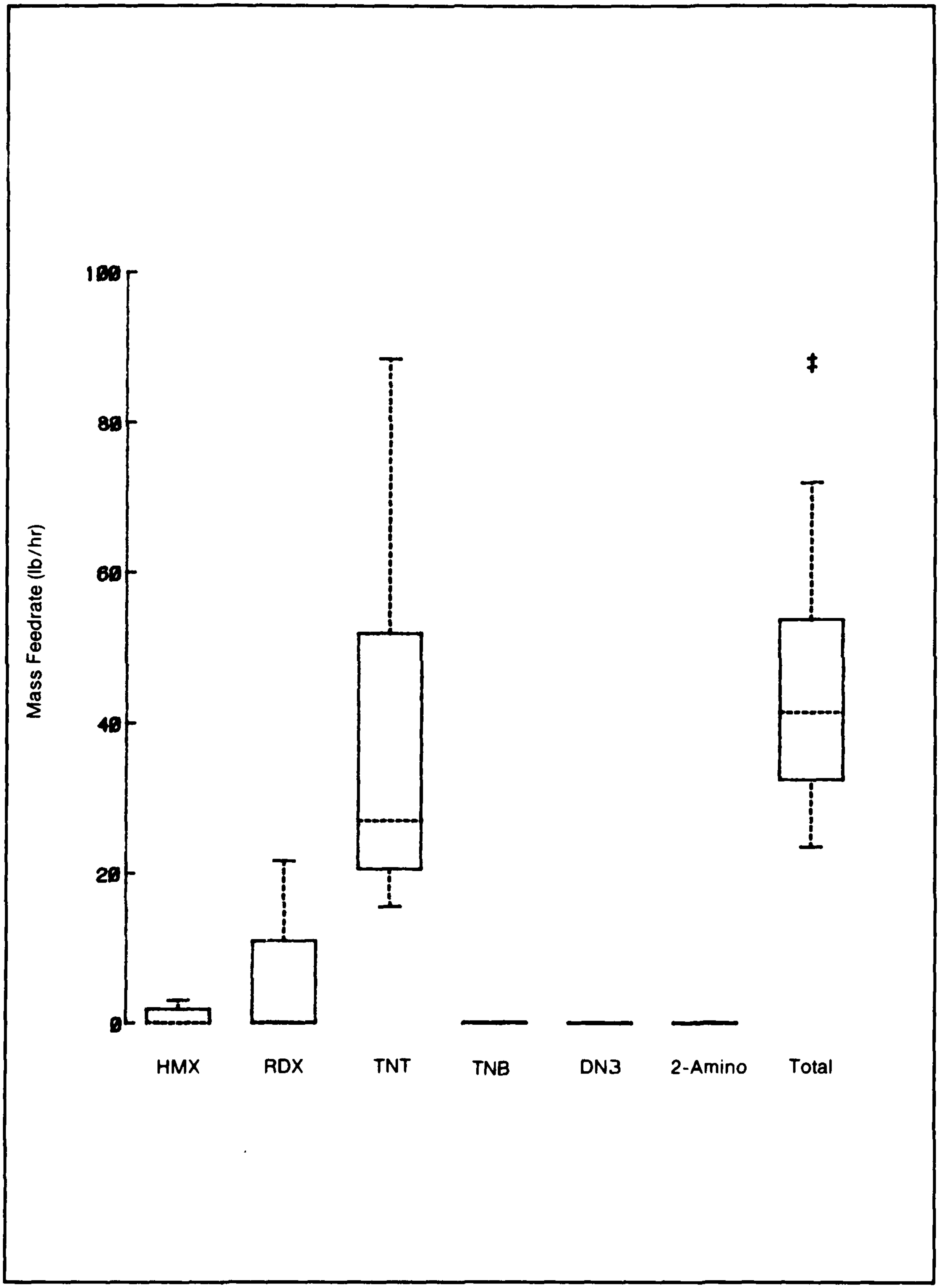

FIGURE B-11 MASS RATE OF EXPLOSIVES IN SOIL FEED

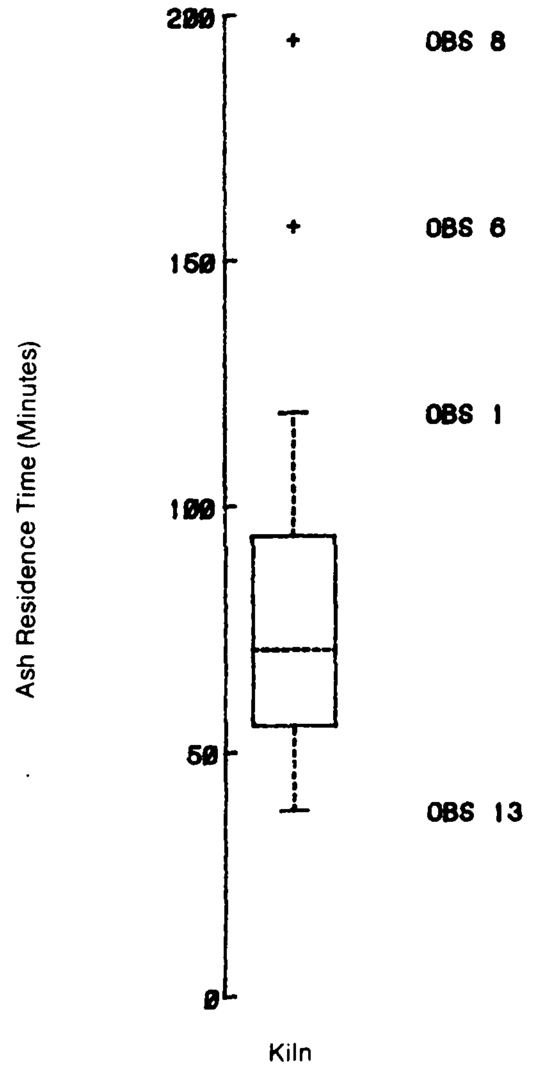

FIGURE B-12 ASH RESIDENCE TIME IN THE PRIMARY CHAMBER

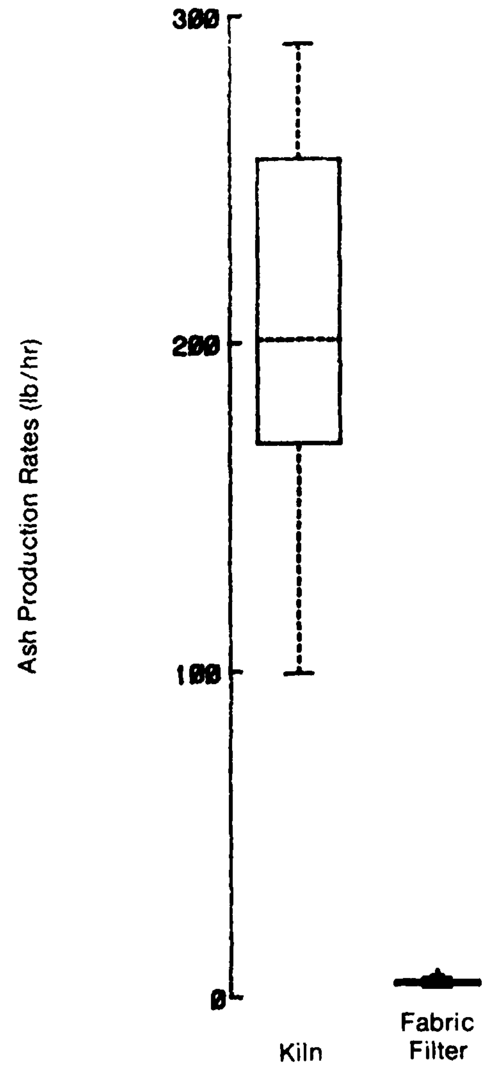

FIGURE B-13 ASH PRODUCTION RATES

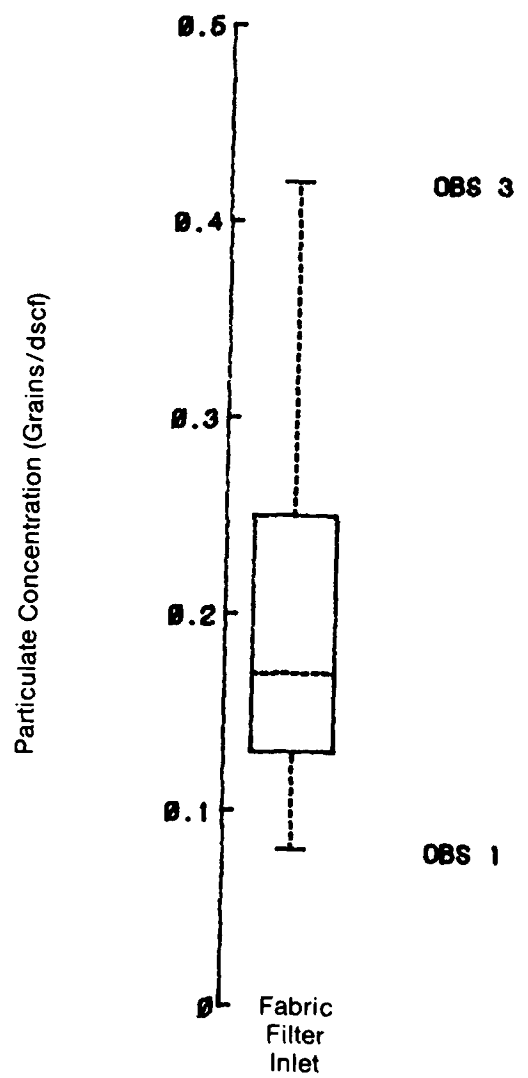

FIGURE B-14 PARTICULATE CONCENTRATION IN FLUE GAS ENTERING FABRIC FILTER

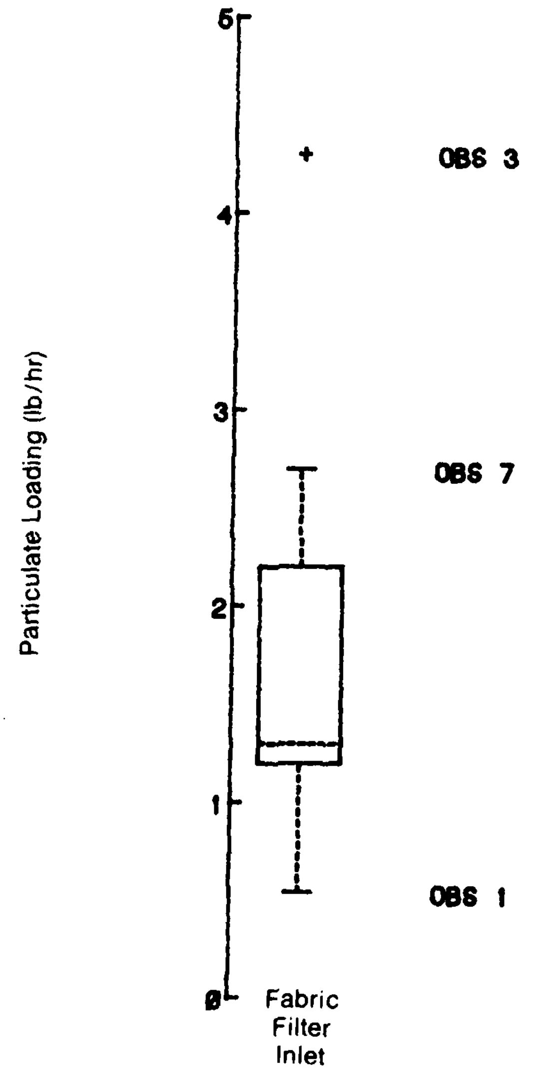

FIGURE B-15 PARTICULATE MASS LANDING IN FLUE GAS ENTERING FABRIC FILTER

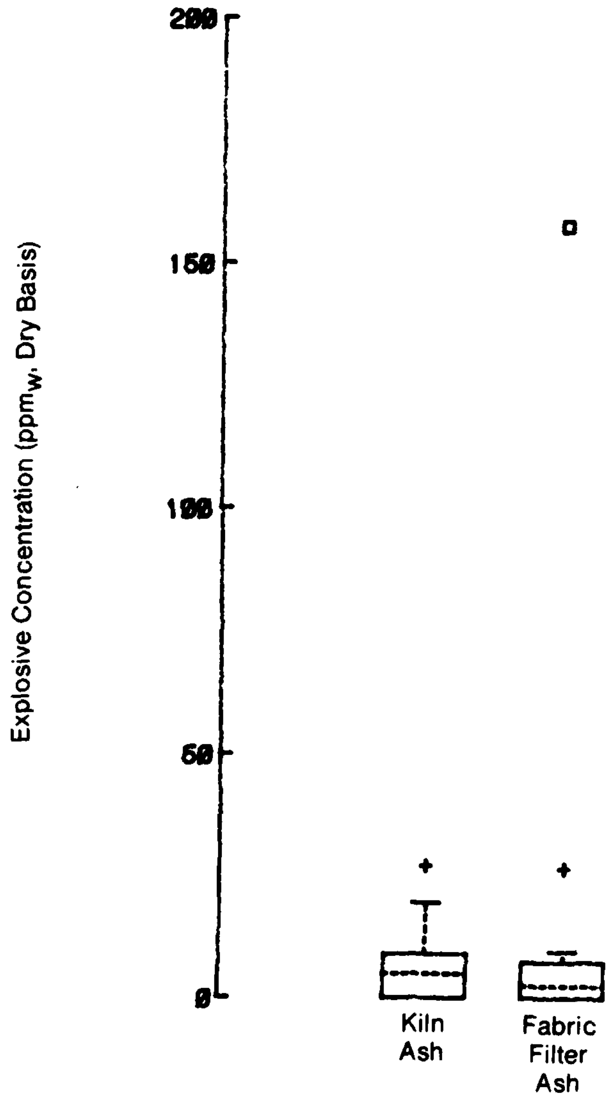

FIGURE B-16 TOTAL EXPLOSIVE CONCENTRATIONS IN THE SYSTEM ASH RESIDUES

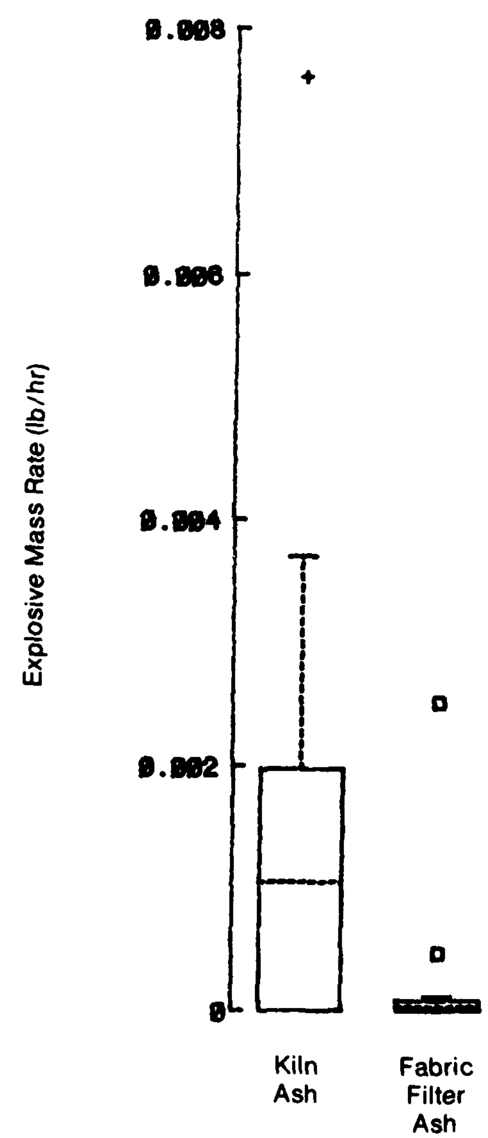

FIGURE B-17 EXPLOSIVE MASS RATES IN SYSTEM ASH RESIDUES

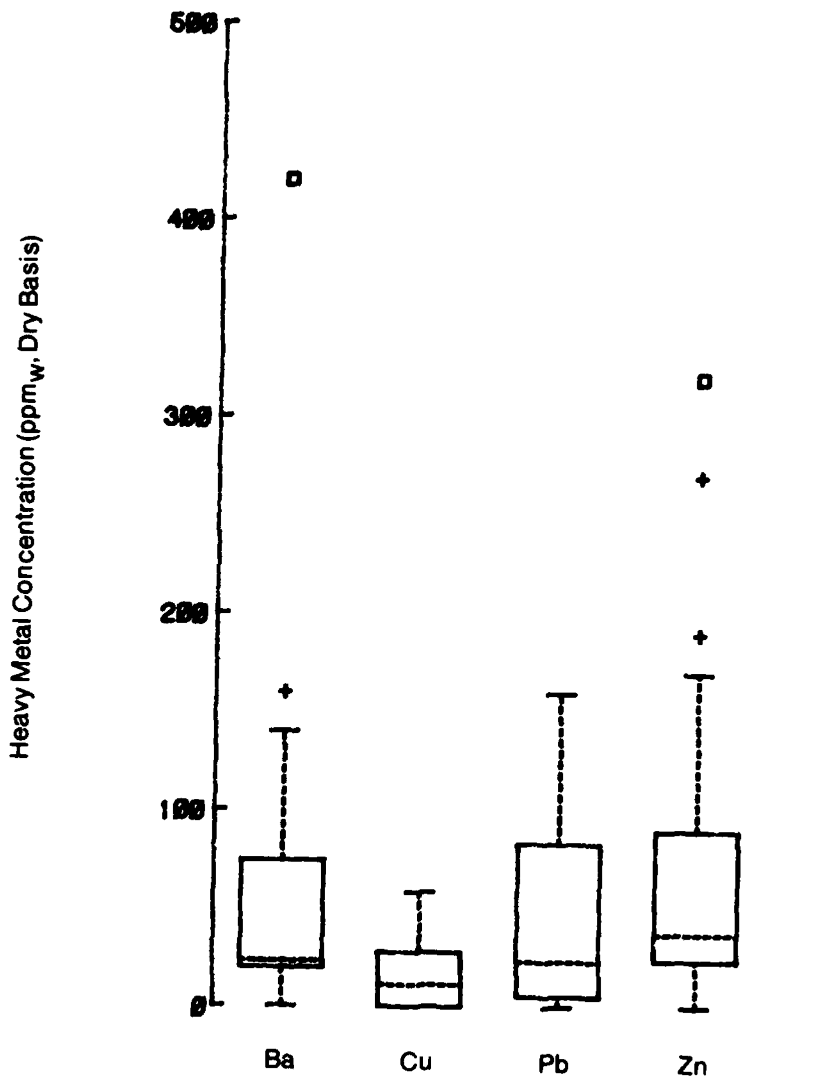

FIGURE B-18 HEAVY METAL CONCENTRATIONS IN KILN ASH

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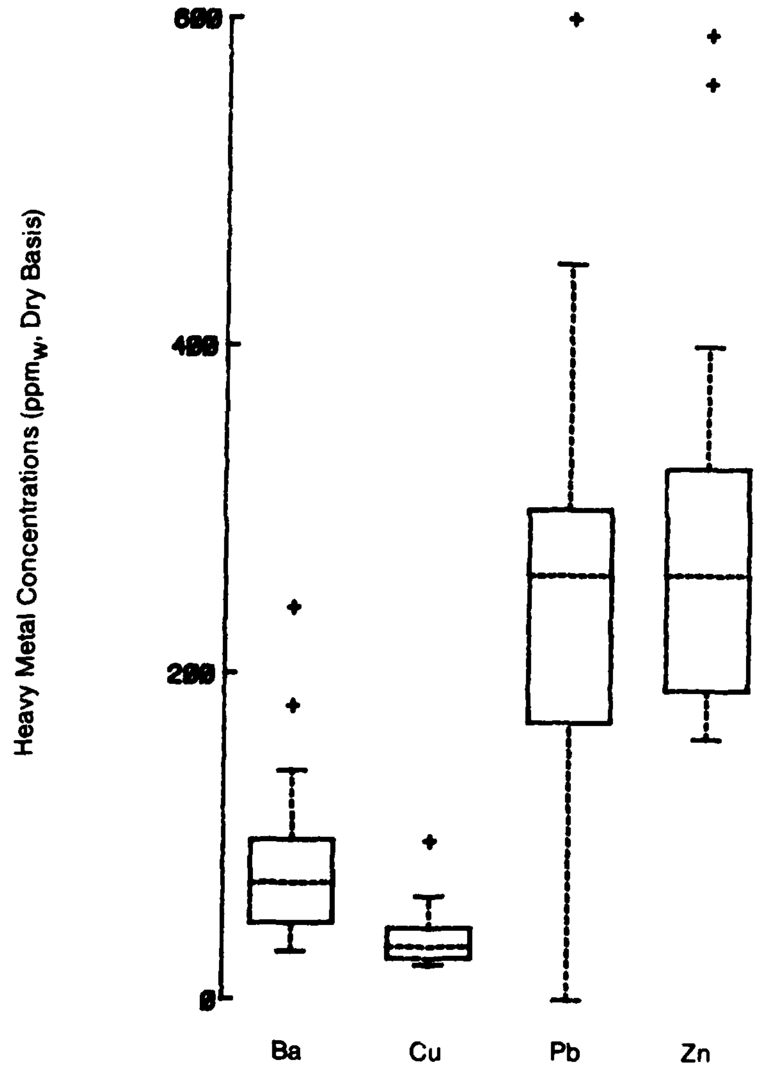

FIGURE B-19 HEAVY METAL CONCENTRATIONS IN FABRIC FILTER ASH

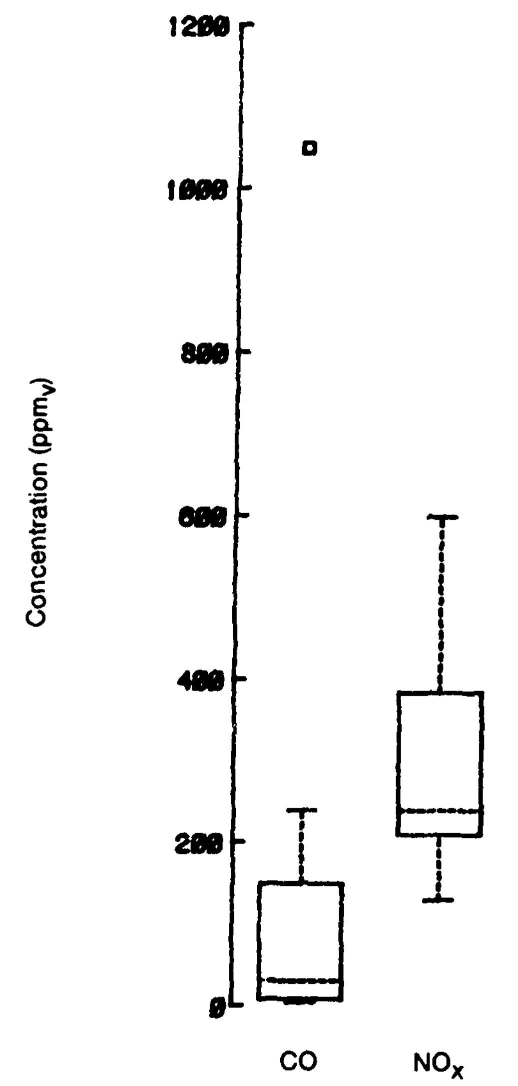

FIGURE B-20 CARBON MONOXIDE AND OXIDES OF NITROGEN CONCENTRATION IN THE STACK GAS

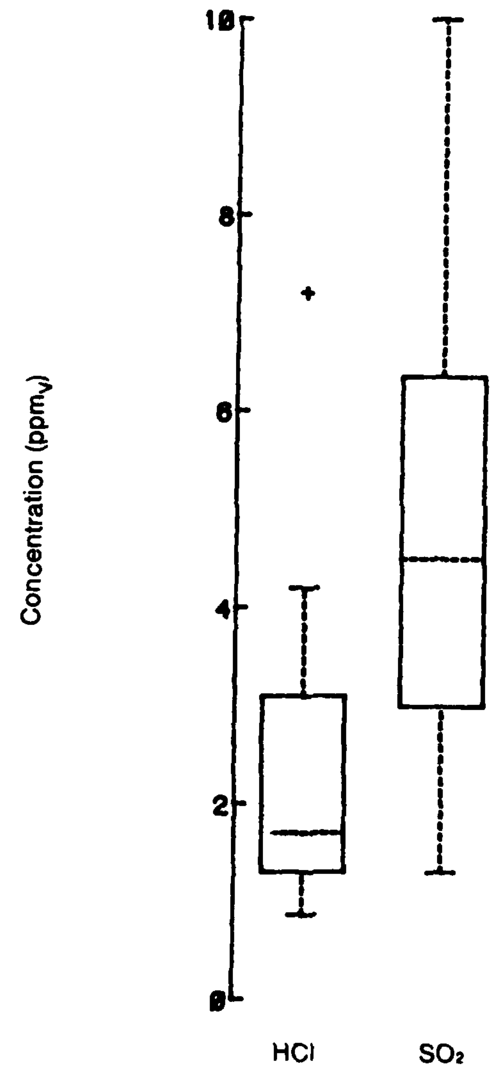

FIGURE B-21 HYDROGEN CHLORIDE AND SULFUR DIOXIDE CONCENTRATION IN THE STACK GAS

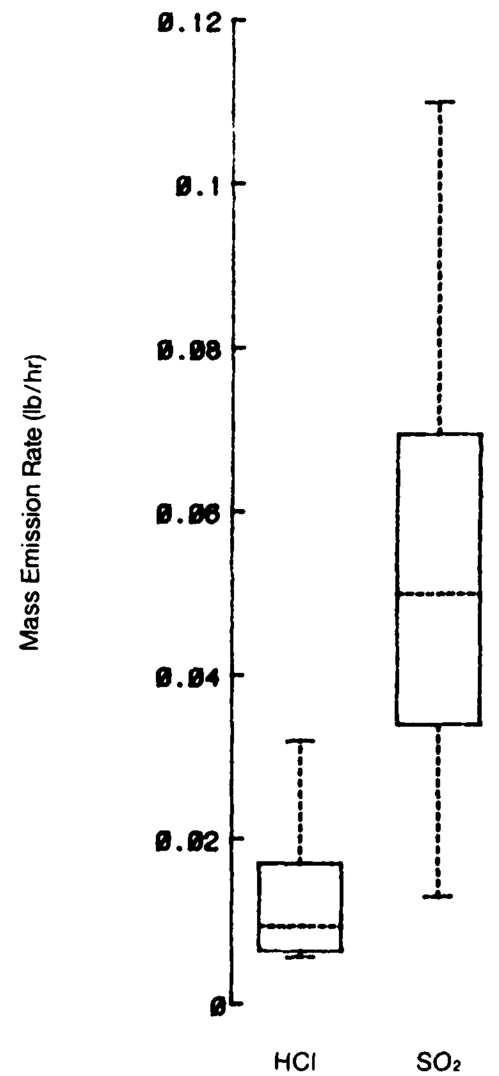

FIGURE B-22 HYDROGEN CHLORIDE AND SULFUR DIOXIDE MASS RATE IN THE STACK GAS

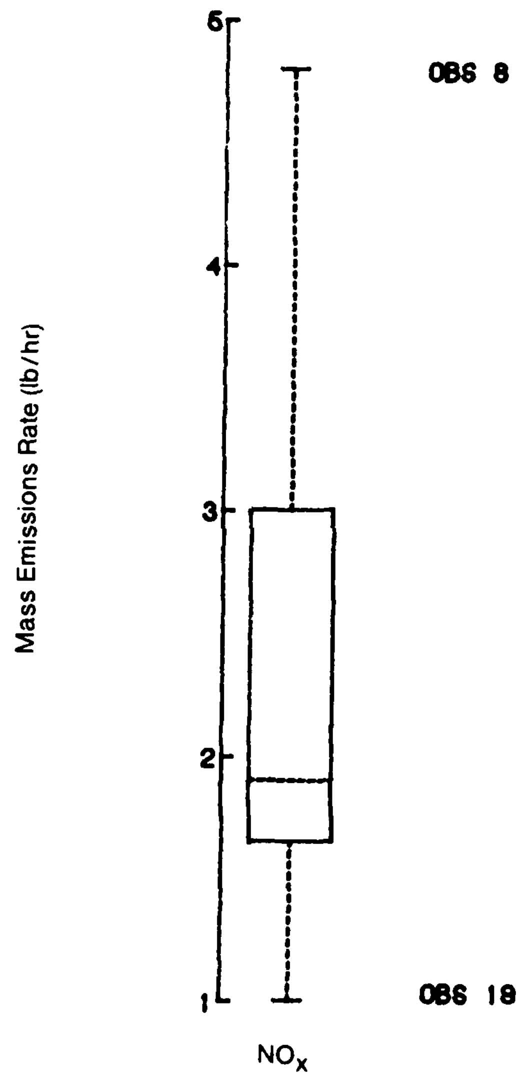

FIGURE B-23 OXIDES OF NITROGEN MASS RATE IN THE STACK GAS

APPENDIX C

FEDERAL REGISTER HAZARDOUS WASTE REFERENCES

40 CFR, PART 261

IDENTIFICATION AND LISTING OF HAZARDOUS WASTE
SECTIONS 261.1 - 261.33
AND
PART 261, APPENDIX VIII

19 MAY 1980

4554A

PART 261—IDENTIFICATION AND LISTING OF HAZARDOUS WASTE

Authority: Secs. 1006, 2002(a), 3001, and 3002 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6905, 6912, 6921 and 6922).

Subpart A—General

§ 261.1 Purpose and scope.

(a) This Part identifies those solid wastes which are subject to regulation as hazardous wastes under Parts 262 through 265 and Parts 122 through 124 of this Chapter and which are subject to the notification requirements of Section 3010 of RCRA. In this Part:

(1) Subpart A defines the terms "solid waste" and "hazardous waste," identifies those wastes which are excluded from regulation under Parts 262 through 265 and 122 through 124 and establishes special management requirements for hazardous waste produced by small quantity generators and hazardous waste which is used, re-used, recycled or reclaimed.

(2) Subpart B sets forth the criteria used by EPA to identify characteristics of hazardous waste and to list particular hazardous wastes.

(3) Subpart C identifies characteristics of hazardous waste.

(4) Subpart D lists particular hazardous wastes.

(b) This Part identifies only some of the materials which are hazardous wastes under Sections 3007 and 7003 of RCRA. A material which is not a hazardous waste identified in this part is still a hazardous waste for purposes of those sections if:

(1) In the case of Section 3007, EPA has reason to believe that the material may be a hazardous waste within the meaning of Section 1004(5) of RCRA.

(2) In the case of Section 7003, the statutory elements are established.

§ 261.2 Definition of solid waste.

(a) A solid waste is any garbage, refuse, sludge or any other waste material which is not excluded under § 261.4(a).

(b) An "other waste material" is any solid, liquid, semi-solid or contained gaseous material, resulting from industrial, commercial, mining or agricultural operations, or from community activities which:

(1) Is discarded or is being accumulated, stored or physically, chemically or biologically treated prior to being discarded; or

(2) Has served its original intended use and sometimes is discarded; or

(3) Is a manufacuring or mining by-product and sometimes is discarded.

(c) A material is "discarded" if it is abandoned (and not used, re-used, reclaimed or recycled) by being:

(1) Disposed of; or

(2) Burned or incinerated, except where the material is being burned as a fuel for the purpose of recovering usable energy; or

(3) Physically, chemically, or biologically treated (other than burned or incinerated) in lieu of or prior to being disposed of.

(d) A material is "disposed of" if it is discharged, deposited, injected, dumped, spilled, leaked or placed into or on any land or water so that such material or any constituent thereof may enter the environment or be emitted into the air or discharged into ground or surface waters.

(e) A "manufacturing or mining by-product" is a material that is not one of the primary products of a particular manufacturing or mining operation, is a secondary and incidental product of the particular operation and would not be solely and separately manufactured or mined by the particular manufacturing or mining operation. The term does not include an intermediate manufacturing or mining product which results from one of the steps in a manufacturing or mining process and is typically processed through the next step of the process within a short time.

§ 261.3 Definition of hazardous waste.

(a) A solid waste, as defined in § 261.2, is a hazardous waste if:

(1) It is not excluded from regulation as a hazardous waste under § 261.4(b); and

(2) It meets any of the following criteria:

(i) It is listed in Subpart D and has not been excluded from the lists in Subpart D under §§ 260.20 and 260.22 of this Chapter.

(ii) It is a mixture of solid waste and one or more hazardous wastes listed in Subpart D and has not been excluded from this paragraph under §§ 260.20 and 260.22 of this Chapter.

(iii) It exhibits any of the characteristics of hazardous waste identified in Subpart C.

(b) A solid waste which is not excluded from regulation under paragraph (a)(1) of this section becomes a hazardous waste when any of the following events occur:

(1) In the case of a waste listed in Subpart D, when the waste first meets the listing description set forth in Subpart D.

(2) In the case of a mixture of solid waste and one or more listed hazardous wastes, when a hazardous waste listed

in Subpart D is first added to the solid waste.

(3) In the case of any other waste (including a waste mixture), when the waste exhibits any of the characteristics identified in Subpart C.

(c) Unless and until it meets the criteria of paragraph (d):

(1) A hazardous waste will remain a hazardous waste.

(2) Any solid waste generated from the treatment, storage or disposal of a hazardous waste, including any sludge, spill residue, ash, emission control dust or leachate (but not including precipitation run-off), is a hazardous waste.

(d) Any solid waste described in paragraph (c) of this section is not a hazardous waste if it meets the following criteria:

(1) In the case of any solid waste, it does not exhibit any of the characteristics of hazardous waste identified in Subpart C.

(2) In the case of a waste which is a listed waste under Subpart D, contains a waste listed under Subpart D or is derived from a waste listed in Subpart D, it also has been excluded from paragraph (c) under §§ 260.20 and 260.22 of this Chapter.

§ 261.4 Exclusions.

(a) *Materials which are not solid wastes.* The following materials are not solid wastes for the purpose of this Part:

(1) (i) Domestic sewage; and

(ii) Any mixture of domestic sewage and other wastes that passes through a sewer system to a publicly-owned treatment works for treatment. "Domestic sewage" means untreated sanitary wastes that pass through a sewer system.

(2) Industrial wastewater discharges that are point source discharges subject to regulation under Section 402 of the Clean Water Act, as amended.

[Comment: This exclusion applies only to the actual point source discharge. It does not exclude industrial wastewaters while they are being collected, stored or treated before discharge, nor does it exclude sludges that are generated by industrial wastewater treatment.]

(3) Irrigation return flows.

(4) Source, special nuclear or by-product material as defined by the Atomic Energy Act of 1954, as amended, 42 U.S.C. 2011 *et seq.*

(5) Materials subjected to in-situ mining techniques which are not removed from the ground as part of the extraction process.

(b) *Solid wastes which are not hazardous wastes.* The following solid wastes are not hazardous wastes:

(1) Household waste, including household waste that has been collected, transported, stored, treated, disposed, recovered (e.g., refuse-derived fuel) or reused. "Household waste" means any waste material (including garbage, trash and sanitary wastes in septic tanks) derived from households (including single and multiple residences, hotels and motels.)

(2) Solid wastes generated by any of the following and which are returned to the soils as fertilizers:

(i) The growing and harvesting of agricultural crops.

(ii) The raising of animals, including animal manures.

(3) Mining overburden returned to the mine site.

(4) Fly ash waste, bottom ash waste, slag waste, and flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels.

(5) Drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil, natural gas or geothermal energy.

§ 261.5 Special requirements for hazardous waste generated by small quantity generators.

(a) Except as otherwise provided in this section, if a person generates, in a calendar month, a total of less than 1000 kilograms of hazardous wastes, those wastes are not subject to regulation under Parts 262 through 265 and Parts 122 through 124 of this Chapter, and the notification requirements of Section 3010 of RCRA.

(b) If a person whose waste has been excluded from regulation under paragraph (a) of this Section accumulates hazardous wastes in quantities greater than 1000 kilograms, those accumulated wastes are subject to regulation under Parts 262 through 265 and Parts 122 through 124 of this Chapter, and the notification requirements of Section 3010 of RCRA.

(c) If a person generates in a calendar month or accumulates at any time any of the following hazardous wastes in quantities greater than set forth below, those wastes are subject to regulation under Parts 262 through 265 and Parts 122 through 124 of this Chapter, and the notification requirements of Section 3010 of RCRA:

(1) One kilogram of any commercial product or manufacturing chemical intermediate having the generic name listed in § 261.33(e).

(2) One kilogram of any off-specification commercial chemical product or manufacturing chemical intermediate which, if it met specifications, would have the generic name listed in § 261.33(e).

(3) Any containers identified in § 261.33(c) that are larger than 20 liters in capacity;

(4) 10 kilograms of inner liners from containers identified under § 261.33(c);

(5) 100 kilograms of any residue or contaminated soil, water or other debris resulting from the cleanup of a spill, into or on any land or water, of any commercial chemical product or manufacturing chemical intermediate having the generic name listed in § 261.33(e).

(d) In order for hazardous waste to be excluded from regulation under this section, the generator must comply with § 262.11 of this Chapter. He must also either treat or dispose of the waste in an on-site facility, or ensure delivery to an off-site treatment, storage or disposal facility, either of which is:

(1) Permitted by EPA under Part 122 of this Chapter, or by a State with a hazardous waste management program authorized under Part 123 of this Chapter;

(2) In interim status under Parts 122 and 265 of this Chapter; or,

(3) Permitted, licensed, or registered by a State to manage municipal or industrial solid waste.

(e) Hazardous waste subject to the reduced requirements of this section may be mixed with non-hazardous waste and remain subject to these reduced requirements even though the resultant mixture exceeds the quantity limitations identified in this section, unless the mixture meets any of the characteristics of hazardous waste identified in Subpart C.

§ 261.6 Special requirements for hazardous waste which is used, re-used, recycled or reclaimed.

(a) Except as otherwise provided in paragraph (b) of this section, a hazardous waste which meets either of the following criteria is not subject to regulation under Parts 262 through 265 or Parts 122 through 124 of this Chapter and is not subject to the notification requirements of Section 3010 of RCRA until such time as the Administrator promulgates regulations to the contrary:

(1) It is being beneficially used or re-used or legitimately recycled or reclaimed.

(2) It is being accumulated, stored or physically, chemically or biologically treated prior to beneficial use or re-use or legitimate recycling or reclamation.

(b) A hazardous waste which is a sludge, or which is listed in Subpart D, or which contains one or more hazardous wastes listed in Subpart D; and which is transported or stored prior to being used, re-used, recycled or reclaimed is subject to the following requirements with respect to such transportation or storage:

(1) Notification requirements under Section 3010 RCRA.

(2) Part 262 of this Chapter.

(3) Part 263 of this Chapter.

(4) Subparts A, B, C, D and E of Part 264 of this Chapter.

(5) Subparts A, B, C, D, E, G, H, I, J and L of Part 265 of this Chapter.

(6) Parts 122 and 124 of this Chapter, with respect to storage facilities.

Subpart B—Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste

§ 261.10 Criteria for identifying the characteristics of hazardous waste.

(a) The Administrator shall identify and define a characteristic of hazardous waste in Subpart C only upon determining that:

(1) A solid waste that exhibits the characteristic may:

(i) Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(ii) Pose a substantial present or potential hazard to human health or the environment when it is improperly treated, stored, transported, disposed of or otherwise managed; and

(2) The characteristic can be:

(i) Measured by an available standardized test method which is reasonably within the capability of generators of solid waste or private sector laboratories that are available to serve generators of solid waste; or

(ii) Reasonably detected by generators of solid waste through their knowledge of their waste.

§ 261.11 Criteria for listing hazardous waste.

(a) The Administrator shall list a solid waste as a hazardous waste only upon determining that the solid waste meets one of the following criteria:

(1) It exhibits any of the characteristics of hazardous waste identified in Subpart C.

(2) It has been found to be fatal to humans in low doses or, in the absence of data on human toxicity, it has been shown in studies to have an oral LD 50 toxicity (rat) of less than 50 milligrams per kilogram, an inhalation LC 50 toxicity (rat) of less than 2 milligrams per liter, or a dermal LD 50 toxicity (rabbit) of less than 200 milligrams per kilogram or is otherwise capable of causing or significantly contributing to an increase in serious irreversible, or incapacitating reversible, illness. (Waste listed in accordance with these criteria will be designated Acute Hazardous Waste.)

(3) It contains any of the toxic constituents listed in Appendix VIII unless, after considering any of the following factors, the Administrator concludes that the waste is not capable of posing a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed:

(i) The nature of the toxicity presented by the constituent.

(ii) The concentration of the constituent in the waste.

(iii) The potential of the constituent or any toxic degradation product of the constituent to migrate from the waste into the environment under the types of improper management considered in paragraph (a)(3)(vii) of this section.

(iv) The persistence of the constituent or any toxic degradation product of the constituent.

(v) The potential for the constituent or any toxic degradation product of the constituent to degrade into non-harmful constituents and the rate of degradation.

(vi) The degree to which the constituent or any degradation product of the constituent bioaccumulates in ecosystems.

(vii) The plausible types of improper management to which the waste could be subjected.

(viii) The quantities of the waste generated at individual generation sites or on a regional or national basis.

(ix) The nature and severity of the human health and environmental damage that has occurred as a result of the improper management of wastes containing the constituent.

(x) Action taken by other governmental agencies or regulatory programs based on the health or environmental hazard posed by the waste or waste constituent.

(xi) Such other factors as may be appropriate.

Substances will be listed on Appendix VIII only if they have been shown in scientific studies to have toxic, carcinogenic, mutagenic or teratogenic effects on humans or other life forms.

(Wastes listed in accordance with these criteria will be designated Toxic wastes.)

(b) The Administrator may list classes or types of solid waste as hazardous waste if he has reason to believe that individual wastes, within the class or type of waste, typically or frequently are hazardous under the definition of hazardous waste found in Section 1004(5) of the Act.

(c) The Administrator will use the criteria for listing specified in this section to establish the exclusion limits referred to in § 261.5(c).

Subpart C—Characteristics of Hazardous Waste

§ 261.20 General.

(a) A solid waste, as defined in § 261.2, which is not excluded from regulation as a hazardous waste under § 261.4(b), is a hazardous waste if it exhibits any of the characteristics identified in this Subpart.

[Comment: § 262.11 of this Chapter sets forth the generator's responsibility to determine whether his waste exhibits one or more of the characteristics identified in this Subpart]

(b) A hazardous waste which is identified by a characteristic in this subpart, but is not listed as a hazardous waste in Subpart D, is assigned the EPA Hazardous Waste Number set forth in the respective characteristic in this Subpart. This number must be used in complying with the notification requirements of Section 3010 of the Act and certain recordkeeping and reporting requirements under Parts 262 through 265 and Part 122 of this Chapter.

(c) For purposes of this Subpart, the Administrator will consider a sample obtained using any of the applicable sampling methods specified in Appendix I to be a representative sample within the meaning of Part 260 of this Chapter.

[Comment: Since the Appendix I sampling methods are not being formally adopted by the Administrator, a person who desires to employ an alternative sampling method is not required to demonstrate the equivalency of his method under the procedures set forth in §§ 260.20 and 260.21.]

§ 261.21 Characteristic of ignitability.

(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

(1) It is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, and has a flash point less than 60°C (140°F), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-93-79, or a Setaflash Closed Cup Tester, using the test method specified in ASTM standard D-3278-78, or as determined by an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.[1]

[1] ASTM Standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103

(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that is creates a hazard.

(3) It is an ignitable compressed gas as defined in 49 CFR 173.300 and as determined by the test methods described in that regulation or equivalent test methods approved by the Administrator under §§ 260.20 and 260.21.

(4) It is an oxidizer as defined in 49 CFR 173.151.

(b) A solid waste that exhibits the characteristic of ignitability, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D001.

§ 261.22 Characteristic of corrosivity.

(a) A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

(1) It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using either the test method specified in the "*Test Methods for the* Evaluation of Solid Waste, Physical/Chemical Methods" [2] (also described in "Methods for Analysis of Water and Wastes" EPA 600/4-79-020, March 1979), or an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.

(2) It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55°C (130°F) as determined by the test method specified in NACE (National Association of Corrosion Engineers) Standard TM-01-69 [3] as standardized in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," or an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.

(b) A solid waste that exhibits the characteristic of corrosivity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D002.

[2] This document is available from Solid Waste Information, U.S. Environmental Protection Agency, 26 W. St. Clair Street, Cincinnati, Ohio 45268.

[3] The NACE Standard is available from the National Association of Corrosion Engineers, P.O. Box 986, Katy, Texas 77450.

§ 261.23 Characteristic of reactivity.

(a) A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has *any* of the following properties:

(1) It is normally unstable and readily undergoes violent change without detonating.

(2) It reacts violently with water.

(3) It forms potentially explosive mixtures with water.

(4) When mixed with water, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

(5) It is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(7) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

(8) It is a forbidden explosive as *defined in* 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

(b) A solid waste that exhibits the characteristic of reactivity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D003.

§ 261.24 Characteristic of EP Toxicity.

(a) A solid waste exhibits the characteristic of EP toxicity if, using the test methods described in Appendix II or equivalent methods approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21, the extract from a representative sample of the waste contains any of the contaminants listed in Table I at a concentration equal to or greater than the respective value given in that Table. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering, is considered to be the extract for the purposes of this section.

(b) A solid waste that exhibits the characteristic of EP toxicity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number specified in Table I which corresponds to the toxic contaminant causing it to be hazardous.

Table I.—Maximum Concentration of Contaminants for Characteristic of EP Toxicity—Continued

EPA hazardous waste number	Contaminant	Maximum concentration (milligrams per liter)
D004	Arsenic	5.0
D005	Barium	100.0
D006	Cadmium	1.0
D007	Chromium	5.0
D008	Lead	5.0
D009	Mercury	0.2
D010	Selenium	1.0
D011	Silver	5.0
D012	Endrin (1,2,3,4,10,10-hexachloro-1,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene.	0.02
D013	Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer.	0.4
D014	Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenyl)ethane).	10.0
D015	Toxaphene ($C_{10}H_{10}Cl_8$, Technical chlorinated camphene, 67-69 percent chlorine).	0.5
D016	2,4-D, (2,4-Dichlorophenoxyacetic acid).	10.0
D017	2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid).	1.0

Subpart D—Lists of Hazardous Wastes

§ 261.30 General.

(a) A solid waste is a hazardous waste if it is listed in this Subpart, unless it has been excluded from this list under §§ 260.20 and 260.22.

(b) The Administrator will indicate his basis for listing the classes or types of wastes listed in this Subpart by employing one or more of the following Hazard Codes:

Ignitable Waste	(I)
Corrosive Waste	(C)
Reactive Waste	(R)
EP Toxic Waste	(E)
Acute Hazardous Waste	(H)
Toxic Waste	(T)

Appendix VII identifies the constituent which caused the Administrator to list the waste as an EP Toxic Waste (E) or Toxic Waste (T) in §§ 261.31 and 261.32.

(c) Each hazardous waste listed in this Subpart is assigned an EPA Hazardous Waste Number which precedes the name of the waste. This number must be used in complying with the notification requirements of Section 3010 of the Act and certain recordkeeping and reporting requirements under Parts 262 through 265 and Part 122 of this Chapter.

(d) Certain of the hazardous wastes listed in § 261.31 or § 261.32 have exclusion limits that refer to § 261.5(c)(5).

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§ 261.31 Hazardous waste from nonspecific sources.

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
Generic:		
F001	The spent halogenated solvents used in degreasing, tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and the chlorinated fluorocarbons, and sludges from the recovery of these solvents in degreasing operations	(T)
F002	The spent halogenated solvents, tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, o-dichlorobenzene, trichlorofluoromethane and the still bottoms from the recovery of these solvents.	(T)
F003	The spent non-halogenated solvents, xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, n-butyl alcohol, cyclohexanone, and the still bottoms from the recovery of these solvents.	(I)
F004	The spent non-halogenated solvents, cresols and cresylic acid, nitrobenzene, and the still bottoms from the recovery of these solvents	(T)
F005	The spent non-halogenated solvents, methanol, toluene, methyl ethyl ketone, methyl isobutyl ketone, carbon disulfide, isobutanol, pyridine and the still bottoms from the recovery of these solvents.	(I, T)
F006	Wastewater treatment sludges from electroplating operations	(T)
F007	Spent plating bath solutions from electroplating operations	(R, T)
F008	Plating bath sludges from the bottom of plating baths from electroplating operations	(R, T)
F009	Spent stripping and cleaning bath solutions from electroplating operations	(R, T)
F010	Quenching bath sludge from oil baths from metal heat treating operations	(R, T)
F011	Spent solutions from salt bath pot cleaning from metal heat treating operations	(R, T)
F012	Quenching wastewater treatment sludges from metal heat treating operations	(T)
F013	Flotation tailings from selective flotation from mineral metals recovery operations	(T)
F014	Cyanidation wastewater treatment tailing pond sediment from mineral metals recovery operations	(T)
F015	Spent cyanide bath solutions from mineral metals recovery operations	(R, T)
F016	Dewatered air pollution control scrubber sludges from coke ovens and blast furnaces	(T)

§ 261.32 Hazardous waste from specific sources.

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
Wood Preservation: K001	Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol	(T)
Inorganic Pigments:		
K002	Wastewater treatment sludge from the production of chrome yellow and orange pigments	(T)
K003	Wastewater treatment sludge from the production of molybdate orange pigments	(T)
K004	Wastewater treatment sludge from the production of zinc yellow pigments	(T)
K005	Wastewater treatment sludge from the production of chrome green pigments	(T)
K006	Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)	(T)
K007	Wastewater treatment sludge from the production of iron blue pigments	(T)
K008	Oven residue from the production of chrome oxide green pigments	(T)
Organic Chemicals:		
K009	Distillation bottoms from the production of acetaldehyde from ethylene	(T)
K010	Distillation side cuts from the production of acetaldehyde from ethylene	(T)
K011	Bottom stream from the wastewater stripper in the production of acrylonitrile	(R, T)
K012	Still bottoms from the final purification of acrylonitrile in the production of acrylonitrile	(T)
K013	Bottom stream from the acetonitrile column in the production of acrylonitrile	(R, T)
K014	Bottoms from the acetonitrile purification column in the production of acrylonitrile	(T)
K015	Still bottoms from the distillation of benzyl chloride	(T)
K016	Heavy ends or distillation residues from the production of carbon tetrachloride	(T)
K017	Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	(T)
K018	Heavy ends from fractionation in ethyl chloride production	(T)
K019	Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	(T)
K020	Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production	(T)
K021	Aqueous spent antimony catalyst waste from fluoromethanes production	(T)
K022	Distillation bottom tars from the production of phenol/acetone from cumene	(T)
K023	Distillation light ends from the production of phthalic anhydride from naphthalene	(T)
K024	Distillation bottoms from the production of phthalic anhydride from naphthalene	(T)
K025	Distillation bottoms from the production of nitrobenzene by the nitration of benzene	(T)
K026	Stripping still tails from the production of methyl ethyl pyridines	(T)
K027	Centrifuge residue from toluene diisocyanate production	(R, T)
K028	Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane	(T)
K029	Waste from the product stream stripper in the production of 1,1,1-trichloroethane	(T)
K030	Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene	(T)
Pesticides:		
K031	By-products salts generated in the production of MSMA and cacodylic acid	(T)
K032	Wastewater treatment sludge from the production of chlordane	(T)
K033	Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane	(T)
K034	Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane	(T)
K035	Wastewater treatment sludges generated in the production of creosote	(T)
K036	Still bottoms from toluene reclamation distillation in the production of disulfoton	(T)
K037	Wastewater treatment sludges from the production of disulfoton	(T)
K038	Wastewater from the washing and stripping of phorate production	(T)
K039	Filter cake from the filtration of diethylphosphorodithioric acid in the production of phorate	(T)
K040	Wastewater treatment sludge from the production of phorate	(T)
K041	Wastewater treatment sludge from the production of toxaphene	(T)
K042	Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T	(T)
K043	2,6-Dichlorophenol waste from the production of 2,4-D	(T)
Explosives:		
K044	Wastewater treatment sludges from the manufacturing and processing of explosives	(R)
K045	Spent carbon from the treatment of wastewater containing explosives	(R)
K046	Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds	(T)
K047	Pink/red water from TNT operations	(R)
Petroleum Refining:		
K048	Dissolved air flotation (DAF) float from the petroleum refining industry	(T)
K049	Slop oil emulsion solids from the petroleum refining industry	(T)
K050	Heat exchanger bundle cleaning sludge from the petroleum refining industry	(T)
K051	API separator sludge from the petroleum refining industry	(T)
K052	Tank bottoms (leaded) from the petroleum refining industry	(T)
Leather Tanning Finishing:		
K053	Chrome (blue) trimmings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish, hair save/chrome tan/retan/wet finish, retan/wet finish, no beamhouse, through-the-blue, and shearing	(T)

§ 261.32 Hazardous waste from specific sources. —Continued

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
K054	Chrome (blue) shavings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearing.	(T)
K055	Buffing dust generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; and through-the-blue.	(T)
K056	Sewer screenings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearing.	(T)
K057	Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue and shearing.	(T)
K058	Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; and through-the-blue.	(R, T)
K059	Wastewater treatment sludges generated by the following subcategory of the leather tanning and finishing industry: hair save/non-chrome tan/retan/wet finish.	(R)
Iron and Steel:		
K060	Ammonia still lime sludge from coking operations	(T)
K061	Emission control dust/sludge from the electric furnace production of steel	(T)
K062	Spent pickle liquor from steel finishing operations	(C, T)
K063	Sludge from lime treatment of spent pickle liquor from steel finishing operations	(T)
Primary Copper: K064	Acid plant blowdown slurry/sludge resulting from the thickening of blowdown slurry from primary copper production	(T)
Primary Lead: K065	Surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities	(T)
Primary Zinc:		
K066	Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production	(T)
K067	Electrolytic anode slimes/sludges from primary zinc production	(T)
K068	Cadmium plant leach residue (iron oxide) from primary zinc production	(T)
Secondary Lead: K069	Emission control dust/sludge from secondary lead smelting	(T)

§ 261.33 Discarded Commercial Chemical Products, Off-Specification Species, Containers, and Spill Residues Thereof.

The following materials or items are hazardous wastes if and when they are discarded or intended to be discarded:

(a) Any commercial chemical product, or manufacturing chemical intermediate having the generic name listed in paragraphs (e) or (f) of this section.

(b) Any off-specification commercial chemical product or manufacturing chemical intermediate which, if it met specifications, would have the generic name listed in paragraphs (e) or (f) of this section.

(c) Any container or inner liner removed from a container that has been used to hold any commercial chemical product or manufacturing chemical intermediate having the generic name listed in paragraph (e) of this section, unless:

(1) The container or inner liner has been triple rinsed using a solvent capable of removing the commercial chemical product or manufacturing chemical intermediate;

(2) The container or inner liner has been cleaned by another method that has been shown in the scientific literature, or by tests conducted by the generator, to achieve equivalent removal; or

(3) In the case of a container, the inner liner that prevented contact of the commercial chemical product or manufacturing chemical intermediate with the container, has been removed.

(d) Any residue or contaminated soil, water or other debris resulting from the cleanup of a spill, into or on any land or water, of any commercial chemical product or manufacturing chemical intermediate having the generic name listed in paragraphs (e) or (f) of this Section.

[Comment: The phrase "commercial chemical product or manufacturing chemical intermediate having the generic name listed in . . ." refers to a chemical substance which is manufactured or formulated for commercial or manufacturing use. It does not refer to a material, such as a manufacturing process waste, that contains any of the substances listed in paragraphs (e) or (f). Where a manufacturing process waste is deemed to be a hazardous waste because it contains a substance listed in paragraphs (e) or (f), such waste will be listed in either §§ 261.31 or 261.32 or will be identified as a hazardous waste by the characteristics set forth in Subpart C of this Part.]

(e) The commercial chemical products or manufacturing chemical intermediates, referred to in paragraphs (a) through (d) of this section, are identified as acute hazardous wastes (H) and are subject to the small quantity exclusion defined in § 261.5(c). These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous waste No.	Substance [1]
	1080 see P058
	1081 see P057
	(Acetato)phenylmercury see P092
	Acetone cyanohydrin see P069
P001	3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts
P002	1-Acetyl-2-thiourea
P003	Acrolein
	Agarin see P007
	Agrosan GN 5 see P092
	Aldicarb see P070
	Aldifen see P048
P004	Aldrin
	Algimycin see P092
P005	Allyl alcohol
P006	Aluminum phosphide (R)
	ALVIT see P037
	Aminoethylene see P054
P007	5-(Aminomethyl)-3-isoxazolol
P008	4-Aminopyridine
	Ammonium metavanadate see P119
P009	Ammonium picrate (R)
	ANTIMUCIN WDR see P092
	ANTURAT see P073
	AQUATHOL see P088
	ARETIT see P020
P010	Arsenic acid
P011	Arsenic pentoxide
P012	Arsenic trioxide
	Athrombin see P001
	AVITROL see P008
	Aziridine see P054
	AZOFOS see P061
	Azophos see P061
	BANTU see P072
P013	Barium cyanide
	BASENITE see P020
	BCME see P016
P014	Benzenethiol
	Benzoepin see P050
P015	Beryllium dust
P016	Bis(chloromethyl) ether
	BLADAN-M see P071
P017	Bromoacetone
P018	Brucine
P019	2-Butanone peroxide
	BUFEN see P092
	Butaphene see P020
P020	2-sec-Butyl-4,6-dinitrophenol
P021	Calcium cyanide
	CALDON see P020
P022	Carbon disulfide
	CERESAN see P092
	CERESAN UNIVERSAL see P092
	CHEMOX GENERAL see P020
	CHEMOX P.E. see P020
	CHEM-TOL see P090
P023	Chloroacetaldehyde
P024	p-Chloroaniline
P025	1-(p-Chlorobenzoyl)-5-methoxy-2-methylindole-3-acetic acid
P026	1-(o-Chlorophenyl)thiourea
P027	3-Chloropropionitrile
P028	alpha-Chlorotoluene
P029	Copper cyanide
	CRETOX see P108
	Coumadin see P001
	Coumafen see P001
P030	Cyanides

Hazardous waste No.	Substance [1]
P031	Cyanogen
P032	Cyanogen bromide
P033	Cyanogen chloride
	Cyclodan see P050
P034	2-Cyclohexyl-4,6-dinitrophenol
	D-CON see P001
	DETHMOR see P001
	DETHNEL see P001
	DFP see P043
P035	2,4-Dichlorophenoxyacetic acid (2,4-D)
P036	Dichlorophenylarsine
	Dicyanogen see P031
P037	Dieldrin
	DIELDREX see P037
P038	Diethylarsine
P039	O,O-Diethyl-S-(2-(ethylthio)ethyl)ester of phosphorothioic acid
P040	O,O-Diethyl-O-(2-pyrazinyl)phosphorothioate
P041	O,O-Diethyl phosphoric acid, O-p-nitrophenyl ester
P042	3,4-Dihydroxy-alpha-(methylamino)-methyl benzyl alcohol
P043	Di-isopropylfluorophosphate
	DIMETATE see P044
	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro endo, endo see P060
P044	Dimethoate
P045	3,3-Dimethyl-1-(methylthio)-2-butanone-O-[(methylamino)carbonyl] oxime
P046	alpha,alpha-Dimethylphenethylamine
	Dinitrocyclohexylphenol see P034
P047	4,6-Dinitro-o-cresol and salts
P048	2,4-Dinitrophenol
	DINOSEB see P020
	DINOSEBE see P020
	Disulfoton see P039
P049	2,4-Dithiobiuret
	DNBP see P020
	DOLCO MOUSE CEREAL see P108
	DOW GENERAL see P020
	DOW GENERAL WEED KILLER see P020
	DOW SELECTIVE WEED KILLER see P020
	DOWICIDE G see P090
	DYANACIDE see P092
	EASTERN STATES DUOCIDE see P001
	ELGETOL see P020
P050	Endosulfan
P051	Endrin
	Epinephrine see P042
P052	Ethylcyanide
P053	Ethylenediamine
P054	Ethyleneimine
	FASCO FASCRAT POWDER see P001
	FEMMA see P001
P055	Ferric cyanide
P056	Fluorine
P057	2-Fluoroacetamide
P058	Fluoroacetic acid, sodium salt
	FOLODOL-80 see P071
	FOLODOL M see P071
	FOSFERNO M 50 see P071
	FRATOL see P058
	Fulminate of mercury see P065
	FUNGITOX OR see P092
	FUSSOF see P057
	GALLOTOX see P092
	GEARPHOS see P071
	GERUTOX see P020
P059	Heptachlor
P060	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo, endo-dimethanonaphthalene
	1,4,5,6,7,7-Hexachloro-cyclic-5-norbornene-2,3-dimethanol sulfite see P050
P061	Hexachloropropene
P062	Hexaethyl tetraphosphate
	HOSTAQUICK see P092
	HOSTAQUIK see P092
	Hydrazomethane see P068
P063	Hydrocyanic acid
	ILLOXOL see P037
	INDOCI see P025
	Indomethacin see P025
	INSECTOPHENE see P050
	Isodrin see P060
P064	Isocyanic acid, methyl ester
	KILOSEB see P020
	KOP-THIODAN see P050
	KWIK-KIL see P108
	KWIKSAN see P092
	KUMADER see P001
	KYPFARIN see P001
	LEYTOSAN see P092
	LIQUIPHENE see P092
	MALIK see P050
	MAREVAN see P001
	MAR-FRIN see P001
	MARTIN'D MAR-FRIN see P001
	MAVERAN see P001
	MEGATOX see P005
P065	Mercury fulminate
	MERSOLITE see P092
	METACID 50 see P071
	METAFOS see P071
	METAPHOR see P071
	METAPHOS see P071
	METASOL 30 see P092
P066	Methomyl
P067	2-Methylaziridine
	METHYL-E 605 see P071
P068	Methyl hydrazine
	Methyl isocyanate see P064
P069	2-Methyllactonitrile
P070	2-Methyl-2-(methylthio)propionaldehyde-o-(methylcarbonyl) oxime
	METHYL NIRON see P042
P071	Methyl parathion
	METRON see P071
	MOLE DEATH see P108
	MOUSE-NOTS see P108
	MOUSE-RID see P108
	MOUSE-TOX see P108
	MUSCIMOL see P007
P072	1-Naphthyl-2-thiourea
P073	Nickel carbonyl
P074	Nickel cyanide
P075	Nicotine and salts
P076	Nitric oxide
P077	p-Nitroaniline
P078	Nitrogen dioxide
P079	Nitrogen peroxide
P080	Nitrogen tetroxide
P081	Nitroglycerine (R)
P082	N-Nitrosodimethylamine
P083	N-Nitrosodiphenylamine
P084	N-Nitrosomethylvinylamine
	NYLMERATE see P092
	OCTALOX see P037
P085	Octamethylpyrophosphoramide
	OCTAN see P092
P086	Oleyl alcohol condensed with 2 moles ethylene oxide
	OMPA see P085
	OMPACIDE see P085
	OMPAX see P085
P087	Osmium tetroxide
P088	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
	PANIVARFIN see P001
	PANORAM D-31 see P037
	PANTHERINE see P007
	PANWARFIN see P001
P089	Parathion
	PCP see P090
	PENNCAP-M see P071
	PENOXYL CARBON N see P048
P090	Pentachlorophenol
	Pentachlorophenate see P090
	PENTA-KILL see P090
	PENTASOL see P090
	PENWAR see P090
	PERMICIDE see P090
	PERMAGUARD see P090
	PERMATOX see P090
	PERMITE see P090
	PERTOX see P090
	PESTOX III see P085
	PHENMAD see P092
	PHENOTAN see P020
P091	Phenyl dichloroarsine
	Phenyl mercaptan see P014
P092	Phenylmercury acetate
P093	N-Phenylthiourea
	PHILIPS 1861 see P008
	PHIX see P092
P094	Phorate
P095	Phosgene
P096	Phosphine
P097	Phosphorothioic acid, O,O-dimethyl ester, O-ester with N,N-dimethyl benzene sulfonamide
	Phosphorothioic acid O,O-dimethyl-O-(p-nitrophenyl) ester see P071
	PIED PIPER MOUSE SEED see P108
P098	Potassium cyanide
P099	Potassium silver cyanide
	PREMERGE see P020
P100	1,2-Propanediol
	Propargyl alcohol see P102
P101	Propionitrile
P102	2-Propyn-1-ol
	PROTHROMADIN See P001
	QUICKSAM see P092
	QUINTOX see P037
	RAT AND MICE BAIT see P001
	RAT-A-WAY see P001
	RAT-B-GON see P001
	RAT-O-CIDE #2 see P001
	RAT-GUARD see P001
	RAT-KILL see P001
	RAT-MIX see P001
	RATS-NO-MORE see P001
	RAT-OLA see P001
	RATOREX see P001
	RATTUNAL see P001
	RAT-TROL see P001
	RO-DETH see P001
	RO-DEX see P108
	ROSEX see P001
	ROUGH & READY MOUSE MIX see P001
	SANASEED see P108
	SANTOBRITE see P090
	SANTOPHEN see P090
	SANTOPHEN 20 see P090
	SCHRADAN see P085
P103	Selenourea
P104	Silver Cyanide
	SMITE see P105
	SPARIC see P020
	SPOR-KIL see P092
	SPRAY-TROL BRAND RODEN-TROL see P001
	SPURGE see P020
P105	Sodium azide
	Sodium coumadin see P001
P106	Sodium cyanide
	Sodium fluoroacetate see P056
	SODIUM WARFARIN see P001
	SOLFARIN see P001
	SOLFOBLACK BB see P048
	SOLFOBLACK SB see P048
P107	Strontium sulfide
P108	Strychnine and salts
	SUBTEX see P020
	SYSTAM see P085
	TAG FUNGICIDE see P092
	TEKWAISA see P071
	TEMIC see P070
	TEMIK see P070
	TERM-I-TROL see P090
P109	Tetraethyldithiopyrophosphate
P110	Tetraethyl lead
P111	Tetraethylpyrophosphate
P112	Tetranitromethane
	Tetraphosphoric acid, hexaethyl ester see P062
	TETROSULFUR BLACK PB see P048
	TETROSULPHUR PBR see P048
P113	Thallic oxide
	Thallium peroxide see P113
P114	Thallium selenite
P115	Thallium (I) sulfate
	THIFOR see P092
	THIMUL see P092
	THIODAN see P050
	THIOFOR see P050
	THIOMUL see P050
	THIONEX see P050
	THIOPHENIT see P071
P116	Thiosemicarbazide
	Thiosulfan tionel see P050
P117	Thiuram
	THOMPSON'S WOOD FIX see P090
	TIOVEL see P050
P118	Trichloromethanethiol
	TWIN LIGHT RAT AWAY see P001
	USAF RH-8 see P069
	USAF EK-4890 see P002
P119	Vanadic acid, ammonium salt
P120	Vanadium pentoxide
	VOFATOX see P071
	WANADU see P120
	WARCOUMIN see P001
	WARFARIN SODIUM see P001
	WARFICIDE see P001
	WOFOTOX see P072
	YANOCK see P057
	YASOKNOCK see P058
	ZIARNIK see P092
P121	Zinc cyanide
P122	Zinc phosphide (R,T)
	ZOOCOUMARIN see P001

[1] The Agency included those trade names of which it was aware; an omission of a trade name does not imply that the omitted material is not hazardous. The material is hazardous if it is listed under its generic name.

(f) The commercial chemical products or manufacturing chemical intermediates, referred to in paragraphs (a), (b) and (d) of this section, are identified as toxic wastes (T) unless otherwise designated and are subject to the small quantity exclusion defined in § 261.5 (a) and (b). These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous Waste No.	Substance [1]
	AAF see U005
U001	Acetaldehyde
U002	Acetone (I)
U003	Acetonitrile (I,T)
U004	Acetophenone
U005	2-Acetylaminofluorene
U006	Acetyl chloride (C,T)
U007	Acrylamide
	Acetylene tetrachloride see U209
	Acetylene trichloride see U228
U008	Acrylic acid (I)
U009	Acrylonitrile
	AEROTHENE TT see U226
	3-Amino-5-(p-acetamidophenyl)-1H-1,2,4-triazole, hydrate see U011
U010	6-Amino-1,1a,2,8,8a,8b-hexahydro-8-(hydroxymethyl)-8a-methoxy-5-methylcarbamate azirino(2',3':3,4) pyrrolo(1,2-a) indole-4, 7-dione (ester)
U011	Amitrole
U012	Aniline (I)
U013	Asbestos
U014	Auramine
U015	Azaserine
U016	Benz[c]acridine
U017	Benzal chloride
U018	Benz[a]anthracene
U019	Benzene
U020	Benzenesulfonyl chloride (C,R)
U021	Benzidine
	1,2-Benzisothiazolin-3-one, 1,1-dioxide see U202
	Benzo[a]anthracene see U018
U022	Benzo[a]pyrene
U023	Benzotrichloride (C,R,T)
U024	Bis(2-chloroethoxy)methane
U025	Bis(2-chloroethyl) ether
U026	N,N-Bis(2-chloroethyl)-2-naphthylamine
U027	Bis(2-chloroisopropyl) ether
U028	Bis(2-ethylhexyl) phthalate
U029	Bromomethane
U030	4-Bromophenyl phenyl ether
U031	n-Butyl alcohol (I)
U032	Calcium chromate
	Carbolic acid see U188
	Carbon tetrachloride see U211
U033	Carbonyl fluoride
U034	Chloral
U035	Chlorambucil
U036	Chlordane
U037	Chlorobenzene
U038	Chlorobenzilate
U039	p-Chloro-m-cresol
U040	Chlorodibromomethane
U041	1-Chloro-2,3-epoxypropane
	CHLOROETHENE NU see U226
U042	Chloroethyl vinyl ether
U043	Chloroethene
U044	Chloroform (I,T)
U045	Chloromethane (I,T)
U046	Chloromethyl methyl ether
U047	2-Chloronaphthalene
U048	2-Chlorophenol
U049	4-Chloro-o-toluidine hydrochloride
U050	Chrysene
	C.I. 23060 see U073
U051	Creosote
U052	Cresols
U053	Crotonaldehyde
U054	Cresylic acid
U055	Cumene
	Cyanomethane see U003
U056	Cyclohexane (I)
U057	Cyclohexanone (I)
U058	Cyclophosphamide
U059	Daunomycin
U060	DDD

Hazardous Waste No.	Substance [1]
U061	DDT
U062	Diallate
U063	Dibenz[a,h]anthracene
	Dibenzo[a,h]anthracene see U063
U064	Dibenzo[a,i]pyrene
U065	Dibromochloromethane
U066	1,2-Dibromo-3-chloropropane
U067	1,2-Dibromoethane
U068	Dibromomethane
U069	Di-n-butyl phthalate
U070	1,2-Dichlorobenzene
U071	1,3-Dichlorobenzene
U072	1,4-Dichlorobenzene
U073	3,3'-Dichlorobenzidine
U074	1,4-Dichloro-2-butene
	3,3'-Dichloro-4,4'-diaminobiphenyl see U073
U075	Dichlorodifluoromethane
U076	1,1-Dichloroethane
U077	1,2-Dichloroethane
U078	1,1-Dichloroethylene
U079	1,2-trans-dichloroethylene
U080	Dichloromethane
	Dichloromethylbenzene see U017
U081	2,4-Dichlorophenol
U082	2,6-Dichlorophenol
U083	1,2-Dichloropropane
U084	1,3-Dichloropropene
U085	Diepoxybutane (I,T)
U086	1,2-Diethylhydrazine
U087	0,0-Diethyl-S-methyl ester of phosphorodithioic acid
U088	Diethyl phthalate
U089	Diethylstilbestrol
U090	Dihydrosafrole
U091	3,3'-Dimethoxybenzidine
U092	Dimethylamine (I)
U093	p-Dimethylaminoazobenzene
U094	7,12-Dimethylbenz[a]anthracene
U095	3,3'-Dimethylbenzidine
U096	alpha,alpha-Dimethylbenzylhydroperoxide (R)
U097	Dimethylcarbamoyl chloride
U098	1,1-Dimethylhydrazine
U099	1,2-Dimethylhydrazine
U100	Dimethylnitrosoamine
U101	2,4-Dimethylphenol
U102	Dimethyl phthalate
U103	Dimethyl sulfate
U104	2,4-Dinitrophenol
U105	2,4-Dinitrotoluene
U106	2,6-Dinitrotoluene
U107	Di-n-octyl phthalate
U108	1,4-Dioxane
U109	1,2-Diphenylhydrazine
U110	Dipropylamine (I)
U111	Di-n-propylnitrosamine
	EBDC see U114
	1,4-Epoxybutane see U213
U112	Ethyl acetate (I)
U113	Ethyl acrylate (I)
U114	Ethylenebisdithiocarbamate
U115	Ethylene oxide (I,T)
U116	Ethylene thiourea
U117	Ethyl ether (I,T)
U118	Ethylmethacrylate
U119	Ethyl methanesulfonate
	Ethylnitrile see U003
	Firemaster T23P see U235
U120	Fluoranthene
U121	Fluorotrichloromethane
U122	Formaldehyde
U123	Formic acid (C,T)
U124	Furan (I)
U125	Furfural (I)
U126	Glycidylaldehyde
U127	Hexachlorobenzene
U128	Hexachlorobutadiene
U129	Hexachlorocyclohexane
U130	Hexachlorocyclopentadiene
U131	Hexachloroethane
U132	Hexachlorophene
U133	Hydrazine (R,T)
U134	Hydrofluoric acid (C,T)
U135	Hydrogen sulfide
	Hydroxybenzene see U188
U136	Hydroxydimethyl arsine oxide
	4,4'-(Imidocarbonyl)bis(N,N-dimethyl)aniline see U014
U137	Indeno(1,2,3-cd)pyrene
U138	Iodomethane
U139	Iron Dextran
U140	Isobutyl alcohol

Hazardous Waste No.	Substance [1]
U141	Isosafrole
U142	Kepone
U143	Lasiocarpine
U144	Lead acetate
U145	Lead phosphate
U146	Lead subacetate
U147	Maleic anhydride
U148	Maleic hydrazide
U149	Malononitrile
	MEK Peroxide see U160
U150	Melphalan
U151	Mercury
U152	Methacrylonitrile
U153	Methanethiol
U154	Methanol
U155	Methapyrilene
	Methyl alcohol see U154
U156	Methyl chlorocarbonate
	Methyl chloroform see U226
U157	3-Methylcholanthrene
	Methyl chloroformate see U156
U158	4,4'-Methylene-bis-(2-chloroaniline)
U159	Methyl ethyl ketone (MEK) (I,T)
U160	Methyl ethyl ketone peroxide (R)
	Methyl iodide see U138
U161	Methyl isobutyl ketone
U162	Methyl methacrylate (R,T)
U163	N-Methyl-N'-nitro-N-nitrosoguanidine
U164	Methylthiouracil
	Mitomycin C see U010
U165	Naphthalene
U166	1,4-Naphthoquinone
U167	1-Naphthylamine
U168	2-Naphthylamine
U169	Nitrobenzene (I,T)
	Nitrobenzol see U169
U170	4-Nitrophenol
U171	2-Nitropropane (I)
U172	N-Nitrosodi-n-butylamine
U173	N-Nitrosodiethanolamine
U174	N-Nitrosodiethylamine
U175	N-Nitrosodi-n-propylamine
U176	N-Nitroso-n-ethylurea
U177	N-Nitroso-n-methylurea
U178	N-Nitroso-n-methylurethane
U179	N-Nitrosopiperidine
U180	N-Nitrosopyrrolidine
U181	5-Nitro-o-toluidine
U182	Paraldehyde
	PCNB see U185
U183	Pentachlorobenzene
U184	Pentachloroethane
U185	Pentachloronitrobenzene
U186	1,3-Pentadiene (I)
	Perc see U210
	Perchlorethylene see U210
U187	Phenacetin
U188	Phenol
U189	Phosphorous sulfide (R)
U190	Phthalic anhydride
U191	2-Picoline
U192	Pronamide
U193	1,3-Propane sultone
U194	n-Propylamine (I)
U196	Pyridine
U197	Quinones
U200	Reserpine
U201	Resorcinol
U202	Saccharin
U203	Safrole
U204	Selenious acid
U205	Selenium sulfide (R,T)
	Silvex see U233
U206	Streptozotocin
	2,4,5-T see U232
U207	1,2,4,5-Tetrachlorobenzene
U208	1,1,1,2-Tetrachloroethane
U209	1,1,2,2-Tetrachloroethane
U210	Tetrachloroethane
	Tetrachloroethylene see U210
U211	Tetrachloromethane
U212	2,3,4,6-Tetrachlorophenol
U213	Tetrahydrofuran (I)
U214	Thallium (I) acetate
U215	Thallium (I) carbonate
U216	Thallium (I) chloride
U217	Thallium (I) nitrate
U218	Thioacetamide
U219	Thiourea
U220	Toluene
U221	Toluenediamine
U222	o-Toluidine hydrochloride

Hazardous Waste No.	Substance[1]
U223	Toluene diisocyanate
U224	Toxaphene
	2,4,5-TP see U233
U225	Tribromomethane
U226	1,1,1-Trichloroethane
U227	1,1,2-Trichloroethane
U228	Trichloroethene
	Trichloroethylene see U228
U229	Trichlorofluoromethane
U230	2,4,5-Trichlorophenol
U231	2,4,6-Trichlorophenol
U232	2,4,5-Trichlorophenoxyacetic acid
U233	2,4,5-Trichlorophenoxypropionic acid alpha, alpha, alpha- Trichlorotoluene see U023
	TRI-CLENE see U228
U234	Trinitrobenzene (R,T)
U235	Tris(2,3-dibromopropyl) phosphate
U236	Trypan blue
U237	Uracil mustard
U238	Urethane
	Vinyl chloride see U043
	Vinylidene chloride see U078
U239	Xylene

[1] The Agency included those trade names of which it was aware; an omission of a trade name does not imply that it is not hazardous. The material is hazardous if it is listed under its generic name.

EPA hazardous waste No.	Hazardous constituents for which listed
K019	Ethylene dichloride, 1,1,1-trichloroethane, 1,1,2-trichloroethane, tetrachloroethanes (1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane), trichloroethylene, tetrachloroethylene, carbon tetrachloride, chloroform, vinyl chloride, vinylidene chloride.
K020	Ethylene dichloride, 1,1,1-trichloroethane, 1,1,2-trichloroethane, tetrachloroethanes (1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane), trichloroethylene, tetrachloroethylene, carbon tetrachloride, chloroform, vinyl chloride, vinylidene chloride.
K021	Antimony, carbon tetrachloride, chloroform.
K022	Phenol, tars (polycyclic aromatic hydrocarbons).
K023	Phthalic anhydride, maleic anhydride
K024	Phthalic anhydride, 1,4-naphthoquinone.
K025	Meta-dinitrobenzene, 2,4-dinitrotoluene.
K026	Paraldehyde, pyridines, 2-picoline.
K027	Toluene diisocyanate, toluene-2, 4-diamine.
K028	1,1,1-trichloroethane, vinyl chloride.
K029	1,2-dichloroethane, 1,1,1-trichloroethane, vinyl chloride, vinylidene chloride, chloroform.
K030	Hexachlorobenzene, hexachlorobutadiene, hexachloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, ethylene dichloride.
K031	Arsenic.
K032	Hexachlorocyclopentadiene.
K033	Hexachlorocyclopentadiene.
K034	Hexachlorocyclopentadiene.
K035	Creosote, chrysene, naphthalene, fluoranthene benzo(b) fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd) pyrene, benzo(a)anthracene, dibenzo(a)anthracene, acenaphthalene.
K036	Toluene, phosphorodithioic and phosphorothioic acid esters.
K037	Toluene, phosphorodithioic and phosphorothioic acid esters.
K038	Phorate, formaldehyde, phosphorodithioic and phosphorothioic acid esters.
K039	Phosphorodithioic and phosphorothioic acid esters
K040	Phorate, formaldehyde, phosphorodithioic and phosphorothioic acid esters.
K041	Toxaphene.
K042	Hexachlorobenzene, ortho-dichlorobenzene.
K043	2,4-dichlorophenol, 2,6-dichlorophenol, 2,4,6-trichlorophenol.
K044	N.A.
K045	N.A.
K046	Lead.
K047	N.A.
K048	Hexavalent chromium, lead.
K049	Hexavalent chromium, lead.
K050	Hexavalent chromium.
K051	Hexavalent chromium, lead.
K052	Lead.
K060	Cyanide, napthalene, phenolic compounds, arsenic.
K061	Hexavalent chromium, lead, cadmium.
K062	Hexavalent chromium, lead.
K069	Hexavalent chromium, lead, cadmium.
K071	Mercury.
K073	Chloroform, carbon tetrachloride, hexachloroethane, trichloroethane, tetrachloroethylene, dichloroethylene, 1,1,2,2-tetrachloroethane.
K083	Aniline, diphenylamine, nitrobenzene, phenylenediamine.
K084	Arsenic.
K085	Benzene, dichlorobenzenes, trichlorobenzenes, tetrachlorobenzenes, pentachlorobenzene, hexachlorobenzene, benzyl chloride.
K086	Lead, hexavalent chromium.
K087	Phenol, naphthalene.
K093	Phthalic anhydride, maleic anhydride.
K094	Phthalic anhydride.
K095	1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane.
K096	1,2-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane.
K097	Chlordane, heptachlor.
K098	Toxaphene.
K099	2,4-dichlorophenol, 2,4,6-trichlorophenol.
K100	Hexavalent chromium, lead, cadmium.
K101	Arsenic.
K102	Arsenic.
K103	Aniline, nitrobenzene, phenylenediamine.
K104	Aniline, benzene, diphenylamine, nitrobenzene, phenylenediamine.
K105	Benzene, monochlorobenzene, dichlorobenzenes, 2,4,6-trichlorophenol.
K106	Mercury.

N.A.—Waste is hazardous because it fails the test for the characteristic of ignitability, corrosivity, or reactivity.

[46 FR 4619, Jan. 16, 1981, as amended at 46 FR 27477, May 20, 1981]

Appendix VIII—Hazardous Constituents

Acetonitrile (Ethanenitrile)
Acetophenone (Ethanone, 1-phenyl)
3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts (Warfarin)
2-Acetylaminofluorene (Acetamide, N-(9H-fluoren-2-yl)-)
Acetyl chloride (Ethanoyl chloride)
1-Acetyl-2-thiourea (Acetamide, N-(aminothioxomethyl)-)
Acrolein (2-Propenal)
Acrylamide (2-Propenamide)
Acrylonitrile (2-Propenenitrile)
Aflatoxins
Aldrin (1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a,8b-hexahydro-endo,exo-1,4:5,8-Dimethanonaphthalene)
Allyl alcohol (2-Propen-1-ol)
Aluminum phosphide
4-Aminobiphenyl ([1,1'-Biphenyl]-4-amine)
6-Amino-1,1a,2,8,8a,8b-hexahydro-8-(hydroxymethyl)-8a-methoxy-5-methylcarbamate azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione, (ester) (Mitomycin C) (Azirino[2'3':3,4]pyrrolo(1,2-a)indole-4,7-dione, 6-amino-8-[((aminocarbonyl)oxy)methyl]-1,1a,2,8,8a,8b-hexahydro-8amethoxy-5-methy-)
5-(Aminomethyl)-3-isoxazolol (3(2H)-Isoxazolone, 5-(aminomethyl)-) 4-Aminopyridine (4-Pyridinamine)
Amitrole (1H-1,2,4-Triazol-3-amine)
Aniline (Benzenamine)
Antimony and compounds, N.O.S.*
Aramite (Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester)
Arsenic and compounds, N.O.S.*
Arsenic acid (Orthoarsenic acid)
Arsenic pentoxide (Arsenic (V) oxide)
Arsenic trioxide (Arsenic (III) oxide)
Auramine (Benzenamine, 4,4'-carbonimidoylbis[N,N-Dimethyl-, monohydrochloride)
Azaserine (L-Serine, diazoacetate (ester))
Barium and compounds, N.O.S.*
Barium cyanide
Benz[c]acridine (3,4-Benzacridine)
Benz[a]anthracene (1,2-Benzanthracene)
Benzene (Cyclohexatriene)
Benzenearsonic acid (Arsonic acid, phenyl-)
Benzene, dichloromethyl- (Benzal chloride)
Benzenethiol (Thiophenol)
Benzidine ([1,1'-Biphenyl]-4,4'diamine)
Benzo[b]fluoranthene (2,3-Benzofluoranthene)
Benzo[j]fluoranthene (7,8-Benzofluoranthene)
Benzo[a]pyrene (3,4-Benzopyrene)
p-Benzoquinone (1,4-Cyclohexadienedione)
Benzotrichloride (Benzene, trichloromethyl-)
Benzyl chloride (Benzene, (chloromethyl)-)
Beryllium and compounds, N.O.S.*
Bis(2-chloroethoxy)methane (Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-])
Bis(2-chloroethyl) ether (Ethane, 1,1'-oxybis[2-chloro-])
N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)
Bis(2-chloroisopropyl) ether (Propane, 2,2'-oxybis[2-chloro-])
Bis(chloromethyl) ether (Methane, oxybis[chloro-])
Bis(2-ethylhexyl) phthalate (1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester)
Bromoacetone (2-Propanone, 1-bromo-)
Bromomethane (Methyl bromide)
4-Bromophenyl phenyl ether (Benzene, 1-bromo-4-phenoxy-)
Brucine (Strychnidin-10-one, 2,3-dimethoxy-)
2-Butanone peroxide (Methyl ethyl ketone, peroxide)
Butyl benzyl phthalate (1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester)
2-sec-Butyl-4,6-dinitrophenol (DNBP) (Phenol, 2,4-dinitro-6-(1-methylpropyl)-)
Cadmium and compounds, N.O.S.*
Calcium chromate (Chromic acid, calcium salt)
Calcium cyanide
Carbon disulfide (Carbon bisulfide)
Carbon oxyfluoride (Carbonyl fluoride)
Chloral (Acetaldehyde, trichloro-)
Chlorambucil (Butanoic acid, 4-[bis(2-chloroethyl)amino]benzene-)
Chlordane (alpha and gamma isomers) (4,7-Methanoindan, 1,2,4,5,6,7,8,8-octachloro-3,4,7,7a-tetrahydro-) (alpha and gamma isomers)
Chlorinated benzenes, N.O.S.*
Chlorinated ethane, N.O.S.*
Chlorinated fluorocarbons, N.O.S.*
Chlorinated naphthalene, N.O.S.*
Chlorinated phenol, N.O.S.*
Chloroacetaldehyde (Acetaldehyde, chloro-)
Chloroalkyl ethers, N.O.S.*
p-Chloroaniline (Benzenamine, 4-chloro-)
Chlorobenzene (Benzene, chloro-)
Chlorobenzilate (Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester)
p-Chloro-m-cresol (Phenol, 4-chloro-3-methyl)
1-Chloro-2,3-epoxypropane (Oxirane, 2-(chloromethyl)-)
2-Chloroethyl vinyl ether (Ethene, (2-chloroethoxy)-)
Chloroform (Methane, trichloro-)
Chloromethane (Methyl chloride)
Chloromethyl methyl ether (Methane, chloromethoxy-)
2-Chloronaphthalene (Naphthalene, beta-chloro-)
2-Chlorophenol (Phenol, o-chloro-)
1-(o-Chlorophenyl)thiourea (Thiourea, (2-chlorophenyl)-)
3-Chloropropionitrile (Propanenitrile, 3-chloro-)
Chromium and compounds, N.O.S.*
Chrysene (1,2-Benzphenanthrene)
Citrus red No. 2 (2-Naphthol, 1-[(2,5-dimethoxyphenyl)azo]-)
Coal tars
Copper cyanide
Creosote (Creosote, wood)
Cresols (Cresylic acid) (Phenol, methyl-)
Crotonaldehyde (2-Butenal)
Cyanides (soluble salts and complexes), N.O.S.*
Cyanogen (Ethanedinitrile)
Cyanogen bromide (Bromine cyanide)
Cyanogen chloride (Chlorine cyanide)
Cycasin (beta-D-Glucopyranoside, (methyl-ONN-azoxy)methyl-)
2-Cyclohexyl-4,6-dinitrophenol (Phenol, 2-cyclohexyl-4,6-dinitro-)
Cyclophosphamide (2H-1,3,2,-Oxazaphosphorine, [bis(2-chloroethyl)amino]-tetrahydro-, 2-oxide)
Daunomycin (5,12-Naphthacenedione, (8S-cis)-8-acetyl-10-[(3-amino-2,3,6-trideoxy)-alpha-L-lyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-)

* The abbreviation N.O.S. (not otherwise specified) signifies those members of the general class not specifically listed by name in this appendix.

DDD (Dichlorodiphenyldichloroethane) (Ethane, 1,1-dichloro-2,2-bis(p-chlorophenyl)-)
DDE (Ethylene, 1,1-dichloro-2,2-bis(4-chlorophenyl)-)
DDT (Dichlorodiphenyltrichloroethane) (Ethane, 1,1,1-trichloro-2,2-bis(p-chlorophenyl)-)
Diallate (S-(2,3-dichloroallyl) diisopropylthiocarbamate)
Dibenz[a,h]acridine (1,2,5,6-Dibenzacridine)
Dibenz[a,j]acridine (1,2,7,8-Dibenzacridine)
Dibenz[a,h]anthracene (1,2,5,6-Dibenzanthracene)
7H-Dibenzo[c,g]carbazole (3,4,5,6-Dibenzcarbazole)
Dibenzo[a,e]pyrene (1,2,4,5-Dibenzpyrene)
Dibenzo[a,h]pyrene (1,2,5,6-Dibenzpyrene)
Dibenzo[a,i]pyrene (1,2,7,8-Dibenzpyrene)
1,2-Dibromo-3-chloropropane (Propane, 1,2-dibromo-3-chloro-)
1,2-Dibromoethane (Ethylene dibromide)
Dibromomethane (Methylene bromide)
Di-n-butyl phthalate (1,2-Benzenedicarboxylic acid, dibutyl ester)
o-Dichlorobenzene (Benzene, 1,2-dichloro-)
m-Dichlorobenzene (Benzene, 1,3-dichloro-)
p-Dichlorobenzene (Benzene, 1,4-dichloro-)
Dichlorobenzene, N.O.S.* (Benzene, dichloro-, N.O.S.*)
3,3'-Dichlorobenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-)
1,4-Dichloro-2-butene (2-Butene, 1,4-dichloro-)
Dichlorodifluoromethane (Methane, dichlorodifluoro-)
1,1-Dichloroethane (Ethylidene dichloride)
1,2-Dichloroethane (Ethylene dichloride)
trans-1,2-Dichloroethene (1,2-Dichloroethylene)
Dichloroethylene, N.O.S.* (Ethene, dichloro-, N.O.S.*)
1,1-Dichloroethylene (Ethene, 1,1-dichloro-)
Dichloromethane (Methylene chloride)
2,4-Dichlorophenol (Phenol, 2,4-dichloro-)
2,6-Dichlorophenol (Phenol, 2,6-dichloro-)
2,4-Dichlorophenoxyacetic acid (2,4-D), salts and esters (Acetic acid, 2,4-dichlorophenoxy-, salts and esters)
Dichlorophenylarsine (Phenyl dichloroarsine)
Dichloropropane, N.O.S.* (Propane, dichloro-, N.O.S.*)
1,2-Dichloropropane (Propylene dichloride)
Dichloropropanol, N.O.S.* (Propanol, dichloro-, N.O.S.*)
Dichloropropene, N.O.S.* (Propene, dichloro-, N.O.S.*)
1,3-Dichloropropene (1-Propene, 1,3-dichloro-)
Dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octa-hydro-endo,exo-1,4:5,8-Dimethanonaphthalene)
1,2:3,4-Diepoxybutane (2,2'-Bioxirane)
Diethylarsine (Arsine, diethyl-)
N,N-Diethylhydrazine (Hydrazine, 1,2-diethyl)
O,O-Diethyl S-methyl ester of phosphorodithioic acid (Phosphorodithioic acid, O,O-diethyl S-methyl ester
O,O-Diethylphosphoric acid, O-p-nitrophenyl ester (Phosphoric acid, diethyl p-nitrophenyl ester)
Diethyl phthalate (1,2-Benzenedicarboxylic acid, diethyl ester)
O,O-Diethyl O-2-pyrazinyl phosphorothioate (Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester
Diethylstilbesterol (4,4'-Stilbenediol, alpha,alpha-diethyl, bis(dihydrogen phosphate, (E)-)
Dihydrosafrole (Benzene, 1,2-methylenedioxy-4-propyl-)
3,4-Dihydroxy-alpha-(methylamino)methyl benzyl alcohol (1,2-Benzenediol, 4-[1-hydroxy-2-(methylamino)ethyl]-)
Diisopropylfluorophosphate (DFP) (Phosphorofluoridic acid, bis(1-methylethyl) ester)
Dimethoate (Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester
3,3'-Dimethoxybenzidine ([1,1'-Biphenyl]-4,4'diamine, 3-3'-dimethoxy-)
p-Dimethylaminoazobenzene (Benzenamine, N,N-dimethyl-4-(phenylazo)-)
7,12-Dimethylbenz[a]anthracene (1,2-Benzanthracene, 7,12-dimethyl-)
3,3'-Dimethylbenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-)
Dimethylcarbamoyl chloride (Carbamoyl chloride, dimethyl-)
1,1-Dimethylhydrazine (Hydrazine, 1,1-dimethyl-)
1,2-Dimethylhydrazine (Hydrazine, 1,2-dimethyl-)
3,3-Dimethyl-1-(methylthio)-2-butanone, O-[(methylamino) carbonyl]oxime (Thiofanox)
alpha,alpha-Dimethylphenethylamine (Ethanamine, 1,1-dimethyl-2-phenyl-)
2,4-Dimethylphenol (Phenol, 2,4-dimethyl-)
Dimethyl phthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)
Dimethyl sulfate (Sulfuric acid, dimethyl ester)
Dinitrobenzene, N.O.S.* (Benzene, dinitro-, N.O.S.*)
4,6-Dinitro-o-cresol and salts (Phenol, 2,4-dinitro-6-methyl-, and salts)
2,4-Dinitrophenol (Phenol, 2,4-dinitro-)
2,4-Dinitrotoluene (Benzene, 1-methyl-2,4-dinitro-)
2,6-Dinitrotoluene (Benzene, 1-methyl-2,6-dinitro-)
Di-n-octyl phthalate (1,2-Benzenedicarboxylic acid, dioctyl ester)
1,4-Dioxane (1,4-Diethylene oxide)
Diphenylamine (Benzenamine, N-phenyl-)
1,2-Diphenylhydrazine (Hydrazine, 1,2-diphenyl-)
Di-n-propylnitrosamine (N-Nitroso-di-n-propylamine)
Disulfoton (O,O-diethyl S-[2-(ethylthio)ethyl] phosphorodithioate)
2,4-Dithiobiuret (Thioimidodicarbonic diamide)
Endosulfan (5-Norbornene, 2,3-dimethanol, 1,4,5,6,7,7-hexachloro-, cyclic sulfite)
Endrin and metabolites (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-1,4:5,8-dimethanonaphthalene, and metabolites)
Ethyl carbamate (Urethan) (Carbamic acid, ethyl ester)
Ethyl cyanide (propanenitrile)
Ethylenebisdithiocarbamic acid, salts and esters (1,2-Ethanediylbiscarbamodithioic acid, salts and esters
Ethyleneimine (Aziridine)
Ethylene oxide (Oxirane)
Ethylenethiourea (2-Imidazolidinethione)
Ethyl methacrylate (2-Propenoic acid, 2-methyl-, ethyl ester)
Ethyl methanesulfonate (Methanesulfonic acid, ethyl ester)
Fluoranthene (Benzo[j,k]fluorene)
Fluorine
2-Fluoroacetamide (Acetamide, 2-fluoro-)
Fluoroacetic acid, sodium salt (Acetic acid, fluoro-, sodium salt)
Formaldehyde (Methylene oxide)
Formic acid (Methanoic acid)
Glycidylaldehyde (1-Propanol-2,3-epoxy)
Halomethane, N.O.S.*
Heptachlor (4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-)
Heptachlor epoxide (alpha, beta, and gamma isomers) (4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7-tetrahydro-, alpha, beta, and gamma isomers)
Hexachlorobenzene (Benzene, hexachloro-)
Hexachlorobutadiene (1,3-Butadiene, 1,1,2,3,4,4-hexachloro-)
Hexachlorocyclohexane (all isomers) (Lindane and isomers)
Hexachlorocyclopentadiene (1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-)
Hexachloroethane (Ethane, 1,1,1,2,2,2-hexachloro-)
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo,endo-dimethanonaphthalene (Hexachlorohexahydro-endo,endo-dimethanonaphthalene)
Hexachlorophene (2,2'-Methylenebis(3,4,6-trichlorophenol))
Hexachloropropene (1-Propene, 1,1,2,3,3,3-hexachloro-)
Hexaethyl tetraphosphate (Tetraphosphoric acid, hexaethyl ester)
Hydrazine (Diamine)
Hydrocyanic acid (Hydrogen cyanide)
Hydrofluoric acid (Hydrogen fluoride)
Hydrogen sulfide (Sulfur hydride)
Hydroxydimethylarsine oxide (Cacodylic acid)
Indeno(1,2,3-cd)pyrene (1,10-(1,2-phenylene)pyrene)
Iodomethane (Methyl iodide)
Iron dextran (Ferric dextran)
Isocyanic acid, methyl ester (Methyl isocyanate)
Isobutyl alcohol (1-Propanol, 2-methyl-)
Isosafrole (Benzene, 1,2-methylenedioxy-4-allyl-)
Kepone (Decachlorooctahydro-1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one)
Lasiocarpine (2-Butenoic acid, 2-methyl-, 7-[(2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy)methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl ester)
Lead and compounds, N.O.S.*
Lead acetate (Acetic acid, lead salt)
Lead phosphate (Phosphoric acid, lead salt)
Lead subacetate (Lead, bis(acetato-O)tetrahydroxytri-)
Maleic anhydride (2,5-Furandione)
Maleic hydrazide (1,2-Dihydro-3,6-pyridazinedione)
Malononitrile (Propanedinitrile)
Melphalan (Alanine, 3-[p-bis(2-chloroethyl)amino]phenyl-, L-)
Mercury fulminate (Fulminic acid, mercury salt)
Mercury and compounds, N.O.S.*
Methacrylonitrile (2-Propenenitrile, 2-methyl-)
Methanethiol (Thiomethanol)
Methapyrilene (Pyridine, 2-[(2-dimethylamino)ethyl]-2-thenylamino-)
Metholmyl (Acetimidic acid, N-[(methylcarbamoyl)oxy]thio-, methyl ester
Methoxychlor (Ethane, 1,1,1-trichloro-2,2'-bis(p-methoxyphenyl)-)
2-Methylaziridine (1,2-Propylenimine)
3-Methylcholanthrene (Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-)
Methyl chlorocarbonate (Carbonochloridic acid, methyl ester)
4,4'-Methylenebis(2-chloroaniline) (Benzenamine, 4,4'-methylenebis-(2-chloro-)
Methyl ethyl ketone (MEK) (2-Butanone)
Methyl hydrazine (Hydrazine, methyl-)
2-Methyllactonitrile (Propanenitrile, 2-hydroxy-2-methyl-)
Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)
Methyl methanesulfonate (Methanesulfonic acid, methyl ester)
2-Methyl-2-(methylthio)propionaldehyde-o-(methylcarbonyl) oxime (Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime)
N-Methyl-N'-nitro-N-nitrosoguanidine (Guanidine, N-nitroso-N-methyl-N'-nitro-)
Methyl parathion (O,O-dimethyl O-(4-nitrophenyl) phosphorothioate)
Methylthiouracil (4-1H-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-)
Mustard gas (Sulfide, bis(2-chloroethyl)-)

Naphthalene
1,4-Naphthoquinone (1,4-Naphthalenedione)
1-Naphthylamine (alpha-Naphthylamine)
2-Naphthylamine (beta-Naphthylamine)
1-Naphthyl-2-thiourea (Thiourea, 1-naphthalenyl-)
Nickel and compounds, N.O.S.*
Nickel carbonyl (Nickel tetracarbonyl)
Nickel cyanide (Nickel (II) cyanide)
Nicotine and salts (Pyridine, (S)-3-(1-methyl-2-pyrrolidinyl)-, and salts)
Nitric oxide (Nitrogen (II) oxide)
p-Nitroaniline (Benzenamine, 4-nitro-)
Nitrobenzine (Benzene, nitro-)
Nitrogen dioxide (Nitrogen (IV) oxide)
Nitrogen mustard and hydrochloride salt (Ethanamine, 2-chloro-, N-(2-chloroethyl)-N-methyl-, and hydrochloride salt)
Nitrogen mustard N-Oxide and hydrochloride salt (Ethanamine, 2-chloro-, N-(2-chloroethyl)-N-methyl-, and hydrochloride salt)
Nitroglycerine (1,2,3-Propanetriol, trinitrate)
4-Nitrophenol (Phenol, 4-nitro-)
4-Nitroquinoline-1-oxide (Quinoline, 4-nitro-1-oxide-)
Nitrosamine, N.O.S.*
N-Nitrosodi-n-butylamine (1-Butanamine, N-butyl-N-nitroso-)
N-Nitrosodiethanolamine (Ethanol, 2,2'-(nitrosoimino)bis-)
N-Nitrosodiethylamine (Ethanamine, N-ethyl-N-nitroso-)
N-Nitrosodimethylamine (Dimethylnitrosamine)
N-Nitroso-N-ethylurea (Carbamide, N-ethyl-N-nitroso-)
N-Nitrosomethylethylamine (Ethanamine, N-methyl-N-nitroso-)
N-Nitroso-N-methylurea (Carbamide, N-methyl-N-nitroso-)
N-Nitroso-N-methylurethane (Carbamic acid, methylnitroso-, ethyl ester)
N-Nitrosomethylvinylamine (Ethenamine, N-methyl-N-nitroso-)
N-Nitrosomorpholine (Morpholine, N-nitroso-)
N-Nitrosonornicotine (Nornicotine, N-nitroso-)
N-Nitrosopiperidine (Pyridine, hexahydro-, N-nitroso-)
Nitrosopyrrolidine (Pyrrole, tetrahydro-, N-nitroso-)
N-Nitrososarcosine (Sarcosine, N-nitroso-)
5-Nitro-o-toluidine (Benzenamine, 2-methyl-5-nitro-)
Octamethylpyrophosphoramide (Diphosphoramide, octamethyl-)
Osmium tetroxide (Osmium (VIII) oxide)
7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (Endothal)
Paraldehyde (1,3,5-Trioxane, 2,4,6-trimethyl-)
Parathion (Phosphorothioic acid, O,O-diethyl O-(p-nitrophenyl) ester
Pentachlorobenzene (Benzene, pentachloro)
Pentachloroethane (Ethane, pentachloro-)
Pentachloronitrobenzene (PCNB) (Benzene, pentachloronitro-)
Pentachlorophenol (Phenol, pentachloro-)
Phenacetin (Acetamide, N-(4-ethoxyphenyl)-)
Phenol (Benzene, hydroxy-)
Phenylenediamine (Benzenediamine)
Phenylmercury acetate (Mercury, acetatophenyl-)
N-Phenylthiourea (Thiourea, phenyl-)
Phosgene (Carbonyl chloride)
Phosphine (Hydrogen phosphide)
Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester (Phorate)
Phosphorothioic acid, O,O-dimethyl O-[p-((dimethylamino)sulfonyl)phenyl] ester (Famphur)
Phthalic acid esters, N.O.S.* (Benzene, 1,2-dicarboxylic acid, esters, N.O.S.*)
Phthalic anhydride (1,2-Benzenedicarboxylic acid anhydride)
2-Picoline (Pyridine, 2-methyl-)
Polychlorinated biphenyl, N.O.S.*
Potassium cyanide
Potassium silver cyanide (Argentate(1-), dicyano-, potassium)
Pronamide (3,5-Dichloro-N-(1,1-dimethyl-2-propynyl)benzamide)
1,3-Propane sultone (1,2-Oxathiolane, 2,2-dioxide)
n-Propylamine (1-Propanamine)
Propylthiouracil
(Undecamethylenediamine, N,N'-bis(2-chlorobenzyl)-, dihydrochloride)
2-Propyn-1-ol (Propargyl alcohol)
Pyridine
Reserpine (Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester)
Resorcinol (1,3-Benzenediol)
Saccharin and salts (1,2-Benzoisothiazolin-3-one, 1,1-dioxide, and salts)
Safrole (Benzene, 1,2-methylenedioxy-4-allyl-)
Selenious acid (Selenium dioxide)
Selenium and compounds, N.O.S.*
Selenium sulfide (Sulfur selenide)
Selenourea (Carbamimidoselenoic acid)
Silver and compounds, N.O.S.*
Silver cyanide
Sodium cyanide
Streptozotocin (D-Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-)
Strontium sulfide
Strychnine and salts (Strychnidin-10-one, and salts)
1,2,4,5-Tetrachlorobenzene (Benzene, 1,2,4,5-tetrachloro-)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) (Dibenzo-p-dioxin, 2,3,7,8-tetrachloro-)
Tetrachloroethane, N.O.S.* (Ethane, tetrachloro-, N.O.S.*)
1,1,1,2-Tetrachlorethane (Ethane, 1,1,1,2-tetrachloro-)
1,1,2,2-Tetrachlorethane (Ethane, 1,1,2,2-tetrachloro-)
Tetrachloroethane (Ethene, 1,1,2,2-tetrachloro-)
Tetrachloromethane (Carbon tetrachloride)
2,3,4,6,-Tetrachlorophenol (Phenol, 2,3,4,6-tetrachloro-)
Tetraethyldithiopyrophosphate (Dithiopyrophosphoric acid, tetraethyl-ester)
Tetraethyl lead (Plumbane, tetraethyl-)
Tetraethylpyrophosphate (Pyrophosphoric acide, tetraethyl ester)
Tetranitromethane (Methane, tetranitro-)
Thallium and compounds, N.O.S.*
Thallic oxide (Thallium (III) oxide)
Thallium (I) acetate (Acetic acid, thallium (I) salt)
Thallium (I) carbonate (Carbonic acid, dithallium (I) salt)
Thallium (I) chloride
Thallium (I) nitrate (Nitric acid, thallium (I) salt)
Thallium selenite
Thallium (I) sulfate (Sulfuric acid, thallium (I) salt)
Thioacetamide (Ethanethioamide)
Thiosemicarbazide (Hydrazinecarbothioamide)
Thiourea (Carbamide thio-)
Thiuram (Bis(dimethylthiocarbamoyl) disulfide)
Toluene (Benzene, methyl-)
Toluenediamine (Diaminotoluene)
o-Toluidine hydrochloride (Benzenamine, 2-methyl-, hydrochloride)
Tolylene diisocyanate (Benzene, 1,3-diisocyanatomethyl-)
Toxaphene (Camphene, octachloro-)
Tribromomethane (Bromoform)
1,2,4-Trichlorobenzene (Benzene, 1,2,4-trichloro-)
1,1,1-Trichloroethane (Methyl chloroform)
1,1,2-Trichloroethane (Ethane, 1,1,2-trichloro-)
Trichloroethene (Trichloroethylene)
Trichloromethanethiol (Methanethiol, trichloro-)
Trichloromonofluoromethane (Methane, trichlorofluoro-)
2,4,5-Trichlorophenol (Phenol, 2,4,5-trichloro-)
2,4,6-Trichlorophenol (Phenol, 2,4,6-trichloro-)
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) (Acetic acid, 2,4,5-trichlorophenoxy-)
2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP) (Silvex) (Propionoic acid, 2-(2,4,5-trichlorophenoxy)-)
Trichloropropane, N.O.S.* (Propane, trichloro-, N.O.S.*)
1,2,3-Trichloropropane (Propane, 1,2,3-trichloro-)
O,O,O-Triethyl phosphorothioate (Phosphorothioic acid, O,O,O-triethyl ester)
sym-Trinitrobenzene (Benzene, 1,3,5-trinitro-)
Tris(1-azridinyl) phosphine sulfide (Phosphine sulfide, tris(1-aziridinyl-)
Tris(2,3-dibromopropyl) phosphate (1-Propanol, 2,3-dibromo-, phosphate)
Trypan blue (2,7-Naphthalenedisulfonic acid, 3,3'-[(3,3'-dimethyl(1,1'-biphenyl)-4,4'-diyl)bis(azo)]bis(5-amino-4-hydroxy-, tetrasodium salt)
Uracil mustard (Uracil 5-[bis(2-chloroethyl)amino]-)
Vanadic acid, ammonium salt (ammonium vanadate)
Vanadium pentoxide (Vanadium (V) oxide)
Vinyl chloride (Ethene, chloro-)
Zinc cyanide
Zinc phosphide

[46 FR 27477, May 20, 1981; 46 FR 29708, June 3, 1981]

PART 262—STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE

Subpart A—General

AUTHORITY: Secs. 1006, 2002, 3002, 3003, 3004, and 3005, Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended, (RCRA), (42 U.S.C. 6905, 6912, 6922, 6923, 6924, 6925).

40 CFR, PART 264

STANDARD FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

SUBPART O - INCINERATORS

SECTIONS 264.340 - 264.347

24 JUNE 1982

4554A

PART 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

Subpart O—Incinerators

1. The authority citation for Part 264 reads as follows:

Authority: Sections 1006, 2002(a), and 3004 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act, as amended (42 U.S.C. 6905, 6912(a) and 6924).

2. Section 264.340 is amended by revising paragraph (b), redesignating and revising paragraph (c) as paragraph (d), and adding new paragraph (c) to read as follows:

§ 264.340 Applicability.

* * * * *

(b) After consideration of the waste analysis included with Part B of the permit application, the Regional Administrator, in establishing the permit conditions, must exempt the applicant from all requirements of this Subpart except § 264.341 (Waste analysis) and § 264.351 (Closure),

(1) If the Regional Administrator finds that the waste to be burned is:

(i) Listed as a hazardous waste in Part 261, Subpart D, of this Chapter solely because it is ignitable (Hazard Code I), corrosive (Hazard Code C), or both; or

(ii) Listed as a hazardous waste in Part 261, Subpart D, of this Chapter solely because it is reactive (Hazard Code R) for characteristics other than those listed in § 261.23)(a) (4) and (5), and will not be burned when other hazardous wastes are present in the combustion zone; or

(iii) A hazardous waste solely because it possesses the characteristic of ignitability, corrosivity, or both, as determined by the test for characteristics of hazardous wastes under Part 261, Subpart C, of this Chapter; or

(iv) A hazardous waste solely because it possesses any of the reactivity characteristics described by § 261.23(a) (1), (2), (3), (6), (7), and (8) of this Chapter, and will not be burned when other hazardous wastes are present in the combustion zone; and

(2) If the waste analysis shows that the waste contains none of the hazardous constituents listed in Part 261, Appendix VIII, of this Chapter, which would reasonably be expected to be in the waste.

(c) If the waste to be burned is one which is described by paragraphs (b)(1)(i), (b)(1)(ii), (b)(1)(iii), or (b)(1)(iv) of this Section and contains insignificant concentrations of the hazardous constituents listed in Part 261, Appendix VIII, of this Chapter, then the Regional Administrator may, in establishing permit conditions, exempt the applicant from all requirements of this Subpart, except § 264.341 (Waste analysis) and § 264.351 (Closure), after consideration of the waste analysis included with Part B of the permit application, unless the Regional Administrator finds that the waste will pose a threat to human health and the environment when burned in an incinerator.

(d) The owner or operator of an incinerator may conduct trial burns subject only to the requirements of § 122.27(b) of this Chapter (Short term and incinerator permits).

3. Section 264.341 is amended by revising paragraph (a) as follows:

§ 264.341 Waste analysis.

(a) As a portion of the trial burn plan required by § 122.27(b) of this Chapter, or with Part B of the permit application, the owner or operator must have included an analysis of the waste feed sufficient to provide all information required by § 122.27(b)(2) or 122.25(b)(5) of this Chapter. Owners or operators of new hazardous waste incinerators must provide the information required by § 122.27(b)(3) or 122.25(b)(5) of this Chapter to the greatest extent possible.

4. Section 264.343 is amended by revising paragraphs (b) and (c) to read as follows:

§ 264.343 Performance standards.

* * * * *

(b) An incinerator burning hazardous waste and producing stack emissions of more than 1.8 kilograms per hour (4 pounds per hour) of hydrogen chloride (HCl) must control HCl emissions such that the rate of emission is no greater than the larger of either 1.8 kilograms per hour or 1% of the HCl in the stack gas prior to entering any pollution control equipment.

(c) An incinerator burning hazardous waste 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 for the amount of oxygen in the stack gas according to the formula:

$$P_c = P_m \cdot \frac{14}{21-Y}$$

Where P_c is the corrected concentration of particulate matter, P_m is the measured concentration of particulate matter, and Y is the measured concentration of oxygen in the stack gas, using the Orsat method for oxygen analysis of dry flue gas, presented in Part 60, Appendix A (Method 3), of this Chapter. This correction procedure is to be used by all hazardous waste incinerators except those operating under conditions of oxygen enrichment. For these facilities, the Regional Administrator will select an appropriate correction procedure, to be specified in the facility permit.

* * * * *

5. Section 264.344 is amended by revising the title and adding new paragraph (c) as follows:

§ 264.344 Hazardous waste incinerator permits.

* * * * *

(c) The permit for a new hazardous waste incinerator must establish appropriate conditions for each of the applicable requirements of this Subpart, including but not limited to allowable waste feeds and operating conditions necessary to meet the requirements of § 264.345, sufficient to comply with the following standards:

(1) For the period beginning with initial introduction of hazardous waste to the incinerator and ending with initiation of the trial burn, and only for the minimum time required to establish operating conditions required in paragraph (c)(2) of this Section, not to exceed a duration of 720 hours operating time for treatment of hazardous waste, the operating requirements must be those most likely to ensure compliance with the performance standards of § 264.343, based on the Regional Administrator's engineering judgment. The Regional Administrator may extend the duration of this period once for up to 720 additional hours when good cause for the extension is demonstrated by the applicant.

(2) For the duration of the trial burn, the operating requirements must be sufficient to demonstrate compliance with the performance standards of § 264.343 and must be in accordance with the approved trial burn plan;

(3) For the period immediately following completion of the trial burn, and only for the minimum period sufficient to allow sample analysis, data computation, and submission of the trial burn results by the applicant, and review of the trial burn results and modification of the facility permit by the Regional Administrator, the operating requirements must be those most likely to ensure compliance with the performance standards of § 264.343, based on the Regional Administrator's engineering judgement.

(4) For the remaining duration of the permit, the operating requirements must be those demonstrated, in a trial burn or by alternative data specified in § 122.25(b)(5)(iii) of this Chapter, as sufficient to ensure compliance with the performance standards of § [illegible]

6. Section 264.345 is [illegible] revising paragraph [illegible] as follows

*

§ 264.345 Operating [illegible]

* * * *

[illegible]

AD-A140 155 INSTALLATION RESTORATION GENERAL ENVIRONMENTAL TECHNOLOGY DEVELOPMENT TAS..(U) WESTON (ROY F) INC WEST CHESTER PA J W NOLAND ET AL. APR 84 DRXTH-TE-CR-84277 3/3

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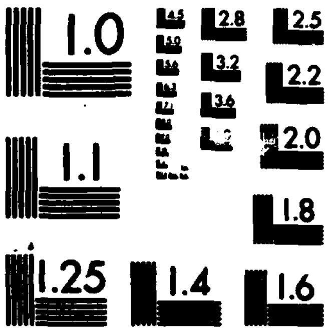


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(c) During start-up and shut-down of an incinerator, hazardous waste (except wastes exempted in accordance with § 264.340) must not be fed into the incinerator unless the incinerator is operating within the conditions of operation (temperature, air feed rate, etc.) specified in the permit.

* * * * *

7. Section 264.347 is amended by revising paragraphs (a)(1) and (b), redesignating paragraph (c) as paragraph (d), and adding new paragraph (c) as follows:

§ 264.347 Monitoring and inspections.

(a) * * *

(1) Combustion temperature, waste feed rate, and the indicator of combustion gas velocity specified in the facility permit must be monitored on a continuous basis.

* * * * *

(b) The incinerator and associated equipment (pumps, valves, conveyors, pipes, etc.) must be subjected to thorough visual inspection, at least daily, for leaks, spills, fugitive emissions, and signs of tampering.

(c) The emergency waste feed cutoff system and associated alarms must be tested at least weekly to verify operability, unless the applicant demonstrates to the Regional Administrator that weekly inspections will unduly restrict or upset operations and that less frequent inspection will be adequate. At a minimum, operational testing must be conducted at least monthly.

(d) This monitoring and inspection data must be recorded and the records must be placed in the operating log required by § 264.73.

40 CFR, PART 264

STANDARD FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

SUBPART O - INCINERATION

SECTIONS 264.10 - 264.351

23 JANUARY 1981

4554A

PART 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

1. In § 264.10, paragraph (b) is revised to read as follows:

§ 264.10 Applicability.

* * * * *

(b) Section 264.18(b) is applicable only to facilities subject to regulation under Part 264, Subparts I, J, K, L, and O.

2. In § 264.13, paragraph (b)(6) is revised to read as follows:

§ 264.13 General waste analysis.

* * * * *

(b) * * *

(6) Where applicable, the methods which will be used to meet the additional waste analysis requirements for specific waste management methods as specified in §§ 264.17 and 264.341.

* * * * *

3. In § 264.15, paragraph (b)(4) is revised to read as follows:

§ 264.15 General inspection requirements.

* * * * *

(b) * * *

(4) The frequency of inspection may vary for the items on the schedule. However, it should be based on the rate of possible deterioration of the equipment and the probability of an environmental or human health incident if the deterioration or malfunction of any operator error goes undetected between inspections. Areas subject to spills, such as loading and unloading areas, must be inspected daily when in use. At a minimum, the inspection schedule must include the terms and frequencies called for in §§ 264.174, 264.194, 264.226, 264.254, and 264.347, where applicable.

* * * * *

4. In § 264.73, paragraph (b) is amended by revising paragraph (b)(3), adding new paragraph (b)(6), and redesignating paragraph (b)(6) and (b)(7) as (b)(7) and (b)(8) respectively revised to read as follows:

§ 264.73 Operating Record.

* * * * *

(b) * * *

(3) Records and results of waste analyses performed as specified in §§ 264.13, 264.17, and 264.341;

* * * * *

(6) Monitoring, testing, or analytical data where required by § 264.347;

(7) For off-site facilities, notices to generators as specified in § 264.12(b); and

(8) All closure cost estimates under § 264.142, and, for disposal facilities, all post-closure cost estimates under § 264.144.

* * * * *

5. In § 264.112, paragraph (a) and paragraph (a)(1) are revised to read as follows:

§ 264.112 Closure plan; amendment of plan.

(a) The owner or operator of a hazardous waste management facility must have a written closure plan. The plan must be submitted with the permit application, in accordance with § 122.25(a)(13) of this Chapter, and approved by the Regional Administrator as part of the permit issuance proceeding under Part 124 of this Chapter. In accordance with § 122.29 of this Chapter, the approved closure plan will become a condition of any RCRA permit. The Regional Administrator's decision must assure that that approved closure plan is consistent with §§ 264.111, 264.113, 264.114, 264.115 and the applicable requirements of §§ 264.178, 264.197, 264.228, 264.258, and 264.351. A copy of the approved plan and all revisions to the plan must be kept at the facility until closure is completed and certified in accordance with § 264.115. The plan must identify steps necessary to completely or partially close the facility at any point during its intended operating life and to completely close the facility at the end of its intended operating life. The closure plan must include, at least:

(1) A description of how and when the facility will be partially closed, if applicable, and finally closed. The description must identify the maximum extent of the operation which will be unclosed during the life of the facility, and how the requirements of §§ 264.111, 264.113, 264.114, 264.115, and the applicable closure requirements of §§ 264.178, 264.197, 264.228, 264.258, and 264.351 will be met;

* * * * *

6. In § 264.142, paragraph (a) is revised to read as follows:

§ 264.142 Cost estimate for facility closure.

(a) The owner or operator must have a written estimate of the cost of closing the facility in accordance with the requirements in §§ 264.111–264.115 and applicable closure requirements in §§ 264.178, 264.197, 264.228, 264.258, and 264.351. The owner or operator must keep this estimate, and all subsequent estimates required in this Section, at the facility. The estimate must equal the cost of closure at the point in the facility's operating life when the extent and manner of its operation would make closure the most expensive, as indicated by its closure plan [see § 264.112(a)].

[*Comment:* For example, the closure cost estimate for a particular landfill may be for the cost of closure when its active disposal operations extend over 20 acres, if at all other times these operations extend over less than 20 acres. The estimate would not include costs of partial closures that the closure plan schedules before or after the time of maximum closure cost.]

* * * * *

7. In 40 CFR Part 264, Subpart O is added to read as follows:

Subpart O—Incinerators

Subpart O—Incinerators

§ 264.340 Applicability.

(a) The regulations in this Subpart apply to owners and operators of facilities that incinerate hazardous waste, except as § 264.1 provides otherwise.

(b) If the Regional Administrator finds, after an examination of the waste analysis included with Part B of the applicants permit application, that the waste to be burned:

(1) Is either (i) listed as a hazardous waste in Part 261, Subpart D, of this Chapter only because it is ignitable (Hazard Code I) or, (ii) that the waste has been tested against the characteristics of hazardous waste under Part 261, Subpart C, of this Chapter and that it meets only the ignitability characteristic; and

(2) That the waste analysis included with Part B of the permit application includes none of the hazardous constituents listed in Part 261, Appendix VIII;

then the Regional Administrator may, in establishing the permit conditions, exempt the applicant from all requirements of this Subpart except § 264.341 (Waste Analysis) and § 264.351 (Closure).

(c) The owner or operator of an incinerator may conduct trial burns, subject only to the requirements of § 122.27(b) of this Chapter (Trial Burn Permits).

§ 264.341 Waste analysis.

(a) As a portion of a trial burn plan required by § 122.27(b) of this Chapter, or with Part B of his permit application, the owner or operator must have included an analysis of his waste feed sufficient to provide all information required by § 122.27(b)(2) or § 122.25(b)(5) of this Chapter.

(b) Throughout normal operation the owner or operator must conduct sufficient waste analysis to verify that waste feed to the incinerator is within the physical and chemical composition limits specified in his permit (under § 264.345(b)).

§ 264.342 Principal organic hazardous constituents (POHCs).

(a) Principal Organic Hazardous Constituents (POHCs) in the waste feed must be treated to the extent required by the performance standard of § 264.343.

(b)(1) One or more POHCs will be specified in the facility's permit, from among those constituents listed in Part 261, Appendix VIII of this Chapter, for each waste feed to be burned. This specification will be based on the degree of difficulty of incineration of the organic constituents in the waste and on their concentration or mass in the waste feed, considering the results of waste analyses and trial burns or alternative data submitted with Part B of the facility's permit application. Organic constituents which represent the greatest degree of difficulty of incineration will be those most likely to be designated as POHCs. Constituents are more likely to be designated as POHCs if they are present in large quantities or concentrations in the waste.

(2) Trial POHCs will be designated for performance of trial burns in accordance with the procedure specified in § 122.27(b) of this Chapter for obtaining trial burn permits.

§ 264.343 Performance standards.

An incinerator burning hazardous waste must be designed, constructed, and maintained so that, when operated in accordance with operating requirements specified under § 264.345, it will meet the following performance standards:

(a) An incinerator burning hazardous waste must achieve a destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent (POHC) designated (under § 264.342) in its permit for each waste feed. DRE is determined for each POHC from the following equation:

$$DRE = \frac{(W_{in} - W_{out})}{W_{in}} \times 100\%$$

Where:

W_{in} = Mass feed rate of one principal organic hazardous constituent (POHC) in the waste stream feeding the incinerator, and

W_{out} = Mass emission rate of the same POHC present in exhaust emissions prior to release to the atmosphere.

(b) An incinerator burning hazardous waste containing more than 0.5% chlorine must remove 99% of the hydrogen chloride from the exhaust gas.

(c) An incinerator burning hazardous waste must not emit particulate matter exceeding 180 milligrams per dry standard cubic meter (0.08 grains per dry standard cubic foot) when corrected for 12% CO_2, using the procedures presented in the Clean Air Act regulations, "Standards of Performance for Incinerators", 40 CFR 60.50, Subpart E.

(d) For purposes of permit enforcement, compliance with the operating requirements specified in the permit (under § 264.345) will be regarded as compliance with this Section. However, evidence that compliance with those permit conditions is insufficient to ensure compliance with the performance requirements of this Section may be "information" justifying modification, revocation, or reissuance of a permit under § 122.15 of this Chapter.

§ 264.344 New wastes: trial burns or permit modifications.

(a) The owner or operator of a hazardous waste incinerator may burn only wastes specified in his permit and only under operating conditions specified for those wastes under § 264.345, except:

(1) In approved trial burns under § 122.27(b) of this Chapter; or

(2) Under exemptions created by § 264.340.

(b) Other hazardous wastes may be burned only after operating conditions have been specified in a new permit or a permit modification as applicable. Operating requirements for new wastes may be be based on either trial burn results or alternative data included with Part B of a permit application under § 122.25(b)(5) of this Chapter.

§ 264.345 Operating requirements.

(a) An incinerator must be operated in accordance with operating requirements specified in the permit. These will be specified on a case-by-case basis as those demonstrated (in a trial burn or in alternative data as specified in § 264.344(b) and included with Part B of a facility's permit application) to be sufficient to comply with the performance standards of § 264.343.

(b) Each set of operating requirements will specify the composition of the waste feed (including acceptable variations in the physical or chemical properties of the waste feed which will not affect compliance with the performance requirement of § 264.343) to which the operating requirements apply. For each such waste feed, the permit will specify acceptable operating limits including the following conditions:

(1) Carbon monoxide (CO) level in the stack exhaust gas;

(2) Waste feed rate;

(3) Combustion temperature;

(4) Air feed rate to the combustion system;

(5) Allowable variations in incinerator system design or operating procedures; and

(6) Such other operating requirements as are necessary to ensure that the performance standards of § 264.343 are met.

(c) During start-up and shut-down of an incinerator, hazardous waste (except ignitable waste exempted in accordance with § 264.340) must not be fed into the incinerator unless the incinerator is operating within the conditions of operation (temperature, air feed rate, etc.) specified in the permit.

(d) Fugitive emissions from the combustion zone must be controlled by:

(1) Keeping the combustion zone totally sealed against fugitive emissions; or

(2) Maintaining a combustion zone pressure lower than atmospheric pressure; or

(3) An alternate means of control demonstrated (with Part B of the permit application) to provide fugitive emissions control equivalent to maintenance of combustion zone pressure lower than atmospheric pressure.

(e) An incinerator must be operated with a functioning system to automatically cut off waste feed to the incinerator when operating conditions deviate from limits established under paragraph (a) of this Section.

(f) An incinerator must cease operation when changes in waste feed, incinerator design, or operating conditions exceed limits designated in its permit.

§ 264.346 [Reserved]

§ 264.347 Monitoring and inspections.

(a) The owner or operator must conduct, as a minimum, the following monitoring while incinerating hazardous waste:

(1) Combustion temperature, waste feed rate, and air feed rate must be monitored on a continuous basis.

(2) CO must be monitored on a continuous basis at a point in the incinerator downstream of the combustion zone and prior to release to the atmosphere.

(3) Upon request by the Regional Administrator, sampling and analysis of the waste and exhaust emissions must be conducted to verify that the operating requirements established in the permit achieve the performance standards of § 264.343.

(b) The incinerator and associated equipment (pumps, valves, conveyors, pipes, etc.) must be completely inspected at least daily for leaks, spills, and fugitive emissions. All emergency waste feed cut-off controls and system alarms must be checked daily to verify proper operation.

(c) This monitoring and inspection data must be recorded and the records must be placed in the operating log required by § 264.73.

§§ 264.348–264.350 [Reserved]

§ 264.351 Closure.

At closure the owner or operator must remove all hazardous waste and hazardous waste residues (including, but not limited to, ash, scrubber waters, and scrubber sludges) from the incinerator site.

[*Comment:* At closure, as throughout the operating period, unless the owner or operator can demonstrate, in accordance with § 261.3(d) of this Chapter, that the residue removed from the incinerator is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with applicable requirements of Parts 262–266 of this Chapter.]

§§ 264.352–264.999 [Reserved]

PART 265—INTERIM STATUS STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

1. In § 265.73, paragraph (b)(3) is revised to read as follows:

§ 265.73 Operating record.

* * * * *

(b) * * *

(3) Records and results of waste analysis and trial tests performed as specified in §§ 265.13, 265.193, 265.225, 265.252, 265.273, 265.341, 265.375, and 265.402;

* * * * *

2. 40 CFR Part 265, Subpart O, is revised to read as follows:

Subpart O—Incinerators

Sec.
265.340 Applicability.
265.341 Waste analysis.
265.342–265.344 [Reserved]
265.345 General operating requirements.
265.346 [Reserved]
265.347 Monitoring and inspection.
265.348–265.350 [Reserved]
265.351 Closure.
265.352–265.399 [Reserved]

§ 265.340 Applicability.

(a) The regulations in this Subpart apply to owners or operators of facilities that treat hazardous waste in incinerators, except as § 265.1 and paragraph (b) of this Section provide otherwise.

(b) Incineration of wastes which:

(1) Meet only the ignitability characteristic under Part 261, Subpart C, of this Chapter, or

(2) Are listed in Part 261, Subpart D, of this Chapter for ignitability only (Hazard Code I),

are exempted from the requirements of this Subpart, except § 265.351, if the owner or operator can document that the waste feed would not reasonably be expected to contain constituents listed in Part 261, Appendix VIII of this Chapter. Such documentation must be in writing and must be kept at the facility.

§ 265.341 Waste analysis.

In addition to the waste analyses required by § 265.13, the owner or operator must sufficiently analyze any waste which he has not previously burned in his incinerator to enable him to establish steady state (normal) operating conditions (including waste and auxiliary fuel feed and air flow) and to determine the type of pollutants which might be emitted. At a minimum, the analysis must determine:

(a) Heating value of the waste;

(b) Halogen content and sulfur content in the waste; and

(c) Concentrations in the waste of lead and mercury, unless the owner or operator has written, documented data that show that the element is not present.

[*Comment:* As required by § 265.73, the owner or operator must place the results from each waste analysis, or the documented information, in the operating record of the facility.]

§§ 265.342–265.344 [Reserved]

§ 265.345 General operating requirements.

During start-up and shut-down of an incinerator, the owner or operator must not feed hazardous waste unless the incinerator is at steady state (normal) conditions of operation, including steady state operating temperature and air flow.

§ 265.346 [Reserved]

§ 265.347 Monitoring and inspections.

The owner or operator must conduct, as a minimum, the following monitoring and inspections when incinerating hazardous waste:

(a) Existing instruments which relate to combustion and emission control must be monitored at least every 15 minutes. Appropriate corrections to maintain steady state combustion conditions must be made immediately either automatically or by the operator. Instruments which relate to combustion and emission control would normally include those measuring waste feed, auxiliary fuel feed, air flow, incinerator temperature, scrubber flow, scrubber pH, and relevant level controls.

(b) The stack plume (emissions) must be observed visually at least hourly for normal appearance (color and opacity). The operator must immediately make any indicated corrections necessary to return visible emissions to their normal appearance.

(c) The complete incinerator and associated equipment (pumps, valves, conveyors, pipes, etc.) must be inspected at least daily for leaks, spills, and fugitive emissions, and all emergency shutdown controls and system alarms must be checked to assure proper operation.

§§ 265.348–265.350 [Reserved]

§ 265.351 Closure.

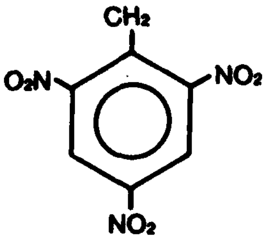
At closure, the owner or operator must remove all hazardous waste and hazardous waste residues (including but not limited to ash, scrubber waters, and scrubber sludges) from the incinerator.

[*Comment:* At closure, as throughout the operating period, unless the owner or operator can demonstrate, in accordance with § 261.3(d) of this Chapter, that the residue removed from his incinerator is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of Parts 262–266 of this Chapter.]

APPENDIX D

MOLECULAR STRUCTURE OF THE EXPLOSIVES

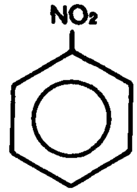
TNT



$C_7H_5N_3O_6$

2,4,6 Trinitrotoluene

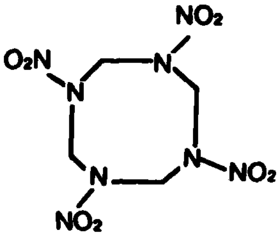
NB



$C_6H_5NO_2$

Nitrobenzene

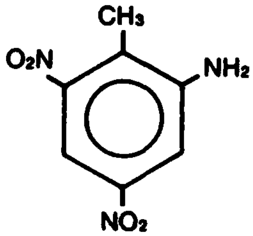
HMX



$C_4H_8N_8O_8$

1,3,5,7-Tetranitro-Octahydro-1,3,5,7-Tetracyclooctane

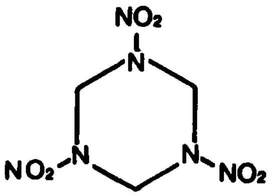
2-Amino



$C_7H_7N_3O_4$

2-Amino-4,6 Dinitrotoluene

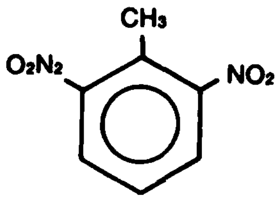
RDX



$C_3H_6N_6O_6$

1,3,5-Trinitro, Hexahydro-1,3,5-Triazine

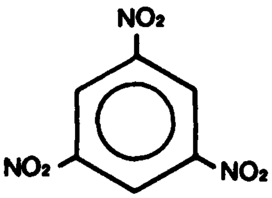
2,6 DNT



$C_7H_6N_2O_4$

2,6-Dinitrotoluene

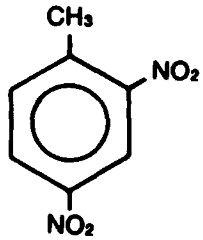
TNB



$C_6H_3N_3O_6$

1,3,5-Trinitrobenzene

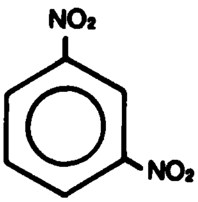
2,4 DNT



$C_7H_6N_2O_4$

2,4-Dinitrotoluene

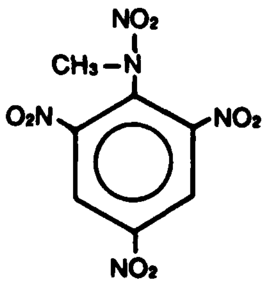
DNB



$C_6H_4N_2O_4$

1,3-Dinitrobenzene

Tetryl



$C_7H_5N_5O_8$

Tetranitromethylaniline

TABLE D-1 MOLECULAR STRUCTURE OF EXPLOSIVES

APPENDIX E

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DOCUMENT DISTRIBUTION LIST

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