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Handbook

Permit Writer's Guide to Test Burn Data

Hazardous Waste Incineration

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Handbook

Permit Writer's Guide to Test Burn Data

Hazardous Waste Incineration

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ABSTRACT

The U.S. Environmental Protection Agency's (EPA's) Center for Environmental Research Information has prepared this test burn data book for use in the permitting and testing of hazardous waste incinerators regulated under the Resource Conservation and Recovery Act (RCRA). The test results summarized represent hazardous waste test burns conducted at 23 full-scale stationary incinerators in the United States. Nine of these tests were designed and conducted by EPA and its contractors as part of EPA's Regulatory Impact Analysis of the RCRA incinerator regulations. The others were conducted separately and individually by private industrial concerns and their contractors as part of their Part B application requirements for obtaining full operating permits under RCRA.

In addition to the incinerator data, this book also presents results of tests at 11 lime, cement, and aggregate kilns and 11 industrial boilers. The EPA Hazardous Waste Engineering Research Laboratory conducted most of these tests as part of an overall research program aimed at determining the efficiency of these thermal units for cofiring (and thereby destroying) hazardous wastes as fuel supplements or replacements.

This is the first time a data book containing results from a wide variety of combustion tests has been assembled. The book is intended to be used as a data source for reference purposes in developing and reviewing trial burn plans. It should be used in conjunction with other EPA guidance documents on hazardous waste incineration, such as the EPA Engineering Handbook for Hazardous Waste Incineration (EPA-SW-889) and the EPA Guidance Manual for Hazardous Waste Incinerator Permits (EPA-SW-966). The user is cautioned to exercise professional judgment when using the data in this document. Some of the data are of questionable value, and accordingly, every effort has been made to identify or flag such information. The user is also cautioned to critically evaluate the procedures and methodologies used to generate the data in this document, and to design future trial test burns in accordance with current guidance.

Finally, since the data for this document was assembled in 1985, the results of several additional incinerator trial burns have been reported to various EPA Regions and authorized States. Thus, additional data are available for expansion of this data base, if desired. EPA Regional and State RCRA permit writers should be contacted for details of these more recent test burns.

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SECTION 1
PURPOSE AND USE OF THIS DOCUMENT

1.1 INTRODUCTION

The Resource Conservation and Recovery Act (RCRA)* requires that hazardous waste incinerators adequately destroy hazardous organic materials while maintaining acceptable levels of particulate and chloride (HCl) emissions. In response to this mandate, the U.S. Environmental Protection Agency (EPA) has developed performance standards for the operation of these incinerators, and owners/operators of the units must demonstrate that they can meet the standards to obtain a full RCRA operating permit. Consequently, industry and control agency personnel have become involved in planning for, conducting, and interpreting the results from incinerator performance tests as an integral part of the RCRA regulatory and permitting process.

This data book has been prepared as a reference document for State and Federal permit writers and others concerned with the permitting and testing of hazardous waste incinerators and other thermal treatment devices that are now or soon may be regulated under RCRA. The document summarizes the test results from hazardous waste burns conducted at 23 full-scale stationary incinerators in the United States. Tests at nine of these sites were designed and conducted by EPA's Hazardous Waste Engineering Research Laboratory (HWERL) and its contractors as part of the Agency's program supporting the RCRA incinerator regulations. Tests at the other 14 sites were conducted separately and individually as trial burns by private industrial concerns and their contractors as part of the Part B application requirements for obtaining full operating permits under RCRA.

In addition to the incinerator data, this document also presents the results of hazardous waste test burns at 11 lime, cement, and aggregate kilns and 11 industrial boilers. Although the burning of hazardous wastes in boilers, kilns, and industrial furnaces is not currently regulated, proposed standards are under development and expected to be published in 1987. In anticipation and support of this regulatory activity, EPA-HWERL conducted these tests as part of an overall research program aimed at determining the efficiency of these units for thermally destroying hazardous wastes.

*Public Law 94-580, as amended

1.2 HAZARDOUS WASTE INCINERATION STANDARDS UNDER RCRA

The hazardous waste incineration standards set forth in 40 CFR Parts 264 and 270 specify three major requirements regarding incinerator performance:

1. Principal organic hazardous constituents (POHC's) designated in each waste feed must be destroyed and/or removed to an efficiency (DRE) of 99.99% or better; dioxins and PCBs must achieve a DRE of 99.9999%. POHC's are hazardous organic substances in the waste feed that are representative of those constituents most difficult to burn and most abundant in the waste.
2. Particulate emissions must not exceed 180 mg per dry standard cubic meter (dscm), corrected to 7% oxygen in the stack gas.
3. Gaseous hydrogen chloride (HCl) emissions must *either* be controlled to 4 lb/h or less, or be removed at 99% efficiency.

The standards also specify a number of requirements for waste analysis and for incinerator operation, monitoring, and inspection. Finally, they establish the procedures by which permits will be granted. In addition to the specific standards for incineration, owners and operators of hazardous waste incinerators must comply with the general facility standards and administrative requirements for all hazardous waste management facilities (also contained in 40 CFR Part 264).

Compliance with the EPA standards for incineration of hazardous wastes may be established through the submission of performance data gathered from an existing incinerator operating under interim status or, in the case of new incinerators, from the performance of a trial burn. A trial burn may possibly be waived if the new facility can demonstrate that a similiar incinerator burning a similar waste has proved compliance. During the designated test period, the applicant determines the incinerator's ability to destroy hazardous wastes that are representative of those intended to be treated at the facility. Generally, the goal in conducting a test burn is to identify the most efficient conditions or range of conditions

under which the incinerator can be operated in compliance with the performance standards.

The Part B application submitted to EPA by owners/operators seeking permits must contain either data demonstrating compliance with the standards or a plan for testing the incinerator to obtain such data. Such a plan is referred to as a trial burn plan.

After the trial burn is completed and/or the performance data and other information submitted in the Part B application have been reviewed and evaluated by the EPA or State permit writer, a RCRA permit will be developed. This permit will specify, among many other things, a set of operating requirements for the incinerator for the following four parameters:

- Carbon monoxide in the stack exhaust gas
- Waste feed rate
- Combustion temperature
- Combustion gas flow rate

The numerical values of these parameters will vary among incinerators and will be governed by the performance data submitted by the applicant. Thus, as a minimum for each test run, values should be reported for carbon monoxide in the stack gas, waste feed or thermal input rate, combustion temperature, and combustion gas flow rate, in addition to the DRE, HCl, and particulate results. Normal fluctuations encountered in the monitoring of each of these parameters should also be reported. The permit conditions ultimately developed for each parameter at a given site usually reflect the ranges tested successfully during the trial burn.

1.3 USE OF THIS DOCUMENT

This document can be used to locate and study the following types of information relative to hazardous waste incineration:

- POHC's that have been tested previously (by site)
- POHC's that have been tested previously (by POHC)
- Types of incinerators, boilers, and kilns that have been tested previously
- Problems encountered during trial and test burns
- The relationship between POHC, waste feed concentration, and DRE
- The relationship between POHC, DRE, and temperature
- Chlorine emission results by site (controlled and uncontrolled)
- Particulate emission results by site (controlled and uncontrolled)
- Dioxin and furan emissions from hazardous waste incineration
- Metal emissions from hazardous waste incinerators, boilers, and kilns
- Product of incomplete combustion (PIC) emissions from incinerators, boilers, and kilns
- O_2, CO, CO_2, and total unburned hydrocarbon (THC) emissions from incinerators, boilers, and kilns

The various tables presented in Section 3 and at the end of Appendix B should be especially useful to those interested in locating incinerator performance data for a particular POHC or for a specific type of incineration system.

This data book is intended to be used in conjunction with other EPA guidance documents on hazardous waste incineration. The following publications should be consulted for guidance during the Part B review and trial burn planning, testing, reporting, and evaluation phases of the RCRA permitting process:

- Monsanto Research Corporation, Engineering Handbook for Hazardous Waste Incineration. EPA-SW-889, PB81-248163, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1981, 487 pp.
- Mitre Corporation. Guidance Manual for Hazardous Waste Incinerator Permits. EPA-SW-966, PB84-100577, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1983, 126 pp.
- Midwest Research Institute. Practical Guide—Trial Burns for Hazardous Waste Incinerators. EPA/600/2-86/050, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1986, 63 pp.
- A.D. Little, Inc. Sampling and Analysis Methods for Hazardous Waste Combustion. First Edition. EPA/600/8-84/002, PB84-155845/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1983, 113 pp.
- Mitre Corporation. Profile of Existing Hazardous Waste Incineration Facilities and Manufacturers in the United States. EPA/600/2-84/052, PB84-157072/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1984, 166 pp.
- Protocol for the Collection and Analysis of Volatile Principal Organic Hazardous Constituents (POHC's) Using Volatile Organic Sampling Train (VOST). EPA/600/8-84/007, PB84-170042, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1984.
- Modified Method 5 Train and Source Assessment Sampling System: Operator's Manual. EPA/600/8-85/003, PB85-169878/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1985.

The user is cautioned to exercise professional judgment when using the data in this document. Some of the data are of questionable value because of sampling and analysis difficulties encountered during the tests or because of operational factors (malfunctions, excursions from the norm, etc.). Accordingly, considerable effort has been made to identify and flag such

problem data and to explain the circumstances believed responsible for the problem. The user is also cautioned to critically evaluate the procedures and methods used to generate the data presented in this document, and to design future trial and test burns in accordance with current guidance.

1.4 CONTENTS AND ORGANIZATION

Section 2 of this document presents a brief discussion of the major types of incinerators, boilers, and process kilns now in use in the United States. Schematic diagrams are included to help the reader visualize each type of unit. The design information presented gives only a technical overview of these processes. Additional details can be found in the EPA Engineering Handbook for Hazardous Waste Incineration.

Sections 3, 4, and 5 present discussions on the results of test burns conducted at incinerators, boilers, and kilns, respectively. These sections describe the types of units tested, goals or objectives of the tests, operating conditions during the tests, emission test results, problems encountered, and notable trends in the data.

The names and addresses of incinerator manufacturers and vendors are listed in Appendix A. Appendices B (incinerators), C (boilers), and D (kilns) present detailed data summary sheets describing each test burn, and providing references for obtaining additional information on each test.

The performance data presented in Appendices B, C, and D for each incinerator, boiler, or kiln tested have been extracted from the original detailed test reports submitted to EPA. The data from each test have been organized into a summary format similar to that shown in Figure 1. These summaries contain, where available, basic information on the type of unit tested (including a process flow diagram), the type of waste tested, the operating conditions during the test, parameters monitored and methods used, emission results, comments on the study, and the original source (reference) of the data. Readers are urged to review the test report referenced on the data forms to gain full appreciation of the designs, objectives, methods, problems, and results of each test. This step is especially important for proper understanding of trial burn test results. Regional and State RCRA permitting offices where incinerator trial burn reports are housed should be contacted directly to obtain information on specific trial burn reports and procedures for viewing them. These documents are in the public domain and are available for viewing, but copies are limited, and access must be scheduled. Copies may not be removed from regional or State offices.

The following reports containing the results of EPA-sponsored tests at hazardous waste incinerators are available in limited quantities through EPA's Center for Environmental Research Information in Cincinnati, Ohio, or through the National Technical Information Center, 5285 Port Royal Road, Springfield, Virginia 22161:

- Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerators, Vols. 1-5. EPA/600/2-84/181a-181e, PB85-129500/REB, PB85-129518/REB, PB85-129526/REB, PB85-129534/REB, PB85-129542/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1985.
- Gorman, P. G., and K. P. Ananth. Trial Burn Protocol Verification at a Hazardous Waste Incinerator. EPA/600/2-84/048, PB84-159193/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1984.

1.5 TERMS

Several terms used throughout this report are listed and defined here.

Boiler - (Taken from 40 CFR 260.10). An enclosed device using controlled flame combustion to generate thermal energy for recovery and use and generally having the following characteristics:

(1) Unit must physically provide for recovering at least 60% of the thermal value of the fuel, and exporting or utilizing at least 75% of the recovered thermal energy in the form of steam, heated fluids, or heated gases.

(2) The unit's combustion chamber and primary energy recovery section(s) must be of integral design.

DRE - Destruction and removal efficiency. A calculated measure of the efficiency of an incinerator or other device to destroy and remove hazardous constituents of the waste. Expressed as a percentage of the hazardous constituents in the waste feed that are either destroyed in the combustion chamber or removed by air pollution control equipment.

Eutectic - An alloy or mixture whose composition yields the lowest possible melting point for that particular combination of metals or substances.

Incinerator - Any enclosed device using controlled-flame combustion that neither meets the criteria for classification as a boiler nor is listed as an industrial furnace (40 CFR Part 260.10).

Industrial furnace - (Taken from 40 CFR Part 260.10.) Any of the following devices that are integral components of manufacturing processes and that use controlled-flame devices to accomplish recovery of materials and energy:

(1) Cement kilns
(2) Lime kilns
(3) Aggregate kilns
(4) Phosphate kilns
(5) Coke ovens
(6) Blast furnaces

INCINERATOR TRIAL BURN SUMMARY

Date of Trial Burn: _____
Run No.: _____

Incinerator Information
Type of unit: _____
Capacity: _____
Pollution control system: _____
_____
Waste feed system: _____
_____
Residence time: _____
Commercial ☐ Private/Industrial ☐

Trial Burn Conditions:
Waste Feed data:
Type of waste(s) burned: _____
_____
_____
Length of burn: _____
Total amount of waste burned: _____
Waste feed rate: _____
POHC's selected and concentration in waste feed:

Name	Concentration

Btu content _____ Chlorine content: _____
Ash content: _____ Moisture content: _____

Operating Conditions:
Temperature: Range _____ Average _____
Auxiliary fuel used: _____
_____
_____
Excess air: _____
Other: _____
_____

Monitoring Methods:
POHC's: _____
Cl: _____
Particulate: _____
Other: _____
_____
_____

Emission and DRE Results:
POHC's: _____
_____
_____
_____
_____
Cl: _____
Particulate: _____
THC: _____
CO: _____
Other: _____
PIC's: _____
_____
_____

Reference(s):
_____
_____

Comments: _____
_____
_____

Figure 1. Example Data Summary Format.

(7) Smelting, melting, and refining furnaces
(8) TiO_2 chloride process oxidation reactors
(9) Methane reforming furnaces
(10) Pulping liquor recovery furnaces
(11) Combustion devices for sulfur recovery from spent sulfuric acid
(12) Other devices added by the Administration

MEK - Methyl ethyl ketone.

MIBK - Methyl isobutyl ketone.

PIC - Product of incomplete combustion. In the EPA test burns, PIC's were defined as any Appendix VIII compound that was found in the stack but was not found in the waste feed in concentrations above 100 ppm.

POHC - Principal organic hazardous constituent. POHC's are Appendix VIII constituents that are present in the waste feed and selected by the permit writer as representative of those constituents believed to be most difficult to burn, most abundant in the waste, or of particular interest because of acute toxicity, etc. During the trial burn, the destruction and removal efficiency (DRE) is measured for the POHC's, and the incinerator's performance in treating these substances is considered indicative of the unit's overall performance in combusting organic waste. Typically, two to three POHC's at concentrations of 1000 ppm or more in the waste feed are selected for monitoring during each trial burn. EPA's Practical Guide - Trial Burns for Hazardous Waste Incinerators (EPA/600/2-86/050, 1986) should be consulted for further guidance on the definition and criteria for selecting POHC's for trial burn testing.

PM - Particulate matter.

TCE - Trichloroethylene.

Trial burn - As defined by RCRA, a test of a hazardous waste incinerator to demonstrate its ability to destroy and remove POHC's, chlorine, and particulates from the emissions. A trial burn usually consists of several runs with varying conditions (e.g., feed rate, type of waste burned, temperature, etc.)

TUHC - Total unburned hydrocarbon, as measured in the stack gases during a test or trial burn. Also commonly referred to as THC.

Turndown ratio - Maximum to minimum operating range of an incinerator or other thermal treatment unit.

SECTION 2
OVERVIEW OF THERMAL TREATMENT TECHNOLOGY IN THE UNITED STATES

Hazardous waste can be thermally destroyed through burning under oxidative or pyrolytic conditions in incineration systems designed specifically for this purpose and in various types of industrial kilns, boilers, and furnaces. An incineration system typically includes primary and secondary combustion chambers. Pollution controls for reducing particulate and chloride emissions may be added, depending on the chloride and ash content of the waste. Some systems also include energy recovery devices. The incinerator portion of the system (i.e., the primary and secondary combustion chambers) is an enclosed device that used controlled flame combustion to treat (i.e., destroy) waste material. By definition, the primary purpose of the incinerator is the destruction of the waste. In such a unit, wastes are subjected to high temperatures [generally in excess of 980°C (1800°F)] for a period of time long enough to destroy either the hazardous constituents of the waste, or the bulk of the waste, or both.

In contrast to incinerators, the primary purpose of industrial kilns, boilers, or furnaces is to produce a commercially viable product such as cement, lime, or steam. These units require large inputs of energy (i.e., fuel) to produce the desired product. Owners and operators of such units often view hazardous waste material as an economical alternative to fossil fuels for energy and heat supply. In the process of producing energy and heat, the wastes themselves are subjected to high temperatures for sufficient time to destroy the hazardous content or the bulk of the waste.

Hazardous waste incinerators, boilers, and cement and lime kilns have been shown to achieve 99.99% DRE for hazardous wastes with a wide range of properties. However, hazardous waste incinerators are the only thermal treatment units widely used to destroy hazardous wastes. The present deterrents to the use of boilers and process kilns for hazardous waste destruction include:

- Uncertainty about RCRA regulations and their requirements for hazardous-waste-as-fuel applications.
- Uncertainty about the effects of hazardous waste burning on boiler and kiln equipment and product quality (cement and lime) over the long term.
- Special requirements for personnel training and waste-handling facilities when hazardous wastes are burned.
- Public concern regarding the local presence and management of hazardous wastes at these facilities.

These concerns are at least partly offset by fuel savings, and in many cases, by the ability to destroy hazardous wastes onsite rather than having to transport them elsewhere.

This section further describes and differentiates incinerators, boilers, and kilns, which are the major alternative thermal treatment technologies now available for destroying hazardous wastes. Basic design and operational data are presented for each type of unit, and a population profile is given for available units in the United States that are either currently burning hazardous wastes or have the potential to do so.

2.1 INCINERATORS*

Five types of incinerators are available and operating today:

- Liquid injection
- Hearth
- Fluidized bed
- Rotary kiln
- Fume

Estimates of the total number and distribution of hazardous waste incinerators by type and EPA Region that were believed to be operating in 1984 are listed in Table 1.

Figure 2 shows the national distribution of hazardous waste incineration facilities by State that responded to an EPA survey conducted in 1981. According to the results of this survey, liquid injection incinerators are by far the most prevalent, with 136 units in operation. More than 70 incinerator units of other types also have liquid incineration capabilities. As Figure 2 and Table 1 show, most hazardous waste incineration facilities are located in known chemical industry centers (i.e., Regions II through VI). Almost 24% of the facilities responding to EPA's survey are located in two southern states - Texas and Louisiana. Approximately 80% of all units in use today are less than 10 years old, and 50% are 6 to 10 years old.[2]

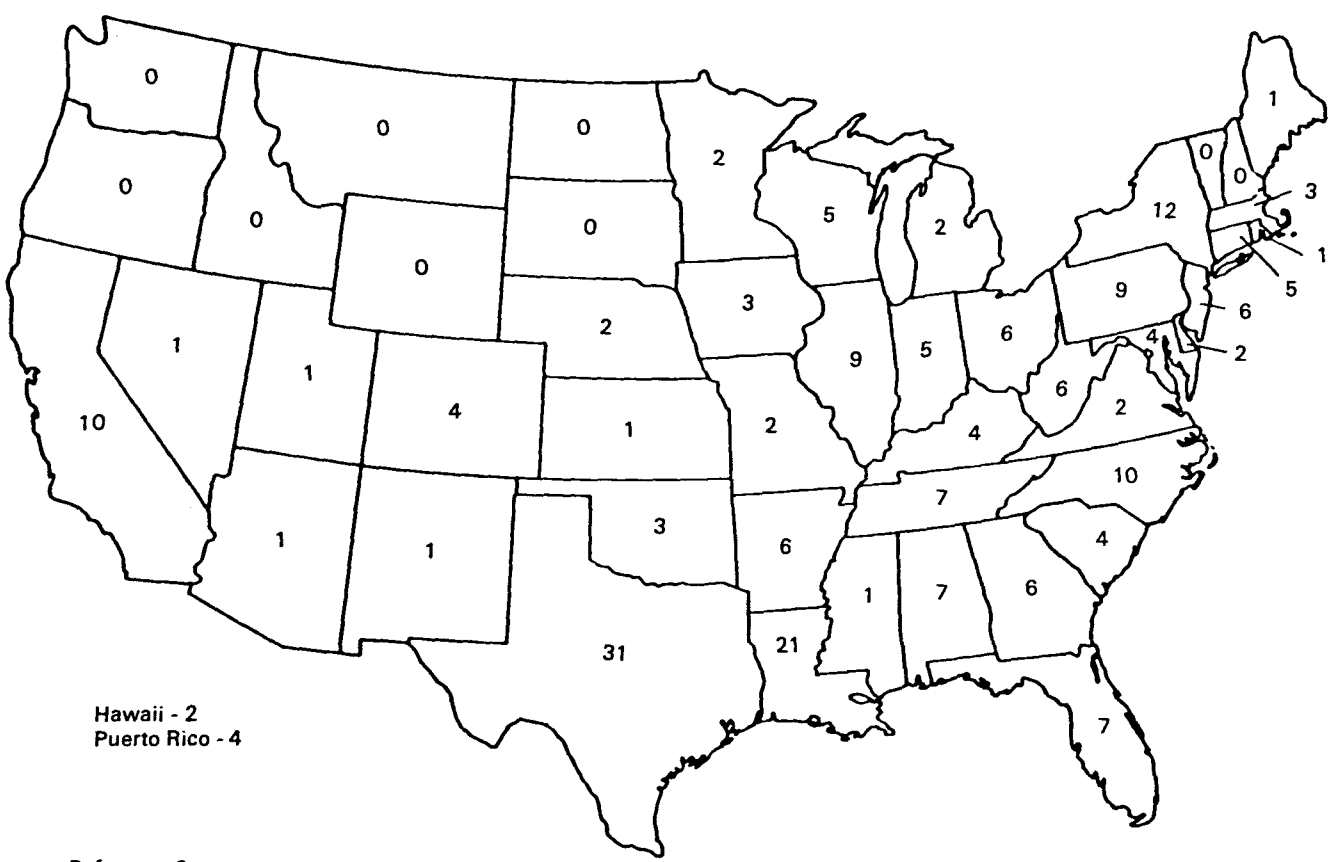
*More complete descriptions of incinerator designs can be found in Reference 1.

Table 1. Estimated Number of Hazardous Waste Incinerators in Each EPA Region*

Type	EPA Region I	II	III	IV	V	VI	VII	VIII	IX	X	Total
Liquid injection	7	15	12	23	16	57	2	—	4	—	136
Hearth with liquid capability	—	1	4	8	4	10	2	3	1	—	33
Fume with liquid capability	—	—	2	10	—	6	1	—	5	—	24
Rotary kiln with liquid capability	—	2	—	4	1	3	—	—	—	—	10
Combination system†	—	1	—	—	2	2	—	—	—	—	5
Rotary kiln (solids only)	—	—	—	1	—	—	—	—	—	—	1
Hearth (solids only)	1	3	8	1	2	6	1	—	1	—	23
Ammunition and explosives (military)	—	—	1	2	—	4	—	2	2	—	11
Ammunition and explosives (nonmilitary)	—	—	—	1	—	—	—	—	—	—	1
Drum burner	—	1	—	4	1	1	—	—	—	—	7
Other‡	4	2	1	2	1	1	1	—	1	—	13
Type not specified	—	3	2	3	4	5	1	—	2	—	20
Total	12	28	30	59	31	95	8	5	16	0	284

*Source: Reference 2
†Includes interconnected multiple units (e.g., hearth or rotary kiln connected in series with liquid injection unit).
‡Includes at least four fluidized bed units.

Figure 2 Distribution of hazardous waste incinerators, by state.



Source: Reference 2

Table 2. Manufacturers of Major Incinerator Types*

Hearth Incinerators	Liquid Injection Incinerators	Rotary Kiln Incinerators	Fluidized Bed Incinerators	Other Types of Incinerators
Basic Environmental Engineering	Brule'	CE Raymond	CE Raymond	Midland-Ross-Rotary Hearth
Bayco	C&H Combustion	C&H Combustion	Copetech	Pyro-Magnetics-Induction Heating
Burn-Zol	CE Raymond	Fuller Company	Dorr Oliver	Rockwell-Molten Salt
Econo-Therm Energy Systems	CJS Energy Resources, Inc.	Industronics	Fuller Company	Shirco-Infrared
Ecolaire ECP	Coen	International Incinerators	Sur-Lite	
Epcon Industrial Systems, Inc.	Entech Industrial Systems	Thermall, Inc.		
Midland-Ross	Hirt Combustion	Trofe Incineration		
Therm-Tech	McGill	Vulcan Iron Works		
Washburn and Granger	Peabody International	U.S. Smelting Furnace		
	Prenco			
	Shirco			
	Sur-Lite			
	Trane Thermal			
	John Zink			

*Appendix A contains a complete listing of manufacturers with addresses and phone numbers.
Source: Reference 18.

Each incinerator type is distinguished from the others primarily by combustion chamber design. Sometimes two types are designed to be used together (e.g., a rotary kiln with liquid injection). Several incinerator types are described in Sections 2.2.1 through 2.2.5. Table 2 lists current manufacturers of various types of incinerators (see also Appendix A).

Table 3 shows typical incinerator capacities expressed in terms of thermal input.

Table 3. Thermal Capacities of Hazardous Waste Incinerator Types As Reported by Manufacturers*

Incinerator Type	Range, 10^6 Btu/h	Typical Value, 10^6 Btu/h
Liquid injection	0.125 — 130	8
Hearth	0.17 — 17.5	4.9
Rotary kiln	1 — 150	10.3
Fluidized bed	8.5 — 67	45.5

*Source: Reference 2.

Each incinerator is usually designed to achieve maximum incineration efficiency for the amount and specific type(s) of wastes it will handle. Some manufacturers have been requested to bid on facilities with thermal capacities as large as 300 million Btu/h. Such large incinerators may have several primary combustion chambers ducted to a common secondary chamber.

Incinerator manufacturers design hazardous waste units to operate at specific conditions, depending on the type and size of the incinerator, characteristics of the wastes to be burned, and current or expected regulatory limitations on emissions. The most important operating conditions directly controlled by design are the combustion zone temperature, combustion gas residence time, and excess air usage. Table 4 summarizes typical operating conditions for units in operation today.

During incineration, combustion zone temperatures may reach 1600°C (2900°F). The flue gas from such processes has substantial heating value, which can be recovered and used if the volumetric gas flow rate is adequate. The installation of energy-recovery equipment on hazardous waste incinerators is primarily governed by economic considerations. Three factors that may preclude installation of energy-recovery equipment are the economy of installation on small incinerators, the presence of corrosive constituents such as hydrogen chloride in the flue gases (which can quickly deteriorate energy-recovery equipment), and the presence of adhesive particulates in the flue gas (which can cause buildup on the heat exchanger tubes). Generally, energy recovery on incinerators smaller than 7 million Btu/h has proved to be uneconomical.

Table 4. Typical Incinerator Operating Conditions, As Reported by Manufacturers*

Incinerator Type	Combustion Zone Temperature, °C (°F)	Combustion Gas Residence Time, S	Excess Air, % Stoichiometric
Liquid injection	980-1650 (1800-3000)	0.3-2.0	120-250
Fume	700-820 (1300-1500)	0.3-0.5	50-200
Rotary kiln	650-1260 (1200-2300)	2 h (solids)	50-250
Afterburner	1100-1370 (2000-2500)	1.0-3.0	120-200
Hearth			
Primary chamber	650-980 (1200-1800)	—	30-200
Secondary chamber	760-1200 (1400-2200)	1.5-2.5	200-400
Fluidized bed	760-1100 (1400-2000)	1.0-5.0	100-150

*Source: Reference 2.
These conditions are typical of most units in operation in the United States between 1980 and 1985. Note that some individual units may be designed to operate outside these typical ranges.

To meet Federal and State emission standards under RCRA and the Clean Air Act, hazardous waste incinerators are usually equipped with mechanical devices to control particulate, hydrogen chloride, chlorine, sulfur oxides, and other emissions to the atmosphere. The following factors can affect the ultimate selection of the control device for these units:

- Federal, State, and local emission regulations
- Properties of the waste being incinerated
- Type of incinerator used
- Customer preference
- Equipment cost

Most hazardous waste incinerators are currently equipped with devices to control both gaseous and particulate emissions. However, units burning nonchlorinated wastes with little or no ash content (e.g., less than 0.5%) may not need this equipment.

Air pollution control equipment, which is located downstream of the final combustion chamber and any energy-recovery equipment, can consist of one or more of the following devices or components:

- A quench chamber for (1) lowering exhaust gas temperatures to protect the exhaust system of the downstream air pollution control equipment (e.g., fan, ducts, and stack); (2) saturating the gas stream with water to improve scrubber performance; and (3) lowering exhaust gas volume to reduce the size of the air pollution control device.
- A particulate collection device (e.g., cyclone, venturi scrubber, fabric filter, electrostatic precipitator).
- A gas-absorbing device for removing gaseous pollutants such as SO_2, NO_x, HCl, etc. (e.g., packed bed scrubber, plate scrubber, free-jet scrubber, spray tower scrubber).
- A mist eliminator for dewatering the gases before discharge.

Most hazardous waste incinerator manufacturers buy air pollution control equipment from vendors rather than manufacture the equipment themselves.

2.1.1 Fixed-Hearth (Controlled or Starved Air)

The combustion chamber of the hearth incinerator is a stationary unit into which solids and sludges are introduced and burned. Although many units of this type have only a single (or primary) combustion chamber, others have both a primary and secondary chamber. Liquid waste may be introduced into either the primary or secondary chamber. The addition of a grate system allows combustion air to flow above and below the waste (termed "overfire" and "underfire air," respectively) to enhance combustion.

The combustion chamber of the fixed-hearth incinerator may be cylindrical or rectangular. Small units are usually built vertically to occupy less space. Rectangular units often have primary and secondary chambers divided by a refractory wall within the same steel shell. Cylindrical units often have separate primary and secondary combustion chambers; the secondary unit is installed on top of the primary unit. Oil or gas burners are usually installed in both the primary and secondary chambers for startup and for providing auxiliary fuel as needed.

Typical waste-loading system capacities range from 400 to 2400 lb/h (3.0 to 18 million Btu/h). Systems for loading wastes into fixed-hearth combustion chambers are usually hydraulic-ram/hopper systems or cart-dumping systems. Generally, it is not economical to install loaders on incinerators with capacities of less than 200 lb/h (1.5 million Btu/h). Such units are usually loaded manually.

Ash-removal systems are usually equipped with a hydraulic ram or series of hydraulic rams to push the ash toward the opposite end of the combustion chamber from the charging door. The ash is conveyed to or dumped directly into a quench tank filled with water. Ash-removal systems are economical to install on continuously operating incinerators with capacities greater than 500 lb/h (3.75 million Btu/h).

Fixed-hearth incinerators have the following advantages and disadvantages:

Advantages:

1. A wide variety of wastes with different chemical properties can be handled.
2. Maintenance costs are typically low because there are no moving parts inside the incineration chamber.
3. The small size of these units makes them favorable for onsite treatment of small quantities of hazardous waste.
4. Generally, the low combustion air input volume (starved air) in the primary chamber maintains a quiescent environment resulting in lowered entrained ash or particulate matter in the combustion gases entering the secondary combustion chamber.

Disadvantages:

1. Supplemental fuel must be provided for many of the solid hazardous wastes that are typically incinerated in these units.
2. Because of their small size, these units are not applicable to incineration of large volumes of hazardous waste.
3. A secondary hearth is generally necessary for the required destruction of hazardous waste.

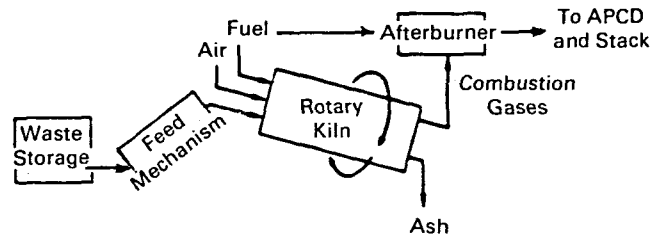
2.1.2 Rotary Kiln Incinerators

Rotary kiln incinerators are refractory-lined, rotating cylindrical steel shells mounted slightly inclined from the horizontal, as shown in Figure 3. The incline facilitates ash and slag removal. Rotation of the shell provides transportation of the waste through the kiln and enhances mixing of the waste with combustion air. The rotational speed is used to control waste residence time and mixing.

Rotary kiln incineration systems generally have at least two combustion chambers: a rotating or rocking kiln and an afterburner. Afterburners are used to ensure complete combustion of flue gases before their treatment for air pollutants. A tertiary combustion chamber can be added if needed.

Both castable and brick refractories are used in rotary kilns and afterburners. Castable refractories are generally used in small rotary kilns (those rated less than

Figure 3. Schematic of rotary kiln incinerator.



Source: Reference 1.

6 million Btu/h). Larger kilns, which comprise the majority, are typically lined with 5 to 10 cm (2 to 4 in.) of insulating refractory covered by 15.2 to 25.4 cm (6 to 10 in.) of temperature and erosion-resistant refractory. Afterburners are usually lined with high-temperature refractory.

Two types of rotary kilns are currently being manufactured: cocurrent and countercurrent. In cocurrent rotary kilns, the burner is located at the front end where the waste is fed; in countercurrent rotary kilns, the burner is located at the end opposite the feed.

Length-to-diameter ratios of the kiln range from 1 to 5. Outside diameters are usually less than 4.6 m (15 ft.), so they can be shipped by rail or truck. The kilns rotate from 1 to 7 revolutions per hour, depending on the nature of the waste. Design heat-release rates normally range from 15,000 to 40,000 Btu/h-ft^3. A typical capacity range is 1323 to 4403 lb/h for solids and 630 to 2250 l/h for liquids at temperatures of 800° to 1600°C (1470° to 2900°F). Because rotary kilns often are used to incinerate wastes with high solids content, most are equipped with ash-collection systems. The ash system includes wet or dry bins, hoppers, and conveying systems.

The waste-loading systems on rotary kilns are often the most complex among the different types of hazardous waste incinerators. Solid, liquid, and containerized wastes are ususally fed simultaneously to the kiln, but liquid wastes also may be injected into the afterburner. Sand or boiler ash can be fed to the kiln to form a slag to protect the refractory from abrasion as long as the slag remains molten. Containers as large as 210-L (55-gal) drums can be fed through loaders equipped with air locks and hydraulic drum dumpers. Other kinds of loading systems include hoppers, screw feeders, hydraulic rams, lances or pipes for introducing sludges, and liquid-injection nozzles and burners.

The rotary kiln incinerator can generally be used for the destruction and ultimate disposal of any form of hazardous waste material that is combustible. It has also been shown to be useful for decontaminating noncombustible materials such as soils, capacitors, and the like. Poor candidates for incineration in a rotary kiln are wastes with a high moisture content or

containing significant amounts of toxic metals. Rotary kiln incinerators have the following advantages and disadvantages:

Advantages:

1. The most unique advantage of a rotary kiln incineration system is its ability to retain and tumble the wastes for achieving complete combustion. This ability is especially important when high ash waste is involved.
2. The rotary kiln incinerator will incinerate a wide variety of liquid and solid wastes.
3. This incinerator will incinerate materials passing through a melt phase.
4. Liquids and solids can be received independently or in combination.
5. Drums and bulk containers can be accepted in the feed.
6. The rotary kiln incinerator is adaptable to a wide variety of feed mechanism designs.
7. The continuous ash removal does not interfere with the waste oxidation.
8. There are no moving parts inside the kiln (except when chains are added to facilitate heat transfer or to enhance mixing).

Disadvantages:

1. Capital cost for installation is high.
2. Operating care is necessary to prevent refractory damage; thermal shock is a particularly damaging event.
3. Airborne particles may be carried out of the kiln before combustion is complete.
4. Spherical or cylindrical items may roll through the kiln before combustion is complete.
5. Problems in maintaining seals at either end of the kiln can result in operating difficulties. Also, the induced draft fan and air pollution control equipment must be oversized to handle extra flue gas flow resulting from infiltration of gas through leaking seals.
6. Under certain conditions (e.g. temperature, rotation speed, waste feed rate and composition), molten solids can form and accumulate on the walls of the kiln, forming layers or rings which can restrict the flow of wastes or interfere with the overall operation of the unit.

2.1.3 Liquid-Injection Incinerators

Liquid-injection incinerators are usually single-chamber units, either vertical or horizontal. Vertical units may be upfired (i.e., the burner is on the lower end and fires upward), and combustion gases exit at the top of the combustion chamber. Downfired units are equipped with a wet quench at the combustion chamber exist at the bottom of the unit; this feature is especially important when wastes have a high salt content. Liquid injection can be used to incinerate virtually any combustible liquid waste, including slurries and sludges with a viscosity of up to 10,000 Saybolt second units. This viscosity represents the upper limit at which atomization can be used to expedite the conversion of liquid waste to a gas before combustion. Atomization is accomplished by the use of gas-fluid nozzles with high-pressure air or steam. Efficient destruction of liquid hazardous waste results from minimizing unevaporated droplets and unreacted vapors.

Castable and brick refractories are used for the combustion chamber in a liquid injection incinerator. Selection of the refractory is based on the waste characteristics. Length-to-diameter ratios of liquid-injection units are typically 2 or 3 to 1, and the diameter is usually less than 3.7 m (12 ft). Burners are normally situated in the chamber so their output will not impinge on the refractory walls. The refractory should be rated for at least 1370°C(2500°F). As the process air comes in contact with the combustion chamber wall, it is preheated to between 150° and 370°C (300° and 700°F) before it enters the combustion zone. Typical heat release rates in the combustion chamber are approximately 25,000 Btu/h-ft^3. Ash-removal systems are generally unnecessary for liquid-injection incinerators because of the low ash content of most liquid wastes. A schematic of a horizontal liquid-injection incinerator is presented in Figure 4.

Liquid wastes are transferred from drums or tank trucks into a feed tank, where recirculation systems or mixers are used to mix the tank contents. Before introduction of the waste liquid, a gaseous auxiliary fuel (such as propane) is normally used to preheat the incinerator system to an equilibrium temperature of about 815°C (1500°F). The waste is then pumped from the tank and sent either directly to the incinerator or to a blending tank to be combined with other wastes before incineration.

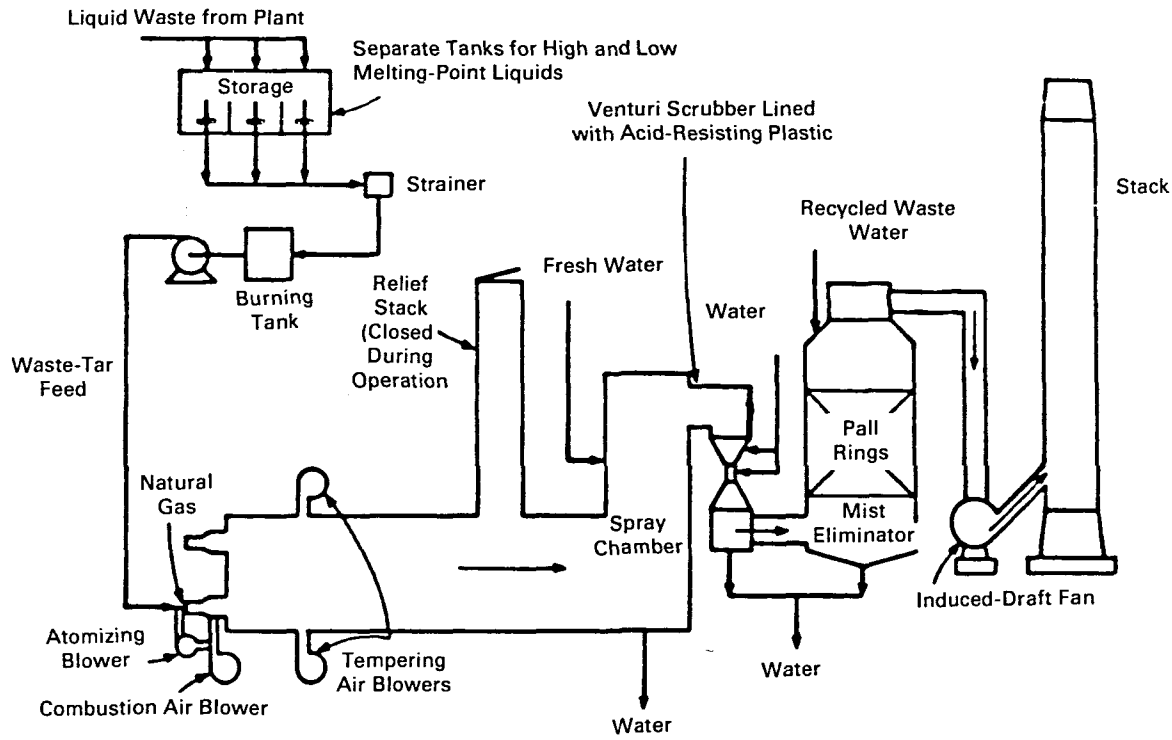
Poor candidates for liquid-injection incinerators are noncombustibles (such as heavy metals), wastes with a high moisture content, inert materials, inorganic salts, and materials with a high inorganic content. Viscous wastes are also unsuitable.

Liquid-injection incinerators have the following advantages and disadvantages:

Advantages:

1. Liquid-injection incinerators can incinerate a wide range of liquid wastes.
2. These systems are capable of a fairly high turndown ratio.
3. These incinerators have virtually no moving parts.

Figure 4. Horizontal liquid-injection incinerator.



Disadvantages:

1. Generally limited to wastes that can be atomized through a burner.
2. Burners are susceptible to plugging. (Burners are designed to accept a certain particle size; thus the particle size of any solids contained in the liquid waste feed is a critical parameter for successful operation.)
3. Burners may not be able to accept a material that dries and cakes as it passes through the nozzles.

2.1.4 Fume Incinerators

Fume incinerators are used to destroy gaseous or fume wastes. The combustion chambers are comparable with those of liquid-injection incinerators in that they are usually single-chamber units, are vertical or horizontal in configuration, and use nozzles to inject the wastes into the unit for combustion. Wastes are injected by pressure or atomization through the burner nozzles. Using the waste in this manner to maintain combustion requirements reduces secondary fuel requirements. Wastes may be combusted solely by thermal or catalytic oxidation.

Castable and brick refractories are used in the combustion chamber of a fume incinerator. The type used depends on the temperature required to incinerate the waste. For some units, combustion chamber temperature is maintained at 650° to 980°C (1200° to 1800°F) with a fume retention time of 0.3 to 1.0 s to achieve maximum conversion to carbon dioxide and water. Use of a catalyst such as alumina coated with noble metals (e.g., platinum, palladium, and rhodium) and other materials (e.g., copper chromate and oxides of copper, chromium, and manganese) can lower the required temperature to 260° to 480°C (500° to 900°F) and can also decrease retention time.

Exhaust gas from the incinerator can be passed through a heat exchanger before discharge to recover heat energy for a variety of uses. Fume incinerators may be equipped with air pollution control devices for removing SO_x or Cl gases, depending on the composition of the waste gases. Particulate controls and ash collection equipment are seldom needed because gaseous wastes yield very little ash when completely incinerated.

Fume incinerators have the following advantages and disadvantages:

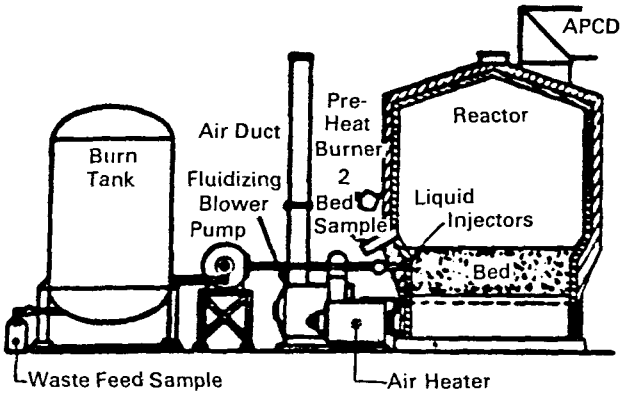
Advantages:

1. Fume incinerators can incinerate a wide range of gaseous wastes.
2. Continuous ash removal and particulate control systems are usually not required.
3. These incinerators have virtually no moving parts.

Disadvantages:

1. If heat content of the burned waste is not adequate to maintain ignition and incineration temperatures, a supplemental fuel must be provided.
2. The catalyst is deactivated and must be replaced periodically.

Figure 5. Fluidized-bed incinerator.



Source: Reference 1.

2.1.5 Fluidized-Bed Incinerators

The combustion chamber of a fluidized-bed incinerator is a vertical vessel containing a bed of inert granular material into which the waste is injected (Figure 5). The inert material consists of alumina, sand, etc., that is kept at a temperature ranging from 450° to 850°C (840° to 1560°F). Gases are blown through the bed material from below at a rate sufficiently high to cause the bed materials to fluidize. The bed is preheated to startup temperatures by a burner whose output impinges on the bed. Wastes are injected into the combustion chamber pneumatically, mechanically, or by gravity. As the waste is fed to the combustion chamber, sufficient heat is transferred from the bed material to the waste to achieve combustion. Conversely, upon combustion, the waste returns heat to the bed. The high temperature of the bed also allows for the combustion of waste gases above the bed.

Some designs include dual recirculating beds and/or afterburners to enhance the overall combustion efficiency. The fluidized-bed incinerator also may be equipped with an ash-drop chamber or cyclone to reduce particulate loading to the air pollution control or heat recovery equipment. In the case of a circulating bed, a cyclone is required to separate the bed material from the ash before it is recirculated to the combustion chamber. Ash removal is needed to maintain a constant bed height and to avoid defluidization or agglomeration of the bed material.

Both brick and castable refractories can be used for the fluidized-bed chamber. The vertical chamber typically ranges from 2.7 to 7.6 m (9 to 25 ft) in diameter. In the fluidized state the bed material is 1.5 to 2.4 m (5 to 8 ft) deep. Variations in the bed depth affect both residence time and air pressure drop, which are important variables for ensuring complete combustion. Bed temperatures are restricted by the fusion temperature of the waste ash or by the softening point of the bed medium, which is about 900°C (1652°F) for sand. Waste and auxiliary fuel are injected radially into the bed, and reaction occurs at temperatures from 450° to 820°C (840° to 1500°F). Further reaction occurs above the bed at temperatures up to 980°C (1800°F). Gas velocities in the bed range from 0.76 to 2.4 m/s (2.5 to 8.0 ft/s); the lower value applies to wet wastes when the water must volatilize. The gas velocity is constrained by the terminal velocity and particle size. Too high a velocity results in bed attrition and heavy particulate loading in the flue gas.

The residence time for liquid hazardous wastes in a fluidized-bed incinerator can be as much as 12 to 14 s. Reactor heat-release rates range up to as much as 15 million kcal/h. Waste input feed rates of up to 1360 L/h are reported for liquids with a heat content of more than 10,000 Btu/lb. and feed rates of up to 7570 L/h are reported for liquids with a heat content of 3000 Btu/lb.

A fluidized-bed incinerator is most effective for the processing of heavy sludges and slurries. Some combinations of organic and inorganic wastes, as well as liquid and gaseous combustible wastes, are also suited for fluidized-bed incinerators. A large amount of solid matter may require sorting, drying, shredding, and special feed considerations before it is fed to the reactor.

Fluidized-bed incinerators have the following advantages and disadvantages:

Advantages:

1. Fluidized-bed incinerators are generally applicable for the disposal of combustible solids, liquids, and gaseous wastes.
2. The design concept is simple, and no moving parts are required in the combustion zone.
3. Because of the compact design resulting from the high heating rate per unit volume (100,000 to 200,000 Btu/h-ft^3), capital costs are relatively low.
4. Relatively low gas temperatures and excess air requirements tend to minimize nitrogen oxide formation and contribute to smaller, lower-cost emission control systems.
5. These incinerators have long lives and low maintenance costs.
6. The large active-surface area resulting from the fluidizing action increases the combustion efficiency.
7. Fluctuations in the feed rate and composition are easily tolerated because of the large quantities of heat stored in the bed.

Table 5. Estimated Number of Industrial Boilers in 1980*

SIC	Industry	Size Range, 10^6 Btu					Total Boilers
		<50	50–99	100–249	250–499	500+	
20	Food and kindred	2,140	800	590	59	9	3,600
22	Textiles	580	400	100	3	—	1,080
26	Paper	720	450	660	340	180	2,350
28	Chemicals	2,510	840	1,070	370	79	4,870
29	Petroleum	680	330	370	130	34	1,540
30	Rubber	420	210	70	7	3	710
33	Primary metals	1,200	290	360	160	63	2,070
36	Electronics	740	160	50	4	—	950
	Other	4,650	830	650	60	12	6,210
	Total	13,640	4,310	3,920	1,130	380	23,380

*Sources: References 6 and 7.

8. These incinerators provide for rapid drying of moisture in the waste feed.
9. Selection of proper bed material suppresses acid gas formation, thereby reducing emission control requirements.
10. There is the potential for metals capture in the bed, thereby preventing emissions to the environment.

Disadvantages:

1. Residual materials are difficult to remove from the bed.
2. Preparation of the fluid bed is required.
3. Feed must be selected to avoid bed degradation caused by corrosion or reaction.
4. Special operating procedures may be required to avoid bed damage.
5. Operating costs may be relatively high, particularly power costs.
6. Formation of eutectics can be a serious problem.
7. Because only a few fluidized-bed units are in operation, hazardous waste incineration practices have not yet been fully developed.
8. These incinerators are not well suited for irregular, bulky wastes, tarry solids, or wastes whose ash has a low fusion temperature.

2.2 BOILERS

In contrast to incinerators, whose main objective is to destroy hazardous wastes, boilers are constructed to produce steam for electrical generation (utility boilers) or for onsite process needs (industrial boilers). Also, hazardous wastes compose the primary feed to incinerators, whereas they are usually a supplementary fuel for boilers. Fuel inputs to industrial boilers vary with process requirements, which may fluctuate considerably more than waste feed to a hazardous waste incinerator. Before chlorinated wastes can be fired to boilers, their compatibility with materials of construction and air pollution control equipment must be considered so as to minimize corrosion problems and hydrogen chloride emissions.

Reportedly there are approximately 2600 fossil-fuel-fired utility boilers and more than 23,000 fossil-fuel-fired industrial boilers (9800 with capacities greater than 50×10^6 Btu/hr) in the United States.[5,6] Coal is the primary fuel in both boiler sectors, but oil and gas are also used. The concept of disposing of hazardous wastes in boilers has centered around industrial boilers because (1) their operation is more flexible than utility boilers, (2) they offer the potential of destroying hazardous wastes generated on site, and (3) the storage and handling facilities for hazardous wastes generated on site generally already exist.

Industrial boilers are prevalent throughout the United States. Table 5 estimates the number of industrial boilers, by size range, used in various industries. all of these industries are potentially major sources of hazardous wastes.[7]

No boilers are presently known to be burning hazardous wastes other than waste oils. EPA conducted a series of test burns on firetube and watertube industrial boilers with capacities ranging from 10 to 250 million Btu/h (approximately 10,000 to 250,000 lb of steam/h). The primary fuels used in these boilers were gas, oil, coal, and wood. The results of these tests are discussed in Section 4.

2.2.1 Boiler Design

Two types of industrial boilers are typically used: watertube and firetube. In watertube boilers, hot gas passes over water- or steam-filled tubes that line the combustion chamber walls. In firetube boilers, hot gas flows directly through tubes that are submerged in water. Other designs (e.g., cast iron or shell units) are occasionally used in applications where low-pressure steam is all that is needed. Most boilers having capacities greater than 30×10^6 Btu/h are watertube boilers.

Watertube boilers can either be field-erected or packaged units (pre-assembled by the manufacturer complete with fuel burning equipment before delivery to a site). Field-erected units usually have capacities greater than 100×10^6 Btu/h, whereas smaller watertube boilers are often packaged units.

Firetube boilers are generally packaged units with capacities less than 30×10^6 Btu/h. The upper pressure limits on firetube boilers range from 150 to 250 psig, whereas small watertube boilers have been built for operation at up to 600 psig.

Industrial boilers may be fueled with coal, oil, gas, or process wastes such as bagasse (dry sugar cane pulp), saw dust, or black liquor (paper pulping). The principal distinction among these boilers is the type of fuel-firing mode; however, such factors as furnace volume, operating pressure, and the configuration of internal heat transfer surface also differ. Firing mode is governed bythe type of firing equipment, the fuel-handling equipment, and the placement of the burners on the furnace walls. The following are the major types of firing modes:

- Single- or opposed-wall
- Tangential
- Cyclone
- Stoker

Except for stoker firing, each of the major firing modes can be used in boilers burning gas, oil, or pulverized coal. (Cyclone-fired boilers are usually designed to fire coal as the principal fuel, however.) For stoker-fired units to fire other fuels (including hazardous wastes), they would have to be retrofitted with burners. Otherwise, these boilers can burn only solid fuels (e.g., coal) that will remain on the stoker grate until burned.

In single- and opposed-wall-fired furnaces, the burners are mounted horizontally on the walls of the combustion chamber. These units have the capacity to burn gas, oil, pulverized coal, or a combination of these fuels. Opposed-wall firing is used in larger units, and heat input capacities generally exceed 4 billion Btu/h. Turbo-fired units are similar to horizontally opposed-wall-fired units, but the burners are set at an angle in the vertical plane. The intermixing of the opposing streams produces highly turbulent conditions, and combustion takes place below the furnace throat.

In tangentially fired units, the furnace is characterized by a square cross-sectional shape, and burners are mounted in two or more corners. The burners are fired tangential to a small imaginary circle in the center of the square, and the flames exhibit a rotating or spinning motion.

In cyclone-fired units, fuel and air are introduced circumferentially into a water-cooled, cylindrical combustion chamber. Cyclone burners were originally designed to burn crushed, low-ash-fusion-temperature coals. Construction of these units was discontinued because of difficulties in obtaining suitable coals and the inability of this design to adapt to low-NO_x operation.

Stoker-fired boilers are designed to burn solid fuels on a bed. The bed is either a stationary grate through which ash falls or a moving grate that dumps the ash into a hopper. The two most common types of stoker designs are underfeed (single- and multiple-retort) and overfeed (spreader) stokers. In the underfeed designs, both fuel and air move in the same relative direction. Rams force the new fuel into the furnace from beneath the fuel bed as ash is pushed aside and collected. Spreader stokers are of the overfeed design, which distributes the fuel by projecting it evenly over the fuel bed. A portion of the coal burns in suspension, however. The upper limit of spreader stoker size is a heat input of about 600×10^6 Btu/h.

Additional information on boiler design and operation can be found in *Steam - It's Generation and Use*, published by the Babcock and Wilcox Company in 1978.

2.3 PROCESS ROTARY KILNS (CEMENT, LIME, AND AGGREGATE)

Industrial process rotary kilns are used to produce cement, lime, and aggregate in the United States. Some 200 process kilns are currently in operation across the country. Typical kilns range in size from 18 m (60 ft) long and 1.8 m (6 ft) in diameter to 230 m (760 ft) long and 7.6 m (25 ft) in diameter. These kilns are often larger than those used to incinerate hazardous wastes.

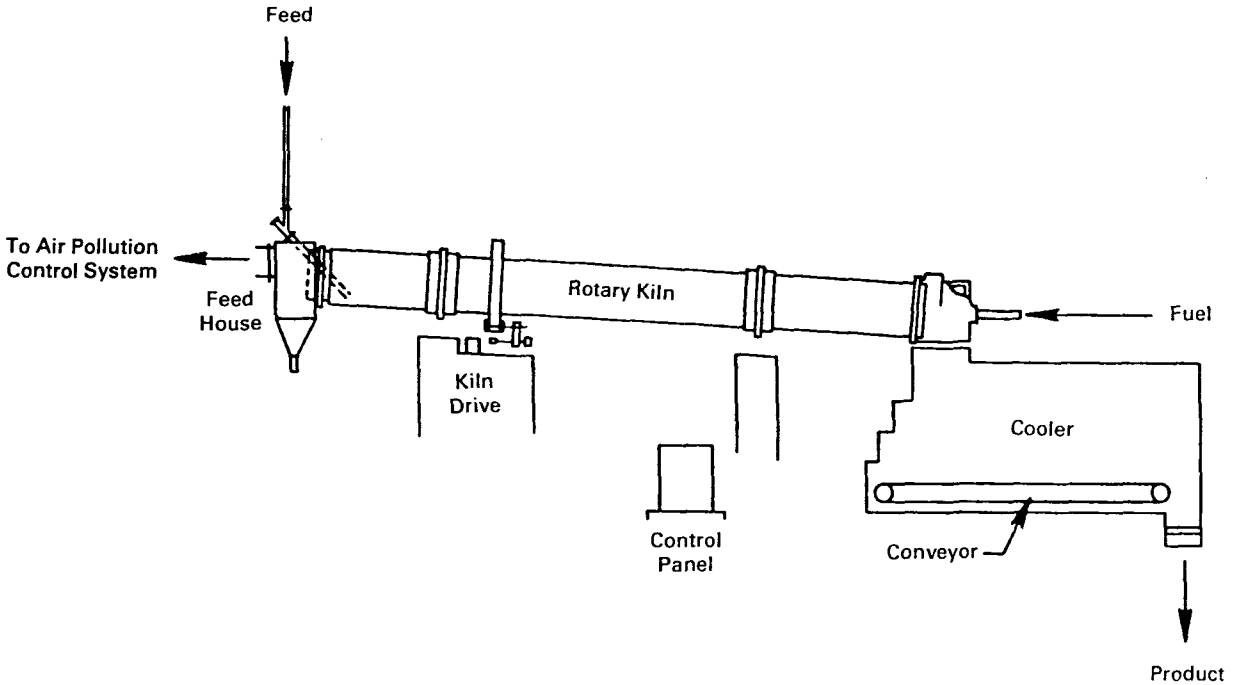
Like rotary kiln incinerators, process kilns are placed in a near-horizontal position and continuously rotated so that raw materials fed into the upper end travel slowly by gravity until they are discharged from the lower end. These kilns can be fired from either end, depending on whether cocurrent or countercurrent flow of the charge and combustion gases is desired. The configuration of the aggregate kiln (Figure 6) is also typical of other process kiln systems, such as those used for cement and lime manufacturing.

2.3.1 Cement Kilns and the Manufacture of Cement

In 1984, more than 70.8 metric tons (78million tons of cement were produced by 143 cement plants in 40 States. These plants were operated by 47 different companies and one State agency. Portland cement accounted for 96% of the total production. Capacities of these plants range from 0.18 to 9.80 metric tons (0.2 to 10.8 million tons/year. Figure 7 presents the distribution of U.S. cement kilns by State as of 1980.

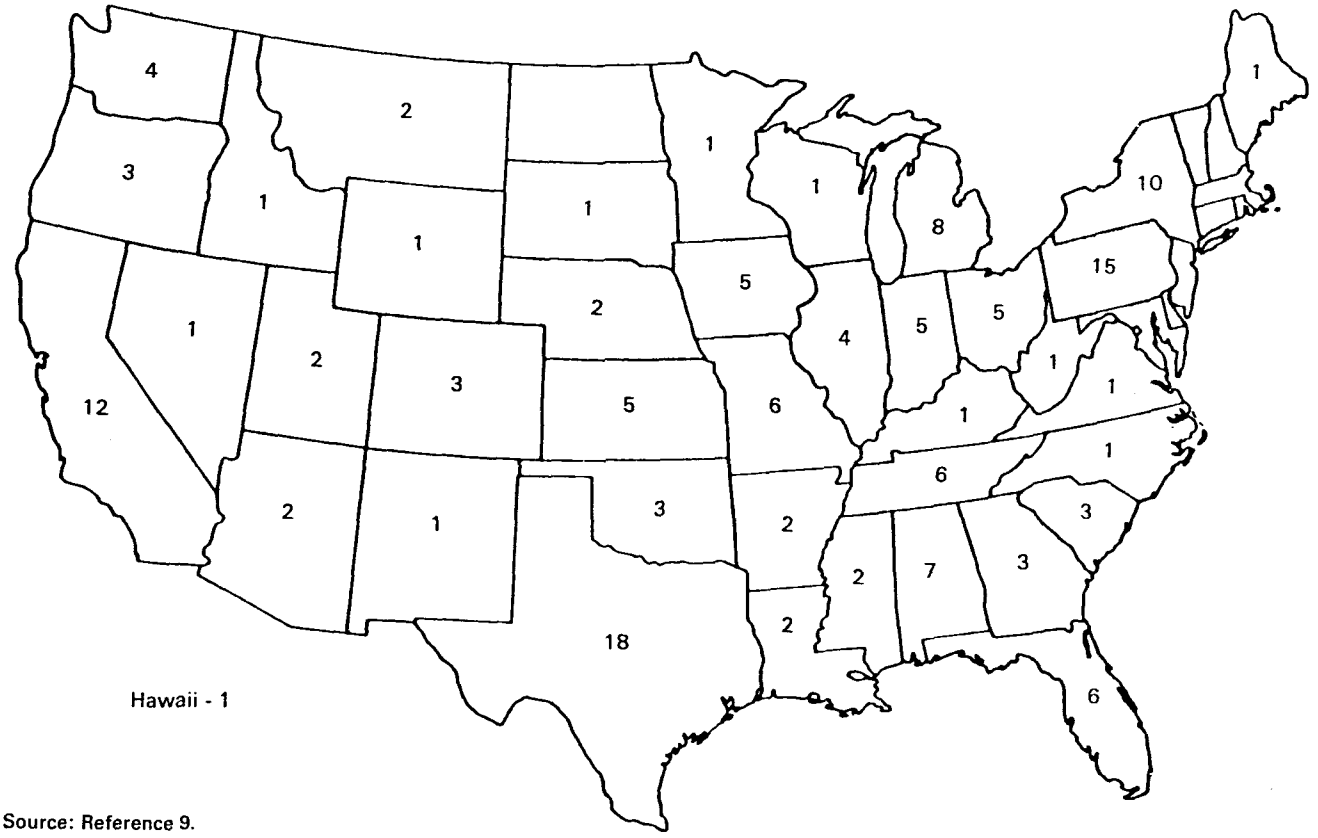
The production of cement involves four steps: (1) quarrying and crushing the raw materials, (2) grinding and blending these materials into feed at proper proportions, (3) calcining the raw materials at extremely high temperatures to form clinker (an interim product), and (4) finish-grinding of the clinker, blending the clinker with gypsum, and packaging the finished product. About 2.9 metric tons (3.2 tons) of raw material (limestone, alumina, silica, and iron) and 6.1 million Btu are required to produce 1 ton of cement. About 90% of the energy is supplied by coal.

Figure 6. **Lightweight aggregate rotary kiln cooler.**



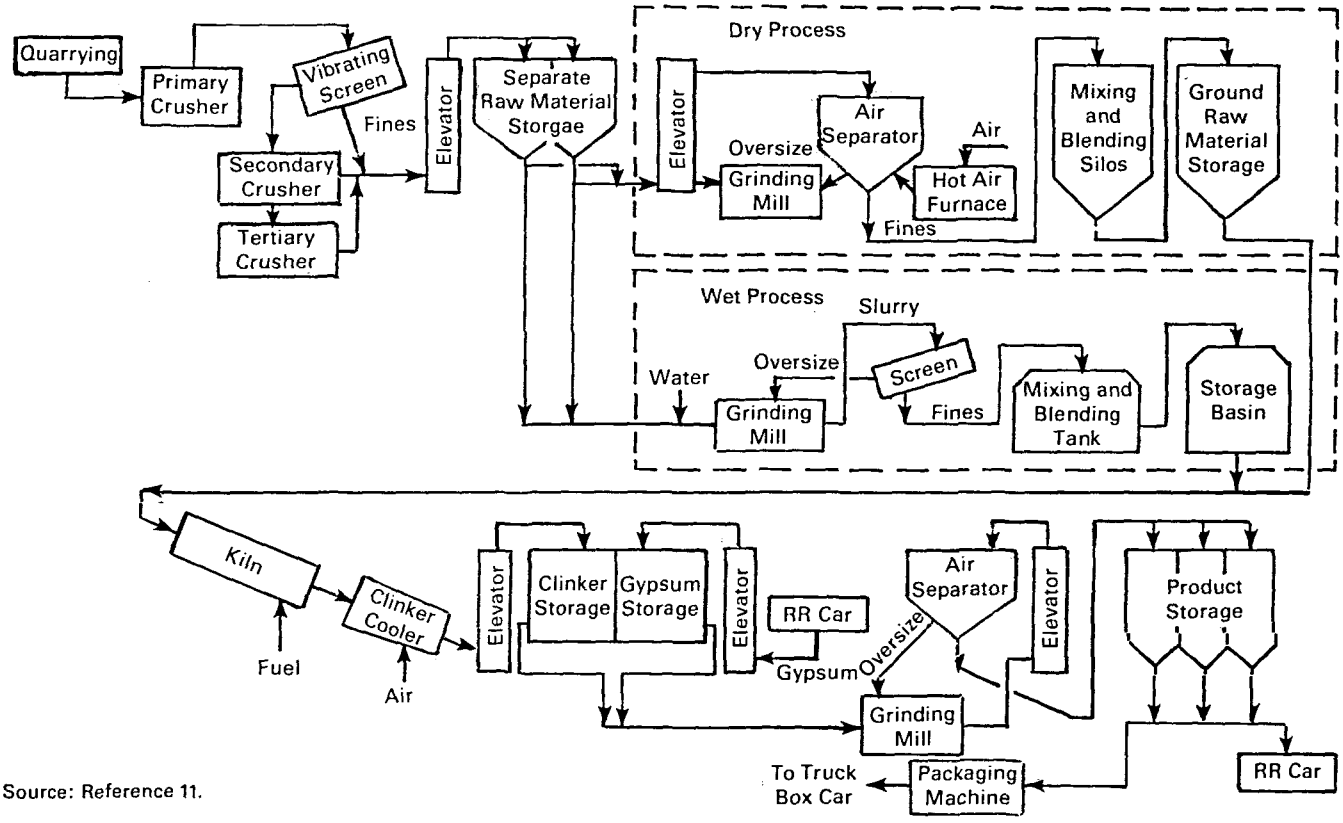
Source: Reference 8.

Figure 7. **Distribution of Portland cement plants, by state.**



Source: Reference 9.

Figure 8. Schematic diagram of Portland cement process flow.

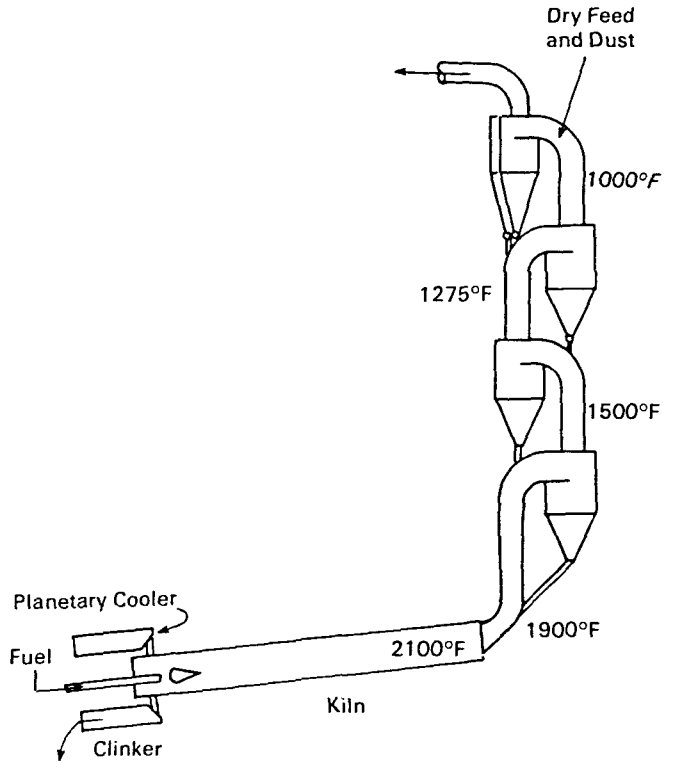


Source: Reference 11.

The cement industry uses four basic processes in cement making — the wet process, the dry process, the semiwet process, and the preheater precalcining process. In the wet process (Figure 8), the raw materials are formed into a slurry containing 30% to 35% water. The wet slurry facilitates blending and mixing, which can compensate for variations in the chemical composition of the raw materials. This step is important in maintaining uniform clinker quality. Approximately 44% of the cement plants now use the wet process. This process is highly energy-intensive, however, and great improvements have been made in dry blending and material handling; thus almost all new cement plants use the dry process, and many old wet process plants are including conversion to the dry process in their modernization plans. In the dry process (Figure 8), the moisture content is reduced to less than 1% before or during grinding, and the dry powder is fed directly into the kiln. The dry process can be as much as twice as energy-efficient as the wet process because there is no water to evaporate from the feed.[11] The semiwet process is similar to both the wet and dry processes in that the raw feed is slurried to approximately 20% water to obtain a homogeneous mixture and then preheated by kiln exhaust gas to drive off the water before the feed enters the kiln.[12]

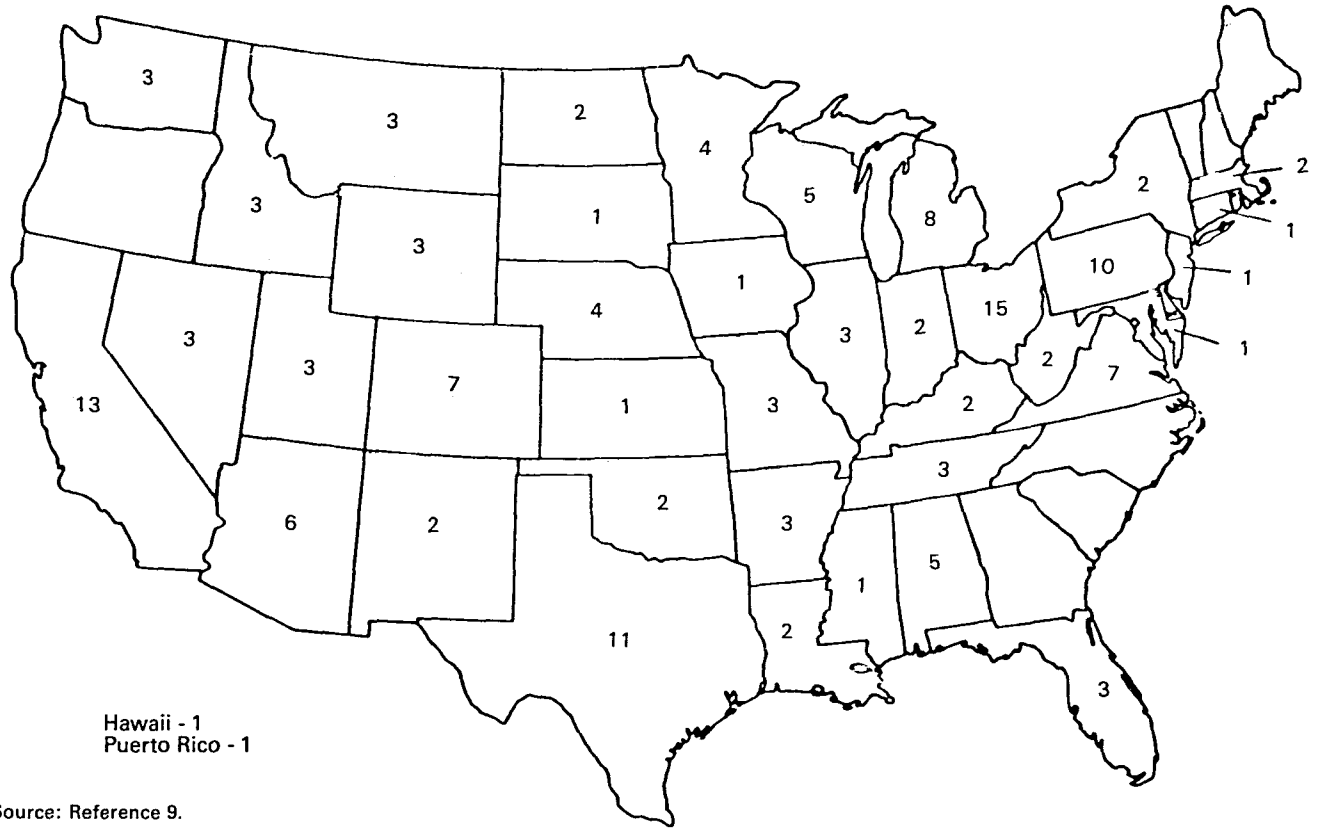
Most new dry-process kilns use preheaters, which increase energy efficiency and permit shorter kilns

Figure 9. Four-stage preheater kiln.



Source: Reference 13.

Figure 10. Distribution of domestic lime plants, by state.



Source: Reference 9.

because heating, drying, and even partial calcining of the feed material take place before the feed enters the kiln. The suspension preheater, used only in the dry process, uses a multistage cyclone/suspension system to ensure direct contact of the kiln exhaust and the dry raw feed. The kiln exhaust gases flow countercurrently to the raw feed through a series of staged cyclones[11] (Figure 9).

Cement kilns range from 18.2 m (60 ft) long and 1.8 m (6 ft) in diameter to 232 m (760 ft) long and 7.6 m (25 ft) in diameter. They are constructed of steel casings lined with refractory brick. The kiln, which is placed in a near-horizontal position (with a slope of 3 to 6 degrees), rotates at about 1 rpm on its longitudinal axis. The blended feed material is fed into the upper (higher) end of the kiln. The kiln is fired at the lower end (with coal, gas, oil, or some other liquid fuel) so that the flow of the exhaust gases is countercurrent to that of the feed material. As the kiln rotates, the feed first passes through the chain section, which is the first 18.3 to 21.3 m (60 to 70 ft) of the kiln. Chains are used to aid heat transfer, mixing, and drying (if the kiln is wet-process). As the feed slowly moves down the kiln, it is exposed to increasing temperatures, which initiate heating, drying, calcining, and sintering.

2.3.2 *Lime Kilns*[14,15,16]

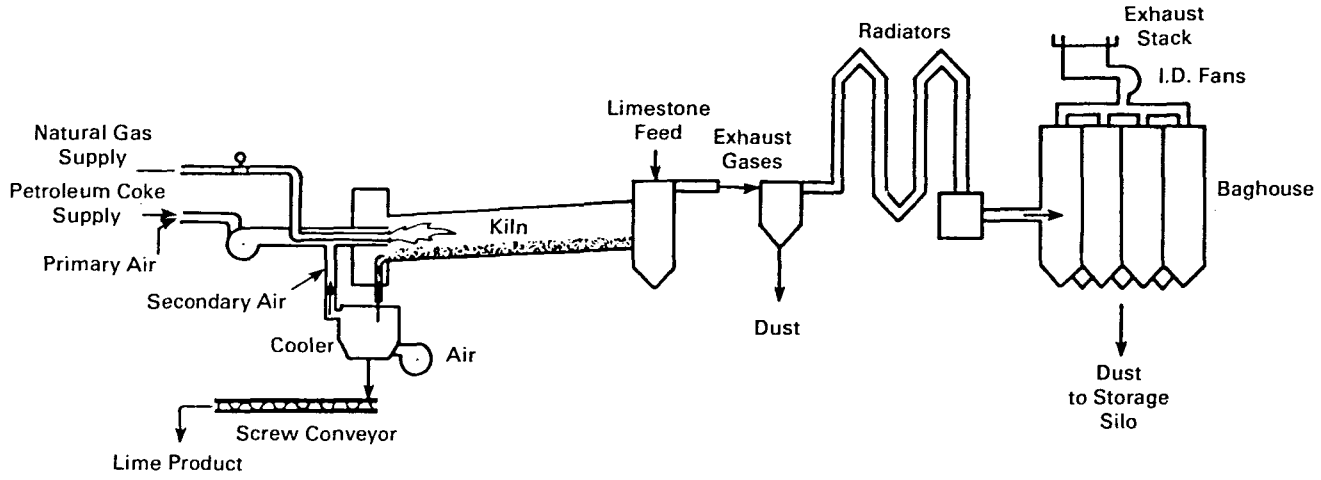
The United States is the second largest producer of lime in the world. In 1984, lime producers at 137 plants in 38 states sold or used 14.6 metric tons (16.1 million tons) of lime. The term "lime" is a general term that includes the various chemical and physical forms of quicklime and hydrated lime, the two types generally produced. Figure 10 presents the distribution of lime kilns by state.

About 6.7 million Btu of energy is required for each 0.91 metric ton (1 ton) of quicklime produced. The cost of this high energy requirement has led to increased energy efficiency in the industry and to the use of more readily available and lower-cost fuels, especially coal. Recent new plant installations and modernization projects have incorporated pulverized-coal-burning systems and energy-saving preheater systems.

The lime manufacturing process is similar to that of cement in that the raw material (usually limestone or dolomite) is quarried, crushed and sized, and calcined in a kiln at 1093°C (2000°F) (Figure 11). Although a variety of kiln types can be used, about 85% of the U.S. producers use the rotary kiln. Kiln sizes vary. The largest is 152 m (500 ft) long and 5.2 m (17 ft) in diameter and is capable of producing more than 1090 metric tons (1200 tons) of quicklime per day.

The calcining drives off nearly half the limestone's weight as carbon dioxide (CO_2) and leaves a soft, porous, highly reactive lime known as quicklime (CaO). Heating beyond this stage can result in lumps of inert, semi-vitrified material (known as overburned

Figure 11. Schematic diagram of lime kiln process.



Source: Reference 17.

or dead-burned lime) that is often used in the manufacture of refractory materials. The quicklime is discharged at the lower end of the kiln into the cooling system, where it is air-cooled, and then stored in silos. A portion of the quicklime is hydrated before storage. Hydrated lime is produced by combining quicklime with sufficient water to cause formation of a dry, white powder.

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SECTION 3
SUMMARY AND ANALYSIS OF INCINERATOR PERFORMANCE DATA

3.1 OVERVIEW

This section discusses and analyzes available test burn data gathered from 23 incinerators located throughout the United States. These test data were taken from trial burn reports submitted to EPA by RCRA permit applicants covering 14 different incinerators, and from the test reports of EPA HWERL-sponsored studies at nine other operating units. The tests were conducted between September 1981 and November 1984. All of the tests consisted of multiple runs in which one or more hazardous organic constituents in the waste were monitored at varying feed concentrations or rates, temperatures, or residence times. Detailed summaries of the data generated during each test can be found in Appendix B.

3.2 TEST OBJECTIVES AND PROCEDURES

3.2.1 EPA Tests[1,2]

The EPA tests were conducted by ORD's HWERL in Cincinnati and its contractor, Midwest Research Institute of Kansas City, Missouri, between 1981 and 1984. The first test, conducted in September 1981 at Cincinnati's Metropolitan Sewer District (MSD) incinerator, was aimed at verifying the trial burn protocol presented in a 1981 draft EPA report (Guidance Manual for Evaluating Permit Applications for the Operation of Hazardous Waste Incinerator Units. Mitre Corp. EPA Contract No. 68-01-6092, Draft Report dated April 17, 1981).

The second round of tests was conducted between 1982 and 1984 at eight sites across the country in response to a Congressional mandate to EPA calling for a regulatory impact analysis of the costs and benefits associated with the regulation of hazardous waste incinerators. The goal of this latter study was therefore to develop an extensive data base for use in characterizing incinerator performance. To do this, EPA chose the following eight sites for study:

- Ross Incineration Services, Grafton, Ohio
- American Cyanamid Co., Willow Island, West Virginia
- E.I. duPont de Nemours & Co., LaPlace, Louisiana
- The Upjohn Company, LaPorte, Texas
- Mitchell Systems, Inc., Spruce Pine, North Carolina
- Trade Waste Incineration, Inc., Sauget, Illinois (TWI)
- Zapata Industries, Inc., Butner, North Carolina
- Confidential Site B - Name and location unreported

These incinerators utilized a variety of combustion chamber designs and control equipment, as shown below in Table 6. Waste feeds and operating conditions also varied from one site to another. Typically, operating conditions during the tests were those selected by the plants as their normal conditions. However, at two sites (Site B and TWI), conditions during some test runs were purposely altered from normal to study the effect on performance. Any existing operating problems were usually corrected prior to the tests.[1]

Table 6. Distribution of Incinerator Types and Control Devices in EPA's Eight-Site Study

Item	No. of Facilities†
Incinerator type:	
Liquid injection	8
Rotary kiln	2
Hearth	2
Gas injection	1
Control device:	
None	3
HCl scrubber	5
Various particulate controls	4

*Source: Reference No. 1.

†Does not total 8 because some units have multiple incineration capabilities and either particulate or HCl controls or both.

Three of the sites tested by EPA were commercial operations burning a variety of wastes generated offsite by others. The other five incinerators destroyed waste feeds generated onsite.

The primary peformance measures examined during the EPA tests were the DRE's for the organics that were monitored, and removal rates for HCl and particulates from the stack gases. Additional parameters measured at one or more sites included organics in liquid and solid effluents (e.g., ash and scrubber waters), PIC's in the stack gas, metal content in ash and particulates, and dioxin and furan content in par-

ticulates. Emissions of CO_2, CO, O_2 and total hydrocarbons (THC) were also monitored. Standard EPA sampling and analysis methods were used where applicable, but other state-of-the-art techniques (e.g., volatile organic sampling train, or VOST which was under development at the time) were evaluated and used as necessary. Experience with the sampling and analysis methods was reviewed, and the entire body of data was scrutinized for information that might be useful in a regulatory impact assessment or in incineration studies. Analyses of the data collected were directed toward documenting specific observations for sampling and analysis methods, identifying impacts of particular incineration conditions, and developing general conclusions on incinerator performance from data gathered throughout the program. As a result, the EPA tests add a substantial amount of data to existing information on full-scale incinerators.

To properly interpret the results of the EPA test results, several qualifying statements must be made. First, the tests were not intended to thoroughly document the relationships between incinerator designs and destruction of hazardous constituents. A rigorous experimental matrix of incineration parameters was not used, nor were detailed facility characterizations prepared. Instead, as a rule, the facilities were tested under normal operations, with the fewest possible changes in typical operating conditions. As a result, the EPA tests do not provide a complete characterization of incinerator performance for specific POHC's under varied operating conditions. Also, it must be recognized that the EPA tests were not official trial burns, although they did include most of the sampling and analysis normally required for trial burns. Finally, new sampling and analysis procedures for volatile organics were evaluated during the study, even though the purpose of the study was not to investigate methods development. The new sampling method that was tested is now known as the Volatile Organic Sampling Train or VOST, and it was designed to allow the measurement of lower concentrations of volatile organics than was possible with current methods at that time. Since the completion of the test program, EPA has conducted validation studies of the method and found it to be both effective and reliable.

The EPA testing consisted of three or more test burns or runs at each site. The waste feed at each site was analyzed for RCRA Appendix VIII (40 CFR 261) organic compounds, and any such compound found in concentrations of approximately 100 ppm or more was monitored. The compounds most frequently monitored were toluene, tetrachloroethylene, carbon tetrachloride, and trichloroethylene. If they were not already present, carbon tetrachloride and trichloroethylene were spiked into the wastes, to provide a set of data for these two compounds across all sites (except American Cyanamid). PIC's were defined as Appendix VIII compounds that were detected in the stack gas but were not found in the waste feed at concentrations exceeding 100 ppm.

Volatile emissions (including PIC's) were monitored by the following three methods:

EPA Method 25 (Tedlar gas bags into which 15 L of gas were drawn over a 1-h sampling period)

Fast VOST (1 L/min for 20 min per pair of samples; six pairs of samples for a total sampling time of 120 min)

Slow VOST (0.25 L/min for 20 or 40 min; usually three pairs of samples for a total sampling time of 120 min)

Semivolatiles were monitored by Modified Method 5 (MM5). Gas bags, fast VOST, and MM5 were used at all sites to monitor organic emissions; slow VOST was only tested at three sites (TWI, DuPont, and Mitchell).

3.2.2 Trial Burn Reports[3-16]

In addition to the test burn results generated by EPA at nine sites, this document contains data generated during trial burn tests of 14 other full-scale incinerators seeking operating permits under RCRA, as listed below:

- Akzo Chemie America, Morris, Illinois
- Ciba-Geigy Corp., McIntosh, Alabama
- Dow Chemical U.S.A., Midland, Michigan
- E.I. duPont de Nemours & Co., Inc., Parkersburg, West Virginia
- E.I. duPont de Nemours & Co., Inc., Wilmington, Delaware
- Gulf Oil Corp., Philadelphia, Pennsylvania
- McDonnell Douglas Corp., St. Charles, Missouri
- Olin Corp., Brandenberg, Kentucky
- Pennwalt Corp., Calvert City, Kentucky
- SCA Chemical Services, Chicago, Illinois
- Smithkline Chemicals, Conshohocken, Pennsylvania
- Stauffer Chemical, Baytown, Texas
- 3M, Cottage Grove, Minnesota
- Union Carbide, South Charleston, West Virginia

Incinerator types and control devices represented by this trial burn group of sites are summarized in Table 7.

All of the trial burn studies consisted of multiple tests or runs that monitored one or more POHC's. The sampling and analysis protocols for each test were different and unique, designed to meet the permit objectives for each particular incinerator. Similarly, the results of each trial burn were organized and presented differently in each report. Typically, baseline tests were conducted (though not reported herein) to

determine emission levels attributable to the burning of auxillary fuel only or POHC-free wastes. Also, test runs in which problems were encountered were often aborted and/or not reported in the RCRA Part B submittals. As a rule, PIC's, metals, dioxins, and other nonregulated emissions were not monitored and/or reported.

Table 7. Distribution of Incinerator Types and Control Devices for 14 Sites Submitting Trial Burn Reports

Item	No. of Facilities*
Incinerator type:	
Liquid injection	7
Rotary kiln	5
Hearth	4
Gas injection	4
Fluidized-bed	1
Control device:	
None	2
HCl scrubber	11
Various particulate controls	9

*Does not total 14 because some units have multiple incineration capabilities and either chlorine or particulate controls or both.

3.3 TEST RESULTS AND DISCUSSION

The entire data base contained within this report has not been statistically evaluated for correlations between parameter pairs such as POHC concentrations in the waste feed and DRE, temperature and DRE, CO emissions and DRE, etc. Though such an evaluation would be beneficial to understanding the thermodynamic processes and interrelationships involved with the thermal destruction of wastes, it is beyond the scope of this data collection project.

Nevertheless, portions of the data base developed through EPA-sponsored testing have been regorously studied for insights into typical incinerator performance.[1] The following subsections present the results and conclusions generated by analysis of the EPA test data, as well as general observations relative to the entire data base contained within this document.

3.3.1 POHC's, PIC's and DRE

This document contains test results for 57 different compounds tested at 23 sites during 126 different runs for a total of 534 compound/test run combinations. Table 8 gives basic overview information on the 23 test sites, the type of incinerator tested, and the organic compounds that were monitored.

A complete tabulation of key data from these tests can be found in summary Tables B-1 and B-2 of Appendix B; the data are grouped either by compound tested (Table B-1) or by facility (Table B-2). These tables can be used to quickly identify compound-specific DRE results, concentrations tested, temperatures tested, and questionable test data. When used in combination with other tables presented in this section, the appendix listings can be useful in studying performance relative to various types of incinerators and wastes or controlled and uncontrolled conditions.

Table 9 presents a detailed listing of the DRE failures, listing for each entry the test site, compound tested, concentration in the waste feed, test run number, test sponsor, temperature, and where available, the particulate and HCl emission results. Overall, the data show that about 80% of the DRE failures occurred when the concentration of the test compound in the waste feed was less than 0.1% (1000 ppm) or when the temperature was less than 1093C (2000F). The test summaries presented in Appendix B give specific reasons believed responsible for many of the DRE failures occurring in this data base.

Another factor identified by EPA as having negative impact on DRE involves choosing as POHC's those compounds that are also likely to be present as PIC's in the stack gases. Several compounds have been previously identified as PIC's at other facilities (especially chloroform, methylene chloride, benzene, and naphthalene). The formation of these compounds during the incineration of chlorinated organics would increase their concentration in the stack gas, resulting in lower DRE's.

Data compiled from the eight EPA tests were not sufficient to define parametic relationships between residence time, temperature, heat input, or 0_2 concentration and DRE. In a multivariate analysis of these four operating conditions, only temperature showed a marginal correlation with DRE.

The eight EPA tests and at least one of the trial burn tests investigated test compound levels in scrubber water and ash; the results show that levels in these media are generally very low or nondetectable. These data suggest that the majority of organics are destroyed rather than merely transferred to another medium in the incineration process.

Some Appendix VIII compounds detected in the stack (primarily trihalomethanes) appear to be stripped from the scrubber water by the hot stack gas. Compounds of this type are often used in scrubber waters to control microbial growth. In the EPA tests, trihalomethanes detected in the scrubber inlet waters frequently were not detected in the effluent waters. When such compounds are chosen as POHC's, the effect can be lower measured or calculated DRE's even though the destruction mechanisms may have been unaffected. Recent guidance from EPA states that all POHC's in the exhaust gases, including any stripped from the scrubber, should be included in DRE calculations. (EPA memorandum dated June 26, 1985, from J.H. Skinner, Director, Office of Solid Waste, to R.W. Schrecongost, Acting Director, Hazardous Waste Management Division of Region III. Subject: Effect of Water-Stripped POHC's on Incinerator DRE.)

In the EPA tests, stack gas concentrations of PIC's (defined as Appendix VIII compounds detected in the

Table 8. Average DRE's by Compound and Incinerator Test Site

Facility	Test Sponsor	Type of Incinerator	Controlled (c) Uncontrolled (u)	Types of Wastes Tested	Source of Wastes	Approximate Temperature Range Tested, °F	Compound Tested	Average DRE, % (No. of Values)	No. of DRE Values Less than 99.99%
3M	Private	Rotary kiln with secondary chamber	c	Misc. aqueous, pumpable organic, and containerized wastes		1880-2030	1,1,2-Trichloroethane	99.9973 (10)	0
							Carbon tetrachloride	99.9988 (10)	0
Akzo	Private	Vertical cylinder	u	Fatty liquids	In-house	1620-1830	Formaldehyde	99.993777 (9)	0
American Cyanamid	EPA	Single-chamber	u	Liquid chemical wastes	In-house	1160-1240	Aniline	99.999918 (4)	0
							Diphenylamine	99.999133 (3)	0
							m-Dinitrobenzene	99.99 (1)	0
							Mononitrobenzene	99.99991 (1)	0
							Phenylene diamine	99.9984 (3)	0
Ciba Geigy	Private	Rotary kiln with secondary chamber	c	Synthetic liquid	In-house	1800	Chlorobenzene	99.99916 (5)	0
							Hexachloroethane	99.9958 (5)	0
							Methylbenzene	99.99856 (5)	0
							Tetrachloroethene	99.992 (5)	1
Cincinnati MSD	EPA	Rotary kiln and cyclonic furnace	c	Liquids — variable	Commercial	1660-2410	Bromodichloromethane	99.98 (2)	1
							Carbon tetrachloride	99.966 (5)	2
							Chloroform	99.99 (5)	0
							Dichlorobenzene	99.99 (3)	0
							Hexachlorobenzene	99.99 (6)	0
							Hexachloroethane	99.99 (3)	0
							Hexachloroethene	99.99 (6)	0
							Hexachlorocyclopentadiene	99.981666 (6)	2
							Pentachloroethane	99.99 (3)	0
							Tetrachloroethane	99.99 (2)	0
							Tetrachloroethene	99.986 (5)	1
							Trichloroethane	99.99 (1)	0
							Trichloroethylene	99.99 (1)	0
Confidential Site B	EPA	Unknown	c	Liquid organic and aqueous wastes	Unknown	1780-1950	Butyl benzyl phthalate	99.9687 (3)	1
							Carbon tetrachloride	99.90636 (5)	4
							Chloroform	99.362 (5)	5
							Diethyl phthalate	99.959666 (3)	3
							Naphthalene	99.862333 (3)	3
							Phenol	99.981333 (3)	3
							Tetrachloroethylene	99.975516 (5)	2
							Toluene	99.991306 (5)	2
							Trichloroethylene	99.9026 (5)	5
Dow	Private	Rotary kiln with secondary chamber	c	Chemical process wastes, rubbish, and sludge	In-house	1060-1890	1,1,1-Trichloroethane	99.997 (2)	0
							Carbon tetrachloride	99.9975 (2)	0
							Trichlorobenzenes	99.9935 (2)	0
DuPont — DE	Private	Vertical-cylinder	c	Assorted liquid chemicals and solid wastes	In-house	1730-2100	Carbon tetrachloride	99.999851 (7)	0
							Dichloromethane	99.999642 (7)	0
DuPont — LA	EPA	Rotary kiln with secondary chamber	c	Liquid organic wastes and drummed solids	In-house	1380-2640	1,1,1-Trichloroethane	99.932 (1)	1
							Benzyl chloride	99.999533 (3)	0
							Carbon tetrachloride	99.99985 (3)	0

(Continued)

Table 8. (Continued).

Facility	Test Sponsor	Type of Incinerator	Controlled (c) Uncontrolled (u)	Types of Wastes Tested	Source of Wastes	Approximate Temperature Range Tested, °F	Compound Tested	Average DRE, % (No. of Values)	No. of DRE Values Less than 99.99%
				(Paint, filter cake, and coke wastes)			Chloroform	99.990733 (3)	1
							Cis-dichlorobutene	99.999953 (3)	0
							Dichloromethane	99.999103 (3)	0
							Hexachloroethane	99.99 (3)	0
							Naphthalene	98.166666 (3)	3
							Tetrachloroethylene	99.999486 (3)	0
							Toluene	99.999883 (3)	0
							Trans-dichlorobutene	99.999906 (3)	0
							Trichloroethylene	99.99798 (3)	0
DuPont — WV	Private	Single-chamber	u	Liquid and gas wastes from plastics manufacture	In-house	1660-1770	Formaldehyde	99.996666 (3)	0
Gulf Oil	Private	Fluidized-bed	c	Slop oil emulsion and other sludge	In-house	1275-1340	Naphthalene	99.998 (3)	0
							Phenol	99.993333 (3)	0
McDonnell Douglas	Private	Double-chamber	c	Assorted solid and liquid chemicals, solvents, and pesticides	In-house	1800	1,1,1-Trichloroethane	99.999992 (4)	0
							Carbon tetrachloride	99.999957 (4)	0
							Tetrachloroethylene	99.997555 (4)	0
							Trichloroethylene	99.999855 (4)	0
Mitchell Systems	EPA	Double-chamber	u	Liquid organic and aqueous wastes	Commercial	1850-2050	Benzene	99.903 (2)	2
							Bis(ethylhexyl)phthalate	99.995833 (2)	0
							Butyl benzyl phthalate	99.986666 (3)	1
							Carbon tetrachloride	99.994375 (4)	1
							Methyl ethyl ketone	99.991675 (4)	2
							Naphthalene	99.975333 (3)	3
							Phenol	99.998153 (3)	0
							Tetrachloroethylene	99.9929 (1)	0
							Toluene	99.96075 (4)	4
							Trichloroethylene	99.988975 (4)	2
Olin Corp.	Private	Single-chamber	c	Synthetic organic liquid and halocarbon gas	In-house	2040-2120	Dichlorodifluoromethane	99.99 (2)	0
							Trichlorofluoromethane	99.99985 (2)	0
Pennwalt	Private	Single-chamber	c	Halocarbon liquid and gas	In-house	2220	Dichlorofluoroethane	99.998142 (7)	0
Ross Incineration	EPA	Rotary kiln	c	Aqueous, liquid organic and misc. drummed wastes	Commercial	2040-2110	1,1,1-Trichloroethane	99.999173 (3)	0
							1,1,2-Trichloroethane	99.999994 (3)	0
							2,4-Dimethylphenol	99.9992 (3)	0
							Aniline	99.998 (3)	0
							Butyl benzyl phthalate	99.998866 (3)	0
							Carbon tetrachloride	99.996133 (3)	0
							Cresol(s)	99.999133 (3)	0
							Dichloromethane	99.978333 (3)	3
							Methyl ethyl ketone	99.99943 (3)	0
							Methyl pyridine	99.998 (3)	0
							N,N-dimethylacetamide	99.999866 (3)	0
							Naphthalene	99.993 (3)	0
							Phenol	99.994 (3)	0
							Phthalic anhydride	99.99 (3)	0

(Continued).

Table 8. (Continued).

Facility	Test Sponsor	Type of Incinerator	Controlled (c) Uncontrolled (u)	Types of Wastes Tested	Source of Wastes	Approximate Temperature Range Tested, °F	Compound Tested	Average DRE, % (No. of Values)	No. of DRE Values Less than 99.99%
							Tetrachloroethylene	99.998473 (3)	0
							Toluene	99.998513 (3)	0
							Trichloroethylene	99.997676 (3)	0
SCA	Private	Rotary kiln with secondary chamber	c	PCB-containing solids and liquids	Commercial	1790-2250	PCB	99.999762 (4)	0
Smith Kline	Private	Single-chamber	c	Solvent and aqueous liquid wastes	In-house	1620-1760	Chloroform	99.99999 (3)	0
							Methylbenzene	99.998243 (3)	0
							Tetrachloroethene	99.999983 (3)	0
Stauffer Chemical	Private	Acid regeneration furnace	c	Spent acid and other liquids	In-house	1830	1,1,1-Trichloroethane	99.999979 (4)	0
							Benzene	99.999995 (4)	0
							Carbon tetrachloride	99.999979 (4)	0
TWI	EPA	Double-chamber	c	Aqueous, liquid organic and solid ink sludge wastes	Commercial	1810-2080	1,1,1-Tricholorethane	99.8145 (8)	8
							Benzene	99.992951 (8)	3
							Bis(ethylhexyl)phthalate	99.93275 (4)	4
							Carbon tetrachloride	99.997178 (8)	0
							Chlordane	99.999866 (3)	0
							Chlorobenzene	99.861237 (8)	7
							Chloroform	99.4555 (8)	8
							Dibromomethane	99.983503 (8)	4
							Dichloromethane	99.7385 (8)	8
							Hexachlorobutadiene	99.98 (1)	1
							Hexachlorocyclopentadiene	99.9924 (4)	0
							Naphthalene	99.996 (1)	0
							Tetrachloroethylene	99.860428 (7)	7
							Toluene	99.996716 (8)	0
							Trichloroethylene	99.995168 (8)	1
Union Carbide	Private	Three-chamber	c	Spent solvents and other containerized chemical wastes	In-house	1600-1800	1,2-Dichlorobenzene	99.999705 (12)	0
							Chlorobenzene	99.999366 (12)	0
							Hexachloroethane	99.999906 (12)	0
							Tetrachloroethylene	99.99979 (12)	0
Upjohn	EPA	Horizontal cylinder	c (HCl only)	Liquid and gas production wastes	In-house	2040	1,2,4-Trichlorobenzene	99.333333 (3)	3
							Aniline	99.992866 (3)	1
							Bis(ethylhexyl)phthalate	99.97 (3)	3
							Carbon tetrachloride	99.994166 (3)	0
							Chlorobenzene	99.9025 (2)	2
							Chloromethane	99.9971 (3)	0
							Chlorophenyl isocyanate	99.9991 (1)	0
							m-Dichlorobenzene	99.919666 (3)	3
							o-Dichlorobenzene	99.997 (3)	0
							p-Dichlorobenzene	99.997666 (3)	0
							Phenyl isocyanate	99.999913 (3)	0
							Phosgene	99.99575 (2)	0
							Trichloroethylene	99.99892 (3)	0
Zapata	EPA	Double-chamber	u	Varnish and liquor wastes	In-house	1240-1660	Carbon tetrachloride	99.993327 (4)	1
							Chlorobenzene	99.99665 (4)	0
							Dichloromethane	99.906 (1)	1
							Toluene	99.98305 (4)	1
							Trichloroethylene	99.9925 (4)	1

Table 9. Listing of Incinerator Test Runs that Failed to Achieve a 99.99% DRE

SITE	COMPOUND	CONC,%	DRE,%	TEMP, °F	HCL, lb/h	TSP, gr/dscf	TEST No.	SPONSOR
TWI	1,1,1 trichloroethane	0.0162	99.47	2120	h	h	8A	EPA
TWI	1,1,1 trichloroethane	0.016	99.88	2230	h	h	6	EPA
TWI	1,1,1 trichloroethane	0.0123	99.87	2140	h	h	8B	EPA
TWI	1,1,1 trichloroethane	0.011	99.81	2030	0.4	0.127	2	EPA
TWI	1,1,1 trichloroethane	0.0105	99.86	2070	0.6	0.048	3	EPA
TWI	1,1,1 trichloroethane	0.0087	99.84	2050	h	h	7	EPA
TWI	1,1,1 trichloroethane	0.00792	99.966	2080	0.3	0.075	1	EPA
TWI	1,1,1 trichloroethane	0.0051	99.82	1810	0.2	0.044	4	EPA
DUPONT-LA	1,1,1 trichloroethane	0.001	99.932	2640	0.5	0.015	1	EPA
UPJOHN	1,2,4 trichlorobenzene	0.027	99.65	2040	0.9	0.094	2	EPA
UPJOHN	1,2,4 trichlorobenzene	0.039	99.75	2040	1.7	0.013	4	EPA
UPJOHN	1,2,4 Trichlorobenzene	0.029	98.6	2040	1.2	0.08	3	EPA
UPJOHN	aniline	c	99.981	2040	1.7	0.013	4	EPA
TWI	benzene	1.43	99.984	2070	0.6	0.048	3	EPA
TWI	benzene	1.18	99.989	2030	0.4	0.127	2	EPA
TWI	benzene	0.889	99.988	1810	0.2	0.044	4	EPA
MITCHELL SYSTEMS	benzene	0.0116	99.986	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	benzene	0.0067	99.82	2050	f	f	3	EPA
TWI	bis(ethylhexyl) phthalate	0.00574	99.94	2070	0.6	0.048	3	EPA
TWI	bis(ethylhexyl) phthalate	0.00511	99.96	2030	0.4	0.127	2	EPA
TWI	bis(ethylhexyl) phthalate	0.00429	99.951	2080	0.3	0.075	1	EPA
TWI	bis(ethylhexyl) phthalate	0.00261	99.88	1810	0.2	0.044	4	EPA
UPJOHN	bis(ethylhexyl)phthalate	0.05	99.98	2040	0.9	0.094	2	EPA
UPJOHN	bis(ethylhexyl)phthalate	0.13	99.98	2040	1.7	0.013	4	EPA
UPJOHN	bis(ethylhexyl)phthalate	0.05	99.95	2040	1.2	0.08	3	EPA
CINCINNATI MSD	bromodichloromethane	0.28	99.97	1650	5	0.107	7	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate	0.0064	99.973	1975	3.8	0.378	4	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate	0.00416	99.92	1952	1.83	0.187	2	EPA
ZAPATA INDUSTRIES	carbon tetrachloride	1.2	99.978	1570	2.2	0.03	1	EPA
CINCINNATI MSD	carbon tetrachloride	0.23	99.9	2400	89.7	f	6	EPA
MITCHELL SYSTEMS	carbon tetrachloride	0.223	99.984	2050	f	f	3	EPA
CONFIDENTIAL SITE B	carbon tetrachloride	0.163	99.984	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	carbon tetrachloride	0.142	99.976	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	carbon tetrachloride	0.12	99.949	1776	h	h	4	EPA
CONFIDENTIAL SITE B	carbon tetrachloride	0.118	99.63		h	h	5	EPA
CINCINNATI MSD	carbon tetrachloride	0.11	99.96	2000	7.8	0.056	5	EPA
UPJOHN	chlorobenzene	0.68	99.945	2040	1.7	0.013	4	EPA
UPJOHN	chlorobenzene	0.41	99.86	2040	1.2	0.08	3	EPA
TWI	chlorobenzene	0.0184	99.978	2120	h	h	8A	EPA
TWI	chlorobenzene	0.0174	99.6	2230	h	h	6	EPA
TWI	chlorobenzene	0.0152	99.73	2050	h	h	7	EPA
TWI	chlorobenzene	0.0102	99.7	2030	0.4	0.127	2	EPA

(Continued)

Table 9. (Continued.)

SITE	COMPOUND	CONC,%	DRE,%	TEMP, °F	HCL, lb/h	TSP, gr/dscf	TEST No.	SPONSOR
TWI	chlorobenzene	0.00956	99.956	2070	0.6	0.048	3	EPA
TWI	chlorobenzene	0.00858	99.965	2080	0.3	0.075	1	EPA
TWI	chlorobenzene	0.0047	99.966	1810	0.2	0.044	4	EPA
DUPONT-LA	chloroform	0.229	99.987	2640	0.6	0.004	2	EPA
CONFIDENTIAL SITE B	chloroform	0.0154	99.7	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	chloroform	0.0102	99.66	1952	4.47	0.161	3	EPA
TWI	chloroform	0.0082	99.1	2230	h	h	6	EPA
CONFIDENTIAL SITE B	chloroform	0.0074	99.86	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	chloroform	0.00725	97.9		h	h	5	EPA
TWI	chloroform	0.00654	99.78	1810	0.2	0.044	4	EPA
TWI	chloroform	0.00478	99.02	2050	h	h	7	EPA
TWI	chloroform	0.00476	99.92	2140	h	h	8B	EPA
TWI	chloroform	0.00443	99.88	2120	h	h	8A	EPA
CONFIDENTIAL SITE B	chloroform	0.00428	99.69	1776	h	h	4	EPA
TWI	chloroform	0.00283	98.2	2030	0.4	0.127	2	EPA
TWI	chloroform	0.00224	99.944	2080	0.3	0.075	1	EPA
TWI	chloroform	0.00201	99.8	2070	0.6	0.048	3	EPA
TWI	dibromomethane	0.322	99.974	2230	h	h	6	EPA
TWI	dibromomethane	0.172	99.964	2070	0.6	0.048	3	EPA
TWI	dibromomethane	0.159	99.982	1810	0.2	0.044	4	EPA
TWI	dibromomethane	0.126	99.956	2030	0.4	0.127	2	EPA
ROSS INCINERATION	dichloromethane	0.67	99.989	2090	0.3	0.077	2	EPA
ROSS INCINERATION	dichloromethane	0.36	99.978	2040	0.3	0.061	3	EPA
ROSS INCINERATION	dichloromethane	0.23	99.968	2110	0.1	0.061	1	EPA
TWI	dichloromethane	0.021	99.88	2070	0.6	0.048	3	EPA
ZAPATA INDUSTRIES	dichloromethane	0.017	99.906	1600	1.4	0.022	2	EPA
TWI	dichloromethane	0.013	99.51	2230	h	h	6	EPA
TWI	dichloromethane	0.0116	99.63	1810	0.2	0.044	4	EPA
TWI	dichloromethane	0.0109	99.53	2050	h	h	7	EPA
TWI	dichloromethane	0.00881	99.9	2140	h	h	8B	EPA
TWI	dichloromethane	0.00832	99.83	2120	h	h	8A	EPA
TWI	dichloromethane	0.00762	99.71	2030	0.4	0.127	2	EPA
TWI	dichloromethane	0.00627	99.918	2080	0.3	0.075	1	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0572	99.974	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0524	99.962	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.037	99.943	1952	1.83	0.187	2	EPA
TWI	hexachlorobutadiene	0.0144	99.98	1810	0.2	0.044	4	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.01-1.2	99.97	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.009-0.31	99.96	1650	3.7	f	4	EPA
UPJOHN	m-dichlorobenzene	2.1	99.922	2040	0.9	0.094	2	EPA
UPJOHN	m-dichlorobenzene	3.1	99.932	2040	1.7	0.013	4	EPA
UPJOHN	m-dichlorobenzene	2.3	99.905	2040	1.2	0.08	3	EPA

(Continued)

Table 9. (Continued).

SITE	COMPOUND	CONC,%	DRE,%	TEMP, °F	HCL, lb/h	TSP, gr/dscf	TEST No.	SPONSOR
MITCHELL SYSTEMS	MEK	0.284	99.987	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	MEK		99.988	2050	f	f	3	EPA
MITCHELL SYSTEMS	naphthalene	0.0395	99.986	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	naphthalene	0.0192	99.96	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	naphthalene	0.0148	99.98	2000	4.9	0.313	2	EPA
DUPONT-LA	naphthalene	0.011	98	2640	0.5	0.015	1	EPA
DUPONT-LA	naphthalene	0.009	99.1	2640	0.6	0.004	2	EPA
DUPONT-LA	naphthalene	0.006	97.4	2640	0.9	0.011	3	EPA
CONFIDENTIAL SITE B	napthalene	0.0177	99.927	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	napthalene	0.0174	99.85	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	napthalene	0.0118	99.81	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	phenol	0.249	99.976	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	phenol	0.169	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	phenol	0.148	99.979	1952	0.64	f	1	EPA
UPJOHN	phosgene	20.2	99.981	2040	1.7	0.013	4	EPA
CIBA-GEIGY	tetrachloroethene	5.03	99.982	1800	99.9	0.14	5	Private
CINCINNATI MSD	*tetrachloroethene*	0.34	99.97	2400	89.7	f	6	EPA
CONFIDENTIAL SITE B	tetrachloroethylene	0.29	99.937		h	h	5	EPA
CONFIDENTIAL SITE B	tetrachloroethylene	0.235	99.948	1776	h	h	4	EPA
TWI	tetrachloroethylene	0.0183	99.982	1810	0.2	0.044	4	EPA
TWI	tetrachloroethylene	0.0124	99.88	2070	0.6	0.048	3	EPA
TWI	tetrachloroethylene	0.00636	99.78	2030	0.4	0.127	2	EPA
TWI	tetrachloroethylene	0.00567	99.965	2080	0.3	0.075	1	EPA
TWI	tetrachloroethylene	0.0044	99.966	2140	h	h	8B	EPA
TWI	tetrachloroethylene	0.0041	99.64	2230	h	h	6	EPA
TWI	tetrachloroethylene	0.00377	99.81	2050	h	h	7	EPA
CONFIDENTIAL SITE B	toluene	1.317	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	toluene	1.3	99.982		h	h	5	EPA
ZAPATA INDUSTRIES	toluene	0.11	99.952	1570	2.2	0.03	1	EPA
MITCHELL SYSTEMS	toluene	0.105	99.941	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	toluene	0.0957	99.957	2050	f	f	3	EPA
MITCHELL SYSTEMS	toluene	0.0738	99.966	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	toluene	0.0618	99.979	1975	3.8	0.378	4	EPA
CINCINNATI MSD	trichloroethane	0.96	99.985	1650	5	0.107	7	EPA
ZAPATA INDUSTRIES	trichloroethylene	1.1	99.979	1570	2.2	0.03	1	EPA
TWI	trichloroethylene	0.956	99.989	2230	h	h	6	EPA
MITCHELL SYSTEMS	trichloroethylene	0.223	99.984	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	trichloroethylene	0.222	99.985	1930	4.1	0.491	1	EPA
CONFIDENTIAL SITE B	trichloroethylene	0.166	99.981	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	trichloroethylene	0.147	99.8	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	trichloroethylene	0.136	99.983	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	trichloroethylene	0.124	99.949	1776	h	h	4	EPA
CONFIDENTIAL SITE B	trichloroethylene	0.123	99.8		h	h	5	EPA

*Many of the DRE failures are believed to be due to low concentrations in the waste feeds tested and/or to sampling and analytical problems associated with measuring the compound input and output. Operational excursions from normal conditions such as low temperatures or high waste feed rates may also account for some of the failures. See Appendix B for more specific information on individual DRE failures.

stack that were not found in waste feed in concentrations exceeding 100 ppm) were typically as high as or higher than those for the total of all Appendix VIII compounds detected in the stack. The PIC output rate infrequently exceeded 0.01% of the POHC input rate. (The 0.01% criterion was proposed in FR Vol. 45, No. 197, October 8, 1980.) The three likely mechanisms that explain the presence of most PIC's are:[1]

- Appendix VIII compounds present at low concentrations (<100 ppm) in the waste feed were destroyed at a relatively low DRE;
- Appendix VIII compounds were added to the system from sources other than the waste feed (e.g., auxiliary fuel, scrubber water);
- Appendix VIII compounds were formed in the system as products of incomplete combustion or of complex side reactions including recombination.

Another possible explanation may be solvent contamination from analytical sources.

Data from the tests suggest that benzene, toluene, chloroform, tetrachloroethylene, and naphthalene have a high potential for appearing in the stack gases as combustion byproducts.

3.3.2 Particulate and Hydrogen Chloride Emissions

Emissions of particulate matter and HCl are limited by 40 CFR 264.343 as follows:

Particulate matter	0.08 gr/dscf corrected to 7% O_2
HCl	4 lb/h, or an HCl removal efficiency of at least 99%.

Although these emissions are generally a function of the ash and chloride contents of the waste burned, the outlet concentration also depends on the exhaust gas control system. Because control systems varied from site to site, correlating the particulate and HCl emissions with input concentrations is impossible. Although the available data do not permit the development of such a relationship, they do indicate that, in general, the HCl and particulate emission limits are achievable.

Table 10 presents an overview of the tests relative to HCl and particulate emission control. Unfortunately, data presentations in many of the trial and test burn reports were either incomplete, difficult to locate, or difficult to interpret, thereby making it very difficult to determine with certainty the overall HCl and particulate compliance frequency. For HCl emissions, only enough information was readily available to conclude that 17 of the 23 sites clearly met at least one of the standards in all runs tested. For the remaining six sites, the conclusions that can be drawn regarding compliance are less readily apparent. For example, both HCl emission limits were exceeded in three of nine runs at Cincinnati MSD; however, in the other six runs, at least one of the standards was achieved. At Mitchell, two of four runs failed the 4-lb/h limit, but the data reported do not clearly indicate whether the HCl removal efficiency met or failed the 99% level. Union Carbide reported HCl removal efficiencies of less than 99%, but the information in the report was insufficient to determine whether emissions from this site were within the 4-lb/h limit.

Eleven of the 23 sites reported periodic problems in limiting particulate emissions to the 0.08 gr/dscf regulatory limit. Seven of the nine sites studied by EPA exceeded the 0.08 gr/dscf (corrected to 7% O_2) during one or more of the test runs. Four sites (Ciba Geigy, Cincinnati MSD, Mitchell, and Confidential Site B) were particularly deficient in control of particulate matter. Data from the EPA tests suggest that any facility firing wastes with ash content greater than 0.5% will need a particulate control device to meet the standard. See the individual test summary data sheets in Appendix B for more detailed data from each test site.

3.3.3 Other Results

Other important findings from the incineration tests conducted by EPA relative to (1) heat of combustion, (2) CO, THC, and dioxin emissions, and (3) the sampling and analysis of waste feed and stack gases are presented as follows.

Heat of Combustion --

- Analysis of the data collected in the EPA program showed no clear correlation between DRE and heat of combustion for the POHC's tested.

CO, THC, and Dioxin Emissions --

- CO and THC were monitored on a continuous basis to assess their utility as indicators of incinerator performance. The analysis indicates that CO and THC may provide some indication of changes in incinerator performance and gross malfunctions in the combustion process. Under the conditions of these tests, however, CO and THC levels did not appear to be good predictors of POHC emissions or DRE, either across the plants tested or at a specific site, for DRE's in the vicinity of 99.99%. Also note that these tests were not conducted in a parametric fashion specifically designed to determine whether such a correlation could be found.
- Of six sites that were tested by EPA for tetra- and penta-chlorinated dioxins and furans, dioxins were found at one site, and furans were found at three sites. No 2,3,7,8-TCDD was detected. The maximum concentrations detected were 0.06 ng/L of chlorinated furans and 0.02 ng/L of chlorinated dioxins.

Sampling and Analysis --

- The VOST method used in the EPA tests provided a consistent and reliable data base

Table 10. Overview of HCl and Particulate Emission Control Results by Incinerator Test Site

Test Site	Test Sponsor	Controlled	Normal Operations	Passed HCl Standard (Less than 4 lb/h or 99% Removal)	Passed PM Standard (Less than 0.08 gr/scf at 7% O_2)	Comments
Akzo Chemie America	Private	No	Yes	Yes	Yes	
American Cyanamid Co.	EPA	No	Yes	Yes	See comments	Three of four runs passed.
Ciba-Geigy Corp.	Private	Yes	Yes	Yes	See comments	Failed all six runs.
Cincinnati Metropolitan Sewer District	EPA	Yes	See comments	See comments	See comments	Incinerator experienced problems with demister and pH controls during tests. HCl monitoring may also have been faulty. Three of nine runs failed both HCl standards. Four of five runs in which PM was tested failed.
Confidential Site B	EPA	Yes	See comments	See comments	See comments	Runs 1 through 3 normal; 4 through 5 not normal. Runs 1 and 2 passed HCl standard, but Run 3 failed. Runs 4 and 5 not tested for HCl or PM.
Dow Chemical U.S.A.	Private	Yes	Yes	Yes	See comments	Data unclear.
E.I. duPont de Nemours & Co., Inc., LaPlace, Louisiana	EPA	Yes	Yes	Yes	Yes	
E.I. duPont de Nemours & Co., Inc., Parkersburg, West Virginia	Private	No	Yes	Yes	Yes	No chlorine in waste feed (Cl less than or equal to 0.12%).
E.I. duPont de Nemours & Co., Inc., Wilmington, Delaware	Private	Yes	Yes	Yes	Yes	
Gulf Oil Corp.	Private	Yes	Yes	See comments	See comments	Two of three runs passed the particulate standard. Report is unclear about whether HCl standard was achieved.
McDonnell Douglas Corp.	Private	Yes	Yes	Yes	Yes	
Mitchell Systems, Inc.	EPA	No	Yes	See comments	See comments	Two of four runs failed 4-lb/h HCl standard. Three of four runs failed particulate.
Olin Corp.	Private	Yes	Yes	Yes	Yes	
Pennwalt Corp.	Private	Yes	Yes	Yes	Yes	
Ross Incineration Services, Inc.	EPA	Yes	Yes	Yes	See comments	Run 2 passed particulate, but Run 3 failed; other runs not tested.
SCA Chemical Services	Private	Yes	Yes	Yes	Yes	
Smith Kline Chemicals	Private	Yes	Yes	Yes	Yes	
Stauffer Chemical Co.	Private	Yes	Yes	Yes	Yes	
3M	Private	Yes	Yes	Yes	See comments	Four of ten runs failed particulate.
Trade Waste Incineration, Inc.	EPA	Yes	See comments	Yes	See comments	Runs 1-4 conducted under normal operative conditions; conditions altered for Runs 6-8. Three of four normal runs passed particulate; PM and HCl not tested in Runs 6-8.
Union Carbide	Private	Yes	Yes	See comments	See comments	Eleven of twelve runs passed particulate. Data unclear about HCl.
The Upjohn Co.	EPA	Yes	Yes	Yes	See comments	Two of three runs passed.
Zapata Industries, Inc.	EPA	No	Yes	Yes	Yes	

when operated by personnel familiar with the apparatus and procedures. Proper use of these procedures was critical to obtaining reliable data.

- Of the two methods used in the EPA program for sampling volatile organics in the stack--VOST and gas bags--the VOST method provided lower blank values than gas bags, resulting in a higher percentage of quantifiable data points. Also, the VOST method was less cumbersome and less prone to contamination than gas bags.
- Hazardous waste samples contain a complex matrix of compounds that present a variety of analytical difficulties. Analysis by a gas chromotograph/mass spectrometer (GC/MS) was highly successful for identifying Appendix VIII compounds in the waste streams and effluents. Prescreening by a gas chromotograph/flame ionization detector (GC/FID) was useful when analyzing waste streams.
- Because small concentrations of organics must be measured in stack gases, sample contamination can present significant problems. Careful cleaning and handling of run samples and control blanks and well defined blank correction procedures are required.
- The results of the external and internal quality assurance program used in the EPA study indicate that established quality assurance procedures were followed and that the overall quality of laboratory and field work was adequate to meet the objectives of the study.
- Evaluation of the quality assurance data for the eight incinerator tests indicated low or erratic recoveries in the analyses of phenol, cis- and trans- 1,2, -dichlorobutene, naphthalene, aniline, and bis(2-ethylhexyl)phthalate for the complex waste feed matrices encountered during this program. Caution should be used when evaluating these compounds as POHC's during actual trial burns.
- The results from waste sampling and analysis at plants where Appendix VIII compounds were spiked into the liquid waste feed line indicate that inadequate mixing and, as a result, nonrepresentative waste feed samples may have been a problem at some facilities. One approach used to alleviate the problem was the use of in-line mixers. This approach was successful at the one facility where it was used during the program.

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SECTION 4
SUMMARY AND ANALYSIS OF BOILER PERFORMANCE DATA

4.1 OVERVIEW

The heat of combustion of many hazardous wastes is high enough to make them candidates for cofiring with conventional fuels in boilers. Also, many industrial boilers have been designed to fire multiple fuels either concurrently or sequentially, usually from separate burners. Hazardous waste can be similarly fired into the boiler through a separate burner or, in some cases, blended with the primary fuel. For example, the waste could be mixed with solid fuel for stoker boilers, or it could be blended with fuel oil for oil-fired boilers.

Field emission tests were performed on 11 industrial boilers cofired with conventional fuels and hazardous wastes. Screening of candidate sites was based on the representativeness of the boiler design, the wastes being fired, and the availability and accessibility for cofiring tests.

4.2 TEST OBJECTIVES AND PROCEDURES

4.2.1 EPA Test Program

The selected test sites spanned a broad range of design and operating conditions: firetube and watertube designs, steam capacities ranging from 8500 to 250,000 lb/h, loads from 25% to 100% of rated capacity, wastes ranging more than an order of magnitude in heat of combustion, residence time and heat release variations of more than an order of magnitude, and gas, oil, coal, and wood firing. Table 11 summarizes the boiler design and general operating characteristics of each of the test sites.

Sites A and H were both fired by solid fuels. Site A was equipped with a cyclone, and Site H with an electrostatic precipitator. Sites G and J were fired with chlorinated hydrocarbons without auxiliary conventional fuel. Site G was equipped with two scrubber columns for HCl recovery and cleanup. Site J had no air pollution controls. At all the other sites, either natural gas or No. 6 fuel oil was fired, and none of them had air pollution control equipment. As a means of extending the range of waste destruction characteristics tested, the wastes at Sites E through K were spiked with carbon tetrachloride and (in most cases) monochlorobenzene and trichloroethylene.

A typical test series involved an initial conventional fuel baseline test (to characterize unit operation and emissions in the absence of waste firing) followed by two or more cofiring tests. The unit load was held constant during each test to allow comparisons of results. In most other respects, however, routine operational variations (such as excess air levels and waste flow rates) were tolerated to obtain results representative of normal operation. Table 12 summarizes boiler operation and fuel parameters during the test series.

4.2.2 Test Procedures

The major inlet and outlet streams were sampled and analyzed (as shown in Figure 12 for a coal-fired unit), and boiler operational data were taken to characterize performance with and without waste firing. Details on the protocol are summarized in Table 13. Waste and fuel grab samples were taken approximately every hour, composited, and analyzed in the laboratory for ultimate and proximate analyses, chloride content, and POHC concentration. Bottom and hopper ash composite samples were analyzed for chlorides, POHC's, and carbon content. The major sampling effort took place at the stack, where the following samples were taken:[2]

- Continuous-monitor analyses of O_2, CO, CO_2, NO_x, and TUHC.
- Volatile organics extractive samples by the VOST.
- Semivolatile organics and particulates by the MM5 extractive sampling train.
- Chlorides by a Method 6 extractive sampling train.
- C_1 - C_6 hydrocarbons by a gas bomb grab sample and gas chromatograph analyses.

Each test required approximately 6 h of run time. Post-test analyses of the volatile and semivolatile samples collected on resin traps were done by gas chromatography/mass spectroscopy (GC/MS).

For the most part, test boilers were operated under normal conditions of excess combustion air, heat input rates, ratio of waste to primary fuel, total chlorine input, etc., as dictated by test site operating practices. Tests generally were performed during relatively steady boiler operations to minimize possible impacts of sudden transients on emissions. At two plants (plants E and J), operating conditons were modified for some tests to investigate the effects of minor operational changes on POHC destruction and overall organic emission rate. The boiler was oper-

Table 11. Boiler Summary for U.S. Environmental Protection Agency Hazardous Waste Cofiring Test Program*

Site	Boiler Type	Number of Baseline Tests and Primary Fuel(s) used	Number and Type of Test and Waste Description	Emission Control Device	Operational Conditions
A	Keeler CP, 308-hp (10,000 lb/h of steam) watertube boiler	No baseline test; wood waste (chips, bark, and sawdust)	Four cofire tests using creosote sludge containing chlorinated aromatics including pentachlorophenol, phenol, naphthalene, and fluorene.	Multicyclone for particulate collection	Typical wood boiler operation with high excess air and high combustible emissions. Baseline fuel contaminated with creosote. Boiler poorly instrumented.
B	Cleaver-Brooks, 250-hp (8,400 lb/h of steam) firetube boiler	One baseline test; natural gas	Three cofire tests using alkyd wastewater with paint resin containing toluene, xylenes, and several acids.	None	Low load tests. Several waste feed problems caused by inefficient mixing of waste and plugging of screens. Fluctuations in waste feed flow.
C	Babcock & Wilcox, 29-kg/s (230,000 lb/h of steam) multiburner watertube	One baseline test; natural gas	Three cofire tests using phenolic waste containing phenol, alkyl-benzenes, and long-chain aromatic and aliphatic hydrocarbons.	None	Low boiler load and high excess air. No operational transients.
D	Babcock & Wilcox, 11.4-kg/s (90,000 lb/h of steam) multiburner watertube†	One baseline test; No. 6 oil	Three cofire tests using waste stream No. 1 (mixture of methanol xylenes and tetrachloroethylene), and Three cofire tests using waste stream No. 2 (mixture of toluene and bis (2-chloroethyl)ether).	None	Burner problems experienced with waste stream No. 1. Waste feed interruption was due to filter plugging. No transients with waste stream No. 2.
E	Combustion Engineering, 13.9 kg/s (110,000 lb/h) of steam, single-burner, packaged watertube	One baseline test; No. 6 oil and natural gas	One cofire test using waste stream No. 1 (mixture of methyl methacrylate, and fluxing oils), Six cofire tests using waste stream No. 2 (waste stream No. 1 spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene), and One cofire test using waste stream No. 3 (mixture of toluene and methyl methacrylate).	None	Smoke emissions and transients experienced with spiked waste stream No. 1. Generally higher excess air required during cofiring. Smoke generation sensitive to orientation of waste fuel guns and surges in waste flow rates.
F	Babcock & Wilcox, 7.6-kg/s (60,000 lb/h of steam) multiburner watertube	One baseline test; No. 6 oil	Three cofire tests using purge thinnner containing mixed methyl esters, butyl cellosolve acetate, aromatic hydrocarbons, and aliphatic hydrocarbons. Spiked with chlorobenzene, trichloroethylene, and carbon tetrachloride.	None	Improper setting of burners caused several flame-outs independent of waste feed.

(Continued)

Table 11. (Continued).

Site	Boiler Type	Number of Baseline Tests and Primary Fuel(s) used	Number and Type of Test and Waste Description	Emission Control Device	Operational Conditions
G	Johnston modified firetube boiler, 5.0 kg/s (40,000 lb/h of steam or 1,200 hp), thermal heat recovery oxidizer (THROX)‡	None; natural gas used only for startup	Three primary firings using mixture of chlorinated hydrocarbons containing up to 55% by weight chlorine. Major components were bis(2-chloroisopropyl)ether and epichlorohydrin spiked with carbon tetrachloride.	Two chloride recovery/ removal water scrubber columns in series	Steady-state operation. No primary fuel burned.
H	Combustion Engineering tangential NSPS coal-fired boiler, 3.2 kg/s (250,000 lb/h) of superheated steam	One baseline test; pulverized bituminous coal	Three cofire tests using crude methyl acetate spiked with trichloroethane, carbon tetrachloride, and chlorobenzene.	Cold-side electrostatic precipitator	High boiler load with steady-state operation. Low waste/coal heat input.
I	Foster Wheeler AG252 forced-draft, bent-tube boiler, 7.8 kg/s (62,000 lb/h of steam)	One baseline test staged, one baseline test unstaged; natural gas	One cofire staged test and 1 cofire unstaged test using liquid waste containing nitrobenzene and aniline benzene. Spiked with carbon tetrachloride, trichloroethylene, chlorobenzene, and toluene.	None	Nominal load. No significant boiler transients. Damage to waste feed pumps caused several pump replacements.
J	North American 3200X (200-hp) packaged firetube boiler	None	Six tests with carbon tetrachloride, monochlorobenzene, and two different levels of trichloroethylene.	None	Half and full loads high and normal EA. No significant boiler transients or impacts.
K	Combustion Engineering VU-10 balanced-draft, watertube boiler, 7.6 kg/s (60,000 lb/h) of steam	One baseline test; No. 6 oil	One cofire test using light and heavy oil mixtures. Spiked with carbon tetrachloride, trichloroethylene, and chlorobenzene.	None	Nominal test load with no significant boiler operational transients.

*Source: Reference 1.
†Boiler originally stoker-coal-fired; converted to oil burning.
‡Patented process for heat generation and chemical recovery of highly halogenated hydrocarbons.

Table 12. Summary of Boiler Operation and Fuel Parameters*

Site	Volumetric Heat Release Rate, kW/m³ (10^3 Btu/h-ft³)	Waterwall Surface Heat Release Rate, kW/m² (10^3 Btu/h-ft²)	Bulk Furnace Temperature,† °C (°F)	Bulk Furnace Residence time,† s	Primary Fuel Flow Rate	Waste Fuel Flow Rate, mL/s (gal/h)	Waste Fuel Heating Value, kJ/kg (Btu/lb)	Waste Heat Input, % of Total
A	300 (29)	48 (16)	1,370 (2,500)	1.2	0.24 kg/s (1,950 lb/h)	50 (48)	38,700 (16,700)	40
B	745 (72)	106 (34)	1,320 (2,400)	0.8	20.4 L/s (2,590 ft³/h)	34.3 (33.2)	30-108 (12-77)	<1
C	78 (7.5)	150 (48)	1,320 (2,400)	2.0	420 L/s (53,000 ft³/h)	257 (245)	38,500 (16,600)	38
D	230-400 (22-39)	100-180 (33-57)	1,370-1,430 (2,500-2,600)	1.1-1.3	0.18-0.51 kg/min (24-67 lb/h)	190-270 (180-260)	20,600-42,000 (8,800-18,000)	18-48
E	380-480 (37-47)	24-32 (7.6-10)	1,480-1,590 (2,700-2,900)	0.8-1.1	204-354 L/s gas (430-750 ft³/h)	240-260 (220-240)	26,700-37,000 (11,500-16,000)	33-56
	380-770 (37-74)	24-49 (7.6-15)	1,480-1,590 (2,700-2,900)	0.5-1.0	0.21-0.62 kg/min oil (27-79 lb/h)	195-260 (190-250)	24,500-27,300 (10,500-11,741)	19-43
F	114 (11)	104 (34)	1,370 (2,500)	2.0	0.19 kg/s (26 lb/h)	30 (29)	32,500 (14,000)	9.0
G	820 (79)	262 (81)	1,300-1,400 (2,400-2,500)	0.3-0.5	0	215 (208)	21,000 (9,000)	100
H	180 (17)	183 (58)	1,370 (2,500)	2.0	2.8 kg/s (22,000 lb/h)	160-270 (140-250)	16,500 (7,000)	2.4-4.3
I	340 (33)	181 (57)	1,430 (2,600)	1.8	330 L/s (12 ft³/h)	38 (36)	24,700 (10,600)	8.2
J	690-1,750 (65-170)	118-300 (37-95)	1,310-1,370 (2,400-2,500)	0.3-0.7	0	26-68 (25-64)	41,500 (17,900)	100
K	270 (26)	370 (117)	1,370 (2,500)	1.8	13 kg/min (1700 lb/h)	250 (240)	40,400 (17,400)	65

*Source: Reference 1.
†Not measured values.

Table 13. Sampling and Analysis Protocols for Boiler Test Burns*

Site	No. of Baseline Tests	No. of Cofired Tests	Fuel Sampling and Analysis Protocols	Sample Location	Flue Gas Sampling and Analysis Protocols			Other Wet Sampling Systems	Sampling and Analysis Protocols for Solid and Liquid Discharge Streams
					Continuous Monitors	VOST†	Modified EPA Method 5 (MM5)		
A	—	4	Creosote sludge: POHC's, other semivolatile organics, and ultimate analysis Wood and creosote mixture: ultimate analysis	Multicyclone outlet (stack)	O_2, CO_2, CO, NO_x, and TUHC	NA‡	Semivolatile POHC's and EPA priority pollutants Particulate		Multicyclone fly ash: semivolatile and nonvolatile priority pollutants
B	1	3	Alkyd resin wastewater: POHC's, other priority organics, and ultimate analysis	Stack	O_2, CO_2, CO, NO_x, and TUHC	NA	Semivolatile POHC's and EPA priority pollutants Particulate		
C	1	3	Phenolic cumene waste: POHC's, other priority organics, and ultimate analysis	Stack	O_2, CO_2, CO, NO_x, and TUHC	NA	Semivolatile POHC's and EPA priority pollutants Particulate		
D	1	6	Two separate chlorinated waste fuels: POHC's, other priority organics, and ultimate analysis	Stack	O_2, CO_2, CO, NO_x, and TUHC	Volatile organics: primary POHC's	Semivolatile POHC's and EPA priority pollutants Particulate	Modified EPA Method 6: total chloride C_1-C_6 by FID	
E	1	8	Three separate chlorinated and nonchlorinated waste fuels: POHC's, other semivolatile organics, and ultimate analysis Oil: ultimate analysis	Stack	O_2, CO_2, CO, NO_x, and SO_2	Volatile organics: POHC's and other EPA priority and nonpriority pollutants	Semivolatile POHC's and EPA priority pollutants Particulate	Modified EPA Method 6: total chloride C_1-C_6 by FID	
F	1	3	Chlorinated purge paint thinner: volatile POHC's and ultimate analysis	Stack	O_2, CO_2, CO, NO_x, and TUHC	Volatile organics: POHC's and other volatile priority pollutants	Semivolatile POHC's and EPA priority pollutants Particulate	Modified EPA Method 6: total chloride C_1-C_6 by FID	

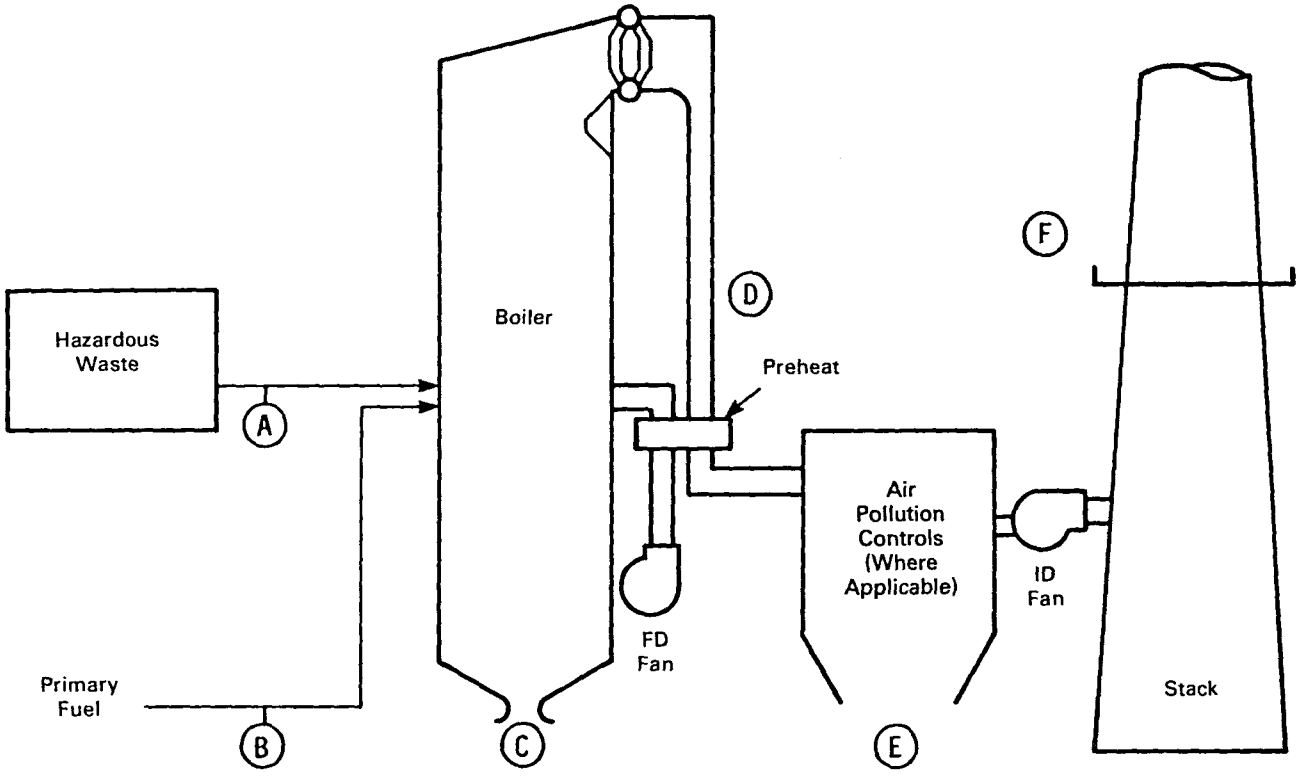
(Continued)

Table 13. (Continued).

Site	No. of Baseline Tests	No. of Cofired Tests	Fuel Sampling and Analysis Protocols	Sample Location	Flue Gas Sampling and Analysis Protocols: Continuous Monitors	Flue Gas Sampling and Analysis Protocols: VOST†	Flue Gas Sampling and Analysis Protocols: Modified EPA Method 5 (MM5)	Flue Gas Sampling and Analysis Protocols: Other Wet Sampling Systems	Sampling and Analysis Protocols for Solid and Liquid Discharge Streams
G		3	Highly chlorinated fuel: volatile and semivolatile POHC's, other major semivolatile organics, and ultimate analysis	Recovery scrubber and HCl scrubber outlet (stack)	O_2, CO_2, CO, NO_X, and TUHC	Volatile organics: POHC's and other volatile priority pollutants	Semivolatile POHC's and EPA priority pollutants Particulate	Modified EPA Method 6: total chloride C_1-C_6 by FID	
H	1	3	Chlorinated methyl acetate: volatile POHC's Coal: ultimate analysis and metals	ESP outlet (stack)	O_2, CO_2, CO, NO_X, SO_2, and TUHC	Volatile organics: POHC's and other volatile priority pollutants	Semivolatile POHC's and EPA priority pollutants Particulate Metals	Modified EPA Method 6: total chloride C_1-C_6 by FID	Inlet and outlet of scrubbers: volatile priority pollutants and total chloride
I	2	2	Chlorinated nitrobenzene, aniline, and benzene mixture: volatile and semivolatile POHC's, metals, and ultimate analysis	Stack	O_2, SO_2, CO, NO_X, and TUHC	Volatile organics: POHC's and other volatile priority pollutants	Semivolatile POHC's, EPA priority pollutants, total chloride, and selected metals	Semivolatile POHC's by FID	ESP fly ash: semivolatile priority pollutants Bottom ash: semivolatile priority pollutants, metals
J	---	6	Chlorinated toluene mixture: volatile POHC's	Stack	O_2, CO_2, CO, NO_X, and TUHC	Volatile POHC's§	Semivolatile POHC's	Modified EPA Method 6: total chloride	
K	---	2	Heavy and light oil: ultimate analysis, metals Chlorinated oil: volatile POHC's and semivolatile organics	Stack	O_2, CO_2, CO, NO_X, SO_2, and TUHC	Volatile POHC's§	Semivolatile POHC's, other semivolatile organics, and metals	EPA Method 6: total chloride	

*Source: Reference 1.
†Tenax sorbent sampling at sites A, B, and C was performed with a rudimentary sampling system and before the development of the VOST protocol. For sites D and E, a developmental VOST was used. All other test sites used the EPA-approved VOST.
‡NA = not available.
§EPA Method 23 (bag samples) was also used at this site to compare results obtained with VOST. EPA Method 23 results are not discussed in this report.

Figure 12. Typical boiler sampling schematic.



A - Liquid Waste Grab Samples (composite)
B - Fuel Grab Samples (composite)
C - Boiler Bottom Ash Grab Samples (composite)
D,F - Stack Emissions
E - Particulate Collector Hopper Ash or Scrubber Liquid

Source: Reference 2.

ated at a specific combination of high or low excess air and high or low boiler loads for each test. During some tests at other plants (i.e., Plants A, B, D, E, and F), combustion instability resulted in periods of high CO and smoke emissions. Although emission testing was normally halted during these periods, some impact of these unsteady operating conditions is evident in the emission results.

4.3 TEST RESULTS AND DISCUSSION

4.3.1 Organic Emissions and DRE[7]

Emission measurements of specific organic compounds, which were identified in the waste feed, were used as the basis for determining DRE's at each test site during cofiring periods. The primary test compounds for which DRE's were determined were carbon tetrachloride, trichloroethylene, chlorobenzene, and toluene. These volatile compounds were monitored at several sites. Additional volatile compounds whose emissions were measured at only one or two sites were 1,1,1-trichloroethane, benzene, tetrachloroethylene, and methylmethacrylate. Semivolatile emissions of phenol, pentachlorophenol, 2,4-dimethylphenol, naphthalene, aniline, nitrobenzene, and fluorene were determined at three sites.

Tables 14 and 15 summarize the calculated DRE's for these volatile and semivolatile compounds, respectively. The emission rates and DRE's for each test are listed in Appendix C. Calculated DRE's are based on blank-corrected emission rates measured during cofiring, but they are not corrected for any measured test compound emissions that occurred during baseline tests.

Results indicate a wide range in DRE's, from 99.5% to greater than 99.999%. Although the average DRE for each compound tested was generally greater than 99.99% (the current RCRA incinerator standard), some were below this level. These low DRE's often coincided with seemingly unsteady boiler operation and burner combustion instability. For example, the low DRE's for carbon tetrachloride, chlorobenzene, and trichloroethylene that occurred at Site F (mass weighted average) are generally attributable to improper burner settings, which resulted in coking at the burner nozzle, fuel impingement on the burner throat, and occasionally high levels of combustible CO and soot emissions during burner flameouts.

The low DRE for methylmethacrylate at Site E was the result of measurements taken during a cofired test in

Table 14. Summary of Average DRE's for Volatile Compounds from Boiler Tests*

Compound	Site B	Site D	Site E	Site F	Site G	Site H	Site I	Site J	Site K	Range	Weighted Average
Carbon tetrachloride	---	---	99.9990 to 99.9998 (99.9996)†	99.98 to 99.9990 (99.995)	99.990 to 99.9990 (99.998)	99.97 to 99.9994 (99.98)	99.9990 to 99.9993 (99.9993)	99.997 to 99.9998 (99.9990)	99.9998	99.97 to 99.99998	99.9992
Trichloroethylene	---	---	99.994 to 99.9995 (99.998)	99.98 to 99.998 (99.996)			99.99990 to 99.99992 (99.99991)	99.998 to 99.99993 (99.9996)	99.99990	99.98 to 99.99993	99.9994
1,1,1-Trichloroethane	---	---	---	---	---	99.97 to 99.9996 (99.994)	---	---	---	99.97 to 99.9996	99.994
Chlorobenzene	---	---	99.995 to 99.99990 (99.998)	99.96 to 99.992 (99.98)	---	99.990 to 99.997 (99.992)	99.997 to 99.9990 (99.998)	99.8 to 99.97 (99.95)	99.99992	99.8 to 99.99992	99.992
Benzene	---	---	---	---	---	---	99.97 to 99.98 (99.97)	---	99.996	99.97 to 99.996	99.990
Toluene	99.991	99.9992 to 99.99990 (99.9996)	99.997	99.90 to 99.97 (99.95)	---	---	99.998	99.9990 to 99.9997 (99.9990)	99.99996	99.90 to 99.99996	99.998
Tetrachloroethylene	---	99.994 to 99.9992 (99.998)	---	---	---	---	---	---	---	99.994 to 99.9992	99.998
Methylmethacrylate	---	---	99.95 to 99.997 (99.991)	---	---	---	---	---	---	99.95 to 99.995	99.991
Mass-weighted average	99.991	99.994 to 99.99990 (99.998)	99.95 to 99.9990 (99.995)	99.90 to 99.9990 (99.98)	99.995 to 99.9990 (99.998)	99.97 to 99.9996 (99.991)	99.97 to 99.99992 (99.998)	99.8 to 99.99993 (99.9990)	99.996 to 99.99996 (99.9997)	99.8 to 99.99996	99.998

*Source: Reference No. 1

†Numbers in parentheses represent the site-average DRE for the compound.

Table 15. DRE's for Semivolatile Compounds. %*†

Site	Phenol	Penta-chlorophenol	Fluorene	Naphthalene	2-4-Dimethyl-phenol	Nitrobenzene	Aniline
A	99.5 to 99.993 (99.96)	99.97 to 99.993 (99.98)	99.98 to 99.9998 (99.998)	99.94 to 99.995 (99.98)	99.96 to 99.995 (99.98)	—	—
C	99.998 to 99.99990 (99.9996)	—	—	—	—	—	—
I	—	—	—	—	—	99.9990 to 99.99998 (99.99996)	99.9994 to 99.9996 (99.9995)

*Source: Reference 1.
†Numbers in parentheses represent the test average DRE.

which waste feed rates were unstable and combustion air was insufficient. These operating conditions led to several high CO and smoke emission episodes during the test.

Wood-fired stokers such as the Site A boiler typically operate with high excess air and are high CO emitters. These conditions result from the physical properties of wood waste (e.g., wood chip size and high moisture content), combustion cooling by very high excess air levels, and inefficient fuel-air mixing during combustion on the fuel bed. Half of the DRE's calculated at Site A were below 99.99%.

Baseline (fossil fuel only) tests at Plants D, E, F, G, and H indicate that both chlorinated and nonchlorinated volatile organics are formed as PIC's and emitted as the result of fossil fuel combustion. These PIC emissions included most of the test compounds under investigation; they may have had a measurable impact on the total emissions measured (and therefore on the DRE's calculated) under cofiring conditions. Volatile PIC emissions measured during baseline tests included several chlorinated organics (e.g., chloromethane, chloroform, methylene chloride, tetrachloroethylene, trichloroethane, dichloroethane, and dichloropropylene) as well as nonchlorinated organics (e.g., toluene and benzene). Chloromethane, methylene chloride, and chloroform accounted for more than 75% of the total chlorinated PIC's. Toluene contributed the bulk of total nonchlorinated PIC's.

Test results indicate that industrial boilers can achieve DRE's in excess of 99.99% destruction under typical industrial operating conditions for heat input, waste/fuel ratio, and excess air. Measured DRE's ranged from about 99.90% to 99.99996%. Examination of site-specific test data and corresponding boiler operating conditions during the tests has revealed several possible mitigating factors that can either affect the DRE or indicate its success rate. These factors include combustion efficiency, test compound in the waste feed, the formation of PIC's NO_x formation, and the surface heat release rate of the water wall.

Test results at three sites (A, E, and F) suggest that DRE's may be reduced greatly during boiler operating conditions that are conducive to soot formation and high CO and smoke emission (i.e., poor combustion efficiency). Soot formation with high CO and smoke emissions can result from several transient boiler operations or from improper burner settings. Ineffective fuel/air mixing at the Site A wood stoker accompanied by combustion cooling through high excess air levels resulted in high CO and DRE's generally below 99.99%. Surges in waste fuel flow, plugging of fuel jets, and insufficient excess air resulted in less than 99.99% DRE for some compounds at Site E. Improper fuel gun position in the burner throat, probable jet impingement on walls, and ineffective atomization through burner tip coking resulted in a consistently low DRE for all test compounds at Site F.

The data do not clearly support the concept of CO or hydrocarbon emissions as a surrogate for DRE determination. One possible explanation is that CO emissions can be manifested through several mechanisms, depending on boiler type and fuel. Operating conditions that can lead to higher CO emissions may result in no measurable change in DRE if the operating condition's effect on the destruction of individual test compounds is not similar to its effect on the formation of CO. For example, sufficiently low excess air will result in elevated CO emissions. In oil-fired burners, these emisions will be followed by smoke. Neither temperature nor residence time is reduced significantly, however; thus the DRE can remain high. Kinetics data based on pyrolytic destruction of several compounds suggest that both temperature and time in industrial boiler furnaces are sufficiently high to permit nearly complete destruction by pyrolysis alone.

The data suggest a trend toward higher DRE's with increasing test compound concentration in the waste feed, but the data are not sufficient to determine a reasonable correlation. Site average DRE's of greater than 99.990% appear to be more likely for a waste fuel with a hazardous organic constituent concentration of greater than 3000 ppm corrected for the waste-to-

Table 16. Particulate and HCl Gas Emissions from Boilers*

Site	No. of Tests	Primary Fuel	Waste Fuel	Total Particulate Emissions, gr/dscf†	Chlorine Emissions as HCl, lb/h‡	Waste Feed Ash, %	Waste Feed Chlorine, %
A	4	Wood	Creosote waste	0.16	NA§	0.82 avg.	0.15 to 0.21
D	1	No. 6 oil	None	0.29	1.7	0.05**	0.03**
	3	No. 6 oil	Tetrachloroethylene in methanol waste	0.051 to 0.084 (0.061)††	69 to 320 (192)	0.10 to 0.17	3.9 to 22.0
	3	No. 6 oil	Bis(2-chloroethyl) ether in toluene waste	0.017 to 0.019 (0.018)	32 to 45 (39)	<0.01 to 0.02	1.6 to 2.4
E	1	No. 6 oil	None	0.018	0.4 to 2.1 (1.3)	0.05**	0.40**
	1	No. 6 oil	TSB with MMA polymers	0.017	0 to 1.5 (0.6)	0.01	0.10
	5	No. 6 oil	TSB spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene	0.12 to 0.049 (0.023)	52 to 98 (68)	0.02 to 0.05	1.8 to 3.35
	1	Natural gas	TSB spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene	0.005	63 to 74 (68)	0.02	2.36
	1	Natural gas	Toluene/MMA mixture	0.012	0.2 to 0.5 (0.4)	<0.01	0.16
F	1	No. 6 oil	None	0.008	<0.1 to 6.1 (3.1)	0.03**	0.12**
	3	No. 6 oil	Waste paint solvents spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene	0.033 to 0.041 (0.038)	7.2 to 40 (23)	0.83 to 1.44	1.68 to 6.95
G	3	None	Chlorinated organics spiked with carbon tetrachloride	0.045 to 0.39 (0.086)‡‡	3.2 to 4.0 (3.7)‡‡	<0.01	36.5 to 47.9
I	2	Natural gas	None	NA	0.03 to 0.26 (0.11)	NA	NA
	2	Natural gas	Aniline and nitrobenzene waste spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene	NA	18 to 23 (20)	NA	NA
J	6	None	Toluene, carbon tetrachloride, chlorobenzene, and trichloroethylene	NA	1.0 to 7.1 (4.0)	NA	1.45 to 2.60
K	1	No. 6 oil	None	NA	0.26 to 0.28 (0.27)	0.05**	0.10**
	1	No. 6 oil	Light oil mixture spiked with carbon tetrachloride, chlorobenzene, and trichloroethylene	NA	21 to 22 (21)	0.05 to 0.07	1.21 to 2.88

*Source: Reference 1.
†Neither particulate nor chlorine data are available for Sites B, C, and H.
‡Numbers in parentheses indicate average of values obtained for each test.
§NA = not available.
**Ash or chlorine content of baseline fuel.
††Multicyclone system was used to trap ash.
‡‡Halogen recovery and HCl scrubbers used to control Cl^- emissions.

total-fuel heat input ratio. This trend may be attributed to two major sources of error. The first is the relative amount of background contamination and sampling and analytical error associated with low-level detection of volatile organics. The effect of these sources of error on the DRE calculation grows as the concentration in the waste feed decreases. A second source of error associated with low concentrations in the waste feed and low DRE's is the relative level of PIC's generated by the combustion of fossil fuels alone. Evidence of PIC organic emissions during baseline testing suggests that their contribution to the total emissions during cofiring can be significant. This implies that test compound concentrations in the waste feed should be high enough to insure demonstration of 99.99% DRE over and above the background PIC level. Alternatively, only organic compounds that are not also PIC's should be chosen for DRE testing.

4.3.2 Particulate and Hydrogen Chloride Emissions

Particulate and HCl emissions (Table 16) were measured in the stack downstream of any pollution control device. Particulate emissions during cofiring at Site D were lower than those during baseline conditions because of the reduced contribution of inorganic ash in residual fuel oil when it was cofired with methanol and toluene waste streams. The increase in total chlorine input during cofiring at Site D probably caused the increase in HCl emissions. Similar results were obtained at Site E. No change or general reductions in particulate emissions were measured during most cofired tests with the exception of a high load test and other tests characterized by high smoke emissions. HCl emissions followed the chlorine input rate of waste fuels. Measurement showed increases in both particulate and HCl emissions at Site F; these were due to increases in both ash and chlorine input with cofired fuels.

At Site G, flue gas HCl emissions were controlled by a halogen recovery scrubber and an HCl scrubber positioned in series. Measurements of stack HCl emissions indicated greater than 99% scrubbing efficiency. The HCl results provided by test Sites I through K showed emission increases resulting from cofiring with carbon tetrachloride, chlorobenzene, and trichloroethylene. Overall, the measured chlorine in the output streams accounted for 80% to 130% of the total chlorine input from waste fuel combustion.

4.3.3 Other Results

The flue gas at the stack was sampled continuously for O_2, CO_2, CO, NO_x, and TUHC at Sites A through K. The TUHC measurement devices were not always operational, so these data are missing at some sites. The CO, NO_x, and TUHC values were corrected to a 3% O_2 basis. In addition, sampling trains were used to measure total solid particulate matter and hydrochloric acid emissions at all sites, and gaseous hydrocarbons at Sites D, E, and G.

The data show a wide range in the gaseous emissions among sites. The average CO value corrected to 3% O_2 ranged from 18 ppm at Site C to more than 4000 ppm at Site A; NO_x emissions ranged from about 40 ppm at Site B to 1100 ppm at Site I; and TUHC emissions, when available, ranged from less than 0.5 to 160 ppm.

Measurements generally showed an increase in gaseous C_1 to C_6 hydrocarbons when the boiler operation was converted to hazardous waste cofiring. This is evidenced by results at Sites D and E. Also, the level of hydrocarbon emissions does not indicate a dependence on the type of primary waste fuel used. Generally higher C_1 to C_6 hydrocarbon emissions, however, were measured during tests characterized by boiler transients, increases in stack opacity, and higher soot emission levels.

Two parameters that appeared to vary with the DRE are NO_x emissions and surface heat release rates of furnace waterwalls. Both No_x formation (through thermal NO) and surface heat release rates can be indicators of the thermal environment in the flame and throughout the furnace. Both parameters showed similar trends — that is, higher NO_x and surface heat release rates generally resulted in higher measured DRE's. DRE's of less than 99.990% were generally found to correspond with NO_x gas concentration of less than 250 ppm and surface heat release rates of less than 60,000 Btu/h-ft^2. The higher the NO_x and surface heat release rates were, the higher the range was in measured POHC DRE. These trends indicate that lower boiler loads may be more likely to result in lower DRE's and that the temperature dependence of POHC destruction is more significant than furnace residence time.

4.4 REFERENCES

1. Castaldini, C., S. Unnash, and H.B. Mason. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers. Volumes 1 and 2. EPA-600/2-84-177A and B, PB85-197838/REB, PB85-197846/REB, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1985.
2. Castaldini, C., H.B. Mason, and R.J. DeRosier. Field Tests of Industrial Boilers Cofiring Hazardous Wastes. In: Proceedings from the Tenth Annual Research Symposium. EPA-600/9-84-022, PB85-116291/REB.

SECTION 5
SUMMARY AND ANALYSIS OF KILN PERFORMANCE DATA

5.1 OVERVIEW

Since 1975, the burning of hazardous wastes in kilns has been investigated in a variety of tests on industrial kilns. These have included EPA tests of seven kilns, State agency tests of three kilns, some Canadian tests, and one Swedish test. The types of wastes tested included chlorinated hydrocarbons, aromatic compounds, and waste oils. In some cases, hazardous waste was used as a supplemental fuel to coal or fuel oil, and in others, the waste served as the primary fuel source. Lime kilns, cement kilns (including the dry and wet processes), aggregate kilns, and a clay drying kiln have been used in these tests. Test data from each individual kiln tested are presented in Appendix D. Specifically, the appendix includes basic design information about each kiln; descriptions of the pollution control system, the waste, and its constituents; operating information; sampling and emission results; and references to sources of additional information about the test methodology and results.

5.2 TEST OBJECTIVES AND PROCEDURES

5.2.1 Kiln Test Burns

Table 19 summarizes the types of kilns tested and general information about the test burns. Kiln temperatures, both during testing and during normal operation, were typically above 1093°C (2000°F), with the exception of those for the clay dryer, which normally ran 593° to 649°C (1100° to 1200°F). To the extent possible, normal operating conditions with respect to temperatures, total fuel input (Btu/h), feed and production rates, and combustion air were maintained during each test. In many cases, however, adjustments were made to the air pollution control equipment or to certain process operating parameters to compensate for the effects of burning hazardous wastes. For example, the Paulding, Ohio, facility had already adjusted the electrostatic precipitator (ESP) for chlorinated waste combustion, as this plant cofires waste solvents as part of normal operation. Other plants (e.g., Marquette Cement) did not observe a significant difference in ESP performance when burning hazardous waste, even though they made no special adjustments.

Problems at Rockwell Lime during the kiln tests included fluctuations in CO, poor fuel mixing during combustion, and poor product quality at times.[4] The CO fluctuations may have been partly due to the inability to fine tune the kiln to minimize operational fluctuations when cofiring waste fuel.[5] The waste fuel was burned only 8 h/day, whereas at least 24 h of operation is generally required to make appropriate adjustments.[4] Wide CO fluctuations were not only attributed to firing waste fuel but also to normal variations in the fuel feed rate and to a wet supply of primary fuel (petroleum coke), which resulted in clumps of coke being fed into the kiln (and therefore excess fuel conditions). The waste-fuel feed and burner system (a fuel pipe laid on top of the main burner) did not allow mixing of the fuels.[4] At low waste-fuel feed rates, this design caused puffing of the flame. Rockwell Lime also experienced poor product quality because of increased sulfur in the lime. This condition was attributed to the combustion of the highly volatile waste fuel, which in turn produced combustion conditions that favored increasing the sulfur content in the product instead of having high SO_2 emissions from the stack.[4]

5.2.2 Test Procedures

Because of the various test sponsors, their differing objectives, and available testing and analytical methods at the time the tests were performed, testing and analytical procedures and the pollutants that were investigated varied among the test sites. Table 17 shows the pollutants measured at each kiln, and Table 18 presents an example sampling and analytical program for the kilns tested most recently. Figure 13 is a simplified schematic of a kiln and the typical sampling sites.

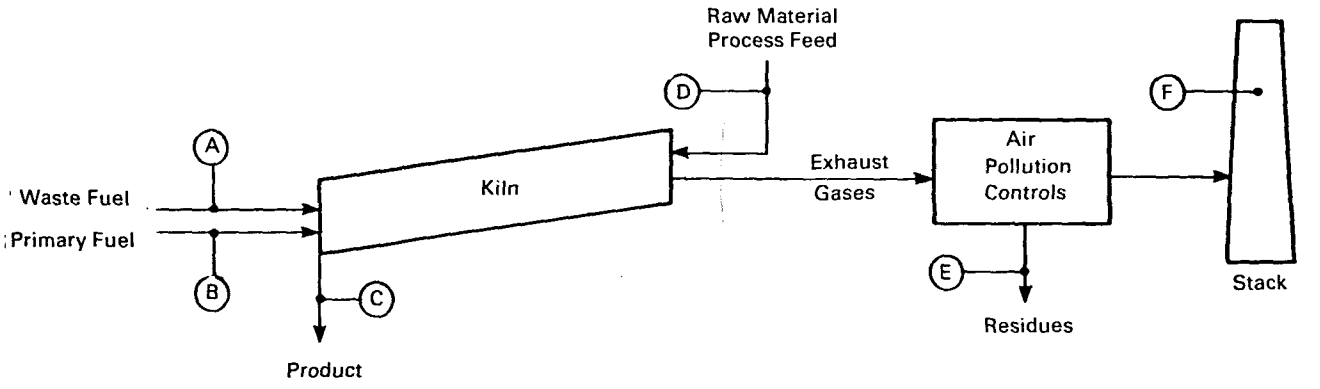
The sampling programs were generally designed to identify the major pollutants generated by burning waste fuel in kilns, to quantify their respective emission rates, and to determine their DRE's. In several tests, the distribution of metals and chlorine was measured in all of the process input and output streams — that is, the conventional or primary fuel feed, waste feed, raw material feed, product, and air pollution control discharge. The conventional and waste fuels were also analyzed for sulfur, ash, and heat content. In most cases, the waste fuel was artificially spiked with various organic compounds so that outlet concentrations would be above detectable limits and thus allow DRE's to be calculated.

Table 17. Summary of Kiln Test Burns*

Site	Date	Process	Air Pollution Control	Primary Fuel	Pollutants Measured: PM†	Hazardous Organic Waste Constituents	PIC's	Cl	Metals	Type of Hazardous Waste Tested
St. Lawrence Cement, Mississauga, Ontario	1975-76	Wet cement	ESP	Fuel oil	X	X		X	X	Chlorinated aliphatics (ethylene dichloride), chlorinated aromatics (chlorotoluene), PCB's
Stora Vika, Sweden	1978	Wet cement	ESP	Coal	X	X	X	X		Chlorinated aliphatics (methylene chloride), chlorinated aromatics (PCB 1242), chlorophenols and phenoxy acids, freon (trichlorotrifluoroethane)
Marquette Cement, Oglesby, Illinois	1981	Dry cement	ESP	Coal	X	X		X	X	Chlorinated aliphatics, methyl ethyl ketone (MEK), toluene
San Juan Cement, Puerto Rico	1981-82	Wet cement	Baghouse	Fuel oil	X	X	X	X	X	Chlorinated aliphatics
General Portland, Los Robles, California	1982	Dry cement	Baghouse	Coal		X		X	X	Aromatics and chlorinated aliphatics
General Portland, Paulding, Ohio	1983	Wet cement	ESP	Coal	X	X	X	X	X	Chlorinated aliphatics, MEK, toluene
Lone Star Industries, Oglesby, Illinois	1983	Dry cement	ESP	Coal/coke	X	X	X	X	X	Chlorinated aliphatics, MEK, toluene
Rockwell Lime, Rockwood, Wisconsin	1983	Lime	Baghouse	Coke	X	X		X	X	Chlorinated aliphatics, MEK, toluene
MID-Florida Mining Region IV — Site I	1984	Clay	Baghouse	Fuel oil	X	X	X	X	X	Waste solvents and waste oil
Carolina Solite Corp. Region IV — Site II	1984	Aggregate	Scrubber	Coal	X	X	X	X	X	Waste solvents
Florida Solite Corp.	1983	Aggregate	Scrubber	Coal	X	X		X	X	MEK, methyl isobutyl ketone (MIBK), tetrachloroethylene (perc), toluene

*Sources: Reference Nos. 1, 2, 3 and 4.
†PM = particulate matter.

Figure 13. ***Simplified schematic diagram of a kiln and sampling locations.***



A - Liquid Waste Grab Samples (composite)
B - Primary Fuel Grab Samples (composite)
C - Product Grab Samples (composite)
D - Process Feed Samples (composite)
E - Air Pollution Control Residue Samples (composite)
F - Stack Emissions

Table 18. **Summary of Typical Kiln Sampling and Analytical Program**

Parameter	Sampling Method	Analytical Method
Stack gas:		
POHC's (e.g., tetrachloroethylene, toluene, MEK, MIBK)	VOST	GC/MS, thermal desorption and GC/single ion monitoring
Particulate matter, metals on particulate	EPA 5 EPA 5	EPA 5 Inductively coupled plasma
Hydrogen chloride	Impinger absorption in 0.5 M sodium acetate (back half of EPA 5)	Specific ion electrode
CO_2 and O_2	EPA 3 or continuous	Fyrite
Nitrogen oxides	EPA 7 or continuous	EPA 7 Chemiluminescence photometric analyzer
Sulfur dioxide	EPA 6 or continuous	EPA 6 Pulsed fluorescence TECO analyzer
Carbon monoxide	Continuous	Infrared — EPA Method 10
Total hydrocarbons	Continuous	Flame ionization detector
Waste fuel:		
Principal organics	Grab → composite	GC/MS
Metals	Grab → composite	ICP
Chlorine, sulfur	Grab → composite	X-ray fluorescence
Btu content	Grab → composite	ASTM D240-64
Ash content	Grab → composite	ASTM D482-IP4
Coal:		
Metals	Grab → composite	ICP
Chlorine, sulfur	Grab → composite	X-ray fluorescence
Btu and ash content	Grab → composite	ASTM D240-64

*Sources: Reference Nos. 2 and 4.

Table 19. Summary of Kiln DRE's for Selected Compounds*†

Site	Waste Component	DRE
St. Lawrence Cement	Chlorinated aliphatics	>99.990
	Chlorinated aromatics	>99.989
	PCB's	>99.986
Stora Vika	Methylene chloride	>99.995
	Trichloroethylene	>99.9998
	All chlorinated hydrocarbons	>99.988
	PCB	>99.99998
	Chlorinated phenols	>99.99999
	Phenoxy acids	>99.99998
	Freon 113	>99.99986
San Juan Cement	Methylene chloride	93.292-99.997
	Trichloromethane	92.171-99.96
	Carbon tetrachloride	91.043-99.996
General Portland (Los Robles)	Methylene chloride	>99.99
	1,1,1-Trichloroethane	99.99
	1,3,5-Trimethylbenzene	>99.95
	Xylene	>99.99
General Portland (Paulding)	Methylene chloride	99.956-99.998
	Freon 113	>99.999
	Methyl ethyl ketone	99.978-99.997
	1,1,1-Trichloroethane	99.991-99.999
	Toluene	99.940-99.988
Lone Star Industries (Oglesby)	Methylene chloride	99.90-99.99
	Freon 113	99.999
	Methyl ethyl ketone	99.997-99.999
	1,1,1-Trichloroethane	>99.999
	Toluene	99.986-99.998
Marquette Cement (Oglesby)	Methylene chloride	99.85-99.92‡
	Methyl ethyl ketone	99.96‡
	1,1,1-Trichloroethane	99.60-99.72‡
	Toluene	99.95-99.97‡
Rockwell Lime	Methylene chloride	99.9947-99.9995
	Methyl ethyl ketone	99.9992-99.9997
	1,1,1-Trichloroethane	99.9955-99.9982
	Trichloroethylene	99.997-99.9999
	Tetrachloroethylene	99.997-99.9999
	Toluene	99.995-99.998

*(Continued)

5.3 TEST RESULTS AND DISCUSSION

5.3.1 Organic Emissions and DRE

The following specific compounds were monitored at the kilns burning hazardous wastes:

trichloromethane (chloroform)
dichloromethane (methylene chloride)
carbon tetrachloride
1,2-dichloroethane
1,1,1-trichloroethane
trichloroethylene
tetrachloroethylene
1,1,2-trichloro-1,2,2-trifluorethane (Freon 113)
chlorobenzene
benzene
xylene
toluene
1,3,5-trimethylbenzene
methyl ethyl ketone
methyl isobutyl ketone

In addition, the following groups of related organics were monitored at one or more plants:

PCB's
phenoxy acids
chlorinated hydrocarbons
chlorinated aliphatics
chlorinated aromatics

The calculated DRE results for the emission measurements of these compounds are summarized in Table 19. Overall, the data suggest that DRE's exceeding 99.99% can be achieved when cofiring hazardous waste in kilns during normal operations.

One of the first tests to examine the DRE of hazardous waste in cement kilns was conducted at the St. Lawrence Cement plant in Canada. The reported DRE's were >99.99% for wastes with mostly chlorinated aliphatics, >99.989% for chlorinated aromatics, and >99.986% for the PCB mixture. DRE's were calculated

Table 19. (Continued).

Site	POHC or Waste Component	DRE
Site I	1,1,1-Trichloroethane	99.88-99.98§
	Trichloroethylene	99.8 -99.994§
	Benzene	82.5 -98.5§
	Tetrachloroethylene	99.87-99.989§
	Toluene	99.7 -99.90§
	Chlorobenzene	99.3 -99.4§
	Methyl ethyl ketone	99.93-99.98§
	Freon 113	99.988-99.998
Site II	Methylene chloride	>99.99996->99.99998
	1,2-Dichloroethane	99.91->99.9993§
	1,1,1-Trichloroethane	99.9998-99.9999§
	Carbon tetrachloride	99.8 -99.995§
	Trichloroethylene	99.996-99.9993§
	Benzene	99.75-99.93§
	Tetrachloroethylene	99.998-99.9998
	Toluene	99.997-99.9998
	Chlorobenzene	99.92-99.97§
	Methyl ethyl ketone	99.996->99.999992
	Freon 113	99.99991-99.99998
Florida Solite Corp.	Methyl ethyl ketone	99.992-99.999
	Methyl isobutyl ketone	99.995-99.999
	Tetrachloroethylene	99.995-99.999
	Toluene	99.998-99.999

*Sources: Reference Nos. 1, 2, 4 and 6.
†Corrections were not made for baseline levels of waste component emissions. Higher DRE's may be calculated if this factor is included.
‡Test compounds were not detectable in stack exhaust. The DRE calculations were based on minimum detectable limits of the analysis.
§Waste component concentration < 1000 ppm. Testing and analytical error as well as component contribution from PIC's caused by either primary fuel and/or waste combustion may have resulted in lower-than-actual DRE.

conservatively by not subtracting or correcting for (1) the background levels in the baseline test or (2) interferences (contamination) on the control blanks. The DRE's were based on total chlorinated organics in and out instead of analysis of specific compounds in and out.

A test similar to the one at St. Lawrence was conducted in Sweden at a wet process kiln in Stora Vika. None of the waste fuel's major components was detected in the stack gas. Based on the detection limit, the DRE of methylene chloride exceeded 99.995%, and the DRE of trichloroethylene exceeded 99.9998%.

Site I kiln (clay dryer) tests had the lowest DRE's of all the kilns tested (from 82.5% to 98.5% for benzene through 99.988% to 99.998% for Freon 113). These low DRE values may have been caused by the low concentrations of the chemical components in the waste feed (many less than 1000 ppm), PIC formation, and the relatively low gas temperature 593° to 649°C (1100° to 1200°F).[3] In addition, the kiln was operating under unsteady combustion conditions during the first test. Lower DRE's were measured during this test for several volatile compounds, which could indicate a direct effect of kiln operation on the destruction of organics at test operating temperatures.[3]

Low DRE's were also calculated at Marquette Cement in Oglesby, Illinois, (from 99.60% to 99.72% for 1,1,1 - trichloroethane to 99.95% to 99.97% for toluene). In this case, however, the test compounds were not detectable in the stack exhaust, and DRE's had to be calculated based on the minimum detectable limits of the analysis. If the detection limit had been lower, the calculated DRE's might have been much higher.

The DRE calculations did not include corrections for test compounds measured during baseline tests. At Paulding, for example, methylene chloride contamination was a problem, and the DRE's for this compound should be viewed as unreliably low because of the contamination. Similarly, the methyl ethyl ketone results reflect a contamination problem, although on a scale much smaller than the methylene chloride. However, no problems with contaminants were noted with the 1,1,1-trichloroethane and Freon 113 results, which demonstrated DRE's of 99.999% or greater.

The toluene emissions at General Portland (Paulding) were found to originate from coal combustion. Baseline and waste burn emissions of toluene were the same, and the highest toluene rates occurred during a kiln upset at baseline conditions. No blank contamination problems were experienced with this compound. Benzene emission rates during baseline (coal only) and waste plus coal burns were also about the same. Similar results were also observed during a baseline test at General Portland (Los Robles) with coal fuel. Here both benzene and toluene were found at concentrations similar to those at Paulding.

The tests at San Juan Cement also showed measurable rates of the test compounds during the baseline

Table 20. Particulate and Hydrogen Chloride Emissions from Process Kilns

Site	Test Condition	Particulate Emissions, gr/scf	HCl Emissions, lb/h	Waste Feed Ash, %	Waste Feed Chlorine, %*
St. Lawrence Cement	Chlorinated aliphatics	0.21†	<1	NA‡	37.9
	Chlorinated aromatics	0.086	<1	—	42.6
	PCB's	0.078	<1	—	35.0
	Baseline	0.038	<1	—	0.028 to 0.064§
Stora Vika	Aliphatics	0.039	—	NA	NA
	PCB's	0.024	—		
	Chlorophenols and phenoxy-acids	0.058	—	—	—
	Freon 113	0.062	—	—	—
	Baseline	0.014	—	—	—
San Juan Cement	Wastes	0.043	0.8	0.05 to 0.38	6.5 to 35.1
	Baseline	0.041	<0.2	NA	NA
General Portland (Los Robles)	Wastes	—	1.0	NA	NA
	Baseline	—	0.6	NA	NA
General Portland (Paulding)	Wastes	0.030	4.6	3.4 to 5.3	0.59 to 4.01
	Baseline	0.030	1.2	13.1 to 20.5	0.08 to 0.09§
Lone Star	Wastes	**	25	3.94 to 4.81	1.64 to 2.15
	Baseline	0.17	2.9	11.1 to 11.6§	0.11 to 0.13§
Marquette Cement	Waste solvents	0.104	120	6.8 to 12.1	1.75 to 2.10
	Baseline	0.093	190	NA	NA
Rockwell Lime	Wastes	0.016	0.4	NA	2.66 to 3.51
	Baseline	0.013	0.2	0.3 to 2.42§	0.026 to 0.0234§
Site I	Wastes	0.0006	1.8	0.66 to 0.70	0.60 to 0.74
Site II	Wastes	0.112	6.3	2.53 to 3.09	0.55 to 1.08
Florida Solite Corp.	Wastes	0.101	0.05	6.18 to 15.5	0.55 to 1.08
	Baseline	0.071	0.05	6.23 to 9.06§	Not detected

*Other chlorine added to kiln by primary fuel and raw feed materials.
†Ring formation and ESP difficulties.
‡NA = Not available.
§Ash or chlorine content of primary fuel during all tests.
**ESP malfunctioned.

test. Blank samples showed no contamination problems; however, the above-normal free lime content of the clinker and removal of chloride in the clinker instead of in the waste dust suggest that operating difficulties were experienced. The detection of test compounds during the baseline make the DRE results difficult to interpret. If the measured test compounds originated from sources other than the burning of waste fuel, the actual DRE's may have been higher than those measured.[7]

The burning of complex mixtures of organic compounds can yield PIC's. Several tests at kilns have attempted to identify and quantify both volatile (boiling point <100°C or <212°F) and semivolatile organic compounds that are emitted under baseline and waste-fuel test conditions.[1] The baseline results are particularly interesting because of the byproducts formed from coal combustion. As with the tested compounds, the interpretation of the results of waste combustion on PIC's is confounded somewhat by the presence of many of the same compounds during baseline tests and the potential for high bias from low-level contamination or background levels.[1]

During some tests, the results for PIC's showed some minor increases resulting from waste combustion (several compounds at San Juan and chloroform at Stora Vika). The test results for coal combustion only indicate that many of the compounds are byproducts of coal combustion. Polychlorinated dibenzodioxins and dibenzofurans have not been confirmed as PIC's from waste combustion.[1] Trace quantities (<23 parts per trillion) were found at San Juan during a kiln upset, and trace quantities may have been present when chlorophenols and phenoxy-acids were burned at Stora Vika.[1] Tests at two other kilns (Lone Star and General Portland, Paulding) and most of the analyses at San Juan and Stora Vika revealed no detectable quantities of these compounds.[1]

5.3.2 Particulate and Hydrogen Chloride Emissions

Table 20 summarizes particulate and hydrogen chloride emission data from kiln tests. Although it has been suggested that particulate emissions increase with increasing chlorine input,[8] a review of the relationship between chlorine content in the feed and particulate emissions reveals this is not always the case. San Juan Cement, which has a baghouse, showed no increase in particulate emissions with increased chlorine content. Extensive tests at St. Lawrence Cement and Stora Vika, which are equipped with ESP's, indicated that controlled particulate emis-

sions increased as the chloride loading increased. However, the study also showed that this increase in emissions could be offset by adjusting the ESP to compensate for changes in the dust resistivity, by controlling chloride input, and by altering the chloride cycle in the kiln. In normal ranges of chlorine input, upset conditions should not occur, and particulate emissions should not increase.

In most cases, HCl emissions (Table 22) appeared to increase with increases in the chloride loading; however, generally more than 90% (and in some cases more than 99%) of the additional chlorine entering the kiln was retained in the process solids (waste dust and clinker). Most of the additional chloride is believed to be removed with the waste dust, and several plants increased the rate of waste dust removal to help control the chloride cycle. Although chloride accumulation probably varies from kiln to kiln, it appears to start in the range of 6 to 9 kg Cl/Mg (12 to 18 lb/ton) clinker and has a tendency toward ring formation (i.e., accumulation of condensed solids around the inside perimeter of the kiln) at the upper end of the range.[1] In another evaluation of data from five of the kilns[5], however, the data indicate the following: (1) An increase in HCl emissions with an increase in chlorine input at three kilns (General Portland in Paulding, Ohio; Lone Star in Oglesby, Illinois; and San Juan Cement in Puerto Rico), (2) a decrease in HCl emissions at one kiln (Rockwell Lime), and (3) inconclusive results at one kiln (St. Lawrence Cement) because the HCl content of the exhaust gases was below detectable limits for the test equipment used. It is interesting to compare these data with the 1.8 kg/h (3.96 lb/h) limitation in 40 CFR 264.343(b). The HCl emissions at two of five kilns (General Portland and Lone Star) averaged greater than 1.8 kg/h (3.96 lb/h) (the HCl regulation for hazardous waste incinerators), and emissions from one kiln (General Portland) reached 1.8 kg/h (3.96 lb/h) during baseline conditions.

5.3.3 Other Results

In general, sulfur dioxide (SO_2) emissions tend to decrease when sulfur-containing fossil fuels are replaced by waste fuels. In addition, the SO_2 emission levels normally exhausted from kiln stacks can be affected by several other operating variables such as oxygen input and temperature. Although cement kilns can be effectively operated to obtain low stack gas emissions of SO_2[1], lime kilns are deliberately operated at conditions favoring higher SO_2 emission levels to minimize sulfur contamination in the lime product.

Test results show that substitution of the sulfur-containing primary fuel with a low-sulfur waste fuel decreased SO_2 emissions at Marquette Cement and General Portland (Paulding). The test at San Juan Cement, however, showed an increase in SO_2 emissions when waste fuel was burned. This increase was attributed to a lower O_2 input (as evidenced by lower NO_x emissions) and to the need to also remove HCl emissions in a relatively low-alkaline kiln during the burning of the highly chlorinated wastes (average of 5.5 kg Cl/Mg [11 lb/ton] clinker).

The SO_2 emission results for Rockwell Lime represent an exceptional case and are not at all similar to results at other kilns. At this plant, operating conditions are controlled to prevent SO_2 absorption into the product because the presence of sulfur in the lime is undesirable. As a result, stack gas SO_2 levels are unusually high compared with other process kilns. No significant difference in SO_2 emissions was observed between the baseline and waste fuel burns; concentrations in the stack gases averaged 500 to 600 ppm during each.

Emissions of NO_x are not significantly affected by hazardous waste combustion. Rather, concentrations of NO_x are primarily affected by oxygen input, primary to secondary air ratio, and temperatures, which vary over time at any given kiln. Thus, NO_x concentrations depend greatly on the specific operating conditions of a given kiln and are not likely to be affected by waste burning. Continuous NO_x monitors respond rapidly to process changes. Data from these monitors show that NO_x emissions are quite variable, ranging from less than 100 to 1500 ppm within hours. The Site I kiln, a clay dryer, was operated at the lowest temperatures 593° to 649°C (1100° to 1200°F) and the highest excess air (280%) of the kilns tested.[3] NO_x emissions from this kiln ranged from 59 to 81 ppm (corrected to 15% O_2). At General Portland's Los Robles cement plant, a steady decrease in NO_x emissions on one test day (from 1054 to 526 ppm) was attributed to a decrease in kiln excess air (from 1.3% to 0.5% O_2). The somewhat lower NO_x emissions during the waste burn and one baseline test were attributed to additional chains that were installed to improve heat transfer from the gas to the incoming feed. The more efficient use of heat permitted the firing end of the kiln to be operated at lower temperatures with a resulting reduction in NO_x.[11] At Lone Star Industries (Oglesby, Illinois), the variation of NO_x with secondary air flow was demonstrated by oscillations in undergrate pressure. Increases in undergrate pressure yielded increased NO_x concentrations, and periodic fluctuations of 100 ppm or more were observed.[12]

The test at Rockwell Lime showed the NO_x and SO_2 concentrations changing simultaneously in opposite directions.[4] Emissions of NO_x increased with increasing O_2 input and degree of preheating, whereas emissions of SO_2 decreased under the same conditions. The same trends were observed in the Paulding test during the waste fuel burn. Concentrations of NO_x and SO_x tracked together showed swings in the opposite direction. At times, the swings were several hundred parts per million in

amplitude for both NO_x and SO_2 over 1- to 2-h periods.[9]

Overall, the kiln test results suggest the existence of an interrelationship between NO_x, SO_2, and O_2 input. Continuous monitoring results indicate that shifts in the NO_x concentrations are often accompanied by SO_2 swings in the opposite direction. An increase of O_2 input increases NO_x emissions and decreases SO_2 emissions.

Emissions of carbon monoxide, especially during coal combustion, can exhibit short-lived spikes, which are generally indicative of combustion instability. During the Paulding test, several process parameters were changed, and large swings in CO (as well as other monitored gas concentrations) were observed. The CO results at Stora Vika showed a range of 50 to 1500 ppm for both the baseline and waste fuel burns. The CO results at Lone Star Industries were the most consistently low. This kiln was operated with higher O_2 input (to aid in drying wet coal), which apparently resulted in consistently low levels of THC, CO, and SO_2 and increased NO_x concentrations. The operation of the Los Robles kiln was also very stable during three waste firing tests; the maximum CO was 100 ppm.

Analysis of the test data from the five major kiln studies[4,6,7,9,12] revealed no correlation between POHC emissions and concentrations of NO_x, SO_2, CO, and O_2 in the exhaust gases.[5] Also, no correlation was shown between POHC emissions and the quantity of POHC fed into the kiln.[5]

5.4 REFERENCES

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11. Jenkins, A.C. Supplemental Fuels Project, General Portland, Inc., Los Robles Cement Plant. Report C-82-080, State of California Air Resources Board, Sacramento, California, 1982.
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APPENDIX A
LIST OF INCINERATOR MANUFACTURERS

Basic Environmental Engineering, Inc.
21 W. 161 Hill Avenue
Glen Ellyn, IL 60137
(312) 469-5340: John Basic, President

Bayco Industries of California
2108 Davis Street
San Leandro, CA 94577
(415) 562-6700: C.H. Beckett, President

Brule C.E. & E., Inc.
13920 Southwestern Avenue
Blue Island, IL 60406
(312) 388-7900: Al Schmid

Burn-Zol Corporation
P.O. Box 109
Dover, NJ 07801
(209) 931-1297: Ed Avencheck

C&H Combustion
1104 East Big Beaver Road
Troy, MI 48083
(313) 524-2007: Douglas Frame

CJS Energy Resources, Inc.
P.O. Box 85
Albertson, NY 11507
(215) 362-2242: Michael Budin

C.E. Raymond Co.
Bartlett Snow Division
Combustion Engineering, Inc.
200 W. Monroe Street
Chicago, IL 60606
(312) 236-4044: Tom Valenti

Coen Company
1510 Rollins Road
Burlingame, CA 94010
(415) 697-0440: Dick Brown

Copetech
125 Windsor Drive
Oak Brook, IL 60521
(312) 986-8564: Brian Copeland

Dorr Oliver, Inc.
77 Havemeyer Lane
Stamford, CT 06904
(203) 358-3741: John Mullen

Econo-Therm Energy Systems Corp.
P.O. Box 1229
Tulsa, OK 74101
1-800-322-7867: Bob Malekowski

EPCON Industrial Systems, Inc.
The Woodlands, TX 77380
(713) 353-2319: Aziz Jamaluddin

Ecolaire ECP
11100 Nations Ford Road
P.O. Box 15753
Charlotte, NC 28210
(704) 588-1620: Bud Strope

Environmental Elements Corp.
(Sub. of Koppers Co., Inc.)
P.O. Box 1318
Baltimore, MD 21203
(301) 368-7166: Jim Nicotri

Fuller Company
2040 Avenue C
LeHigh Valley Industrial Park
Bethlehem, PA 18001
(215) 264-6011: R.J. Aldrich

HPD, Inc.
1717 N. Naper Boulevard
Naperville, IL 60540
(312) 357-7330: John Karoly

Hirt Combustion Engineers
931 South Maple Avenue
Montebello, CA 90640
(213) 728-9164: Ms. Corinne Gordon

Industronics, Inc.
489 Sullivan Avenue
P.O. Drawer G
S. Windsor, CT 06074
(203) 289-1551: Brian E. Caffyn (x307)

International Incinerators, Inc.
P.O. Box 19
Columbus, GA 31902
(404) 327-5475: Ronald Hale

John Zink Company
4401 Peoria Avenue
Tulsa, OK 74105
(918) 747-1371: Duane Schaub (x454)

Lurgi Corporation
One Davis Drive
Belmont, CA 94002
(201) 967-4916: Dieter Schroer

McGill, Inc.
P.O. Box 9667
Tulsa, OK 74107
(918) 445-2431: Jim Newburn

Midland-Ross Corporation
2275 Dorr Street
Toledo, OH 43691
(419) 537-6145: Val Daiga

Niro Atomizer, Inc.
9165 Rumsey Road
Columbia, MD 21045
(301) 997-8700: Steve Lancos

Peabody International Corporation
4 Landmark Square
Stamford, CT 06901
(203) 327-7000: Donald Hubickey

Prenco, Inc.
29800 Stephenson Hwy.
Madison Heights, MI 48071
(313) 399-6262: John Brophy

Rockwell International
8900 DeSoto Avenue
Canoga Park, CA 91304
(818) 700-5468: Al Stewart

Shirco Infrared Systems, Inc.
1195 Empire Central
Dallas, TX 75247
(214) 630-7511: Mike Hill

Sur-Lite Corporation
8130 Allport Avenue
Santa Fe Springs, CA 90670
(213) 693-0796: John Sachs

ThermAll, Inc.
P.O. Box 1776
Peapack, NJ 07977
(201) 234-1776: George Fraunfelder

Therm Tech
Box 1105
Tualatin, OR 97062
(503) 692-1490: Dean Robbins

Trane Thermal Company
Brook Road
Conshohocken, PA 19428
(215) 828-5400: Gene Irrgang

Appendix B

INCINERATOR TEST SUMMARIES

Summary of Test Data for Akzo Chemie America
Morris, Illinois

Date of Test: September 18-20, 1984

Run No.: 1-18 ***Test Sponsor:*** Akzo

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 252.25 lb/h (Formaldehyde); 2268 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.01%

Btu content: 731 Btu/lb
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1616°F
Auxiliary fuel used: Natural gas

Excess air: 11% O_2

Monitoring Methods:
POHC's: Modified Method 5
HCl: Method 5
Particulate: Method 5
Other: CO - NDIR, continuous
O_2 - continuous

Emission and DRE Results:
POHC's: Formaldehyde - 99.996% DRE

HCl: None detected
Particulate: 0.0372 gr/dscf @ 7% O_2
THC: 2.2 ppm
CO: >300 ppm
Other:
PIC's:

Reference(s): Akzo Chemie America, Morris, Illinois. Trial burn test report by ARI Environmental, Paletine, Illinois, 1985.

Process Flow Diagram: Not Available

Date of Test: September 18-20, 1984

Run No.: 2-18

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 255.27 lb/h (Formaldehyde); 2285 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.05%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1631°F
Auxiliary fuel used: Natural gas

Excess air: 11.5% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.992% DRE

HCl: None detected
Particulate: 0.0298 gr/dscf @ 7% O_2
THC: 3.8 ppm
CO: 121.8 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 3-18

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 251.75 lb/h (Formaldehyde); 2258 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.03%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1652°F
Auxiliary fuel used: Natural gas

Excess air: 11.5% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.998% DRE

HCl: None detected
Particulate: 0.0522 gr/dscf @ 7% O_2
THC: 3.1 ppm
CO: 152.7 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 1-19

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 302.7 lb/h (Formaldehyde); 2697 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.09%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1778°F
Auxiliary fuel used: Natural gas

Excess air: 10.6% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.992% DRE

HCl: None detected
Particulate: 0.0481 gr/dscf @ 7% O_2
THC: 6 ppm
CO: 0.8 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 2-19

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 304.2 lb/h (Formaldehyde); 2696 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.14%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1778°F
Auxiliary fuel used: Natural gas

Excess air: 10.6% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.993% DRE

HCl: None detected
Particulate: 0.0404 gr/dscf @ 7% O_2
THC: 8.5 ppm
CO: 0.3 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 3-19

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 302.7 lb/h (Formaldehyde); 2697 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.09%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1778°F
Auxiliary fuel used: Natural gas

Excess air:

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.992% DRE

HCl: None detected
Particulate: 0.0396 gr/dscf @ 7% O_2
THC: 7.4 ppm
CO: 1.2 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 1-20

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 481.89 lb/h (Formaldehyde); 4224 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.24%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1832°F
Auxiliary fuel used: Natural gas

Excess air: 7.5% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.995% DRE

HCl: None detected
Particulate: 0.0413 gr/dscf @ 7% O_2
THC: 10.5 ppm
CO: 2.1 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 2-20

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 469.67 lb/h (Formaldehyde); 4222 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.01%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1832°F
Auxiliary fuel used: Natural gas

Excess air: 7.5% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.993% DRE

HCl: None detected
Particulate: 0.0401 gr/dscf @ 7% O_2
THC: 14.8 ppm
CO: 7.9 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Date of Test: September 18-20, 1984

Run No.: 3-20

Equipment information:
Type of unit: Incinerator - Vertical cylinder
Commercial __ Private X
Capacity: 6 tons/day
Pollution control system: None; exhaust gases vented to a waste heat boiler

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Formaldehyde and animal fats

Length of burn:
Total amount of waste burned:
Waste feed rate: 480.22 lb/h (Formaldehyde); 4228 lb/h (fats)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde	10.20%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Average - 1832°F
Auxiliary fuel used: Natural gas

Excess air: 7.4% O_2

Monitoring Methods: See Run 1-18

Emission and DRE Results:
POHC's: Formaldehyde - 99.993% DRE

HCl: None detected
Particulate: 0.0432 gr/dscf @ 7% O_2
THC: 13.9 ppm
CO: 10.3 ppm
Other:
PIC's:

Reference(s): See Run 1-18

Summary of Test Data for American Cyanamid Company
Willow Island, West Virginia

Date of Test: October 26-30, 1982

Run No.: 2 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Single-chamber liquid injection incinerator
Commercial ___ Private X
Capacity: Heat input during test run was 4.8×10^6 Btuh
Pollution control system: None

Waste feed system: Aniline - pressurized tank, fed once/day - burned 1½ to 2 h/day
Mononitrobenzene - burned similarly but only 1 hour every 7 to 10 days

Residence time: 0.21 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Aniline waste

Length of burn: 1 hour (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 5.54 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration, wt. %*
Volatiles	all <0.01
Semivolatiles	
Aniline	55
Phenyl diamine	0.23
Diphenylamine	0.62
Mononitrobenzene	<0.01
m-Dinitrobenzene	<0.01

Btu content: 14,522 Btu/lb
Ash content: 0.19%
Chlorine content: 0.015%
Moisture content: 5.2%

Operating Conditions:

Temperature: Average 1240°F measured at thermocouple in lower part of stack (see comments and diagram)
Auxiliary fuel used: Natural gas for startup only

Excess air: 12.4% O_2

Monitoring Methods:

Waste Feed: One composite per run made up of grab samples taken every 15 minutes during the run

Combustion Emissions:
Volatile POHC's and PIC's: gas bags and VOST (fast)
Semivolatile POHC's and PIC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Metals: Modified Method 5 (Run 3 only)
CO_2 and O_2: gas bag for Orsat analysis

Continuous monitors:
O_2 - Beckman Model 742 (polarographic sensor)
CO - Beckman Model 215A (NDIR)
CO_2 - Horiba Model PIR-2000S (NDIR)
THC - Beckman Model 402 (FID)
Dioxins and furans (tetra- and penta-chlorinated only) - Modified Method 5

Emission and DRE Results:

POHC's:

Semivolatiles		*DRE, %*
Aniline	-	99.999989
Phenylene diamine	-	99.997
Diphenyl amine	-	99.999
Mononitrobenzene	-	Not calculable because of low concentration in waste
m-Dinitrobenzene	-	Not calculable because of low concentration in waste

HCl: 0.004 lb/h
Particulate: 0.0746 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 30.6 ppm
Other: Dioxins and furans - none detected
PIC's:

PIC's[a]	*Fast VOST, avg., g/min*	*Gas bag, g/min*	*MM5, g/min*
Volatiles			
Chloroform	0.0017	0.0017	-
Benzene	0.00135	0.00032	-
Toluene	0.00019	0.0014	-
1,1,1-Trichloroethane	0.000028	0.00012	-
Carbon tetrachloride	0.00005	0.000030	-
Trichloroethylene	0.00053	0.00045	-
Tetrachloroethylene	0.000026	0.000077	-
Chlorobenzene	0.00020	0.00044	-
Semivolatiles			
Naphthalene	-	-	0.013
o-Nitrophenol	-	-	0.0086

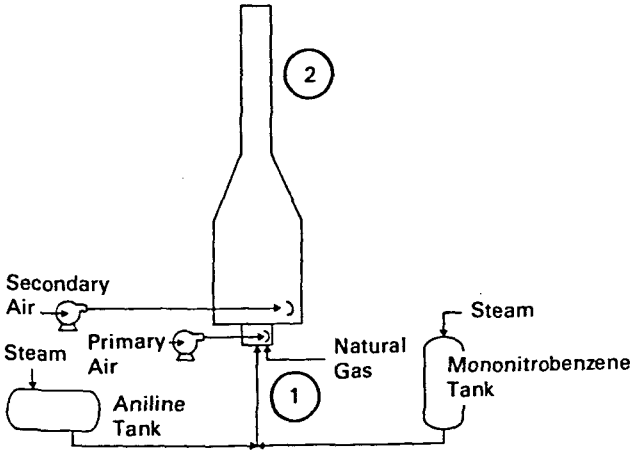
[a]Not blank corrected

Reference: A. Trenholm, P. Gorman, and G. Jungclaus . Performance Evaluation *of Full-Scale Hazardous Waste Incinerators*, Final Report, Volumes II and IV (Appendix G). EPA Contract 68-02-3177 to Midwest Research Institute, Kansas City, MO. EPA Project Officer - Mr. Don Oberacker, Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio 45268.

Comments: Unlike other tests in this EPA series, chemicals were not spiked into the waste feed. Aniline wastes were used in Runs 1, 2, 3, and 5 and mononitrobenzene wastes in Run 4. Data from Run 1 are believed invalid because stack gas flow was cyclonic. To correct this, flow straighteners were installed in the stack after Run 1, but no other operational changes were made. However, the temperature readings in Runs 2-5 were 300°F lower than those of Run 1. There is reason to believe that the actual temperature of Runs 2-5 may have been 300°F higher than the thermocouple reading indicated. Because of a limited supply of waste, each run was held to about 1 hour. DRE values for aniline may be biased high because of poor recoveries (~7%) of aniline spiked to the XAD samples. See Reference, Volume II, Page 102.

PROCESS FLOW DIAGRAM

Diagram of process and sampling locations.



Note: Natural Gas is burned only during startup. Aniline and mononitrobenzene waste feeds are always burned separately.

AMERICAN CYANAMID

Date of Test: October 26-30, 1982

Run No.: 3

Equipment information:

Type of unit: Single-chamber liquid injection incinerator

Commercial __ Private X

Capacity: Heat input during test run was 4.2×10^6 Btuh

Pollution control system: None

Waste feed system: Pressurized tanks

Residence time: 0.24 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Aniline waste

Length of burn: ~1 hour (sampling time)

Total amount of waste burned: Not reported

Waste feed rate: 4.88 lb/min

POHC's selected and concentration in waste feed:

Name	*Concentration, wt. %*
Volatiles	all <0.01
Semivolatiles	
Aniline	60
Phenyl diamine	0.53
Diphenylamine	0.58
Mononitrobenzene	<0.01
m-Dinitrobenzene	<0.01

Btu content: 14,490 Btu/lb

Ash content: 0.19%

Chlorine content: 0.020%

Moisture content: 5.5%

Operating Conditions:

Temperature: Average 1164°F (see comments, Run 2)

Auxiliary fuel used: Natural gas for startup only

Excess air: 14.6% O_2 (taken from Method 5 test data)

Monitoring Methods: See Run 2

Emission and DRE Results:

POHC's:

Semivolatiles		*DRE, %*
Aniline	-	>99.999992
Phenylene diamine	-	>99.9992
Diphenyl amine	-	>99.9992
Mononitrobenzene	-	Not calculable because of low concentration in waste
m-Dinitrobenzene	-	Not calculable because of low concentration in waste

HCl: 0.007 lb/h

Particulate: 0.0686 gr/dscf @ 7% O_2

THC: <1 ppm

CO:

Other: Dioxins and furans - none detected

Metals - Chromium and nickel >5 μg/g in waste feed and >20,000 μg/g in particulate emissions

PIC's:

PIC's[a]	*Fast VOST, avg., g/min*	*Gas bag, g/min*	*MM5, g/min*
Volatiles			
Chloroform	0.000217	0.00016	-
Benzene	0.00035	0.0012	-
Toluene	0.000246	0.00072	-
1,1,1-Trichloroethane	0.000004	<0.000011	-
Carbon tetrachloride	0.000050	0.00055	-
Trichloroethylene	0.000227	0.0031	-
Tetrachloroethylene	0.000006	0.000072	-
Chlorobenzene	0.000031	0.00040	-
Semivolatiles			
Naphthalene	-	-	0.0014
o-Nitrophenol	-	-	<0.0003

[a]Not blank corrected

Reference(s): See Run 2

Comments: See Run 2

Process Flow Diagram: See Run 2

Date of Test: October 26-30, 1982

Run No.: 4

Equipment information:

Type of unit: Single-chamber liquid injection incinerator
Commercial __ Private X
Capacity: Heat input during test run was 4.5×10^6 Btuh
Pollution control system: None

Waste feed system: Pressurized tanks

Residence time: 0.23 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Mononitrobenzene waste

Length of burn: ~1 hour (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 6.97 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration, wt. %*
Volatiles	all <0.01
Semivolatiles	
Aniline	0.8
Phenyl diamine	<0.01
Diphenylamine	<0.01
Mononitrobenzene	64
m-Dinitrobenzene	<0.31

Btu content: 10,780 Btu/lb
Ash content: Less than 0.05%
Chlorine content: 0.013%
Moisture content: 0.57%

Operating Conditions:

Temperature: Average 1254°F (see comments, Run 2)
Auxiliary fuel used: Natural gas for startup only

Excess air: 12.7% O_2

Monitoring Methods: See Run 2

Emission and DRE Results:

POHC's:

Semivolatiles		*DRE, %*
Aniline	-	>99.9997
Phenylene diamine	-	Not calculable because of low concentration in waste
Diphenyl amine	-	Not calculable because of low concentration in waste
Mononitrobenzene	-	99.99991
m-Dinitrobenzene	-	>99.99

HCl: 0.007 lb/h
Particulate: 0.0066 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 10.8 ppm
Other: Dioxins and furans - none detected
PIC's:

PIC's[a]	*Fast VOST, avg., g/min*	*Gas bag, g/min*	*MM5, g/min*
Volatiles			
Chloroform	0.000164	0.000069	-
Benzene	0.00032	<0.00003	-
Toluene	0.00012	0.00086	-
1,1,1-Trichloroethane	0.000012	0.00014	-
Carbon tetrachloride	0.000025	<0.000012	-
Trichloroethylene	0.000182	0.00025	-
Tetrachloroethylene	0.0000062	0.00014	-
Chlorobenzene	0.000046	0.000029	-
Semivolatiles			
Naphthalene	-	-	0.0091
o-Nitrophenol	-	-	<0.0006

[a]Not blank corrected

Reference(s): See Run 2

Comments: See Run 2

Process Flow Diagram: See Run 2

AMERICAN CYANAMID

Date of Test: October 26-30, 1982

Run No.: 5 - Aniline waste

Equipment information:

Type of unit: Single-chamber liquid injection incinerator
Commercial __ Private X
Capacity: Heat input during test run was 4.3×10^6 Btuh
Pollution control system: None

Waste feed system: Aniline - pressurized tank, fed once/day - burned 1½ to 2 h/day
Mononitrobenzene - burned similarly but only 1 hour every 7 to 10 days

Residence time: 0.21 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Aniline waste

Length of burn: ~1 hour (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 4.95 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration, wt. %*
Volatiles	all <0.01
Semivolatiles	
Aniline	53
Phenyl diamine	0.46
Diphenylamine	0.54
Mononitrobenzene	<0.01
m-Dinitrobenzene	<0.01

Btu content: 14,460 Btu/lb
Ash content: Less than 0.5%
Chlorine content: 0.019%
Moisture content: 7.3%

Operating Conditions:

Temperature: Average 1198°F (see comments, Run 2)
Auxiliary fuel used: Natural gas for startup only

Excess air: 13.0% O_2

Monitoring Methods: Same as Run 2 except VOST not used in this run.

Emission and DRE Results:

POHC's:

Semivolatiles		*DRE, %*
Aniline	-	>99.999992
Phenylene diamine	-	>99.999
Diphenyl amine	-	>99.9992
Mononitrobenzene	-	Not calculable because of low concentration in waste
m-Dinitrobenzene	-	Not calculable because of low concentration in waste

HCl: 0.007 lb/h
Particulate: 0.1750 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 6.1 ppm
Other: Dioxins and furans - none detected
PIC's:

PIC's[a]	*Gas bag,*[b] *g/min*	*MM5, g/min*
Volatiles		
Chloroform	0.00002	-
Benzene	0.00057	-
Toluene	0.0012	-
1,1,1-Trichloroethane	0.000034	-
Carbon tetrachloride	0.000051	-
Trichloroethylene	0.00042	-
Tetrachloroethylene	0.000062	-
Chlorobenzene	0.000090	-
Semivolatiles		
Naphthalene	-	0.0040
o-Nitrophenol	-	0.00036

[a]Not blank corrected
[b]Measured from gas bag; VOST not used for this test run

Reference(s): See Run 2

Comments: See Run 2

Process Flow Diagram: See Run 2

Summary of Test Data for Ciba-Geigy Corporation McIntosh, Alabama

Date of Test: November 12-17, 1984

Run No.: 1 ***Test Sponsor:*** Ciba-Geigy

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 5.05 s (kiln); 3.09 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, only synthetic hazardous liquid waste was tested

Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 480 gal (liquid) and 0 lb (solid)
Waste feed rate: 4 gpm (liquid); 0 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,200 Btu/lb
Ash content: Not measured
Chlorine content: 20.8% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1750° - 1850°F (kiln)
1950° - 2050°F (Secondary chamber)
Average 1800°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 10.3% Oxygen

Monitoring Methods:

POHC's: XAD 2 sorbent module attached to Method 5 particulate train
HCl: Ion electrode on first impinger in Method 5 train
Particulate: Modified Method 5
Other: CO_2: Method 3
O_2: Method 3
CO: Long-cell type MSA Model 202 "Lira" NDIR (for verification); Ciba-Geigy has NDIR on stack; mfgr. not reported.

Emission and DRE Results:

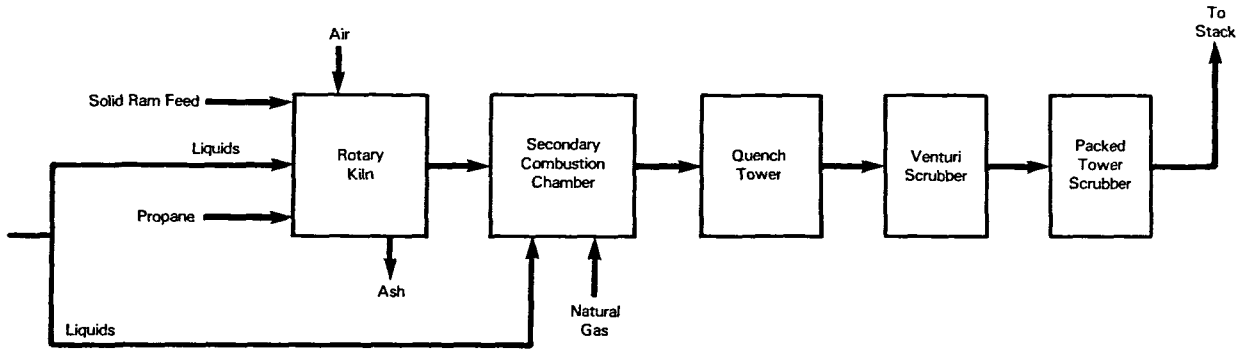
POHC's:

POHC	*DRE,%*	
Hexacloroethane	99.998	
Tetrachlorethene	99.997	Calculated using
Chlorobenzene	99.9997	method detection
Toluene	99.9994	limit

HCl: 99.998% collection efficiency
Particulate: 0.21 gr/dscf @ 7% O_2
THC: Not measured
CO: 10 ppm
Other: No POHC's detected in scrubber water
PIC's: Not measured

Reference(s): Ciba-Geigy McIntosh Facility, RCRA Part B Application, Incinerator Test Burn Parts 1 and 3. February 1985

PROCESS FLOW DIAGRAM



Date of Test: November 1984

Run No.: 2

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 5.05 s (kiln); 3.09 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, only synthetic hazardous liquid waste was tested

Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 458 gal (liquid) and 0 lb (solid)
Waste feed rate: 3.8 gpm (liquid); 0 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,100 Btu/lb
Ash content: Not measured
Chlorine content: 12.8% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1700° - 1850°F (kiln)
1950° - 2050°F (Secondary chamber)
Average 1800°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 10.8% Oxygen

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE,%*	
Hexacloroethane	99.997	
Tetrachlorethene	99.995	Calculated using
Chlorobenzene	99.9994	method detection
Toluene	99.9992	limit

HCl: 99.995% collection efficiency
Particulate: 0.20 gr/dscf @ 7% O_2
THC: Not measured
CO: <5 ppm
Other: No POHC's detected in scrubber water
PIC's: Not measured

Reference(s): See Run 1

Process Flow Diagram: See Run 1

CIBA-GEIGY

Date of Test: November 12-17, 1984

Run No.: 3

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 5.05 s (kiln); 3.09 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, only synthetic hazardous liquid waste was tested

Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 427 gal (liquid) and 0 lb (solid)
Waste feed rate: 3.55 gpm (liquid); 0 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,300 Btu/lb
Ash content: Not measured
Chlorine content: 14.9% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1650° - 1750°F (kiln)
1950° - 2050°F (Secondary chamber)
Average 1700°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 11.0% Oxygen

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE,%*
Hexacloroethane	99.997
Tetrachlorethene	99.995
Chlorobenzene	99.9995
Toluene	99.9992

HCl: 99.998% collection efficiency
Particulate: 0.14 gr/dscf @ 7% O_2
THC: Not measured
CO: <5 ppm
Other: No POHC's detected in scrubber water
PIC's: Not measured

Reference(s): See Run 1

Process Flow Diagram: See Run 1

Date of Test: November 12-17, 1984

Run No.: 4

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 4.93 s (kiln); 3.04 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, both synthetic hazardous liquid waste and nonhazardous solid waste were tested
Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 252 gal (liquid) and 3865 lb (solid)
Waste feed rate: 2.1 gpm (liquid); 1932 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,100 Btu/lb
Ash content: Not measured
Chlorine content: 14.2% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1650° - 1850°F (kiln)
1975° - 2050°F (Secondary chamber)
Average 1750°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 11.0% Oxygen

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE,%*
Hexacloroethane	99.995
Tetrachlorethene	99.991
Chlorobenzene	99.9992
Toluene	99.998

HCl: 99.998% collection efficiency
Particulate: 0.19 gr/dscf @ 7% O_2
THC: Not measured
CO: <5 ppm
Other: No POHC's detected in scrubber water
PIC's: Not measured

Reference(s): See Run 1

Process Flow Diagram: See Run 1

Date of Test: November 12-17, 1984

Run No.: 5

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 4.93 s (kiln); 3.04 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, both synthetic hazardous liquid waste and nonhazardous solid waste were tested

Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 124 gal (liquid) and 5228 lb (solid)
Waste feed rate: 1.03 gpm (liquid); 2614 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,100 Btu/lb
Ash content: Not measured
Chlorine content: 14.9% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1000° - 1950°F (kiln)
1950° - 2050°F (Secondary chamber)
Average 1750°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 10.6% Oxygen

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE,%*
Hexacloroethane	99.992
Tetrachlorethene	99.982
Chlorobenzene	99.998
Toluene	99.997

HCl: 99.996% collection efficiency
Particulate: 0.14 gr/dscf @ 7% O_2
THC: Not measured
CO: <5 ppm
Other: No POHC's detected in scrubber water
PIC's: Not measured

Reference(s): See Run 1

Process Flow Diagram: See Run 1

Date of Test: November 12-17, 1984

Run No.: 6

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber, Vulcan Iron
Commercial __ Private X
Capacity: 50 tpd with 10% excess capacity (30 x 10^6 Btuh for each burner)
Pollution control system: Quench tower, Polycon venturi scrubber (25-in. Δp), and packed tower scrubber

Waste feed system:
Liquid: Hauck Model 780 wide range burners (kiln and secondary burners)
Solid: Ram feed

Residence time: 4.93 s (kiln); 3.04 s (secondary chamber)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Hazardous liquid and nonhazardous solid wastes usually burned; for this run, both synthetic hazardous liquid waste and nonhazardous solid waste were tested

Length of burn: 6 to 9 h (2-h sampling time)
Total amount of waste burned: 215 gal (liquid) and 6154 lb (solid)
Waste feed rate: 1.8 gpm (liquid); 3077 lb/h (solid)
POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Hexachloroethane	4.87
Tetrachlorethene	5.03
Chlorobenzene	29.52
Toluene	60.58

Btu content: 15,100 Btu/lb
Ash content: Not measured
Chlorine content: 16.2% (calculated)
Moisture content: Not measured

Operating Conditions:

Temperature:
Range 1600° - 1850°F (kiln)
1950° - 2050°F (Secondary chamber)
Average 1750°F (kiln); 2000°F (Secondary chamber)

Auxiliary fuel used:
Natural gas
Primary kiln 1200 scfh natural gas
Secondary chamber 900-1300 scfh

Airflow:
Primary air to kiln: 2200 cfm
Secondary air to kiln: 1400 cfm
Primary air to secondary: 1260 cfm (avg.)
Secondary air to secondary: 0

Excess air: 10.7% Oxygen

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE,%*
Hexacloroethane	99.995
Tetrachlorethene	99.992
Chlorobenzene	99.9993
Toluene	99.998

HCl: 99.998% collection efficiency
Particulate: 0.18 gr/dscf @ 7% O_2
THC: Not measured
CO: <5 ppm
Other: No POHC detected in scrubber water
PIC's: Not measured

Reference(s): See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Cincinnati Metropolitan Sewer District
Cincinnati, Ohio

Date of Test: Week of July 19, 1981

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - Rotary kiln/cylonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 3.3-3.7 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic, pesticide-containing liquid waste (see comments)

Length of burn: 10.5 h

Total amount of waste burned:

Waste feed rate: 4,288 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration µg/g (ppm)*
Volatiles	
Chloroform	12,000
Carbon tetrachloride	2,200
Tetrachloroethylene	2,400
Semivolatiles	
Hexachloroethane	100[a]-150
Hexachlorobenzene	100[a]
Hexachlorocyclopentadiene[b]	3700-5600

[a]Value reported as "at or near detection limit." See Reference, pp. 145-146.
[b]A pesticide.

Btu content: 4,949 Btu/lb

Ash content: 0.93%

Chlorine content: 2.91%

Moisture content: 65.3%

Operating Conditions:

Temperature: Average - 1677°F in combustion chamber

Auxiliary fuel used: Oil (1.36 gpm)

Excess air: 12.6% O_2

Monitoring Methods:

Grab samples of fuel oil, ash, scrubber effluent, and quench water for POHC's

Stack:

- POHC's: Volatiles by integrated gas bag and semivolatiles by Modified Method 5
- HCl: midget impinger trains (Runs 1-6) and Modified Method 5 without alkaline impinger (Runs 7-9)
- Particulate: Modified Method 5
- Continuous monitors for CO, O_2, NO_x, and total HC
- Orsat for O_2 and CO_2
- Metals - Modified Method 5
- PICS - gas bag

Waste:

Two 2-hour integrated samples and one 6-hour integrated sample (composited every 15 minutes) plus one daily grab sample analyzed for POHC's, metals, Cl, HHV, viscosity, flash point, and proximate/ultimate analyses

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	99.998
Carbon tetrachloride	>99.995
Tetrachloroethylene	99.999
Semivolatiles	
Hexachloroethane	>99.99 to >99.998
Hexachlorobenzene	>99.99 to >99.997
Hexachlorocyclopentadiene	>99.999 to 99.9999

HCl: 1.87 lb/h; 98.5% removal (avg.)[a]

Particulate: Not reported

THC: 0.5 - 10.4 ppm (2.1 ppm avg.)

CO: 0 - 1.8 ppm (0.6 ppm avg.)

Other: NO_x: 84 - 140 ppm (122 ppm avg.)
O_2: 10.9 - 13.7 ppm (12.2 ppm avg.)

PIC's: bromoform - 30 µg/m^3
dibromochloromethane - 10 µg/m^3

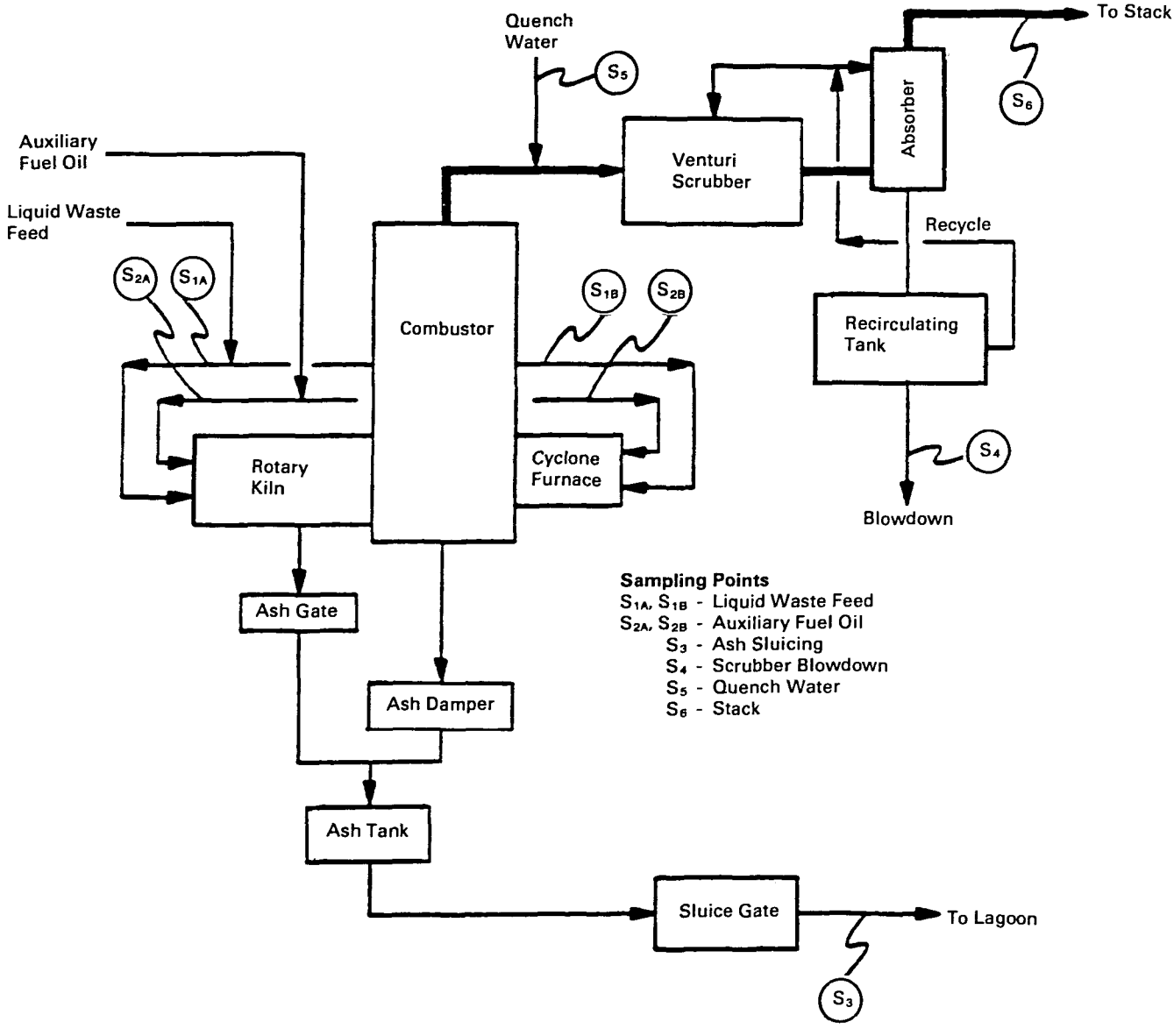
[a]Excludes Cl^- found on glass wool plug preceding HCl probe on chloride train.

Reference(s): Gorman, P. G. and K. P. Ananth. Trial Burn Protocol Verification at a Hazardous Waste Incinerator. EPA-600/2-84-048. February 1984.

Comments: Although the incineration system is designed to handle solids, none were used in the nine MSD tests. The waste burned consisted of two liquid phases plus one semi-solid phase. Although every effort was made to blend the waste prior to feeding it to the incinerator, analyses showed hour-by-hour variations in composition (water content, Btu content, chlorine content, etc.). The wastes burned in Runs 1-6 were multiphased, higher in water content (29-65%), and lower in chlorine content (3-7%) than wastes burned in Runs 7-9 (single-phased, chlorine 15-16% and about 15% water). Waste feed analyses were conducted on time-integrated samples taken every 15 minutes throughout each run. Wastes burned in Runs 1-6 contained 100-16,000 ppm of the pesticide hexachlorocyclopentadiene. Sampling difficulties and malfunctions of demister and scrubber pH control were believed responsible for <99% HCl control. Demister and sound dampener malfunctions also were believed responsible for high particulate emissions in Runs 2, 7, 8, and 9.

PROCESS FLOW DIAGRAM

Schematic diagram of the Cincinnati MSD incinerator.



Date of Test: Week of July 19, 1981

Run No.: 2

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 3.3-3.7 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic liquid waste (see Run 1)

Length of burn: 7.0 h

Total amount of waste burned: 31,241 lb

Waste feed rate: 4,463 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration μg/g (ppm)*
Volatiles	
Chloroform	7,600
Carbon tetrachloride	1,500
Tetrachloroethylene	3,300
Semivolatiles	
Hexachloroethane	100[a]-190
Hexachlorobenzene	<100 -160
Hexachlorocyclopentadiene	690 -7600

[a]Value reported as "at or near detection limit."

Btu content: 6,039 Btu/lb

Ash content: 0.22%

Chlorine content: 3.13%

Moisture content: 57.2%

Operating Conditions:

Temperature: Average - 1976°F in combustion chamber

Auxiliary fuel used: Oil (1.11 to 1.40 gpm)

Excess air: 9.1% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	a
Carbon tetrachloride	a
Tetrachloroethylene	a
Semivolatiles	
Hexachloroethane	>99.993 to >99.998
Hexachlorobenzene	>99.99
Hexachlorocyclopentadiene[b]	>99.996 to 99.99992

[a]Not reported; gas bag leaked and sample was lost. No analysis could be performed

[b]Three of four calculated values were >99.99. A fourth calculated value could not be determined because of low POHC concentrations in the waste feed (<100 ppm) and in the Modified Method 5 sample (<1 ppm)

HCl: 0.84 lb/h; 99.4% removal (avg.)[a]

Particulate: 0.1210 gr/scf @ 7% O_2 (327 mg/dscm @ 12% CO_2)[b]

THC: 0 - 9.6 ppm (3.3 ppm avg.)

CO: 0 - 56 ppm (3.6 ppm avg.)

Other: NO_x: 131 - 163 ppm (146 ppm avg.)
O_2: 7.5 - 12 ppm (10.3 ppm avg.)

PIC's: bromoform - sample lost
dibromochloromethane - sample lost

[a]Excludes HCl found on glass wool plug preceding HCl probe on chloride train.

[b]See comments for Run 1.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

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Date of Test: Week of July 19, 1981

Run No.: 3

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 3.3-3.7 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic liquid waste (see Run 1)

Length of burn: 6.3 h

Total amount of waste burned: 31,660 lb

Waste feed rate: 5,025 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration μg/g (ppm)*
Volatiles	
Chloroform	17,200
Carbon tetrachloride	2,600
Tetrachloroethylene	3,800
Semivolatiles	
Hexachloroethane	110 - 200
Hexachlorobenzene	100 - 260
Hexachlorocyclopentadiene	2,400 - 16,000

Btu content: 9,848 Btu/lb

Ash content: 1.29%

Chlorine content: 7.08%

Moisture content: 33.54%

Operating Conditions:

Temperature: Average - 2325°F in combustion chamber

Auxiliary fuel used: Oil (1.23 gpm)

Excess air: 6.8% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	99.9995
Carbon tetrachloride	>99.99993
Tetrachloroethylene	99.999
Semivolatiles	
Hexachloroethane	>99.99 to >99.999
Hexachlorobenzene	>99.99 to >99.999
Hexachlorocyclopentadiene	>99.998 to >99.99998

HCl: 1.07 lb/h (99.7% removal, avg.)[a]

Particulate: Not reported

THC: 0 - 9.4 ppm (1.8 ppm avg.)

CO: 0 - 17.5 ppm (8.2 ppm avg.)

Other: NO_x: 64 - 182 ppm (118 ppm avg.)
O_2: 6.3 - 14.7 ppm (7.8 ppm avg.)

PIC's: bromoform - 50 μg/m³
dibromochloromethane - 30 μg/m³

[a]Excludes HCl found on glass wool plug preceding HCl probe on chloride train.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of July 19, 1981

Run No.: 4

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic liquid waste (See Run 1)

Length of burn: 6.65 h

Total amount of waste burned: 47,480 lb

Waste feed rate: 7,140 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration, µg/g (ppm)*
Volatiles	
Chloroform	13,200
Carbon tetrachloride	1,600
Tetrachloroethylene	2,600
Semivolatiles	
Hexachloroethane	100 - 140
Hexachlorobenzene	<100 - 100
Hexachlorocyclopentadiene	90 - 3100

Btu content: 5,968 Btu/lb

Ash content: 0.47%

Chlorine content: 3.46%

Moisture content: 57.47%

Operating Conditions:

Temperature: Average - 1665°F in combustion chamber

Auxiliary fuel used: Oil (0.687 to 1.40 gpm)

Excess air: 13.0% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	99.9997
Carbon tetrachloride	>99.999
Tetrachloroethylene	99.997
Semivolatiles	
Hexachloroethane	>99.992 to >99.997
Hexachlorobenzene	99.993[a]
Hexachlorocyclopentadiene[b]	99.96 to 99.9994[b]

[a]Three of four possible DRE calculations could not be made because both input and output POHC values were below detection limits.
[b]The 99.96 value is low due to calculation limitations. The input value of the POHC was only 90 ppm, and the output detection limit was 5 µg.

HCl: 3.70 lb/h (98.5% removal avg.)[a]

Particulate: Not reported

THC: 0.7 - 3.0 ppm (1.1 ppm avg.)

CO: 0 - 42.2 ppm (16.8 ppm avg.)

Other: NO_x: 98 - 160 ppm (137 ppm avg.)
O_2: 11.7 - 14.2 ppm (13.0 ppm avg.)

PIC's: bromoform - 1 µg/m^3
dibromochloromethane - 1 µg/m^3

[a]Excludes HCl found on glass wool plug preceding HCl probe on chloride train.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of July 19, 1981

Run No.: 5

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic liquid waste (see Run 1)

Length of burn: 8.8 h

Total amount of waste burned: 61,640 lb

Waste feed rate: 7,004 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration, μg/g (ppm)*
Volatiles	
Chloroform	10,900
Carbon tetrachloride	1,100
Tetrachloroethylene	2,600
Semivolatiles	
Hexachloroethane	100 - 180
Hexachlorobenzene	100
Hexachlorocyclopentadiene	2500 - 7100

Btu content: 9,948 Btu/lb

Ash content: 0.25%

Chlorine content: 5.88%

Moisture content: 31.66%

Operating Conditions:

Temperature: Average - 2044°F in combustion chamber

Auxiliary fuel used: Oil (1.40 to 2.64 gpm)

Excess air: 11.0% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	>99.9989
Carbon tetrachloride	>99.96[a]
Tetrachloroethylene	>99.99
Semivolatiles	
Hexachloroethane	>99.99 to >99.996
Hexachlorobenzene	>99.99 to >99.996
Hexachlorocyclopentadiene	>99.999 to >99.996

[a]Inadequate amount of sample in gas bag limited the DRE calculation to this value as a minimum.

HCl: 7.82 lb/h (98.1% removal avg.)[a]

Particulate: 0.0563 gr/scf @ 7% O_2 (146 mg/dscm @ 12% CO_2)

THC: 0 - 2.8 ppm (0.7 ppm avg.)

CO: 1.9 - 11.6 ppm (7.0 ppm avg.)

Other: NO_x: 82 - 239 ppm (136 ppm avg.)
O_2: 8.6 - 11.6 ppm (10.5 ppm avg.)

PIC's: bromoform - <60 μg/m³
dibromochloroform - <60 μg/m³

[a]Excludes HCl found on glass wool plug preceding HCl probe on chloride train.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of July 19, 1981

Run No.: 6

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Multiphasic liquid waste (see Run 1)

Length of burn: 6.0 h

Total amount of waste burned: 47,660 lb

Waste feed rate: 7,943 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration, µg/g (ppm)*
Volatiles	
Chloroform	18,000
Carbon tetrachloride	2,300
Tetrachloroethylene	3,400
Semivolatiles	
Hexachloroethane	100 - 230
Hexachlorobenzene	<100 - 160
Hexachlorocyclopentadiene	100 - 12,000

Btu content: 9,864 Btu/lb

Ash content: 0.47%

Chlorine content: 6.97%

Moisture content: 28.61%

Operating Conditions:

Temperature: Average - 2410°F in combustion chamber (1321°C)

Auxiliary fuel used: Oil (1.35 to 3.25 gpm)

Excess air: 8.75% O_2

Monitoring Methods: See Run 1. Stainless steel tanks were also tested as a means of collecting stack gas for volatiles analyses.

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Chloroform	>99.998
Carbon tetrachloride	>99.9[a]
Tetrachloroethylene	>99.97[a]
Semivolatiles	
Hexachloroethane	>99.994 to >99.998
Hexachlorobenzene	>99.993 to >99.998
Hexachlorocyclopentadiene[b]	>99.97 to >99.9998[b]

[a]Small sample size limited DRE calculation to this minimum value.
[b]Low concentration in waste fuel limited one DRE value to > 99.97.

HCl: 89.7 lb/h (83.8% removal)[a]

Particulate: Not reported

THC: 0.3 - 2.3 ppm (1.3 ppm avg.)

CO: 0 - 5.6 ppm (3.0 ppm avg.)

Other: NO_x: 95 - 172 ppm (135 ppm avg.)
O_2: 6.2 - 10.4 ppm (8.4 ppm avg.)

PIC's: bromoform - <60 µg/m^3
dibromochloroform - <60 µg/m^3

[a]Excludes HCl found on glass wool plug preceding HCl probe on chloride train.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of September 27, 1981

Run No.: 7

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: High-chlorine content, single-phase liquid waste (see comments)

Length of burn: 9.5 h

Total amount of waste burned: 61,900 lb

Waste feed rate: 6,515 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration, μg/g (ppm)*
Volatiles	
Trichloroethane[a]	9,600
Tetrachloroethane[a]	1,280
Bromodichloromethane	2,800
Semivolatiles	
Pentachloroethane	4,200 - 8,400
Hexachloroethane	2,200 - 7,700
Dichlorobenzene[a]	900 - 1,500

[a]Combined isomers

Btu content: 11,269 Btu/lb

Ash content: 1.56%

Chlorine content: 15.50%

Moisture content: 13.52%

Operating Conditions:

Temperature: Average - 1657°F in combustion chamber (903°C)

Auxiliary fuel used: Oil (1.00 gpm)

Excess air: 12.5% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Trichloroethane	99.998 (gas bag), 99.985 (stainless steel tank)
Tetrachloroethane	>99.9997 (gas bag), 99.9997 (stainless steel tank)
Bromodichloromethane	99.97 (gas bag), 99.976 (stainless steel tank)
Semivolatiles	
Pentachloroethane	>99.9998
Hexachloroethane	>99.9996
Dichlorobenzene	>99.996

HCl: 5.05 lb/h (99.5% removal)[a]

Particulate: 0.8908 gr/scf @ 7% O_2 (2230 mg/dscm @ 12% CO_2)[b]

THC: 0 - 2.0 ppm (0.5 ppm avg.)

CO: 0 - 20.4 ppm (3.3 ppm avg.)

Other: NO_x: 113 - 151 ppm (132 ppm avg.)
O_2: 11.0 - 13.0 ppm (12.3 ppm avg.)

PIC's: bromoform - 12.5 μg/m^3
dibromochloroform - 17.5 μg/m^3

[a]Estimated from HCl analysis of condensate and H_2O_2 impinger on Modified Method 5 train. Train did not include an alkaline impinger.
[b]See comments for Run 1

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of September 27, 1981

Run No.: 8

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace
Commercial X Private ___
Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)
Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: High-chlorine content, single-phase liquid waste (see comments)

Length of burn: 8.3 h
Total amount of waste burned: 67,680 lb
Waste feed rate: 8,154 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration, μg/g (ppm)*
Volatiles	
Trichloroethane[a]	31,000
Tetrachloroethane[a]	4,500
Bromodichloromethane	4,200
Semivolatiles	
Pentachloroethane	2,700 - 8,300
Hexachloroethane	1,400 - 7,500
Dichlorobenzene[a]	500 - 1,500

[a]Combined isomers

Btu content: 10,819 Btu/lb
Ash content: 1.37%
Chlorine content: 15.08%
Moisture content: 14.86%

Operating Conditions:

Temperature: Average - 1998°F in combustion chamber (1092°C)
Auxiliary fuel used: Oil (1.00 gpm)

Excess air: 10.6% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Trichloroethane	a
Tetrachloroethane	a
Bromodichloromethane	a
Semivolatiles	
Pentachloroethane	>99.9994 to >99.9999
Hexachloroethane	>99.999 to >99.9999
Dichlorobenzene	>99.99 to >99.998

[a]Samples lost

HCl: 16.0 lb/h (98.7% removal)[a]
Particulate: 0.6681 gr/scf @ 7% O_2 (1710 mg/dscm @ 12% CO_2)
THC: 0.5 - 3.0 ppm (1.7 ppm avg.)
CO: 5.4 - 13.6 ppm (8.9 ppm avg.)
Other: NO_x: 140 - 152 ppm (145 ppm avg.)
O_2: 10.0 - 11.5 ppm (10.6 ppm avg.)
PIC's: bromoform - sample lost
dibromochloromethane - sample lost

[a]Estimated from HCl analysis of condensate and H_2O_2 impinger on Modified Method 5 train. Train did not include an alkaline impinger.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Date of Test: Week of September 27, 1981

Run No.: 9

Equipment information:

Type of unit: Incinerator - Rotary kiln/cyclonic furnace

Commercial X Private ___

Capacity: 52 x 10^6 Btuh (kiln); 62 x 10^6 Btuh (furnace)

Pollution control system: Venturi scrubber and sieve tray caustic scrubber

Waste feed system: Liquids pumped from tanks; solids conveyed into kiln (see comments)

Residence time: 1.5-2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: High-chlorine content, single-phase liquid waste (see comments)

Length of burn: 8.0 h

Total amount of waste burned: 65,310 lb

Waste feed rate: 8,164 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration, µg/g (ppm)*
Volatiles	
Trichloroethane[a]	31,000
Tetrachloroethane[a]	2,700
Bromodichloromethane	4,000
Semivolatiles	
Pentachloroethane	4,200 - 8,100
Hexachloroethane	2,100 - 4,700
Dichlorobenzene[a]	1,100 - 1,700

[a]Combined isomers

Btu content: 12,761 Btu/lb

Ash content: 0.21%

Chlorine content: 15.87%

Moisture content: 4.65%

Operating Conditions:

Temperature: Average - 2400°F in combustion chamber (1316°C)

Auxiliary fuel used: Oil (1.69 gpm)

Excess air: 8.9% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*DRE, %*
Volatiles	
Trichloroethane	>99.99996 (gas bag), 99.999 (steel tank)
Tetrachloroethane	>99.9998 (gas bag), >99.9998 (steel tank)
Bromodichloromethane	99.995 (gas bag), 99.996 (steel tank)
Semivolatiles	
Pentachloroethane	>99.9998
Hexachloroethane	>99.9997
Dichlorobenzene	>99.998

HCl: 60.9 lb/h (95.3% removal)[a]

Particulate: 0.4367 gr/scf @ 7% O_2 (1130 mg/dscm @ 12% CO_2)

THC: 0.2 - 1.5 ppm (0.6 ppm avg.)

CO: 6.6 - 15.8 ppm (10.6 ppm avg.)

Other: NO_x: 123 - 134 ppm (130 ppm avg.)
O_2: 8.3 - 9.8 ppm (9.1 ppm avg.)

PIC's: bromoform - 2.5 µg/m^3
dibromochloromethane - 9.5 µg/m^3

[a]Estimated from Cl analysis of condensate and H_2O_2 impinger on Modified Method 5 train. Train did not include an alkaline impinger.

Reference(s): See Run 1

Comments: See comments for Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Confidential Site B

Date of Test: July 21-26, 1984

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - unspecified (see comments)
Commercial __ Private __ Not specified X
Capacity: Not reported
Pollution control system: Wet scrubber for HCl; unit was also equipped with a particulate control device, but it was not described in reference.

Waste feed system: Not reported

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Two liquid wastes: one characterized only as organic and the other as aqueous. The organic waste was continuously spiked with a 50/50 mixture (by volume) of carbon tetrachloride and trichloroethylene.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported; waste heat content input during burn 21.4 x 10^6 Btuh
Waste feed rate: 42.5 lb/min aqueous; 33.2 lb/min organic; 75.7 lb/min total
POHC's selected and concentration in total waste feed:

Name	*Concentration*

SEE EMISSIONS AND DRE RESULTS

Btu content: 4,720 Btu/lb total
Ash content: 2.82% total
Chlorine content: 2.64% total
Moisture content: 68.1% total

Operating Conditions:

Temperature: Range not reported
Average 1952°F (average of Runs 1, 2, and 3; temperature of this specific run not reported)
Auxiliary fuel used: Not reported

Excess air: 11.8% O_2

Monitoring Methods:

Waste feed: One composite per run made up of grab samples taken every 15 minutes during run.
Combustion emissions:
Volatile POHC's and PIC's: gas bags (all runs) and fast VOST (Runs 2 and 4 only)
Semivolatile POHC's and PIC's: Modified Method 5 (Runs 1-3 only)
HCl: Modified Method 5 (Runs 1-3 only)
Particulate: Modified Method 5 (Runs 1-3 only)
Metals: Modified Method 5 (Run 2 only)
CO_2 and O_2: gas bag for Orsat analysis

Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
HC - Beckman Model 402 (FID)
Dioxins and furans (tetra- and penta-chlorinated only) - Modified Method 5

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %
Volatiles		
Chloroform	0.0154	99.70[a]
Carbon tetrachloride	0.163	99.984[a]
Trichloroethylene	0.166	99.981[a]
Tetrachloroethylene	0.582	99.9968[a]
Toluene	2.47	99.99923[a]
Semivolatiles		
Phenol	0.148[b]	99.979[b,c]
Naphthalene	0.0174[b]	99.85[b,c]
Diethyl phthalate	0.0524	99.962[c]
Butyl benzyl phthalate	0.0227	99.9938[c]

[a]Data from gas bags (see comments).
[b]Results are suspect, based on QA analysis of data.
[c]Data from Modified Method 5.

HCl: 0.64 lb/h (0.29 kg/h) or 99.5% removal
Particulate: Not reported - sample lost
THC: <1 ppm avg.
CO: 12.9 ppm avg.
Other: O_2 11.8 ppm avg. CO_2 6.7 ppm avg.
Dioxins and furans: See comments
Metals: See comments
PIC's:

PIC	Emissions, g/min
Volatiles	
Benzene	0.011[a]
Semivolatiles	
m-Dichlorobenzene	0.00065[b]
p-Dichlorobenzene	0.00035[b]
o-Dichlorobenzene	0.00075[b]
1,2,4-Trichlorobenzene	0.0014[b]
Dimethyl phthalate	<0.00015[b]
Hexachlorobenzene	0.0018[b]

[a]Data from gas bags; not blank corrected (see comments).
[b]Data from Modified Method 5; not blank corrected.

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full Scale Hazardous Waste Incinerators, Final Report Volumes II and IV (Appendix D). EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, MO.

Comments: This test report contained no process information or description of the incinerator at this site (Plant B). It also did not describe the test conditions for any of the runs. Conditions during Runs 1-3 were reported as normal, but conditions during Runs 4-5 were purposely altered from normal to study the effect on performance. The nature of the alternations is not described, although the temperatures in Runs 4 and 5 were reported to be about 200°F lower than the average temperature reported for Runs 1, 2, and 3.

Blank values for many of the VOST traps and gas bags used in this test were sufficiently high to significantly complicate the calculation of volatile POHC emission rates. Thus, the volatile POHC emission results should be viewed cautiously.

Tetra- and penta-chlorinated dioxins and furans were detected in the stack emissions at this site. Although three tetra-chlorinated dioxins were identified, 2,3,7,8-TCDD was not found. See Reference, Volume II, Pages 61-62.

Ash from the control device failed the EP toxicity test for cadmium. Run 2 stack emissions were tested for metals; of the 12 metals tested, lead, selenium, and chromium were emitted in the largest quantities.

Date of Test: July 21-26, 1982

Run No.: 2

Equipment information:

Type of unit: Incinerator - unspecified (see comments)
Commercial __ Private __ Not specified X
Capacity: Not reported
Pollution control system: Wet scrubber for HCl; particulate control device not discussed in Reference - see comments

Waste feed system: Not reported

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Two liquid wastes: one characterized only as organic and the other as aqueous. The organic waste was continuously spiked with a 50/50 mixture (by volume) of carbon tetrachloride and trichloroethylene.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported; waste heat content input during burn 24.9 x 10^6 Btuh during run
Waste feed rate: 61.6 lb/min aqueous; 33.7 lb/min organic; 95.3 lb/min total
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 4,350 Btu/lb total
Ash content: 2.40% total
Chlorine content: 2.69% total
Moisture content: 74.8% total

Operating Conditions:

Temperature: Range not reported
Average 1952°F (average of Runs 1, 2, and 3; temperature of this specific run not reported)
Auxiliary fuel used: Not reported

Excess air: 10.3% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*	*DRE, %*
Volatiles		
Chloroform	0.00740	>99.86[a]
Carbon tetrachloride	0.132	99.9928[b]
Trichloroethylene	0.136	>99.983[a]
Tetrachloroethylene	0.347	>99.9966[a]
Toluene	1.317	99.989[a]
Semivolatiles		
Phenol	0.169[c]	99.989[c,d]
Naphthalene	0.0118[c]	99.81[c,d]
Diethyl phthalate	0.0370	99.943[d]
Butyl benzyl phthalate	0.00416	99.92[d]

[a]Data from VOST (see comments).
[b]Data from gas bags.
[c]Results are suspect, based on QA analysis of data.
[d]Data from Modified Method 5.

HCl: 1.83 lb/h (0.83 kg/h) or 98.8% removal
Particulate: 0.187 gr/dscf @ 7% O_2
THC: <1 ppm avg.
CO: <1 ppm avg.
Other: O_2 10.3 ppm avg. CO_2 8.2 ppm avg.
Dioxins and furans: See comments, Run 1
Metals: See comments, Run 1
PIC's:

PIC	*Emissions, g/min*
Volatiles	
Benzene	0.0017[a]
Semivolatiles	
m-Dichlorobenzene	0.0013[b]
p-Dichlorobenzene	0.0010[b]
o-Dichlorobenzene	0.0018[b]
1,2,4-Trichlorobenzene	0.0020[b]
Dimethyl phthalate	<0.00012[b]
Hexachlorobenzene	0.0023[b]

[a]Data from VOST; not blank corrected (see comments).
[b]Data from Modified Method 5; not blank corrected.

Reference(s): See Run 1.

Comments: See comments for Run 1

Date of Test: July 21-26, 1982

Run No.: 3

Equipment information:

Type of unit: Incinerator - unspecified (see comments)
Commercial ___ Private ___ Not specified X
Capacity: Not reported
Pollution control system: Wet scrubber for HCl; particulate control device not specified (see comments)

Waste feed system: Not reported

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Two liquid wastes: one characterized only as organic, the other as aqueous. The organic waste was continuously spiked with a 50/50 mixture of carbon tetrachloride and trichloroethylene.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported; waste heat content input 21.5 x 10^6 Btuh
Waste feed rate: 88.5 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 4,050 Btu/lb total
Ash content: 2.21% total
Chlorine content: 2.11% total
Moisture content: 81.0% total

Operating Conditions:

Temperature: Range not reported
Average 1952°F (average of Runs 1, 2, and 3; temperature of this specific run not reported)
Auxiliary fuel used: Not reported

Excess air: 10.7% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*	*DRE, %*
Volatiles		
Chloroform	0.0102	99.66[a]
Carbon tetrachloride	0.142	99.976[a]
Trichloroethylene	0.147	<99.80[a]
Tetrachloroethylene	0.398	99.99918[a]
Toluene	1.62	99.9923[a]
Semivolatiles		
Phenol	0.249[b]	99.976[b,c]
Naphthalene	0.0177[b]	99.927[b,c]
Diethyl phthalate	0.0572	99.974[c]
Butyl benzyl phthalate	0.0149	99.9923[c]

[a]Data from gas bags (see comments).
[b]Results are suspect, based on QA analysis of the data.
[c]Data from Modified Method 5.

HCl: 4.47 lb/h (2.03 kg/h) or 96% removal
Particulate: 0.161 gr/dscf @ 7% O_2
THC: <1 ppm avg.
CO: 6.8 ppm avg.
Other: O_2 10.7 ppm avg.; CO_2 8.0 ppm avg.
Dioxins and furans: See comments Run 1
Metals: See comments Run 1
PIC's:

PIC	*Emissions, g/min*
Volatiles	
Benzene	0.0031[a]
Semivolatiles	
m-Dichlorobenzene	0.00058[b]
p-Dichlorobenzene	0.00046[b]
o-Dichlorobenzene	0.00067[b]
1,2,4-Trichlorobenzene	0.0011[b]
Dimethyl phthalate	0.00024[b]
Hexachlorobenzene	0.00035[b]

[a]Data from gas bags; not blank corrected (see comments).
[b]Data from Modified Method 5; not blank corrected.

Reference(s): Same as Run 1

Comments: See Comments for Run 1

Date of Test: July 21-26, 1982

Run No.: 4

Equipment information:

Type of unit: Incinerator - unspecified (see comments)
Commercial ___ Private ___ Not specified X
Capacity:
Pollution control system: Wet scrubber for HCl; particulate control device not specified (see comments)

Waste feed system: Not reported

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Two liquid wastes: one characterized as aqueous and the other as organic. The organic waste was continuously spiked with a 50/50 mixture (by volume) of carbon tetrachloride and trichloroethylene.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 103.0 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: Not reported
Ash content: Not reported
Chlorine content: Not reported
Moisture content: Not reported

Operating Conditions:

Temperature: Range not reported
Average 1776°F
Auxiliary fuel used: Not reported

Excess air: 14.3% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*	*DRE, %*
Volatiles		
Chloroform	0.00428	99.69[a]
Carbon tetrachloride	0.120	99.949[b]
Trichloroethylene	0.124	99.949[a]
Tetrachloroethylene	0.235	99.948[a]
Toluene	0.748	99.9940[a]
Semivolatiles		
Phenol	c	c
Naphthalene	c	c
Diethyl phthalate	c	c
Butyl benzyl phthalate	c	c

[a]Data from VOST (sample taken at inlet to control device; outlet data not collected). See comments.
[b]Data from gas bag; VOST sample had interference when analyzed.
[c]Semivolatiles not monitored during this run.

HCl: Not monitored
Particulate: Not monitored
THC: <1 ppm avg.
CO: 6.5 ppm avg.
Other: O_2 14.3 ppm avg.; CO_2 4.8 ppm avg.
Dioxins and furans: See comments Run 1
Metals: See comments Run 1
PIC's:

PIC	*Emissions, g/min*
Volatiles	
Benzene	0.0057[a]
Semivolatiles	
m-Dichlorobenzene	b
p-Dichlorobenzene	b
o-Dichlorobenzene	b
1,2,4-Trichlorobenzene	b
Diemethyl phthalate	b
Hexachlorobenzene	b

[a]Data from VOST; not blank corrected (see comments).
[b]Semivolatiles not monitored during this run.

Reference(s): Same as Run 1.

Comments: See comments for Run 1

CONFIDENTIAL SITE B

Date of Test: July 21-26, 1982

Run No.: 5

Equipment information:

Type of unit: Incinerator - unspecified (see comments)
Commercial __ Private __ Not specified X
Capacity: Not reported
Pollution control system: Wet scrubber for HCl; particulate control device not specified

Waste feed system: Not reported

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Two liquid wastes: one characterized as organic and the other as aqueous. The organic waste was spiked continuously with a 50/50 mixture (by volume) of carbon tetrachloride and trichloroethylene

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 91.1 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSIONS AND DRE RESULTS	

Btu content: Not reported
Ash content: Not reported
Chlorine content: Not reported
Moisture content: Not reported

Operating Conditions:

Temperature: Range not reported
Average 1753°F
Auxiliary fuel used: Not reported

Excess air: 10.1% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*	*DRE, %*
Volatiles		
Chloroform	0.00725	97.9[a]
Carbon tetrachloride	0.118	99.63[a]
Trichloroethylene	0.123	<99.80[a]
Tetrachloroethylene	0.290	99.937[a]
Toluene	1.30	99.982[a]
Semivolatiles		
Phenol	b	b
Naphthalene	b	b
Diethyl phthalate	b	b
Butyl benzyl phthalate	b	b

[a]Data from gas bags (see comments).
[b]Not reported. Semivolatiles not monitored during this run.

HCl: Not monitored
Particulate: Not monitored
THC: 277 ppm
CO: 3347 ppm
Other: O_2 10.1 ppm avg.; CO_2 8.0 ppm avg.
Dioxins and furans: See comments Run 1
Metals: See comments Run 1
PIC's:

PIC	*Emissions, g/min*
Benzene	>0.027[a]
m-Dichlorobenzene	b
p-Dichlorobenzene	b
o-Dichlorobenzene	b
1,2,4-Trichlorobenzene	b
Dimethyl phthalate	b
Hexachlorobenzene	b

[a]Data from gas bags; not blank corrected (see comments).
[b]Semivolatiles not monitored during this run.

Reference(s): Same as Run 1.

Comments: See comments for Run 1

Summary of Test Data for Dow Chemical U.S.A.
Midland, Michigan

Date of Test: October 21, 1982

Run No.: 10212-1 ***Test Sponsor:*** Dow

Equipment information:
Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private X
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.42 s

Test Conditions:
Waste feed data:
Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 5,627 lb/h (process waste); 22 yd^3/h (rubbish); 8 yd^3/h (sludge); 9.4 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 6,550 Btu/lb (process waste); 1,657 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Range 1,297 to 1,526°F (kiln); 1,801 to 1,830°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 14.2% O_2

Monitoring Methods:
POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:
POHC's: 1,1,1 trichloroethane - 99.996% DRE

HCl: 3 mg/m^3 (99.98% removal efficiency)
Particulate: 0.021 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 480 ppm
Other:
PIC's:

Reference(s): Dow RCRA Part B Application - Trial Burn Report, submitted to EPA Region V

Process Flow Diagram: Not Available

Date of Test: October 21, 1982

Run No.: 10212-2

Equipment information:

Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.40 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 4,882 lb/h (process waste); 22 yd^3/h (rubbish); 8 yd^3/h (sludge); 9.3 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 6,982 Btu/lb (process waste); 1,290 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1,179° to 1,285°F (kiln); 1,798° to 1,821°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 14.5% O_2

Monitoring Methods:

POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:

POHC's: 1,1,1 trichloroethane - 99.998% DRE

HCl: 5 mg/m^3 (99.97% removal efficiency)
Particulate: 0.038 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 610 ppm
Other:
PIC's:

Reference(s): Same as Run 10212-1

Date of Test: October 27, 1982

Run No.: 10272-1

Equipment information:

Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.52 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 4,313 lb/h (process waste); 9 yd^3/h (rubbish); 4.5 yd^3/h (sludge); 10 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 9,063 Btu/lb (process waste); 740 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1,063° to 1,454°F (kiln); 1,782° to 1,823°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 13.7% O_2

Monitoring Methods:

POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:

POHC's: Trichlorobenzene - 99.995% DRE

HCl: 42 mg/m^3 (99.69% removal efficiency)
Particulate: 0.029 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 100 ppm
Other:
PIC's:

Reference(s): See Run 10212-1

Date of Test: October 27, 1982

Run No.: 10272-2

Equipment information:
Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.45 s

Test Conditions:
Waste feed data:
Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 5,275 lb/h (process waste); 9 yd^3/h (rubbish); 4.5 yd^3/h (sludge); 10 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 9,064 Btu/lb (process waste); 1,842 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Range 1,189° to 1,312°F (kiln); 1,812° to 1,828°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 14.4% O_2

Monitoring Methods:
POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:
POHC's: Trichlorobenzene - 99.992% DRE

HCl: 32 mg/m^3 (99.8% removal efficiency)
Particulate: 0.029 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 150 ppm
Other:
PIC's:

Reference(s): See Run 10212-1

Date of Test: October 25, 1982

Run No.: 10252-2

Equipment information:
Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.34 s

Test Conditions:
Waste feed data:
Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 1,718 lb/h (process waste); 15 yd^3/h (rubbish); 4.5 yd^3/h (sludge); 19.7 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 3,444 Btu/lb (process waste)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Range 1,081° to 1,299°F (kiln); 1,805° to 1,852°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 14.5% O_2

Monitoring Methods:
POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:
POHC's:

HCl: 5 mg/m^3 (99.92% removal efficiency)
Particulate: 0.080 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 480 ppm
Other:
PIC's:

Reference(s): See Run 10212-1

DOW CHEMICAL

Date of Test: October 25, 1982

Run No.: 10252-3

Equipment information:

Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.35 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 1,718 lb/h (process waste); 8.52 yd^3/h (rubbish); 15 yd^3/h (sludge); 20.4 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 4,486 Btu/lb (process waste)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1,081° to 1,413°F (kiln); 1,816° to 1,837°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 14.7% O_2

Monitoring Methods:

POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:

POHC's:

HCl: 5 mg/m^3 (99.91% removal efficiency)
Particulate: 0.087 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 610 ppm
Other:
PIC's:

Reference(s): See Run 10212-1

Date of Test: November 30, 1982

Run No.: 11302-2

Equipment information:

Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private X
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.50 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 4,512 lb/h (process waste); 9 yd^3/h (rubbish); 4.5 yd^3/h (sludge); 5.8 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 9,222 Btu/lb (process waste); 1,032 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1,420° to 1,621°F (kiln); 1,825° to 1,891°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 13.6% O_2

Monitoring Methods:

POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:

POHC's: Carbon Tetrachloride - 99.999% DRE

HCl: 22 mg/m^3 (99.35% removal efficiency)
Particulate: 0.024 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 30 ppm
Other:
PIC's:

Reference(s): See Run 10212-1

Date of Test: November 30, 1982

Run No.: 11302-3

Equipment information:

Type of unit: Incinerator - rotary kiln with secondary chamber
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber, demister, and wet ESP

Waste feed system: Liquid pumped from storage tank

Residence time: 1.49 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Process waste, rubbish, and sludge

Length of burn:
Total amount of waste burned:
Waste feed rate: 4,862 lb/h (process waste); 9 yd^3/h (rubbish); 4.5 yd^3/h (sludge); 8.3 gpm (liquid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 trichloroethane	
Trichlorobenzene	
Carbon tetrachloride	

Btu content: 10,553 Btu/lb (process waste); 1,128 Btu/lb (sludge)
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1,449° to 1,537°F (kiln); 1,827° to 1,834°F (Secondary chamber)
Auxiliary fuel used: Natural gas

Excess air: 13.5% O_2

Monitoring Methods:

POHC's:
HCl: Method 13
Particulate: Method 5 and MAPCC Method 5C
Other: CO - Ecolyzer

Emission and DRE Results:

POHC's: Carbon tetrachloride - 99.996% DRE

HCl: 16 mg/m^3 (99.67% removal efficiency)
Particulate: 0.022 lb/1000 lb exhaust gas @ 50% excess air
THC:
CO: 125 ppm
Other:
PIC's:

Reference(s): Same as Run 10212-1

Summary of Test Data for E. I. DuPont de Nemours & Company, Inc.
La Place, Louisiana

Date of Test: November 17-18, 1982

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - two units (kiln and liquid incinerator) in parallel (See Attached Figures)

Commercial ___ Private X

Capacity: Not reported

Pollution control system: Kiln has an afterburner (secondary chamber); exhausts from both units are quenched and passed through a cyclone, then combined streams pass through an absorber.

Waste feed system: Liquid waste continually fed to both units; drummed waste fed to kiln intermittently

Residence time:

Gases - 6.5 s (kiln); 0.26 s (liquid waste incinerator, calculated)

Solids — 1 to 4 h (kiln)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid organic wastes; drummed solid wastes consisting of paint, filter cake, and coke wastes.

Length of burn: 2 hours (sampling time)

Total amount of waste burned: Not reported; heat input 18.0 x 10^6 Btuh (kiln) 16.4 x 10^6 Btuh (liquid incinerator), 34.4 x 10^6 Btuh (total)

Waste feed rate: 50.1 lb/min

POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 11,440 Btu/lb

Ash content: 2.44%

Chlorine content: 21.06%

Moisture content: 9.53%

Operating Conditions:

Temperature: Average - 1485°F (Kiln); 1832°F (Afterburner); 2642°F (Liquid incinerator)

Auxiliary fuel used: Natural gas (for startup only)

Excess air: 9.2% O_2

Monitoring Methods:

Waste Feed:

One composite per run made up of grab samples taken every 15 minutes during run

Combustion Emissions:

Volatile POHC's and PIC's: gas bags and VOST

Semivolatile POHC's and PIC's: Modified Method 5

HCl: Modified Method 5

Particulate: Modified Method 5

Metals: Modified Method 5

CO_2 and O_2: gas bag for Orsat analysis

Continuous monitors:

CO_2 - Horiba Model PIR-2000S (NDIR)

CO - Beckman Model 215A (NDIR)

O_2 - Beckman Model 742 (polarographic sensor)

HC - Beckman Model 402 (FID)

Dioxins and furans (tetra- and penta-chlorinated only) - Modified Method 5

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST	Fast VOST	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	1.71	>99.99941	99.99919	>99.99939	-
Chloroform	0.330	>99.9938	99.9929	99.989	-
1,1,1-Trichloroethane	0.000967	>99.932	99.928	>99.966	-
Carbon tetrachloride	6.16	99.99986	99.99990	99.99979	-
Trichloroethylene	0.277	99.9984	99.99971	>99.9917	-
Tetrachloroethylene	1.06	>99.99948	99.99937	>99.99911	-
Toluene	21.54	99.99986	99.99975	99.99980	-
cis-1,4-Dichloro-2-butene	1.63	>99.99990	99.99971	>99.999994	-
Semivolatiles					
trans-1,4-Dichloro-2-butene	4.40	-	-	-	>99.99990
Benzyl Chloride	0.211	-	-	-	>99.9996
Hexachloroethane	0.0440	-	-	-	>99.99
Naphthalene	0.0110	-	-	-	98.0

HCl: 0.518 lb/h
Particulate: 0.0147 gr/dscf @ 7% O_2
THC: 74.6 ppm
CO: 505 ppm
Other: Dioxins and furans: none detected
Metals: See comments

PIC's:

PIC	Gas bag	Emissions, g/min[a]		
		Slow VOST, avg.	Fast FOST, avg.	Modified Method 5
Volatiles				
Benzene	0.12	0.41	0.59	-
Chlorobenzene	0.0041	0.0017	0.0036	-
Bromodichloromethane	0.0021	0.0010	0.0016	-
Dibromochloromethane	0.00052	0.00016	0.00025	-
Bromoform	>0.000074	>0.00015	0.000044	-
Semivolatiles				
Phenol	-	-	-	0.0081

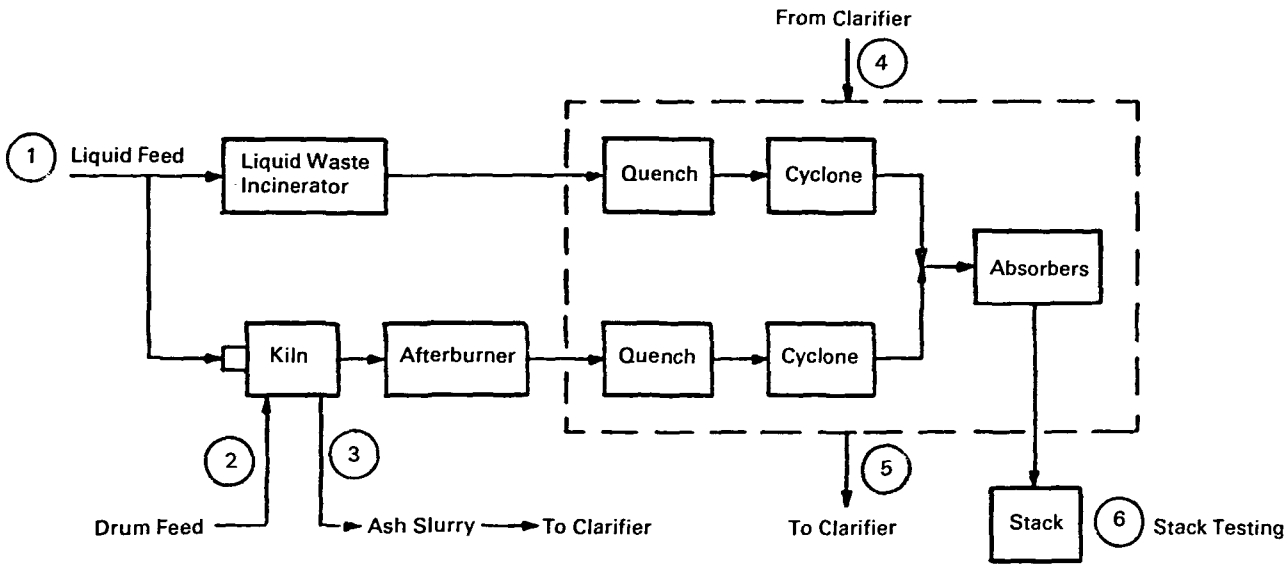
[a]Not blank corrected

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerators, Final Report, Volumes II and IV. EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, MO. EPA Project Officer - Mr. Don Oberacker, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH.

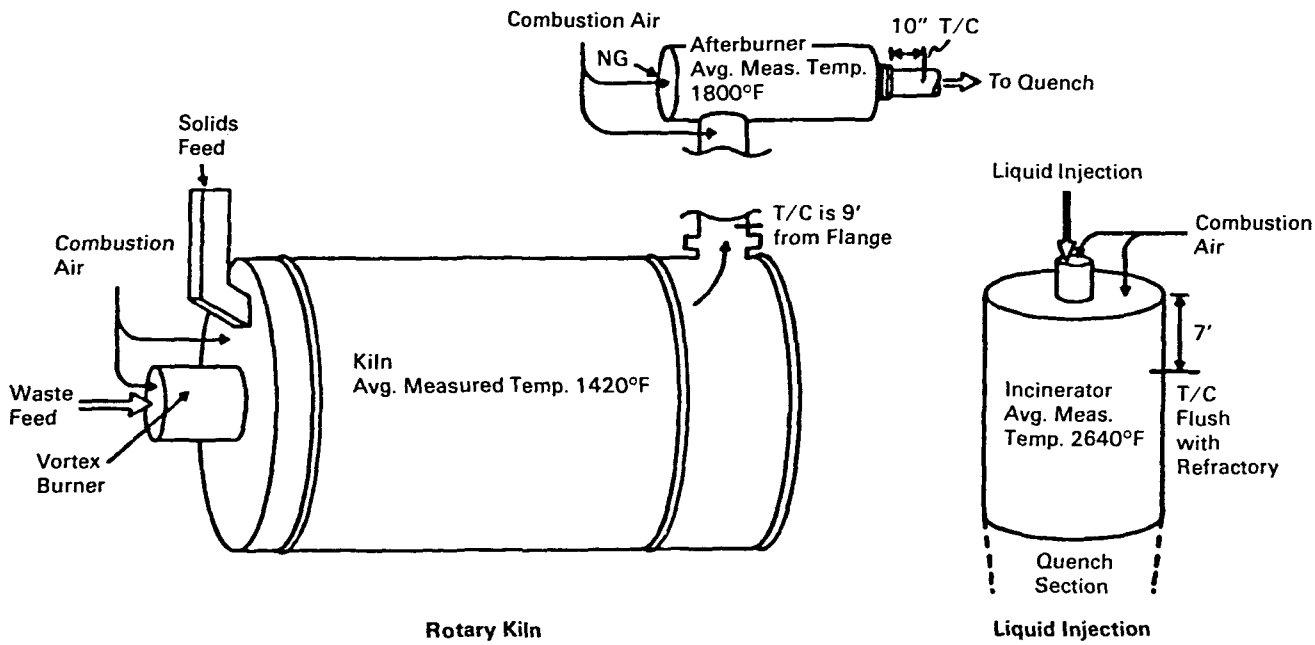
Comments: All runs were conducted under normal operating conditions. Chlorine and particulate emissions for all runs met EPA RCRA standards. Of the metals detected in the particulate emission, Ba, Cr, Ni, and Pb were detected most frequently; Ni and Pb appeared in the largest concentrations.

PROCESS FLOW DIAGRAM

Sampling points—Du Pont.



Combustion chamber configurations.



Rotary Kiln **Liquid Injection**

Note: T/C in kiln and afterburner extend inside, 3" post refractory T/C in liquid injector is flush with edge of brickwork. Chamber dimensions not available.

Date of Test: November 17-18, 1982

Run No.: 2

Equipment information:

Type of unit: Incinerator - two units in parallel
Commercial ___ Private X
Capacity:
Pollution control system: Kiln has an afterburner (secondary chamber); exhausts from both units are quenched and passed through a cyclone, then combined streams pass through an absorber.

Waste feed system: Liquid waste continually fed to both units; drummed waste fed to kiln intermittently

Residence time: 6.3 s (kiln); 0.25 s (liquid waste incinerator)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid organic wastes; drummed solid wastes consisting of paint, filter cake, and coke wastes.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported; heat input 16.4 x 10^6 Btuh (kiln), 16.3 x 10^6 Btuh (liquid incinerator), 32.7 x 10^6 Btuh (total)
Waste feed rate: 49.11 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE ATTACHED LIST

Btu content: 12,000 Btu/lb
Ash content: 1.99%
Chlorine content: 21.68%
Moisture content: 8.30%

Operating Conditions:

Temperature: Average - 1382°F (Kiln); 1787°F (Afterburner); 2642°F (Liquid incinerator)
Auxiliary fuel used: Natural gas (for startup only)

Excess air: 9.6% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST	Fast VOST	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	1.61	>99.9991	99.99954	99.99965	-
Chloroform	0.229	>99.987	99.989	99.986	-
1,1,1-Trichloroethane	<0.01	a	a	a	-
Carbon tetrachloride	5.38	99.99988	99.999928	b	-
Trichloroethylene	0.309	99.9990	99.99975	99.9907	-
Tetrachloroethylene	0.852	>99.99972	99.99960	>99.99922	-
Toluene	20.2	>99.999926	99.999926	>99.999921	-
cis-1,4-Dichloro-2-butene	1.39	>99.99998	>99.999991	>99.999994	-
Semivolatiles					
trans-1,4-Dichloro-2-butene	4.48	-	-	-	>99.99990
Benzyl Chloride	0.233	-	-	-	>99.9996
Hexachloroethane	0.0448	-	-	-	>99.99
Naphthalene	0.00897	-	-	-	99.10

[a]<100 μg/g in waste
[b]Quantitation prohibited due to interference in GC/MS analysis

HCl: 0.651 lb/h
Particulate: 0.0045 gr/dscf @ 7% O_2
THC: 45 ppm
CO: 250 ppm
Other: Dioxins and furans: none detected
Metals: see comments for Run 1
PIC's:

PIC	Emissions, g/min[a]			
	Slow VOST, avg.	Fast VOST, avg.	Gas bag	Modified Method 5
Volatiles				
Benzene	0.033	0.10	0.037	-
Chlorobenzene	0.0011	0.00071	0.00075	-
Bromodichloromethane	0.00034	0.00079	0.00097	-
Dibromochloromethane	<0.00034	0.00037	0.00030	-
Bromoform	<0.00015	0.000037	0.000075	-
Semivolatiles				
Phenol	-	-	-	0.0067

[a]Not blank corrected

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: November 17-18, 1982

Run No.: 3

Equipment information:

Type of unit: Incinerator - two units in parallel
Commercial ___ Private X
Capacity: 34.7 x 10^6 Btuh during test run
Pollution control system: Kiln has an afterburner (secondary chamber); exhausts from both units are quenched and passed through a cyclone, then combined streams pass through an absorber.

Waste feed system: Liquid waste continually fed to both units; drummed waste fed to kiln intermittently

Residence time: 6.9 s (kiln); 0.28 s (liquid waste incinerator)

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid organic wastes; drummed solid wastes consisting of paint, filter cake, and coke wastes.

Length of burn: 2 hours (sampling time)
Total amount of waste burned: Not reported; heat input 18.2 x 10^6 Btuh (kiln), 16.5 x 10^6 Btuh (liquid incinerator), 34.7 x 10^6 Btuh (total)
Waste feed rate: 50.18 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE ATTACHED LIST	

Btu content: 11,520 Btu/lb
Ash content: 2.06%
Chlorine content: 22.35%
Moisture content: 8.38%

Operating Conditions:

Temperature: Average - 1382°F (Kiln); 1773°F (Afterburner); 3642°F (Liquid incinerator)
Auxiliary fuel used: Natural gas (for startup only)

Excess air: 10.3% O_2

Monitoring Methods: See Run 1

DUPONT (LOUISIANA)

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST, avg.	Fast VOST, avg.	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	1.89	>99.9988	99.9989	>99.9987	-
Chloroform	0.404	99.9914	99.9917	99.9915	-
1,1,1-Trichloroethane	<0.01	a	a	a	-
Carbon tetrachloride	5.27	99.99981	99.99976	99.99956	-
Trichloroethylene	0.198	99.9951	99.9985	>99.988	-
Tetrachloroethylene	0.834	99.99926	99.99921	99.9951	-
Toluene	21.9	99.99986	99.999902	>99.99980	-
cis-1,4-Dichloro-2-butene	1.76	>99.99998	>99.999991	>99.999994	-
Semivolatiles					
trans-1,4-Dichloro-2-butene	5.27	-	-	-	>99.99992
Benzyl Chloride	0.219	-	-	-	>99.9994
Hexachloroethane	0.0395	-	-	-	>99.99
Naphthalene	0.00571	-	-	-	97.4

[a]<100 μg/g in waste

HCl: 0.896 lb/h
Particulate: 0.0108 gr/dscf @ 7% O_2
THC: 61 ppm
CO: 529 ppm
Other: Dioxins and furans: none detected
Metals: see comments for Run 1
PIC's:

PIC	Emissions, g/min[a]			
	Gas bag	Slow VOST, avg.	Fast FOST, avg.	Modified Method 5
Volatiles				
Benzene	0.14	0.56	0.046	-
Chlorobenzene	0.0021	0.0012	0.0014	-
Bromodichloromethane	0.0011	0.00096	0.0010	-
Dibromochloromethane	0.00093	0.00032	0.00050	-
Bromoform	0.00014	<0.00014	0.00015	-
Semivolatiles				
Phenol	-	-	-	0.0096

[a]Not blank corrected

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for E. I. DuPont de Nemours & Company, Inc.
Parkersburg, West Virginia

Date of Trial Burn: December 11-14, 1984

Run No.: DIES-2 (see comment)

Test Sponsor: DuPont

Equipment information:

Type of unit: Single-chamber liquid/gas incinerator - two vortex burners and a combustion chamber
Commercial __ Private X
Capacity: Each burner is 30 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid - pumped from storage tank; waste gas - direct from process vent

Residence time: Not measured

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gas waste from plastic (Delrin®) manufacturing

Length of burn: 3.5 h
Total amount of waste burned: 26,533 lb.
Waste feed rate: Liquid = 1,768 lb/h, Gas = 5,813 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde (liquid)	13.2% (wt.)
Formaldehyde (waste gas)	5.8% (wt.)

Btu content: 7,308 Btu/lb (liquid); 1,035 Btu/lb (gas)
Ash content: Less than 0.01%
Chlorine content: 0.10% (liquid)
Moisture content: 24.5% in stack; 63.4% in waste gas

Operating Conditions:

Temperature: Range 1722°-1744°F
Average - 1735°F
Auxiliary fuel used: Natural gas

Excess air: O_2 = 8.8% in incinerator chamber, wet basis
Other: 0.18% solids (in liquid)

Monitoring Methods:

POHC's: Modified Method 5 with DNPH solution
HCl: Not measured at outlet due to low feed content
Particulate: Modified Method 5
Other: CO - continuous monitor
Waste - gas by impinger train with 15% methanol in water followed by DNPH solution to indicate breakthrough
- liquid by tap samples recovered in 15% methanol-water solution

Emission and DRE Results:

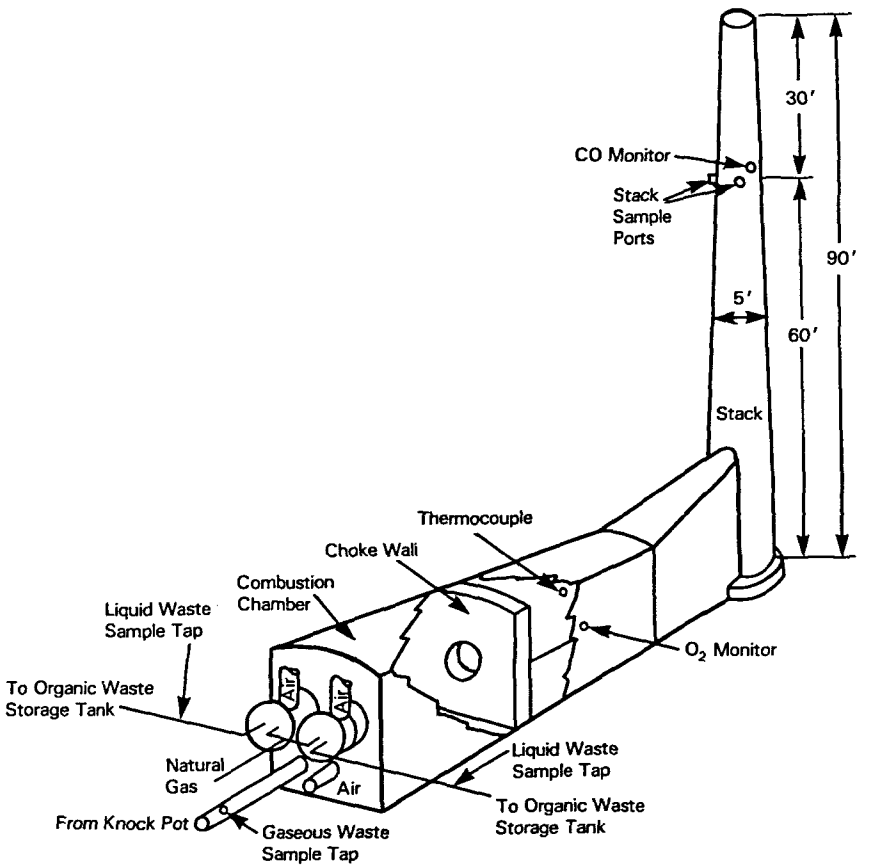
POHC	*DRE, %*
Formaldehyde	99.995

HCl: Not measured
Particulate: 0.018 gr/dscf at 7% O_2
THC: Not measured
CO: Less than 1 ppm
Other: O_2 - 13% (vol.)
PIC's:

Reference(s): RCRA Trial Burn Report, DuPont Washington Works Delrin® Incinerator, December 1984. Trial burn test by PEI Associates, Inc., Cincinnati, Ohio, Project No. 5300

Comments: DIES-1 not representative of normal operation; therefore, results for this run were not included in trial burn report

PROCESS FLOW DIAGRAM



Date of Trial Burn: December 11-14, 1985

Run No.: DIES-3

Equipment information:

Type of unit: Single-chamber liquid/gas incinerator - two vortex burners and combustion chamber

Commercial __ Private X

Capacity: Each burner is 30 x 10^6 Btuh

Pollution control system: None

Waste feed system: Liquid - pumped from storage tank; waste gas - direct from process vent

Residence time: Not measured

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gas waste from plastic (Delrin®) manufacturing

Length of burn: 3.25 h

Total amount of waste burned: 26,442 lb.

Waste feed rate: Liquid = 1,795 lb/h, Gas = 5,760 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde (liquid)	13.7% (wt.)
Formaldehyde (waste gas)	8.9% (wt.)

Btu content: 6,899 Btu/lb (liquid); 1,639 Btu/lb (gas)

Ash content: Less than 0.01%

Chlorine content: 0.04% (liquid)

Moisture content: 25.1% in stack; 59.7% in waste gas

Operating Conditions:

Temperature: Range 1684°-1771°F
Average - 1729°F

Auxiliary fuel used: Natural gas

Excess air: O_2 = 9.3% in incinerator chamber, wet basis

Other: 0.06% solids (in liquid)

Monitoring Methods: See Run DIES-2

Emission and DRE Results:

POHC	*DRE, %*
Formaldehyde	99.997

HCl: Not measured

Particulate: 0.017 gr/dscf at 7% O_2

THC: Not measured

CO: Approximately 1 ppm

Other: O_2 - 12.3% (vol.)

PIC's: not measured

Reference(s): See Run DIES-2

Comments: See Run DIES-2

Process Flow Diagram: See Run DIES-2

DUPONT (WEST VIRGINIA)

Date of Trial Burn: December 11-14, 1985

Run No.: DIES-4

Equipment information:

Type of unit: Single-chamber liquid/gas incinerator - two vortex burners and a combustion chamber

Commercial __ Private X

Capacity: Each burner is 30 x 10^6 Btuh

Pollution control system: None

Waste feed system: Liquid - pumped from storage tank; waste gas - direct from process vent

Residence time: Not measured

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gas waste from plastic (Delrin®) manufacturing

Length of burn: 3.75 h

Total amount of waste burned: 28,500 lb.

Waste feed rate: Liquid = 1,755 lb/h, Gas = 5,845 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration*
Formaldehyde (liquid)	11.4% (in liquid feed) 9.2% (in gas waste)

Btu content: 7,933 Btu/lb (liquid); 1,020 Btu/lb (gas)

Ash content: Less than 0.01%

Chlorine content: 0.12% (liquid)

Moisture content: 26.4% in stack; 61.3% in waste gas

Operating Conditions:

Temperature: Range 1666°-1728°F
Average - 1701°F

Auxiliary fuel used: Natural gas

Excess air: O_2 = 9.5% in incinerator chamber, wet basis

Other: 0.19% solids (in liquid)

Monitoring Methods: See Run DIES-2

Emission and DRE Results:

POHC	*DRE, %*
Formaldehyde	99.998

HCl: Not measured

Particulate: 0.017 gr/dscf at 7% O_2

THC: Not measured

CO: Less than 1 ppm

Other: O_2 - 13.0% (vol.)

PIC's: Not measured

Reference(s): See Run DIES-2

Comments: See Run DIES-2

Process Flow Diagram: See Run DIES-2

Date of Trial Burn: December 11-14, 1985

Run No.: DPIC-1

Equipment information:

Type of unit: Single-chamber liquid/gas incinerator - two vortex burners and a combustion chamber
Commercial ___ Private X
Capacity: Each burner is 30 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid - pumped from storage tank; waste gas - direct from process vent

Residence time: Not measured

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gas waste from plastic (Delrin®) manufacturing

Length of burn: 3 h
Total amount of waste burned: 22,365 lb.
Waste feed rate: Liquid = 1,692 lb/h, Gas = 5,760 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
See Comments	

Btu content: Not measured
Ash content: Not measured
Chlorine content: Not measured
Moisture content: 25.1%

Operating Conditions:

Temperature: Range 1661°-1742°F
Average - 1710°F
Auxiliary fuel used: Natural gas

Excess air: O_2 = 9.6% in incinerator chamber, wet basis
Other:

Monitoring Methods:

PIC's Modified Method 5 with XAD-2 resin

Emission and DRE Results:

POHC's: Not measured

HCl: Not measured
Particulate: Not measured
THC: Not measured
CO: Less than 1 ppm
Other: O_2 - 12.3% (vol.)
PIC's: Phthalates - 0.024 μg/dNm³
Polyaromatic hydrocarbons - 0.081 μg/dNm³
Alkylbenzenes - 0.236 μg/dNm³
Alkylaromatics - 0.528 μg/dNm³
Alkanes and alkenes - 0.497 μg/dNm³
Unknown - 0.009 μg/dNm³

Reference(s): See Run DIES-2

Comments: This run only tested for products of incomplete combustion (PIC's). The same waste as that used in Runs DIES-2, 3, and 4 was used for Runs DPIC-1 and 2. The waste was not analyzed during the PIC tests.

Process Flow Diagram: See Run DIES-2

DUPONT (WEST VIRGINIA)

Date of Trial Burn: December 11-14, 1985

Run No.: DPIC-2

Equipment information:

Type of unit: Single-chamber liquid/gas incinerator - two vortex burners and chamber combustion

Commercial __ Private X

Capacity: Each burner is 30 x 10^6 Btuh

Pollution control system: None

Waste feed system: Liquid - pumped from storage tank; waste gas - direct from process vent

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gas waste from plastic (Delrin®) manufacturing

Length of burn: 3 h

Total amount of waste burned: 23,022 lb

Waste feed rate: Liquid = 1,829 lb/h, Gas = 5,845 lb/h

POHC's selected and concentration in waste feed:

Name	*Concentration*

See comments for Run DPIC-1

Btu content: Not measured

Ash content: Not measured

Chlorine content: Not measured

Moisture content: 25.0%

Operating Conditions:

Temperature: Range 1719°-1760°F
Average - 1740°F

Auxiliary fuel used: Natural gas

Excess air: O_2 = 9.4% in incinerator chamber, wet basis

Other:

Monitoring Methods:

PIC's - Modified Method 5 with XAD-2 resin

Emission and DRE Results:

POHC's: Not measured

HCl: Not measured

Particulate: Not measured

THC: Not measured

CO: Less than 1 ppm

Other: O_2 - 11.7% (vol.)

PIC's:

Phthalates	-	0.020 μg/dNm³
Polyaromatic hydrocarbons	-	0.004 μg/dNm³
Alkylbenzenes	-	N. D. μg/dNm³
Alkylaromatics	-	0.001 μg/dNm³
Alkanes and alkenes	-	0.047 μg/dNm³
Unknown	-	0.029 μg/dNm³

Reference(s): See Run DIES-2

Comments: See Runs DIES-2 and DPIC-1

Process Flow Diagram: See Run DIES-2

Summary of Test Data for E. I. DuPont de Nemours & Company, Inc.
Wilmington, Delaware

Date of Test: April 2-6, 1984

Run No.: 1 ***Test Sponsor:*** DuPont

Equipment information:

Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 2.5 h
Total amount of waste burned: 6,000 lb
Waste feed rate: 2400 lb/h (includes 1,620 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	7.7%
Methylene chloride	7.7%

Btu content: 11,721 Btu/lb
Ash content:
Chlorine content: 13.05%
Moisture content:

Operating Conditions:

Temperature: Range 1730° to 2014°F; Average 1857°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 13.7% O_2

Monitoring Methods:

POHC's: VOST
HCl: Modified Method 5
Particulate: Modified Method 5
Other:
CO - Beckman Model 215A
O_2 - Beckman Model 742
THC - Beckman Model 402

Emission and DRE Results:

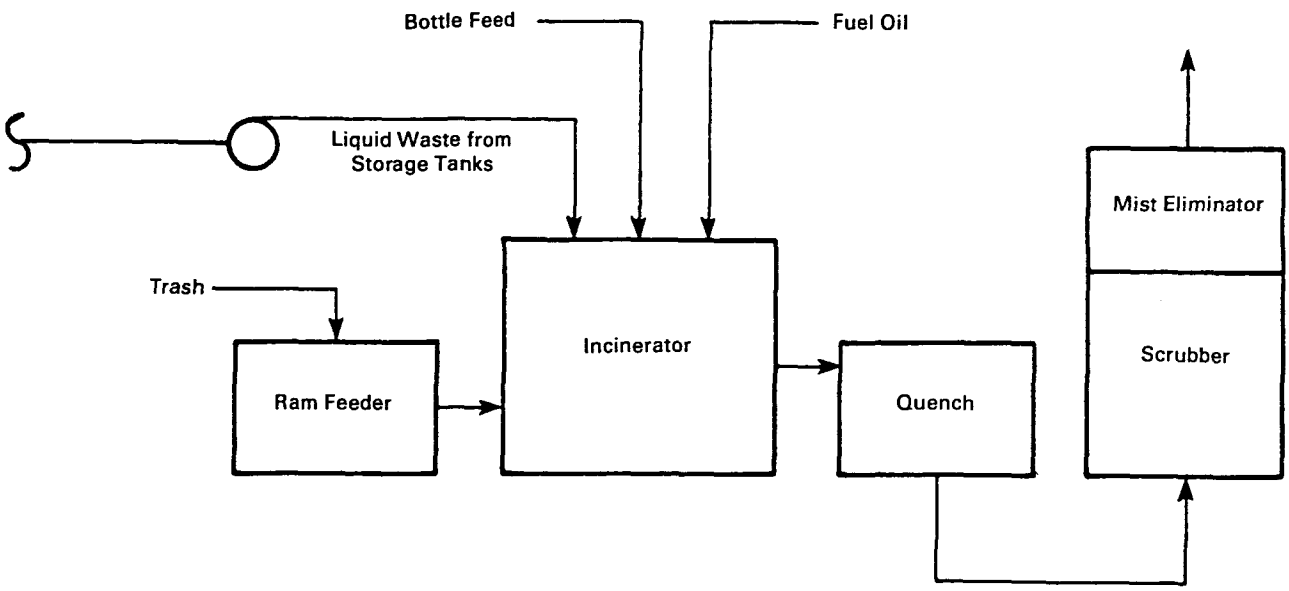
POHC's: Carbon tetrachloride - 99.9994% DRE
Methylene chloride - >99.9990% DRE

HCl: 1.086 lb/h (98.9% removal efficiency)
Particulate: 0.0705 gr/dscf @ 7% O_2
THC: 2.5 ppm
CO: 100 ppm
Other:
PIC's:

Reference(s): E. I. duPont de Nemours & Co. Inc., Wilmington, Delaware. Trial Burn Test Report, prepared by Midwest Research Institute, Kansas City, MO. (Project No. 8046-L), June 18, 1984.

Comments: Additional information available from Delaware DNR, Dover, Delaware.

PROCESS FLOW DIAGRAM



Date of Test: April 2-6, 1984

Run No.: 2

Equipment information:
Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 3.16 h
Total amount of waste burned: 9,150 lb
Waste feed rate: 2,895 lb/h (includes 2,175 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	7.5%
Methylene chloride	5.6%

Btu content: 17,229 Btu/lb
Ash content:
Chlorine content: 10.35%
Moisture content:

Operating Conditions:
Temperature: Range 1816° to 2096°F; Average 1906°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 13% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:
POHC's: Carbon tetrachloride - 99.99992% DRE
Methylene chloride - 99.9997% DRE

HCl: 0.0939 lb/h (98.7% removal efficiency)
Particulate: 0.0547 gr/dscf @ 7% O_2
THC: 1.7 ppm
CO: 35.3 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: April 2-6, 1984

Run No.: 3

Equipment information:
Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 2.08 h
Total amount of waste burned: 4,730 lb
Waste feed rate: 2,273 lb/h (includes 1,220 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	9.4%
Methylene chloride	7.1%

Btu content: 12,067 Btu/lb
Ash content:
Chlorine content: 13.05%
Moisture content:

Operating Conditions:
Temperature: Range 1781° to 1892°F; Average 1831°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 14.3% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:
POHC's: Carbon tetrachloride - 99.99944% DRE
Methylene chloride - 99.9997% DRE

HCl: 2.634 lb/h (98.1% removal efficiency)
Particulate: Not reported
THC: 3.1 ppm
CO: 27.5 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

DUPONT (DELAWARE)

Date of Test: April 2-6, 1984

Run No.: 4

Equipment information:

Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 3.33 h
Total amount of waste burned: 9,140 lb
Waste feed rate: 2,745 lb/h (includes 1,940 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	8.7%
Methylene chloride	8.0%

Btu content: 12,277 Btu/lb
Ash content:
Chlorine content: 13.0%
Moisture content:

Operating Conditions:

Temperature: Range 1764° to 1914°F; Average 1833°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 12.3% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: Carbon tetrachloride - 99.99992% DRE
Methylene chloride - 99.9997% DRE

HCl: 0.637 lb/h (98.4% removal efficiency)
Particulate: 0.0802 gr/dscf @ 7% O_2
THC: 2.2 ppm
CO: 16.5 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: April 2-6, 1984

Run No.: 5

Equipment information:

Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 2.05 h
Total amount of waste burned: 6,380 lb
Waste feed rate: 3,113 lb/h (includes 2,020 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	8.8%
Methylene chloride	6.1%

Btu content: 12,880 Btu/lb
Ash content:
Chlorine content: 12.27%
Moisture content:

Operating Conditions:

Temperature: Range 1734° to 1906°F; Average 1826°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 13.0% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: Carbon tetrachloride - 99.99991% DRE
Methylene chloride - 99.9998% DRE

HCl: 1.736 lb/h (98.7% removal efficiency)
Particulate: Not reported
THC: 1.9 ppm
CO: 13.5 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: April 2-6, 1984

Run No.: 6

Equipment information:
Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 2.5 h
Total amount of waste burned: 7,250 lb
Waste feed rate: 2,900 lb/h (includes 2,250 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	9.3%
Methylene chloride	6.7%

Btu content: 12,783 Btu/lb
Ash content:
Chlorine content: 12.97%
Moisture content:

Operating Conditions:
Temperature: Range 1756° to 2091°F; Average 1864°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 9.6% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:
POHC's: Carbon tetrachloride - 99.99993% DRE
Methylene chloride - 99.99990% DRE

HCl: 1.238 lb/h (98.7% removal efficiency)
Particulate: 0.0787 gr/dscf @ 7% O_2
THC: 0.4 ppm
CO: 17.9 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: April 2-6, 1984

Run No.: 7

Equipment information:
Type of unit: Incinerator - Nichols Monohearth, vertical cylinder
Commercial __ Private X
Capacity: 20 x 10^6 Btuh
Pollution control system: Spray quench, flooded disc scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks; solids ram fed; bottled wastes are drop fed

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: liquid wastes, trash, slurries and solids in bottles; liquids contain CCl_4, methylene chloride, methanol, and hexane

Length of burn: 2.25 h
Total amount of waste burned: 6,010 lb
Waste feed rate: 2,673 lb/h (includes 1,620 lb/h trash)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon tetrachloride (CCl_4)	9.2%
Methylene chloride	4.6%

Btu content: 17,450 Btu/lb
Ash content:
Chlorine content: 10.82%
Moisture content:

Operating Conditions:
Temperature: Range 1815° to 1897°F; Average 1842°F
Auxiliary fuel used: Types 0 and 1 trash (approximately 6,000 Btu/lb) and No. 2 fuel oil

Excess air: 11.1% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:
POHC's: Carbon tetrachloride - 99.99994% DRE
Methylene chloride - 99.9997% DRE

HCl: 1.288 lb/h (98.9% removal efficiency)
Particulate: Not reported
THC: 1.2 ppm
CO: 12.7 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Gulf Oil Corporation
Philadelphia, Pennsylvania

Date of Test: June 25, 1984

Run No.: 1 ***Test Sponsor:*** Gulf

Equipment information:

Type of unit: Incinerator - fluidized bed
Commercial __ Private X
Capacity: 2279 gal/h
Pollution control system: Multicyclone and venturi scrubber

Waste feed system: Liquids pumped from storage tanks

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Slop oil emulsion spiked with phenol, and sludge from oil/water separator

Length of burn: 6 h
Total amount of waste burned: 1692 gal (slop oil emulsion); 6540 gal (API sludge)
Waste feed rate: 4.2 to 5.1 gpm (slop oil emulsion); 17 to 21 gpm (API sludge)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Phenol	0.0707%*
Naphthalene	0.0793%*

Btu content: 8,542 Btu/lb*
Ash content: 46.1%*
Chlorine content: 0.092%*
Moisture content:

Operating Conditions:

Temperature: Range 1275° to 1340°F
Auxiliary fuel used: Fuel oil and refinery gas

Excess air: 3.1 to 4.5%

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Method 10
O_2 - Continuous

*Assumes both wastes have a density of 8 lb/gal

Emission and DRE Results:

POHC's: Phenol - 99.991% DRE
Naphthalene - 99.998% DRE

HCl: 0.12 lb/h (1.62 ppm)
Particulate: 0.027 gr/dscf @ 7% O_2
THC:
CO: 118.1 ppm
Other:
PIC's:

Reference(s): Gulf Oil Company, Philadelphia, Pennsylvania, Trial Burn Report, prepared by Scott Environmental Services, January 1985

Comments: Trial burn conducted under normal operating conditions. Waste feed rates tested were at upper end of normal feed rate range.

Process Flow Diagram: Not Available

Date of Test: June 25, 1984

Run No.: 2

Equipment information:
Type of unit: Incinerator - fluidized bed
Commercial __ Private X
Capacity: 2279 gal/h
Pollution control system: Multicyclone and venturi scrubber

Waste feed system: Liquids pumped from storage tanks

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Slop oil emulsion spiked with phenol, and sludge from oil/water separator

Length of burn: 5 h
Total amount of waste burned: 1,542 gal (slop oil emulsion); 6,270 gal (API sludge)
Waste feed rate: 4.8 to 5.7 gpm (slop oil emulsion); 18.5 to 23 gpm (API sludge)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Phenol	0.115%*
Naphthalene	0.0873%*

Btu content: 9,105 Btu/lb*
Ash content: 43.0%*
Chlorine content: 0.43%*
Moisture content:

Operating Conditions:
Temperature: Range 1285° to 1340°F
Auxiliary fuel used: Fuel oil and refinery gas

Excess air: 2.5 to 3.5%

Monitoring Methods:
POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Method 10
O_2 - Continuous

*Assumes both wastes have a density of 8 lb/gal

Emission and DRE Results:
POHC's: Phenol - 99.996% DRE
Naphthalene - 99.998% DRE

HCl: 0.12 lb/h (1.43 ppm)
Particulate: 0.053 gr/dscf @ 7% O_2
THC:
CO: 62.6 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: Not Available

GULF OIL

Date of Test: June 25, 1984

Run No.: 3

Equipment information:

Type of unit: Incinerator - fluidized bed
Commercial __ Private X
Capacity: 2279 gal/h
Pollution control system: Multicyclone and venturi scrubber

Waste feed system: Liquids pumped from storage tanks

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Slop oil emulsion spiked with phenol, and sludge from oil/water separator

Length of burn: 5 h
Total amount of waste burned: 1,368 gal (slop oil emulsion); 5,520 gal (API sludge)
Waste feed rate: 3.9 to 5.4 gpm (slop oil emulsion); 17 to 20 gpm (API sludge)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Phenol	0.0745%*
Naphthalene	0.0719%*

Btu content: 8,921 Btu/lb*
Ash content: 43.6%*
Chlorine content: 0.34%*
Moisture content:

Operating Conditions:

Temperature: Range 1285° to 1340°F
Auxiliary fuel used: Fuel oil and refinery gas

Excess air: 3.0 to 5.2%

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Method 10
O_2 - Continuous

*Assumes both wastes have a density of 8 lb/gal

Emission and DRE Results:

POHC's: Phenol - 99.993% DRE
Naphthalene - 99.998% DRE

HCl: 0.19 lb/h (2.36 ppm)
Particulate: 0.26 gr/dscf @ 7% O_2
THC:
CO: 21.4 ppm
Other:
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: Not Available

Summary of Test Data for McDonnell Douglas Corporation
St. Charles, Missouri

Date of Test: May 17, 18, 21, 22, 1984

Run No.: 1 - May 17

Test Sponsor: McDonnell Douglas

Equipment information:
Type of unit: Incinerator - 2-chamber pyrolytic
Commercial ___ Private X
Capacity: 330 lb/h
Pollution control system: Caustic wet gas scrubber

Waste feed system:

Residence time:

Test Conditions:
Waste feed data:
Type of waste(s) burned: Kester 5235, Dow Chlorothane, J&S Super Strip, TCE, CCl_4, Diatomaceous Earth

Length of burn: 8.0 h
Total amount of waste burned: 1981.5 lb
Waste feed rate: 330 lb/h (design)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon Tetrachloride (CCl_4)	8.1%
1,1,1-trichloroethane (1,1,1-TCE)	59%
Trichloroethylene (TCE)	21%
Tetrachloroethylene	<0.6%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:
Temperature: Range 1775° - 2200°F (design)
Average Approximately 1800°F
Auxiliary fuel used:

Excess air: 12.9% O_2

Monitoring Methods:
POHC's: VOST
HCl:
Particulate:
Other:

Emission and DRE Results:
POHC's: CCl_4 - 99.99996% DRE
1,1,1-TCE - 99.99999% DRE
TCE - 99.99998% DRE
Tetrachloroethylene - 99.99779% DRE

HCl: 1.67 lb/h
Particulate: 0.0468 gr/dscf @ 7% O_2
THC:
CO: 0%
Other:
PIC's:

Reference(s): McDonnell Douglas Corp., St. Charles, MO. Trial Burn Test Report by Environmental Science and Engineering, Inc., 1984.

Comments: Batch operation; starved air combustion in first chamber. Second chamber maintains combustion temperatures of up to 1800°F.

Process Flow Diagram: Not Available

MCDONNELL DOUGLAS

Date of Test: May 17, 18, 21, 22, 1984

Run No.: 3 - May 21

Equipment information:

Type of unit: Incinerator - 2-chamber pyrolytic
Commercial ___ Private X
Capacity: 330 lb/h
Pollution control system: Caustic wet gas scrubber

Waste feed system:

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Kester 5235, Dow Chlorothane, J&S Super Strip, TCE, CCl_4, Diatomaceous Earth

Length of burn: 8.75 h
Total amount of waste burned: 1981.5 lb
Waste feed rate: 330 lb/h (design)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon Tetrachloride (CCl_4)	8.9%
1,1,1-trichloroethane (1,1,1-TCE)	62%
Trichloroethylene (TCE)	18%
Tetrachloroethylene	<0.64%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1775° - 2200°F (design)
Average Approximately 1800°F
Auxiliary fuel used:

Excess air:

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.99998% DRE
1,1,1-TCE - 99.99999% DRE
TCE - 99.99999% DRE
Tetrachloroethylene - 99.99763% DRE

HCl: 1.64 lb/h
Particulate: 0.0438 gr/dscf @ 7% O_2
THC:
CO: 0%
Other: O_2 - 12.3%
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Date of Test: May 17, 18, 21, 22, 1984

Run No.: 4 - May 22

Equipment information:

Type of unit: Incinerator - 2-chamber pyrolytic
Commercial ___ Private X
Capacity: 330 lb/h
Pollution control system: Caustic wet gas scrubber

Waste feed system:

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Kester 5235, Dow Chlorothane, J&S Super Strip, TCE, CCl_4, Diatomaceous Earth

Length of burn: 10.3 h
Total amount of waste burned: 1927.5 lb
Waste feed rate: 330 lb/h (design)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Carbon Tetrachloride (CCl_4)	8.9%
1,1,1-trichloroethane (1,1,1-TCE)	70%
Trichloroethylene (TCE)	<0.5%
Tetrachloroethylene	<0.64%

Btu content:
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Range 1775° - 2200°F (design)
Average: Approximately 1800°F
Auxiliary fuel used:

Excess air: 12.9% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.99992% DRE
1,1,1-TCE - 99.999999% DRE
TCE - 99.99950% DRE
Tetrachloroethylene - 99.99710% DRE

HCl: 0.74 lb/h
Particulate: 0.0315 gr/dscf @ 7% O_2
THC:
CO: 0%
Other: O_2 - 13.0%
PIC's:

Reference(s): See Run 1

Comments: See Run 1

Summary of Test Data for Mitchell Systems Inc.
Spruce Pine, North Carolina

Date of Test: November 2-5, 1982

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Liquid incinerator - (two chambers) with solids capability
Commercial X Private ___
Capacity: 7.93 x 10^6 Btuh during test run; unit rated at 9.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: All wastes are pumped from holding or blending tanks. Liquid wastes are fed to the primary chamber by two air-atomized injectors.

Residence time: 2.5 s during run (2-3 s, typically)

Test Conditions:

Waste feed data:

Type of waste(s) burned: A liquid organic waste and an aqueous waste

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 1,308 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 6,060 Btu/lb
Ash content: 1.02%
Chlorine content: 0.633%
Moisture content: 55.7%

Operating Conditions:

Temperature: Average - 1850°F (Primary chamber); 1925°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: 9.4% O_2

Monitoring Methods:

Waste Feed:
One composite sample per waste per run made up of grab samples taken every 15 minutes during run.
Combustion Emissions:
Volatile POHC's and PIC's: gas bags (all runs) and VOST (Runs 1, 2, and 3 only)
Semivolatile POHC's and PIC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Metals: Not monitored
CO_2 and O_2: gas bag for Orsat analysis
Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
HC - Beckman Model 402 (FID)
Dioxins and furans (tetra- and penta-chlorinated only) - Modified Method 5

MITCHELL SYSTEMS

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST	Fast VOST	Gas bag	Modified Method 5
Volatiles					
Carbon tetrachloride	0.242	99.9970	99.99966	99.9975	-
Trichloroethylene	0.222	99.985	99.9975	99.975	-
Benzene	0.000101	a	a	a	-
Tetrachloroethylene	0.000647	a	a	a	-
Toluene	0.0738	>99.966	>99.9973	99.947	-
Methyl ethyl ketone	0.273	99.9965	>99.99957	99.9948	-
Semivolatiles					
Phenol	2.73	-	-	-	99.9985
Naphthalene	0.0192	-	-	-	99.96
Butyl benzyl phthalate	0.00758	-	-	-	>99.992
Bis (2-ethyl hexyl) phthalate	0.192	-	-	-	99.9985

[a]<100 μg/g in waste feed

HCl: 4.1 lb/h
Particulate: 0.491 g/scf @ 7% O_2
THC: <1 ppm
CO: 1.4 ppm
Other:
PIC's:

PIC	Emissions, g/min[a]			
	Slow VOST, avg.	Fast VOST, avg.	Gas bag	Modified Method 5
Volatiles				
Methylene chloride	<0.0016	0.000046	0.00067	-
Chloroform	0.00020	0.000095	0.000051	-
1,1,1-Trichloroethane	<0.00006	<0.000005	0.00013	-
Chlorobenzene	0.000061	0.000071	0.00092	-
Semivolatiles				
2,4-Dimenthylphenol	-	-	-	<0.00010

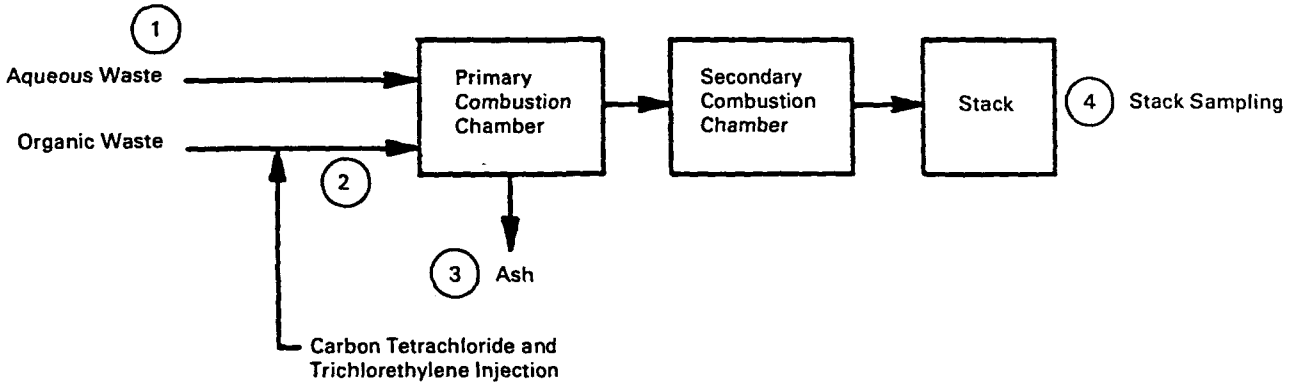
[a]Not blank corrected

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerators, Final Report, Volumes II and IV. EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, Missouri. Don Oberacker, EPA Project Officer, Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio.

Comments: The Mitchell Systems unit was operated near its rated capacity throughout the test. Process monitoring instruments indicated a relatively constant incinerator operation during the four test runs. Metals were not analyzed during this test. The unit has no pollution control system, and particulate and chloride emissions both exceeded RCRA standards. It should be noted that virtually all of the chlorinated materials in the waste feed were added for this test; carbon tetrachloride and trichloroethylene were spiked into the waste feed line during each run. Furans were detected in the particulate emissions but dioxins were not.

PROCESS FLOW DIAGRAM

Schematic diagram of incinerator with sampling locations.



MITCHELL SYSTEMS

Date of Test: November 2-5, 1982

Run No.: 2

Equipment information:

Type of unit: Liquid incinerator - (two chambers) with solids capability
Commercial X Private __
Capacity: 8.54 x 10^6 Btuh during test run
Pollution control system: None

Waste feed system: All wastes are pumped from holding or blending tanks; liquid waste fed to primary chamber by two air-atomized injectors

Residence time: 2.4 s during test (2-3 s, typically)

Test Conditions:

Waste feed data:

Type of waste(s) burned: A liquid organic waste and an aqueous waste

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 1,254 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 6,810 Btu/lb
Ash content: 1.36%
Chlorine content: 0.749%
Moisture content: 54.7%

Operating Conditions:

Temperature: Average - 2000°F (Primary chamber); 1950°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: 10.5% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST	Fast VOST	Gas bag	Modified Method 5
Volatiles					
Carbon tetrachloride	0.263	99.9981	99.99942	99.9984	-
Trichloroethylene	0.232	99.991	99.9977	>99.971	-
Benzene	0.0116	99.86	99.972	>99.976	-
Tetrachloroethylene	0.000126	a	a	a	-
Toluene	0.105	99.941	99.9926	>99.980	-
Methyl ethyl ketone	0.422	99.9952	99.99913	99.998	-
Semivolatiles					
Phenol	1.90	-	-	-	>99.99996
Naphthalene	0.0148	-	-	-	99.98
Butyl benzyl phthalate	0.0137	-	-	-	>99.995
Bis (2-ethyl hexyl) phthalate	0.169	-	-	-	99.993

[a]Waste feed concentration <100 μg/g

HCl: 4.9 lb/h
Particulate: 0.313 g/scf @ 7% O_2
THC: 1.8 ppm
CO: <1 ppm
Other:
PIC's:

PIC	Emissions, g/min[a]			
	Slow VOST, avg.	Fast VOST, avg.	Gas bag	Modified Method 5
Volatiles				
Methylene chloride	0.0016	0.00028	0.00081	-
Chloroform	0.00099	0.00015	0.000021	-
1,1,1-Trichloroethane	0.000084	0.000015	0.00010	-
Chlorobenzene	0.00061	0.000099	0.00079	-
Semivolatiles				
2,4-Dimenthylphenol	-	-	-	<0.00165

[a]Not blank corrected

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

MITCHELL SYSTEMS

Date of Test: November 2-5, 1982

Run No.: 3

Equipment information:

Type of unit: Liquid incinerator - two chambers with solids capability
Commercial X Private ___
Capacity: 9.96 x 10^6 Btuh during test run; unit rated at 9.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: All wastes are pumped from holding or blending tanks. Liquid wastes are fed to the primary chamber by two air-atomized injectors

Residence time: 2.2 s during run (2-3 s, typically)

Test Conditions:

Waste feed data:

Type of waste(s) burned: A liquid organic waste and an aqueous waste

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 1,243 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 8,010 Btu/lb
Ash content: 1.52%
Chlorine content: 0.480%
Moisture content: 49.5%

Operating Conditions:

Temperature: Average - 2050°F (Primary chamber); 2000°F (Secondary chamber)
Auxiliary fuel used: None

Excess air:

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, %			
		Slow VOST	Fast VOST	Gas bag	Modified Method 5
Volatiles					
Carbon tetrachloride	0.223	99.984	99.99946	99.9964	-
Trichloroethylene	0.202	99.9959	99.99906	>99.975	-
Benzene	0.00670	99.82	99.914	>99.88	-
Tetrachloroethylene	0.00861	>99.9929	>99.9985	>99.984	-
Toluene	0.0957	99.957	99.9916	>99.983	-
Methyl ethyl ketone	0.351	99.988	99.9979	99.9952	-
Semivolatiles					
Phenol	a	-	-	-	a
Naphthalene	a	-	-	-	a
Butyl benzyl phthalate	a	-	-	-	a
Bis (2-ethyl hexyl) phthalate	a	-	-	-	a

[a]<100 μg/g in waste feed

HCl: Not reported

Particulate: Not reported

THC:

CO:

Other:

PIC's:

PIC	Emissions, g/min[a]			
	Slow VOST, avg.	Fast VOST, avg.	Gas bag	Modified Method 5
Volatiles				
Methylene chloride	0.0014	0.00012	0.00020	-
Chloroform	0.0030	0.000092	0.000019	-
1,1,1-Trichloroethane	0.00010	<0.000005	0.000037	-
Chlorobenzene	0.00018	0.000071	0.00047	-
Semivolatiles				
2,4-Dimenthylphenol	-	-	-	b

[a]Not blank corrected

[b]Not reported

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

MITCHELL SYSTEMS

Date of Test: November 2-5, 1982

Run No.: 4

Equipment information:

Type of unit: Liquid incinerator - (two chambers) with solids capability
Commercial X Private ___
Capacity: 8.89 x 10^6 Btuh during test run (rated at 9.5 x 10^6 Btuh)
Pollution control system: None

Waste feed system: All wastes are pumped from holding or blending tanks. Liquids are fed to primary chamber by two air-atomized injectors

Residence time: 2.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: A liquid organic waste and an aqueous waste

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 1,304 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSIONS AND DRE RESULTS	

Btu content: 6,820 Btu/lb
Ash content: 0.79%
Chlorine content: 0.725%
Moisture content: 52.1%

Operating Conditions:

Temperature: Average - 1975°F (Primary chamber); 1975°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: 10.8% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %	DRE, % Gas bag	DRE, % Modified Method 5
Volatiles			
Carbon tetrachloride	0.243	99.9984	-
Trichloroethylene	0.223	>99.984	-
Benzene	0.00365	a	-
Tetrachloroethylene	0.00213	a	-
Toluene	0.0618	>99.970	-
Methyl ethyl ketone	0.284	99.987	-
Semivolatiles			
Phenol	1.72	-	>99.9996
Naphthalene	0.0395	-	99.986
Butyl benzyl phthalate	0.00649	-	>99.973
Bis (2-ethyl hexyl) phthalate	0.416	-	99.996

[a]Waste feed concentration <100 μg/g

HCl: 3.8 lb/h
Particulate: 0.378 g/scf @ 7% O_2
THC: <1 ppm
CO: <1 ppm
Other:
PIC's:

PIC	Emissions, g/min[a] Gas bag	Emissions, g/min[a] Modified Method 5
Methylene chloride	0.0016	-
Chloroform	0.000024	-
1,1,1-Trichloroethane	0.000035	-
Chlorobenzene	0.00079	-
2,4-Dimenthylphenol	-	<0.00014

[a]Not blank corrected

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Olin Corporation
Brandenburg, Kentucky

Date of Test: November 28, 1984

Run No.: 2a,b,c ***Test Sponsor:*** Olin

Equipment information:

Type of unit: Incinerator, liquid injection - Trane Thermal Company
Commercial ___ Private X
Capacity: (40 x 10^6 Btuh)
Pollution control system: Packed tower scrubber

Waste feed system: Single nozzle, atomized with 15 psi air, 150 gph max fuel flow, RipCo "R" Series, Tip No. LSA 100-22R

Test Conditions:

Waste feed data:

Type of waste(s) burned:
Synthetic liquid - 10.97% CCl_3F, 1.8% methylene chloride, 87.23% waste polyolefins
Gas - CCl_2F_2

Length of burn: 24 minutes total sampling time
Total amount of waste burned: 39 gal. (liquid); 41.5 scf (gas) during actual sampling
Waste feed rate: Liquid - 1.63 gpm; Gas - 1,726 scfm; Equivalent (liquid and gas) - 1.72 gpm
POHC's selected and concentration in waste feed:

Name	*Concentration*
Trichlorofluoromethane (CCl_3F)	10.32% (liquid and gas)
Dichlorodifluoromethane (CCl_2F_2)	5.79% (liquid and gas)

Btu content: 395.8 Btu/lb (gas only)
10,491 Btu/lb (liquid only)
Ash content: Not measured
Chlorine content: *9.99% calc.; 6.49 to 8.39% measured
Moisture content: Not measured

*Organic chlorine content of combined liquid and gas (CCl_2F_2) feed calculated to be 12.83%

Operating Conditions:

Temperature: Range 2040° to 2124°F
Average 2088°F
Primary fuel used: None used
Residence time: 0.54 s based on stack flow

Excess air: 4.4 - 7.9% O_2
Other: Combustion air flow rate - 98,000 scfh (avg.) (to be used as indicator of combustion gas velocity)

Scrubber water flow - 296 gpm
Total heat input - 9.678 x 10^6 Btuh

Monitoring Methods:

POHC's: EPA Publication No. 600/18-84-002, Method S010 (glass bulb method)
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO_2 - Method 3
O_2 - Method 3
CO - NDIR Rosemont Model 5100 continuous monitor

Emission and DRE Results:

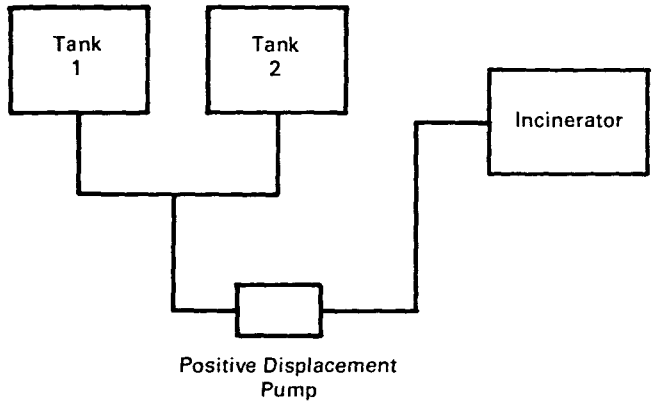
POHC's: CCl_3F >99.9998%
CCl_2F_2 >99.9998

HCl: 0.71 lb/h (avg.) measured as HCl
Particulate: 0.052 gr/dscf corrected to 7% O_2
THC: Not measured
CO: 16 ppm (avg.)
Other: N/A (scrubber waters were not analyzed)
PIC's: Not measured

Reference(s): Olin Part B Information, Section D, November, 1984. Hazardous Waste Incinerator Trial Burn Test Report, February 1985. Miscellaneous correspondence.

Comments: Liquid waste viscosity - 37.4 centistokes. Failure to sample waste feed for ash required another particulate burn to set permit conditions. See 8/13/85 test sheets.

PROCESS FLOW DIAGRAM



Date of Test: November 29, 1984

Run No.: 3a,b,c

Equipment information:

Type of unit: Incinerator, liquid injection - Trane Thermal Company
Commercial __ Private X
Capacity: 40 x 10^6 Btuh
Pollution control system: Packed tower scrubber

Waste feed system: Single nozzle, atomized with 15 psi air, 150 gph max fuel flow, RipCo "R" Series, Tip No. LSA 100-22R

Test Conditions:

Waste feed data:

Type of waste(s) burned:
Synthetic liquid - 14.85% CCl_3F, 2.54% methylene chloride, 82.61% waste polyolefins
Gas - CCl_2F_2

Length of burn: 24 minutes sampling time
Total amount of waste burned: 47 gal. (liquid); 49 scf (gas) during sampling
Waste feed rate: Liquid - 1.95 gpm; Gas - 2.05 scfm; Equivalent (liquid and gas) - 2.07 gpm
POHC's selected and concentration in waste feed:

Name	*Concentration*
Trichlorofluoromethane (CCl_3F)	14.02% (liquid and gas)
Dichlorodifluoromethane (CCl_2F_2)	5.61% (liquid and gas)

Btu content: 395.8 Btu/lb (gas only)
9,862 Btu/lb (liquid only)
Ash content: Not measured
Chlorine content: *13.62% calc.; 7.79 to 10.69% measured
Moisture content: Not measured

*Organic chlorine content of combined liquid and gas (CCl_2F_2) feed calculated to be 16.14%

Operating Conditions:

Temperature: Range 2071° - 2121°F
Average 2095°F
Primary fuel used: None used
Residence time: 0.46 s based on stack flow

Excess air: 3.3 - 5.1% O_2
Other: Combustion air flow rate - 103,000 scfh (avg.) (to be used as indicator of combustion gas velocity)

Scrubber water flow - 304 gpm
Total heat input - 11.186 x 10^6 Btuh

Monitoring Methods:

POHC's: EPA Publication No. 600/18-84-002, Method S010 (glass bulb method)
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO_2 - Method 3
O_2 - Method 3
CO - NDIR Rosemont Model 5100 continuous monitor

Emission and DRE Results:

POHC's: CCl_3F >99.9999%
CCl_2F_2 >99.9998

HCl: 1.16 lb/h (avg.) measured as HCl
Particulate: 0.031 gr/dscf corrected to 7% O_2
THC: Not measured
CO: 58 ppm (avg.)
Other: N/A (scrubber water was not analyzed)
PIC's: Not measured

Reference(s): See data sheet for Runs 2a,b,c

Comments: Liquid waste viscosity - 33.0 centistokes. Failure to sample waste feed for ash required another particulate burner to set permit conditions.

Process Flow Diagram: See Data Sheet for Runs 2a,b,c

OLIN

Date of Test: August 13, 1985

Run No.: 2,3,4 Particulate

Equipment information: See data for Runs 2a,b,c

Test Conditions:

Waste feed data:

Type of waste(s) burned: Waste polyolefins spiked with diatomaceous earth

Length of burn: 4.5 hours
Total amount of waste burned: 540 gallons
Waste feed rate: 2 gpm
POHC's: None tested

Btu content: None
Ash content: 0.83%
Chlorine content: None
Moisture content: Not measured

Operating Conditions:

Temperature: None
Auxiliary fuel used: None

Excess air: 1.8 - 4.7% O_2
Other: Scrubber water flow - 264 gpm

Monitoring Methods:

Particulate: Modified Method 5
Other: CO_2 - Method 3
CO - Method 3 and NDIR continuous monitor
O_2 - Method 3

Emission and DRE Results:

POHC's: Not measured

Particulate: 0.047 gr/dscf corrected to 7% O_2
THC: Not measured
CO: 1000 ppm
PIC's: Not measured

Reference(s): Kenvirons Report, Particulate Emissions From the Hazardous Waste Incinerator at the Olin Chemicals Group DOE Run Facility, August, 1985.

Comments: None

Process Flow Diagram: See Data for Runs 2a,b,c

Summary of Test Data for Pennwalt Corporation
Calvert City, Kentucky

Date of Test: December 3, 1983

Run No.: 22-1 ***Test Sponsor:*** Pennwalt

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial __ Private X
Capacity: 5×10^6 Btuh, 6.78 ft^2 cross section, (11.25 ft long inner chamber)
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Liquid waste pumped from storage, separated into liquid/gas phases. Gas waste consists of gas directly from process and gaseous portion of liquid waste. Liquid waste is steam-atomized (with a Trane External Atomizing Tip)

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b-rich liquid) and gas (Isotron® 143a-rich gas)

Length of burn: ~6 hours to collect all samples
Total amount of waste burned: ~4038 lb.
Waste feed rate: Total waste - 673 lb/h (liquid = 648 lb/h; gas = 25 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = 0.2%, liquid = 9.2%

Btu content: Not measured, 2730 Btu/lb typical liquid
Ash content: Ash not measured; liquid <5% solids
HCl content: Gas = 5.7%, liquid = 1.3% (inorganic)
Chlorine content*: Liquid 19.4% w/w; gas 23% c/o w/w measured as total equivalent HCl
Moisture content: Not measured
HF content: Gas 9%, liquid 30.5% (inorganic)
Total equivalent HF*: 28.4% gas, 50% liquid

*Total equivalent HF and HCl determined by total oxidation of the waste; includes organically bound F and Cl as well as inorganic acids.

Operating Conditions:

Temperature: 2220°F steady upper zone
Primary fuel used: Natural gas (3,270 scfh)
Combustion air feed rate: 1070 scfm (to be used as indicator of combustion gas velocity)
Excess air: Not determined; in stack - 2.6% O_2
Combustion gas velocity: 19 FPS average for all tests; calculated not measured

Monitoring Methods:

Waste liquid - Three grab samples, composited. Unique sampling and analysis procedures were designed to overcome extreme volatility of liquid and high level of anhydrous HF.
Waste gas - Two integrated samples. Unique sampling and analysis procedures were designed to handle high acid content. One sampling train for POHC and acid gases; one for metals.
POHC's: Modified Method 23 (VOST was inappropriate); 5 bag samples per run analyzed on site by GC/ECD
HCl: Modified Method 5, modified; IC analysis
Particulate: Modified Method 5, modified for metals and acid gases
Other: Continuous monitor for CO - Anarad Model 500 NDIR
CO_2 - Method 3
O_2 - Method 3

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - 99.997% DRE

HCl: 99.1% removal at 1.14 lb/h discharged
Particulate: 42.8 mg/dNm^3 at 7% O_2
THC: Not measured
CO: 23 ppm
PIC's: Not measured
Metals were measured in wastes, waters, and stack gases. See reference.
Other: HF = >99.9% removal at 331 lb/h input
POHC was either nondetectable or less than 1 µg/l in water streams for all runs.

Reference(s): "Trial Burn Test Report - Pennwalt Corporation Isotron® 142b Incinerator - Calvert City, Kentucky, December 1983" by PEI Associates, Inc., PN 5269, February 1984.

Part B Permit Application; Drawing Number 6-02-2923-0; and Appendix I.

Comments: Particulate tests were conducted at three different venturi pressure drop settings during the course of the entire trial burn with no apparent correlation.

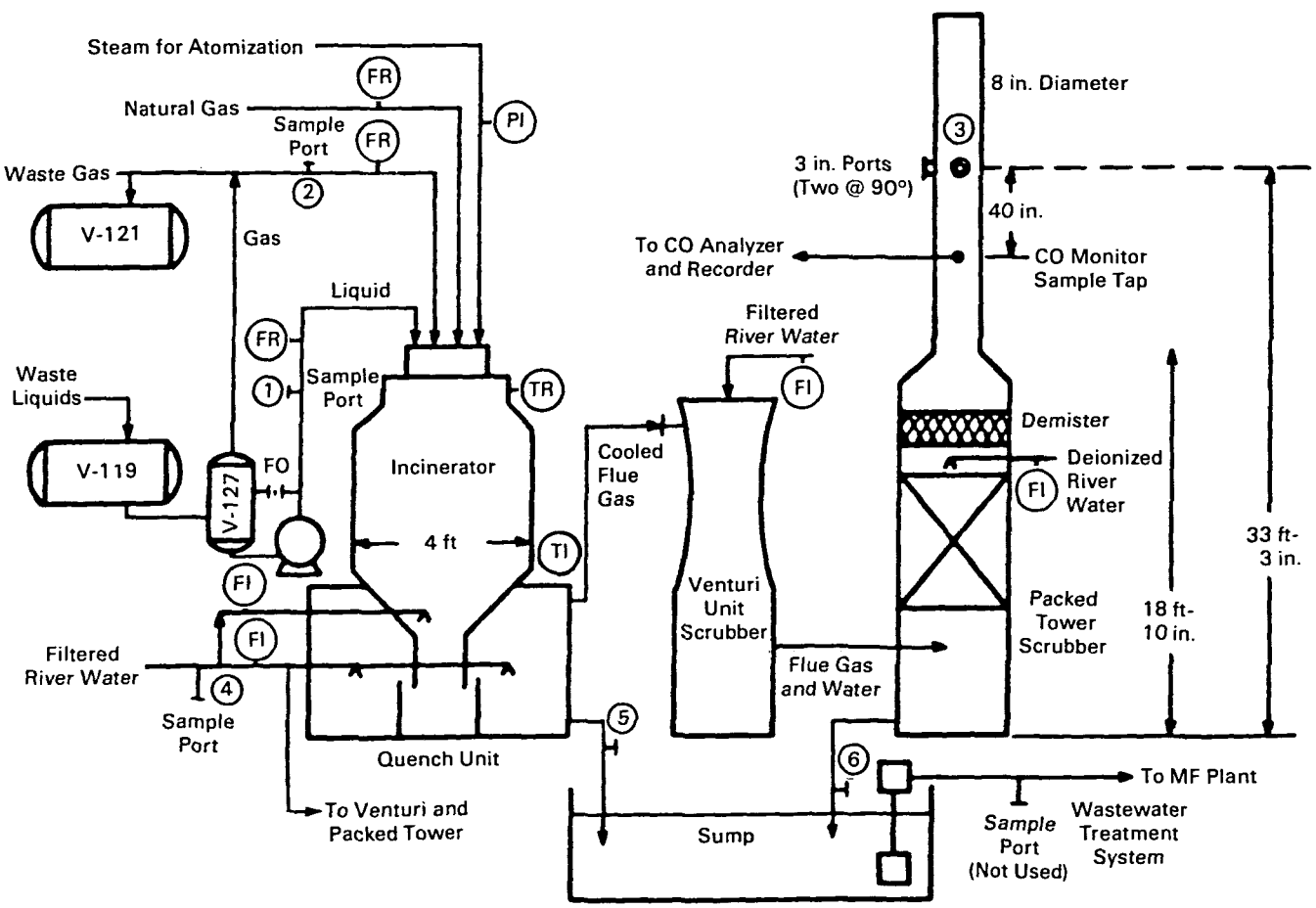
CO levels in stack gas may be biased high due to CO_2 inteference.

Report suggested that the F and Cl content of the composite waste feed based on direct waste analyses may not be as reliable as values determined based on scrubber effluent data.

Waste gas feed rate data highly variable for all tests except Run 23-2.

During this run, the CO level was highly variable and tripped the automatic liquid waste feed cutoff. The test was delayed approximately 1 hour.

PROCESS FLOW DIAGRAM



Date of Test: December 4, 1983

Run No.: 22-2

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial ___ Private X
Capacity: 5 x 10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~6½ hours to collect all samples
Total amount of waste burned: ~4472 lb
Waste feed rate: Total waste - 688 lb/h (liquid = 659 lb/h; gas = 29 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = <0.01%, liquid = 10.7%

Btu content: See Run 22-1
Ash content: See Run 22-1
HCl content: Gas = 22.1%, liquid = 1.2% (inorganics)
Total equivalent HCl: Liquid 25.9%, gas 33% (See Run 22-1)
Moisture content: Not measured
HF content: Gas 6.1%, liquid 29.5% (inorganic)
Total equivalent HF: 21.3% gas, 53.8% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2220°F steady upper zone
Primary fuel used: Natural gas (3,220 scfh)

Excess air: Not measured; in stack - 2.7%O_2
Other: Combustion air feed rate: 1080 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - 99.995% DRE

HCl: 99.5% removal at 0.99 lb/h discharged
Particulate: 16.9 mg/dNm^3 corrected to 7% O_2
THC: Not measured
CO: 25 ppm
Other: HF = >99.9% removal at 361 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1
- During this run, the automatic liquid waste cutoff was tripped by a high CO level spike. The test was delayed ~½ hour.

Process Flow Diagram: See Run 22-1

PENNWALT

Date of Test: December 5, 1983

Run No.: 22-3

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial __ Private X
Capacity: 5 x 10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~6 hours to collect all samples
Total amount of waste burned: ~4290 lb
Waste feed rate: Total waste - 715 lb/h (liquid waste = 653 lb/h; gas waste = 62 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = <0.01%, liquid = 19.3%

Btu content: See Run 22-1
Ash content: See Run 22-1
HCl content: Gas = 11.2%, liquid = 0.9% (inorganic)
Total equivalent HCl: Liquid 15.9% w/w, gas 23.8% (See Run 22-1)
Moisture content: Not measured
HF content: Gas 6.4%, liquid 22.7% (inorganic)
Total equivalent HF: 21.9% gas, 35.6% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2220°F steady upper zone
Primary fuel used: Natural gas (2,700 scfh)

Excess air: Not determined; stack = 4.1%O_2
Other: Combustion air feed rate: 1070 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - >99.999% DRE

HCl: 98.9% removal at 1.34 lb/h discharged
Particulate: 8.6 mg/dNm^3 @ 7% O_2
THC: Not measured
CO: 32 ppm
Other: HF = >99.9% removal at 246 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1

Process Flow Diagram: See Run 22-1

Date of Test: December 9, 1983

Run No.: 22-4

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial ___ Private X
Capacity: 5×10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~7 hours to collect all samples
Total amount of waste burned: ~5621 lb
Waste feed rate: Total waste - 803 lb/h (liquid waste = 649 lb/h; gas waste = 154 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = 3.68%, liquid = 17.7%

Btu content: See Run 22-1
Ash content: See Run 22-1
HCl content: Gas = 12.8%, liquid = 0.4% (inorganic)
Total equivalent HCl: Liquid 37.8%, gas 18.6% (See Run 22-1)
Moisture content: Not measured
HF content: Gas 8.6%, liquid 19.1% (inorganic)
Total equivalent HF: 23.9% gas, 48.1% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2220°F steady upper zone
Primary fuel used: Natural gas (2,930 scfh)
Excess air: Not determined, stack = 3.9%O_2
Other: Combustion air feed rate: 1070 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - >99.999% DRE

HCl: 99.7% removal at 0.86 and 0.58 lb/h (0.72 lb/h average) discharged
Particulate: 9.7 and 11.5 mg/dNm^3 (10.6 average) at 7% O_2 (two samples collected)
THC: Not measured
CO: 27 ppm
Other: HF = >99.9% removal at 349 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1

Process Flow Diagram: See Run 22-1

Date of Test: December 6, 1983

Run No.: 23-1

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial__ Private X
Capacity: 5 x 10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~6 hours to collect all samples
Total amount of waste burned: ~4344 lb
Waste feed rate: Total waste - 724 lb/h (liquid waste = 650 lb/h; gas waste = 74 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = 0.26%, liquid = 10.2%

Btu content: See Run 22-1
Ash content: See Run 22-1
HCl content: Gas = 9.7%, liquid = 1.4%
Total equivalent HCl: Liquid 10.2%, gas 16.9% (See Run 22-1)
Moisture content: Not measured
HF content: Gas 5.0%, liquid 27.9% (inorganic)
Total equivalent HF: 18.7% gas, 37.5% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2300°F steady upper zone
Primary fuel used: Natural gas (3,250 scfh)

Excess air: Not determined; stack = 2.4%O_2
Other: Combustion air feed rate: 1080 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - >99.999% DRE

HCl: 98.9% removal at 0.90 lb/h discharged
Particulate: 6.5 mg/dNm^3 at 7% O_2
THC: Not measured
CO: 46 ppm
Other: HF = >99.9% removal at 257 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1

Process Flow Diagram: See Run 22-1

Date of Test: December 7, 1983

Run No.: 23-2

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial __ Private X
Capacity: 5 x 10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~8 hours to collect all samples
Total amount of waste burned: ~5320 lb
Waste feed rate: Total waste - 665 lb/h (liquid waste = 660 lb/h; gas waste = 5 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = 0.80%, liquid = 15.2%

Btu content: See Run 22-1
Ash content: See Run 22-1
Total equivalent HCl: Liquid 36.5%, gas 34.3% (See Run 22-1)
HCl content: Gas = 25.9%, liquid = 0.9%
Moisture content: Not measured
HF content: Gas 5.5%, liquid 14.4% (inorganic)
Total equivalent HF: 16.1% gas, 35.9% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2300°F steady upper zone
Primary fuel used: Natural gas (2,800 scfh)

Excess air: Not determined; stack = 3.6%O_2
Other: Combustion air feed rate: 1080 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - >99.999% DRE

HCl: 99.4% removal at 1.44 and 1.26 lb/h (1.35 lb/h average) discharged
Particulate: 9.9 and 7.7 mg/dNm^3 (8.8 averages two samples) at 7% O_2
THC: Not measured
CO: 27 ppm
Other: HF = >99.9% removal at 238 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1

Process Flow Diagram: See Run 22-1

Date of Test: December 8, 1983

Run No.: 23-3

Equipment information:

Type of unit: Incinerator Trane Model LV-5, liquid injection
Commercial __ Private X
Capacity: 5×10^6 Btuh, 6.78 ft^2 cross section, 11.25 ft long inner chamber
Pollution control system: Quench chamber, venturi scrubber, and packed column

Waste feed system: Pumped from storage (liquid and gas). See Run 22-1

Residence time: Design - 0.75 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Proprietary liquids (Isotron® 142b reactor bottoms and Isotron® 141b) and gas (Isotron® 143a)

Length of burn: ~7 hours to collect all samples
Total amount of waste burned: ~5131 lb
Waste feed rate: Total waste - 733 lb/h (liquid waste = 650 lb/h; gas waste = 83 lb/h)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1-dichloro-1-fluoroethane	Gas = 1.55%, liquid = 16.1%

Btu content: See Run 22-1
Ash content: See Run 22-1
HCl content: Gas = 18.7%, liquid = 0.6% (inorganic)
Total equivalent HCl: Liquid 35.4%, gas 24.6% (See Run 22-1)
Moisture content: Not measured
HF content: Gas 6.4%, liquid 13.3% (inorganic)
Total equivalent HF: 23.9% gas, 37.6% liquid (See Run 22-1)

Operating Conditions:

Temperature: 2300°F steady upper zone
Primary fuel used: Natural gas (2,880 scfh)

Excess air: Not determined; stack = 3.2%O_2
Other: Combustion air feed rate : 1070 scfm

Monitoring Methods: See Run 22-1

Emission and DRE Results:

POHC's: 1,1-dichloro-1-fluoroethane - >99.999% DRE

HCl: 99.6% removal at 1.16 and 0.82 lb/h (0.99 lb/h average) discharged
Particulate: 9.4 and 8.9 mg/dNm^3 (9.2 average of two samples) at 7% O_2
THC: Not measured
CO: 19 ppm
Other: HF = >99.9% removal at 264 lb/h input
PIC's: Not measured
Metals: See Run 22-1

Reference(s): See Run 22-1

Comments: See Run 22-1

Process Flow Diagram: See Run 22-1

Summary of Test Data for Ross Incineration Services, Inc.
Grafton, Ohio

Date of Test: June 10, 1984

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber
Commercial __ Private X
Capacity: Not reported
Pollution control system: Two packed bed caustic scrubbers (in series) and an ionizing wet scrubber

Waste feed system: Liquid wastes are pumped into secondary chamber (the main incineration chamber) and drummed waste is conveyed into both the kiln and the secondary chamber

Residence time: 6.2 s calculated

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and miscellaneous drummed wastes

Length of burn: ~2 hours sampling time
Total amount of waste burned: Not reported; waste heat input 83 x 10^6 Btuh during test run
Waste feed rate: 13,210 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 6,280 Btu/lb
Ash content: 5.2%
Chlorine content: 3.6%
Moisture content: 47.4%

Operating Conditions:

Temperature: Average - 2110°F in secondary chamber
Primary fuel used: None

Excess air: 10.4% O_2

Monitoring Methods:

Waste Feed: One composite per run made up of grab samples taken every 15 minutes during run

Combustion Emissions:
Volatiles POHC's and PIC's: gas bags and VOST (Fast)
Semivolatiles POHC's and PIC's: Modified Method 5.
HCl: Modified Method 5
Particulate: Modified Method 5
Metals: Modified Method 5
CO_2 and O_2: Gas bag for Orsat analysis
Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
HC - Beckman Model 402 (FID)
Dioxins and furans (tetra- and penta-chlorinated only) - Modified Method 5

Emission and DRE Results:

POHC's:

Name	Concentration, wt. %	DRE, %		
		Fast VOST	Gas bag	Modified Method 5
Volatiles				
Carbon tetrachloride	0.16	>99.9964	99.9930	-
Trichloroethylene	1.04	>99.99963	99.989	-
Tetrachloroethylene	0.78	>99.9986	99.99925	-
Toluene	4.04	>99.99904	99.99946	-
Methylene chloride	0.23	>99.968[a]	99.9974[a]	-
Methyl ethyl ketone	0.86	99.99967	99.999943	-
1,1,1-Trichloroethane	2.55	99.99952	>99.99971	-
1,1,2-Trichloroethane	0.035	>99.999994	>99.9999	-
Semivolatiles				
N,N-Dimethylacetamide	0.83	-	-	>99.998
Phenol	0.012[b]	-	-	>99.997
2,4-Dimethylphenol	0.020	-	-	99.9992
Naphthalene	0.032[b]	-	-	>99.994[b]
Butyl benzyl phthalate	0.10	-	-	>99.9996
Phthalic anhydride	<0.01	-	-	c
Aniline	0.026			>99.998[d]
Methyl pyridine	0.025	-	-	>99.998
Cresol(s)	0.12	-	-	>99.9993

[a]Methylene chloride values should be viewed with caution due to high blank values and large difference in results between runs.
[b]Results suspect based on QA analysis of the data. Note that DRE for phenol is not suspect. See Reference Volume II, p. 101.
[c]Not calculable because of small amount in the waste.
[d]Aniline DRE may be biased high due to potential recovery problems from the XAD resin. See Reference Volume II, p. 102.

HCl: 0.149 lb/h
Particulate: 0.0609 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 4.8 ppm
CO_2: 7.9% avg. THC: <1 ppm avg. O_2: 10.4% avg.
Dioxins and furans: See comments
Metals: See comments

PIC's:

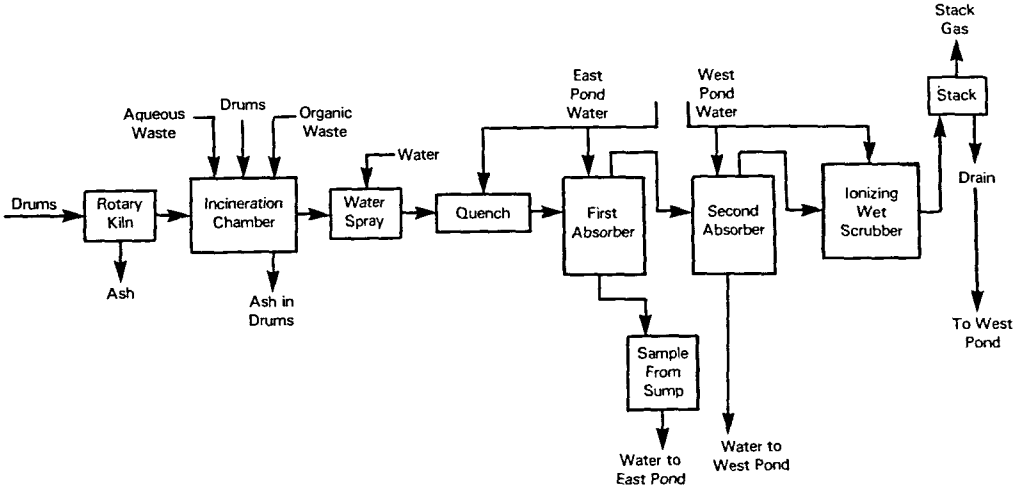
PIC	Fast VOST, avg. g/min	Gas bag g/min	Modified Method 5 g/min
Volatiles			
Chloroform	0.008	0.0064	-
Benzene	0.0062	0.0090	-
Bromomethane	0.00024	0.0060	-
Chloromethane	0.0033	0.18	-
Carbon disulfide	0.036	0.021	-
Bromochloromethane	0.016	0.0090	-
Methylene bromide	0.0090	0.0075	-
Bromodichloromethane	0.0043	0.0039	-
Dibromochloromethane	0.0023	0.0021	-
Bromoform	0.00366	0.0050	-
Semivolatiles			
Fluoranthene	-	-	0.0012
Pyrene	-	-	0.0011

[a]Not blank corrected

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incineration, Final Report, Volumes II and IV (Appendix C). EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, MO. EPA Project Officer Mr. Don Oberacker, Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio 45268. November 1984.

Comments: The Ross incinerator and associated scrubbers operated normally during all three tests. QA audits of the sampling and analysis activities indicated adequate and acceptable performance in all areas with no significant problems. Dioxins and furans were not detected in stack particulate emissions. The most prominent metals found in the waste feed were Ba, Cd, Cr, Sb, an Pb, with Pb having the highest concentration in the organic waste feed (1800-2090 μg/g). These same metals were found in the stack emissions. Lead levels in particulates were especially high (68,900 - 96,100 μg/g). It was estimated that 10% of the lead fed to the incinerator was emitted as part of the particulate emissions. Aniline DRE may be biased high. See Reference Volume II, p. 102.

PROCESS FLOW DIAGRAM



Date of Test: June 11, 1984

Run No.: 2

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber
Commercial X Private __
Capacity: Not reported
Pollution control system: Two packed bed caustic scrubbers (in series) and an ionizing wet scrubber

Waste feed system: Liquid wastes are pumped into secondary chamber (the main incineration chamber) and drummed waste is conveyed into both the kiln and the secondary chamber

Residence time: 6.5 s calculated

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and miscellaneous drummed wastes

Length of burn: ~2 hours sampling time
Total amount of waste burned: Not reported; heat input 57 x 10^6 Btuh during test run
Waste feed rate: 12,940 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 4,400 Btu/lb
Ash content: 6.5%
Chlorine content: 3.2%
Moisture content: 46.6%

Operating Conditions:

Temperature: Average - 2094°F in secondary chamber
Primary fuel used: None

Excess air: 10.5% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's:

Name	Concentration, wt. %	DRE, %		
		Fast VOST	Gas bag	Modified Method 5
Volatiles				
Carbon tetrachloride	0.21	>99.9961	99.970	-
Trichloroethylene	0.47	99.9965	99.935	-
Tetrachloroethylene	0.69	>99.9977	99.99910	-
Toluene	2.87	>99.9987	99.9987	-
Methylene chloride	0.67	>99.989[a]	99.82[a]	-
Methyl ethyl ketone	0.79	99.99930	99.999918	-
1,1,1-Trichloroethane	0.91	>99.9990	99.9979	-
1,1,2-Trichloroethane	0.028	>99.999994	>99.9999	-
Semivolatiles				
N,N-Dimethylacetamide	1.82	-	-	>99.9999
Phenol	0.006[b]	-	-	>99.993
2,4-Dimethylphenol	0.020	-	-	99.9990
Naphthalene	0.036[b]	-	-	>99.994
Butyl benzyl phthalate	0.017	-	-	>99.998
Phthalic anhydride	0.008	-	-	>99.99
Aniline	0.021	-	-	>99.998
Methyl pyridine	0.042	-	-	>99.998
Cresol(s)	0.074	-	-	>99.999

[a]Methylene chloride results should be viewed with caution due to high blank values and large difference in results between runs.
[b]Results suspect based on QA analysis of data. Note DRE for phenol is not suspect. See Reference Volume I, p. 101.

HCl: 0.296 lb/h
Particulate: 0.0770 gr/dscf @ 7% O_2
THC: 0.9 ppm
CO: 9.1 ppm
CO_2: 7.9% avg. THC: <1 ppm avg. O_2: 10.5% avg.
Dioxins and furans: See comments for Run 1
Metals: See comments for Run 1

PIC's:

PIC	Fast VOST, avg. g/min	Gas bag g/min	Modified Method 5 g/min
Volatiles			
Chloroform	0.0079	0.0076	-
Benzene	0.0122	0.016	-
Bromomethane	0.0017	0.00094	-
Chloromethane	0.0046	0.038	-
Carbon disulfide	0.033	0.0028	-
Bromochloromethane	0.016	0.030	-
Methylene bromide	0.016	0.0095	-
Bromodichloromethane	0.0043	0.0055	-
Dibromochloromethane	0.0039	0.0012	-
Bromoform	0.0097	0.0036	-
Semivolatiles			
Fluoranthene	-	-	0.001
Pyrene	-	-	<0.004

[a]Not blank corrected

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

ROSS

Date of Test: June 11, 1984

Run No.: 3

Equipment information:

Type of unit: Incinerator - Rotary kiln with secondary chamber
Commercial X Private ___
Capacity: Not reported
Pollution control system: Two packed bed caustic scrubbers (in series) and an ionizing wet scrubber

Waste feed system: Liquid wastes are pumped into secondary chamber (the main incineration chamber) and drummed waste is conveyed into both the kiln and the secondary chamber

Residence time: 6.7 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and miscellaneous drummed wastes

Length of burn: ~2 hours sampling time
Total amount of waste burned: Not reported; heat input 83 x 10^6 Btuh during test run
Waste feed rate: 13,040 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 6,360 Btu/lb
Ash content: 5.5%
Chlorine content: 3.0%
Moisture content: 45.6%

Operating Conditions:

Temperature: Average - 2043°F in secondary chamber
Primary fuel used: None

Excess air: 10.7% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's:

Name	Concentration, wt. %	DRE, %		
		Fast VOST	Gas bag	Modified Method 5
Volatiles				
Carbon tetrachloride	0.20	>99.9959	99.963	-
Trichloroethylene	0.83	99.9969	99.947	-
Tetrachloroethylene	1.67	99.99912	99.99951	-
Toluene	2.74	>99.9978	99.9969	-
Methylene chloride	0.36	>99.978[a]	99.72[a]	-
Methyl ethyl ketone	1.64	99.99932	99.999952	-
1,1,1-Trichloroethane	0.58	>99.999	99.9951	-
1,1,2-Trichloroethane	0.038	>99.999994	>99.9999	-
Semivolatiles				
N,N-Dimethylacetamide	1.90	-	-	>99.9999
Phenol	0.005[b]	-	-	>99.992
2,4-Dimethylphenol	0.071	-	-	99.9994
Naphthalene	0.024[b]	-	-	>99.991[b]
Butyl benzyl phthalate	0.027	-	-	>99.999
Phthalic anhydride	0.007	-	-	>99.99
Aniline	0.026	-	-	>99.998
Methyl pyridine	0.041	-	-	>99.998
Cresol(s)	0.091	-	-	>99.9991

[a]Methylene chloride results should be viewed with caution because of high blank values and large differences in results between runs.
[b]Results suspect based on QA analysis of data. Note DRE for phenol is not suspect. See Reference Volume I, p. 101.

HCl: 0.290 lb/h
Particulate: 0.0608 gr/dscf @ 7% O_2
THC: 1.0 ppm
CO: 4.7 ppm
CO_2: 8.1% avg. O_2: 10.7% avg. THC: 1 ppm avg.
Dioxins and furans: See comments for Run 1
Metals: See comments for Run 1

PIC's:

PIC	Fast VOST, avg. g/min	Gas bag g/min	Modified Method 5 g/min
Volatiles			
Chloroform	0.0056	0.0074	-
Benzene	0.0070	0.019	-
Bromomethane	0.00106	0.00062	-
Chloromethane	0.0036	0.059	-
Carbon disulfide	0.013	0.0034	-
Bromochloromethane	0.016	0.039	-
Methylene bromide	0.021	0.014	-
Bromodichloromethane	0.0051	0.0028	-
Dibromochloromethane	0.0059	0.0023	-
Bromoform	0.0102	0.0051	-
Semivolatiles			
Fluoranthene	-	-	0.001
Pyrene	-	-	0.001

[a]Not blank corrected

Reference(s): See Run No. 1

Comments: See Run No. 1

Process Flow Diagram: See Run 1

Summary of Test Data for SCA Chemical Services
Chicago, Illinois

Date of Test: July 24-30, 1984

Run No.: 17 ***Test Sponsor:*** SCA

Equipment information:

Type of unit: Incinerator - Rotary kiln with a secondary chamber
Commercial X Private ___
Capacity: 120 x 10^6 Btuh
Pollution control system: 2 packed tower scrubbers followed by 4 parallel ionizing wet scrubbers

Waste feed system: Stored, blended, and conveyed to kiln by ram

Residence time: 2.4 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: PCB in liquid and solid streams

Length of burn: 4 h
Total amount of waste burned: 25,200 lb
Waste feed rate: Liquid - 97 lb/min; sludge - 8 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
PCB	- Liquid - 27%; sludge - 23%

Btu content: Liquid - 14,944 Btu/lb; sludge - 12,727 Btu/lb
Ash content:
Chlorine content: Liquid - 21.13%; sludge - 29.97%
Moisture content:

Operating Conditions:

Temperature: Average 1787°F (Kiln); 2231°F (Secondary chamber)
Auxiliary fuel used: Fuel oil; secondary chamber is gas-fired

Excess air: 9.2% O_2

Monitoring Methods:

POHC's:
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Beckman Model 215A
O_2 - Beckman Model 742A
Liquid waste collected every 15 min; sludge waste every hour

Emission and DRE Results:

POHC's: PCB - 99.99982% DRE

HCl: 1.42 lb/h @ 99.92% removal
Particulate: 0.075 gr/dscf at 7% O_2
THC: 0.4 ppm
CO: 16 ppm
Other:
PIC's:

Reference(s): SCA Chemical Industries, Trial Burn Report by Midwest Research Institute, Kansas City, MO. (Project No. 8137-L), October 12, 1984.

Process Flow Diagram: Not Available

Date of Test: July 24-30, 1984

Run No.: 19

Equipment information:
Type of unit: Incinerator - Rotary kiln with a secondary chamber
Commercial X Private __
Capacity: 120 x 10^6 Btuh
Pollution control system: 2 packed tower scrubbers followed by 4 parallel ionizing wet scrubbers

Waste feed system: Stored, blended, and conveyed to kiln by ram

Residence time: 2.4 s

Trial Burn Conditions:
Waste feed data:
Type of waste(s) burned: PCB in liquid and solid streams

Length of burn: 4 h
Total amount of waste burned:
Waste feed rate: Liquid - 143 lb/min; sludge - 10 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
PCB	Liquid - 28%; sludge - 21%

Btu content: Liquid - 10,219 Btu/lb; sludge - 12,215 Btu/lb
Ash content:
Chlorine content: Liquid - 28%; sludge - 31.68%
Moisture content:

Operating Conditions:
Temperature: Average 1845°F (Kiln); 2212°F (Secondary chamber)
Auxiliary fuel used: Fuel oil; secondary chamber is gas-fired

Excess air: 9.3% O_2

Monitoring Methods: See Run 17

Emission and DRE Results:
POHC's: PCB - 99.99994% DRE

HCl: 2.47 lb/h @ 99.92% removal
Particulate: Not calculated
THC: 0.8 ppm
CO: 3 ppm
Other:
PIC's:

Reference(s): See Run 17

Date of Test: July 24-30, 1984

Run No.: 20

Equipment information:
Type of unit: Incinerator - Rotary kiln with a secondary chamber
Commercial X Private __
Capacity: 120 x 10^6 Btuh
Pollution control system: 2 packed tower scrubbers followed by 4 parallel ionizing wet scrubbers

Waste feed system: Stored, blended, and conveyed to kiln by ram

Residence time: 2.0 s

Trial Burn Conditions:
Waste feed data:
Type of waste(s) burned: PCB in liquid and solid streams

Length of burn: 6 h
Total amount of waste burned:
Waste feed rate: Liquid - 135 lb/min; sludge - 8 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
PCB	Liquid - 22%; sludge - 24%

Btu content: Liquid - 13,648; sludge - 11,383
Ash content:
Chlorine content: Liquid - 26.27%; sludge - 26.67%
Moisture content:

Operating Conditions:
Temperature: Average 1787°F (Kiln); 2247°F (Secondary chamber)
Auxiliary fuel used: Fuel oil; secondary chamber is gas-fired

Excess air: 9.0% O_2

Monitoring Methods: See Run 17

Emission and DRE Results:
POHC's: PCB - 99.99949% DRE

HCl: 2.19 lb/h @ 99.91% removal
Particulate: Not calculated
THC: 0.7 ppm
CO: 4 ppm
Other:
PIC's:

Reference(s): See Run 17

SCA

Date of Test: July 24-30, 1984

Run No.: 21

Equipment information:

Type of unit: Incinerator - Rotary kiln with a secondary chamber
Commercial X Private __
Capacity: 120 x 10^6 Btuh
Pollution control system: 2 packed tower scrubbers followed by 4 parallel ionizing wet scrubbers

Waste feed system: Liquid - fired into combustion chamber by 2 air atomized nozzles

Residence time: 2.9 s

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: PCB in liquid waste only

Length of burn: 6 h
Total amount of waste burned:
Waste feed rate: Liquid - 150 lb/min, no solid feed
POHC's selected and concentration in waste feed:

Name		*Concentration*
PCB	-	19%

Btu content: 10,809 Btu/lb
Ash content:
Chlorine content: 36.03%
Moisture content:

Operating Conditions:

Temperature: Average - Not reported (Kiln); 2225°F (Secondary chamber)
Auxiliary fuel used: Fuel oil; secondary chamber is gas-fired

Excess air: 10.0% O_2

Monitoring Methods: See Run 17

Emission and DRE Results:

POHC's: PCB - 99.99980% DRE

HCl: 3.44 lb/h @ 99.89% removal
Particulate: (Invalid)
THC: 0 ppm
CO: 9 ppm
Other:
PIC's:

Reference(s): See Run 17

Summary of Test Data for Smith Kline Chemicals
Conshohocken, Pennsylvania

Date of Test: Week of August 27, 1984

Run No.: 6

Equipment information:

Type of unit: Incinerator, John Zink liquid
Commercial __ Private __
Capacity:
Pollution control system: Venturi scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic solvent and aqueous wastes

Length of burn:
Total amount of waste burned:
Waste feed rate: 981.3 lb/h (solvent); 2247 lb/h (aqueous)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Tetrachloroethene	1.36%
Chloroform	1.21%
Methylbenzene	4.53%

Btu content: 3,590 Btu/lb
Ash content:
Chlorine content: 2.99%
Moisture content:

Operating Conditions:

Temperature: Range 1638° to 1700°F
Auxiliary fuel used: Natural gas

Excess air: 3% O_2
Other:

Monitoring Methods:

POHC's: VOST
HCl:
Particulate:
Other: CO - Beckman Model 864 NDIR
O_2 - Taylor Servomax

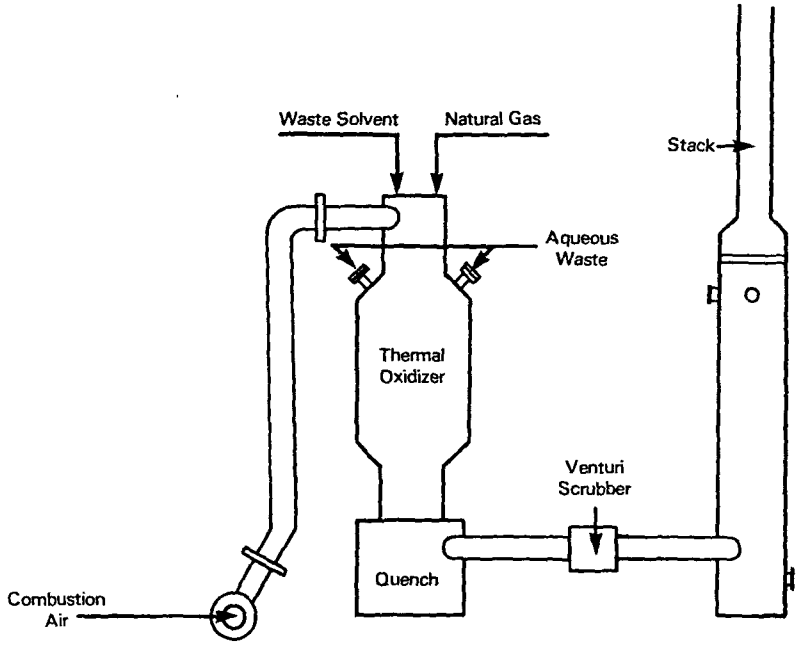
Emission and DRE Results:

POHC's: Tetrachloroethene - 99.9997%
Chloroform - 99.99999%
Methylbenzene - 99.9997%

HCl: 0.55 lb/h (99.20% removal efficiency)
Particulate: 0.05738 gr/dscf @ 7% O_2
THC:
CO: 317 ppm
Other: Formic acid - 99.947% removal efficiency
PIC's:

Reference(s): Trial burn by Battelle Columbus, telephone (614) 424-6424

PROCESS FLOW DIAGRAM



Date of Test: Week of August 27, 1984

Run No.: 7

Equipment information:

Type of unit: Incinerator, John Zink liquid
Commercial __ Private __
Capacity:
Pollution control system: Venturi scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic solvent and aqueous wastes

Length of burn:
Total amount of waste burned:
Waste feed rate: 1,277 lb/h (solvent); 3,689 lb/h (aqueous)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Tetrachloroethene	1.32%
Chloroform	1.10%
Methylbenzene	3.86%

Btu content: 3,096 Btu/lb
Ash content:
Chlorine content: 2.38%
Moisture content:

Operating Conditions:

Temperature: Range 1660° to 1720°F
Auxiliary fuel used: Natural gas

Excess air: 3.525% O_2
Other:

Monitoring Methods:

POHC's: VOST
HCl:
Particulate:
Other: CO - Beckman Model 864 NDIR
O_2 - Taylor Servomax

Emission and DRE Results:

POHC's: Tetrachloroethene - 99.99999%
Chloroform - 99.99999%
Methylbenzene - 99.99953%

HCl: 0.180 lb/h (99.7% removal efficiency)
Particulate: 0.02733 gr/dscf @ 7% O_2
THC:
CO: 888 ppm
Other: Formic acid - 99.9986% removal efficiency
PIC's:

Reference(s): Trial burn by Battelle Columbus, telephone (614) 424-6424

Process Flow Diagram: See Test Run No. 6

SMITH KLINE

Date of Test: Week of August 27, 1984

Process Flow Diagram: See Test Run No. 6

Run No.: 8

Equipment information:

Type of unit: Incinerator, John Zink liquid
Commercial ___ Private ___
Capacity:
Pollution control system: Venturi scrubber and mist eliminator

Waste feed system: Liquid pumped from storage tanks

Residence time:

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic solvent and aqueous wastes

Length of burn:
Total amount of waste burned:
Waste feed rate: 1,018 lb/h (solvent); 3,709 lb/h (aqueous)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Tetrachloroethene	0.98%
Chloroform	0.93%
Methylbenzene	3.20%

Btu content: 2,657 Btu/lb
Ash content:
Chlorine content: 2.58%
Moisture content:

Operating Conditions:

Temperature: Range 1650° to 1760°F
Average 1709°F
Auxiliary fuel used: Natural gas

Excess air: 2.85% O_2

Monitoring Methods:

POHC's: VOST
HCl:
Particulate:
Other: CO - Beckman Model 864 NDIR
O_2 - Taylor Servomax

Emission and DRE Results:

POHC's: Tetrachloroethene - 99.99999%
Chloroform - 99.99999%
Methylbenzene - 99.9982%

HCl: 0.650 lb/h (99.92% removal efficiency)
Particulate: 0.03002 gr/dscf @ 7% O_2
THC:
CO: 1133 ppm
Other: Formic acid - 99.9985% removal efficiency
PIC's:

Reference(s): Trial burn by Battelle Columbus, telephone (614) 424-6424

Summary of Test Data for Stauffer Chemical Company
Baytown, Texas

Date of Trial Burn: February 16-19, 1984

Run No.: 4 ***Test Sponsor:*** Stauffer

Equipment information:

Type of unit: Incinerator - Acid regeneration furnace
Commercial __ Private X
Capacity: Not reported
Pollution control system: Spray scrubber, wet ESP, and tail end acid plant with mist eliminator

Waste feed system: Air atomizers

Residence time: Approximately 3.4 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic formulation of liquid wastes containing POHC's and volcanic ash, and spent sulfuric acid waste

Length of burn: 8-12 h
Total amount of waste burned:
Waste feed rate: 3040 lb/h (synthetic waste); 77,850 lb/h (spent acid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 Trichloroethane	0.466%
Carbon tetrachloride	0.470%
Benzene	2.56%

Btu content: 1,256 Btu/lb
Ash content: 0.197%
Chlorine content: 0.816%
Moisture content: Not reported

Operating Conditions:

Temperature: Average - Approximately 1830°F
Auxiliary fuel used: Natural gas

Excess air: 6.6% O_2

Monitoring Methods:

POHC's: VOST for TCE and CCl_4 and Modified Method 5 for benzene
HCl: Modified Method 6
Particulate: Method 5
Other: CO - Horiba Model 2000 NDIR
Phosgene - Modified Method 6
Waste Feed - composite of grab samples taken throughout each run

Emission and DRE Results:

POHC's:

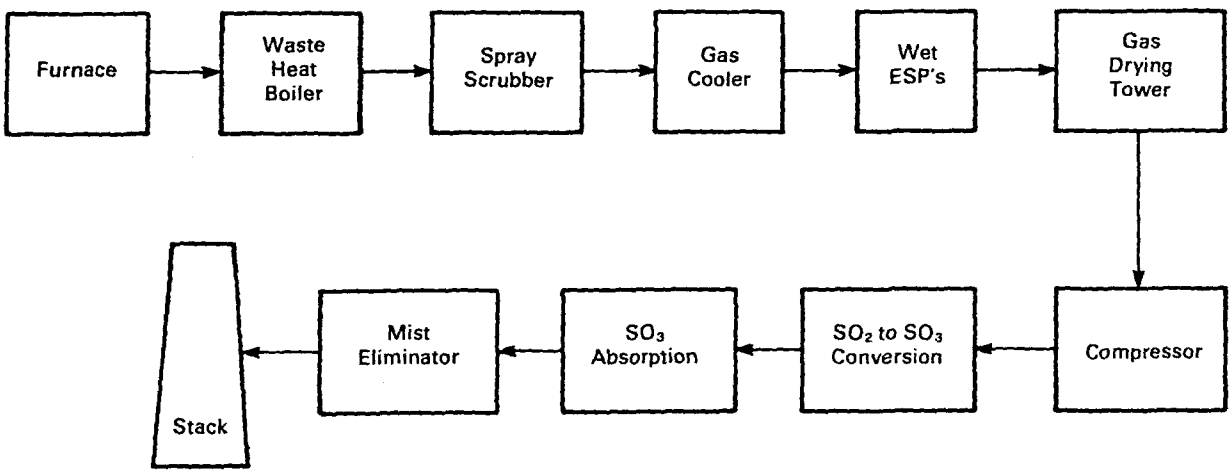
POHC		*DRE, %*
1,1,1 Trichloroethane	-	>99.999980
Carbon tetrachloride	-	>90.999980
Benzene	-	99.999992

HCl: 3.8 ppm (99.857% avg. removal efficiency for all four runs)
Particulate: 0.000868 gr/dscf @ 7% O_2
THC: Not measured
CO: 81.9 ppm
Other: Phosgene - 4.5 ppb avg. for all four runs; NO_x - 22 ppm avg. for all four runs
PIC's: Not measured

Reference(s): Stauffer Chemical Company, Baytown, Texas; trial burn test results (February 1984); submitted in lieu of trial burn for Dominquez, Cal. plant; submitted August 1984 to EPA Region IX

Comments: These tests were conducted at what were considered high waste feed rates for this furnace (~50 lb/min synthetic and 1000-1200 lb/min. spent acid feed). Process conditions were considered to be worst case in terms of residence time and heat input required to adequately decompose the wastes. Runs 1-3 were baseline tests, and results are not included here.

PROCESS FLOW DIAGRAM



Date of Trial Burn: February 16-19, 1984

Process Flow Diagram: See Run 4

Run No.: 5

Equipment information:

Type of unit: Incinerator - Acid regeneration furnace
Commercial __ Private X
Capacity: Not reported
Pollution control system: Spray scrubber, wet ESP, and tail end acid plant with mist eliminator

Waste feed system: Air atomizers

Residence time: Approximately 3.4 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic formulation of liquid wastes containing POHC's and volcanic ash, and spent sulfuric acid waste

Length of burn: 8-12 h
Total amount of waste burned:
Waste feed rate: 3040 lb/h (synthetic waste); 76,860 lb/h (spent acid)
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 Trichloroethane	0.472%
Carbon tetrachloride	0.479%
Benzene	2.67%

Btu content: 1,508 Btu/lb
Ash content: 0.222%
Chlorine content: 0.827%
Moisture content: Not reported

Operating Conditions:

Temperature: Average - Approximately 1830°F
Auxiliary fuel used: Natural gas

Excess air: 6.4% O_2

Monitoring Methods: See Run 4

Emission and DRE Results:

POHC's:

POHC		*DRE, %*
1,1,1 Trichloroethane	-	>99.999979
Carbon tetrachloride	-	>99.999979
Benzene	-	>99.999996

HCl: 4.0 ppm (99.857% avg. removal efficiency for all four runs)
Particulate: 0.00271 gr/dscf @ 7% O_2
THC: Not measured
CO: 52.2 ppm
Other: Phosgene - 4.5 ppb avg. for all four runs; NO_x - 22 ppm avg. for all four runs
PIC's: Not measured

Reference(s): See Run 4

Comments: See Run 4

STAUFFER

Date of Trial Burn: February 16-19, 1984

Process Flow Diagram: See Run 4

Run No.: 6

Equipment information:

Type of unit: Incinerator - Acid regeneration furnace

Commercial ___ Private X

Capacity: Not reported

Pollution control system: Spray scrubber, wet ESP, and tail end acid plant with mist eliminator

Waste feed system: Air atomizers

Residence time: Approximately 3.4 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic formulation of liquid wastes containing POHC's and volcanic ash, and spent sulfuric acid waste

Length of burn: 8-12 h

Total amount of waste burned:

Waste feed rate: 3010 lb/h (synthetic waste); 76,230 lb/h (spent acid)

POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 Trichloroethane	0.498%
Carbon tetrachloride	0.505%
Benzene	2.58%

Btu content: 1,236 Btu/lb

Ash content: 0.207%

Chlorine content: 0.874%

Moisture content: Not reported

Operating Conditions:

Temperature: Average - Approximately 1830°F

Auxiliary fuel used: Natural gas

Excess air: 6.1% O_2

Monitoring Methods: See Run 4

Emission and DRE Results:

POHC's:

POHC		*DRE, %*
1,1,1 Trichloroethane	-	>99.99998
Carbon tetrachloride	-	>99.999981
Benzene	-	99.999996

HCl: 3.8 ppm (99.857% avg. removal efficiency for all four runs)

Particulate: 0.00239 gr/dscf @ 7% O_2

THC: Not measured

CO: 52.2 ppm

Other: Phosgene - 4.5 ppb avg. for all four runs; NO_x 22 ppm avg. for all four runs

PIC's: Not measured

Reference(s): See Run 4

Comments: See Run 4

Date of Trial Burn: February 16-19, 1984

Process Flow Diagram: See Run 4

Run No.: 7

Equipment information:

Type of unit: Incinerator - Acid regeneration furnace
Commercial __ Private X
Capacity: Not reported
Pollution control system: Spray scrubber, wet ESP, and tail end acid plant with mist eliminator

Waste feed system: Air atomizers

Residence time: Approximately 3.4 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Synthetic formulation of liquid wastes containing POHC's and volcanic ash, and spent sulfuric acid waste

Length of burn: 8-12 h
Total amount of waste burned: 3010 lb/h (synthetic waste); 78,030 lb/h (spent acid)
Waste feed rate:
POHC's selected and concentration in waste feed:

Name	*Concentration*
1,1,1 Trichloroethane	0.501%
Carbon tetrachloride	0.483%
Benzene	2.55%

Btu content: 1,163 Btu/lb
Ash content: 0.216%
Chlorine content: 0.843%
Moisture content: Not reported

Operating Conditions:

Temperature: Average - Approximately 1830°F
Auxiliary fuel used: Natural gas

Excess air: 6.4% O_2

Monitoring Methods: See Run 4

Emission and DRE Results:

POHC's:

POHC		*DRE, %*
1,1,1 Trichloroethane	-	>99.999980
Carbon tetrachloride	-	>99.999979
Benzene	-	99.999996

HCl: 4.3 ppm (99.857% avg. removal efficiency for all four runs)
Particulate: 0.000704 gr/dscf @ 7% O_2
THC: Not measured
CO: 38.8 ppm
Other: Phosgene - 4.5 ppb avg. for all four runs; NO_x 22 ppm avg. for all four runs
PIC's: Not measured

Reference(s): See Run 4

Comments: See Run 4

Summary of Test Data for 3M
Cottage Grove, Minnesota

Date of Trial Burn: October 10-17, 1984

Run No.: 1 ***Test Sponsor:*** 3M

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 10,710 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.524 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	0.548 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1985°F (Kiln), 1425°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods:

POHC's: VOST (three pair, 40 minutes each)
HCl: Modified Method 5
Particulate: Modified Method 5
Other: Temperature - ICON pyrometers, Modline infrared thermometers
CO - Horiba, NDIR (0-5000 ppm range used for tests)
O_2 - Teledyne Model 326B (plant monitor)
CO and CO_2 - Teledyne 9300-0-20x (plant monitor)
PIC's: Not monitored

Emission and DRE Results:

POHC's: CCl_4 - 99.998% DRE
1,1,2-TCE - 99.994% DRE

HCl: 0.86 lb/h; 99.1% removal (see Comment d)
Particulate: 0.0623 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 30 to 2000 ppm
Other: O_2: 3.1 - 15.2% CO_2: 2.2 - 17.0%
PIC's: Not evaluated

Reference(s): Trial Burn Test Report, 3M Company Chemolite Facility, Cottage Grove, Minnesota. Volumes I, II, and III. February 1985. Report prepared by PEI Associates, Inc. Cincinnati, Ohio; Project No. 5341

Comments:

a) This incinerator can accept containerized waste. The container is often fed into the unit with the waste. Also, uncontainerized bulk waste can be fed into the kiln via the "drum chute." Other wastes include aqueous wastes, which are fed through a lance and organic liquid wastes, which are fed through any of three burners. Two burners fire the kiln; the third (Burner C) fires the secondary chamber.

b) Since the characteristics of the containerized wastes were not determined, it was not possible to ascertain the overall Btu, ash, chlorine, and moisture content of the total waste feed. Values are available in Reference for some waste streams. The POHC concentration of the total waste feed assumes that POHC's exist only in the burner waste and the so-called "spike" solution. The latter was a POHC-rich solution added to increase the total POHC concentration.

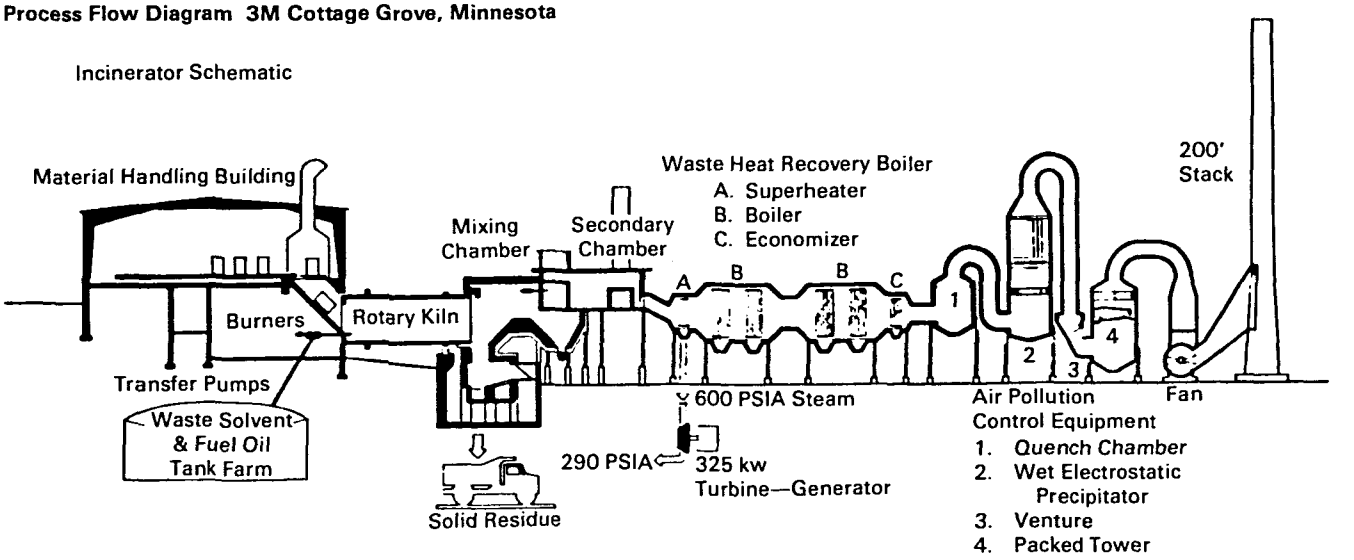
c) Wet ESP water flow rate was lower for Runs 4 through 8 than for runs 1, 2, 3, 9, and 10 because of pump problems.

d) HCl removal was probably biased low because chloride analysis was not performed on all wastes fed to the incinerator (see Comment b above).

e) CCl_4 and 1,1,2-TCE were both spiked into the waste feed.

PROCESS FLOW DIAGRAM

Process Flow Diagram 3M Cottage Grove, Minnesota



Date of Trial Burn: October 10-17, 1984

Run No.: 2

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned:
Waste feed rate: 9,160 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	1.031 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.239 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1950°F (Kiln), 1330°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - >99.999% DRE
1,1,2-TCE - >99.990% DRE

HCl: 0.48 lb/h; 99.7% removal (see Comment d, Run 1)
Particulate: 0.1117 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 40 to 2000 ppm
Other: O_2: 4.0 - 15.0% CO_2: 1.7 - 15.3%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 3

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
- Containerized and bulk wastes - feed chute into kiln
- Pumpable organic wastes - burner nozzles at kiln and secondary chamber
- Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 11,130 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.868 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.225 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 2030°F (Kiln), 1350°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's: CCl_4 - >99.999% DRE
1,1,2-TCE - >99.998% DRE

HCl: 0.44 lb/h; 99.8% removal (see Comment d, Run 1)
Particulate: 0.0848 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 50 to 2000 ppm
Other: O_2: 4.1 - 13.3% CO_2: 4.5 - 15.0%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 12, 1984

Run No.: 4

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 11,870 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	1.068 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.566 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1985°F (Kiln), 1825°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.999% DRE

HCl: 0.20 lb/h; 99.9% removal (see Comment d, Run 1)
Particulate: 0.0910 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 40 to 2000 ppm
Other: O_2: 3.2 - 15.0% CO_2: 3.0 - 15.5%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 5

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and bulk and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 23,370 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.482 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	0.937 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1915°F (Kiln), 1530°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.999% DRE

HCl: 0.50 lb/h; 99.9% removal (see Comment d)
Particulate: 0.0470 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 50 to 270 ppm
Other: O_2: 8.5 - 10.8% CO_2: 6.7 - 10.6%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 6

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and bulk and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 17,550 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.623 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.304 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1905°F (Kiln), 1525°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.999% DRE

HCl: 0.31 lb/h; 99.9% removal (see Comment d, Run 1)
Particulate: 0.0472 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 0 to 1790 ppm
Other: O_2: 7.5 - 16.7% CO_2: 6.8 - 16.0%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 7

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and bulk and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 17,570 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.596 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.066 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1885°F (Kiln), 1480°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.999% DRE

HCl: 0.35 lb/h; 99.9% removal (see Comment d)
Particulate: 0.0479 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 250 to 500 ppm
Other: O_2: 8.7 - 12.5% CO_2: 4.5 - 10.0%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 8

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 14,360 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.990 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.771 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1930°F (Kiln), 1610°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.998% DRE

HCl: 1.21 lb/h; 99.7% removal (see Comment d)
Particulate: 0.1541 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 10 to 800 ppm
Other: O_2: 4.0 - 11.5% CO_2: 5.5 - 15.3%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 9

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 13,120 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	0.881 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.300 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1925°F (Kiln), 1500°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.998% DRE
1,1,2-TCE - 99.998% DRE

HCl: 0.69 lb/h; 99.8% removal (see Comment d)
Particulate: 0.0777 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 30 to 2000 ppm
Other: O_2: 4.3 - 13.7% CO_2: 3.8 - 16.0%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Trial Burn: October 10-17, 1984

Run No.: 10

Equipment Information

Type of unit: Incinerator - rotary kiln with a secondary chamber
Commercial __ Private X
Capacity: 90 x 10^6 Btuh
Pollution control system: Wet ESP, venturi scrubber, and packed tower mist eliminator

Waste feed system:
Containerized and bulk wastes - feed chute into kiln
Pumpable organic wastes - burner nozzles at kiln and secondary chamber
Pumpable aqueous wastes - lance at front end of kiln

Residence time: Not reported

Trial Burn Conditions:

Waste feed data:

Type of waste(s) burned: Miscellaneous (aqueous, pumpable organic, and containerized wastes)

Length of burn: ~2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 14,030 lb/h (Total of all waste, including the spike solution)
POHC's selected and concentration in waste feed:

Name	*Concentration*	
Carbon tetrachloride (CCl_4)	1.021 wt. %	Includes the POHC's in the spike solution; see Comments b and e
1,1,2-trichloroethane (1,1,2 TCE)	1.631 wt. %	Includes the POHC's in the spike solution; see Comments b and e

Btu content: See Comment b
Ash content: See Comment b
Chlorine content: See Comment b
Moisture content: See Comment b

Operating Conditions:

Temperature: Average - 1890°F (Kiln), 1400°F (Secondary chamber)
Auxiliary fuel used: None

Excess air: Not reported

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's: CCl_4 - 99.999% DRE
1,1,2-TCE - 99.999% DRE

HCl: 0.77 lb/h; 99.7% removal (see Comment d)
Particulate: 0.0798 gr/dscf @ 7% O_2
THC: Not evaluated
CO: 30 to 2000 ppm
Other: O_2: 6.5 - 12.6% CO_2: 4.5 - 16.2%
PIC's: Not evaluated

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Trade Waste Incineration, Inc. Saugett, Illinois

Date of Test: February 2-5, 1983

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private __
Capacity: 9.9 x 10^6 Btuh during test run
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 4.7 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid (ink sludge) wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 33.4 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 3,640 Btu/lb
Ash content: 23.7%
Chlorine content: 0.858%
Moisture content: 51.3%

Operating Conditions:

Temperature: Average - 2078°F (Primary chamber); 2030°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil (2.2 lb/min)

Excess air: 12.4% O_2

Monitoring Methods:

Waste feed (1, 2, and 3)[a]: One composite per liquid waste per run made up of grab samples taken every 15 minutes during run; for solid feed, a composite of grab samples taken from every batch
Fuel oil (4): One grab sample per run
Combustion Emissions (11):
Volatile POHC's and PIC's: Gas bags (Runs 1, 2, 3, 4, 6, and 7) and VOST (all runs) (Fast and Slow)
Semivolatile POHC's and PIC's: Modified Method 5 (Runs 1-4 only)
HCl: Modified Method 5 (Runs 1-4 only)
Particulate: Modified Method 5 (Runs 1-4 only)
Metals: Modified Method 5 (Runs 1-4 only)
CO_2 and O_2: Gas bag for Orsat analysis
Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
THC - Beckman Model 402 (FID)
Dioxins: Not monitored
Water Samples: Grab and composite samples of well water (6), city water (7), recirculating water (8), return water (9), and solids (10) in recirculating water tank. Analyzed for POHC's, pH, and/or metals.

[a]Numbers in parentheses refer to sampling locations shown in Process Flow Diagram.

TRADE WASTE

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %[a]	DRE, %			
		Fast VOST	Slow VOST	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	0.00627[b]	>99.918	>99.30	99.48	-
Chloroform	0.00224[b]	>99.944	98.0	97.8	-
Methylene bromide	0.0244	>99.9987	99.9941	99.9954	-
1,1,1-trichloroethane	0.00792[b]	99.966	99.80	>99.75	-
Carbon tetrachloride	0.198	>99.9984	99.9963	99.99946	-
Trichloroethylene	0.178	>99.9962	99.9930	>99.992	-
Benzene	1.52	99.9983	99.9963	99.9963	-
Tetrachloroethylene	0.00567[b]	99.965	99.79	99.74	-
Toluene	7.92	99.99946	99.9986	99.9977	-
Chlorobenzene	0.00858[b]	99.965	99.65	99.46	-
Semivolatiles					
Hexachlorocyclopentadiene	0.00660[b]	-	-	-	99.99
Bis-(2-ethylhexyl)-phthalate	0.00429[b]	-	-	-	99.951
Chlordane	0.462	-	-	-	>99.9998
Naphthalene	<0.000660[b]	-	-	-	c
Hexachlorobutadiene	<0.000660[b]	-	-	-	c

[a]Includes POHC input from the fuel oil.
[b]<100 μg/g
[c]Not reported.

HCl: 0.298 lb/h
Particulate: 0.0751 gr/dscf @ 7% O_2
THC: 2.5 ppm avg.
CO: 4.3 ppm avg.
Other: O_2: 12.4% avg. CO_2: 6.6% avg.
Metals: See comments
PIC's:

PIC	Emissions, g/min			
	Fast VOST, avg.	Slow VOST, avg.	Gas bag[a]	Modified Method 5
Volatiles				
Bromochloromethane	0.000065	b	0.00097	-
Bromodichloromethane	0.000026	b	0.000073	-
Dibromochloromethane	b	b	0.000037	-
Bromoform	b	b	0.00014	-
Semivolatiles				
Naphthalene	-	-	-	0.0035

[a]Grab sample.
[b]Not reported.

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerator. Final Report, Volumes II and IV. EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, MO. EPA Project Officer - Mr. Don Oberacker, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH 45268. November 1984.

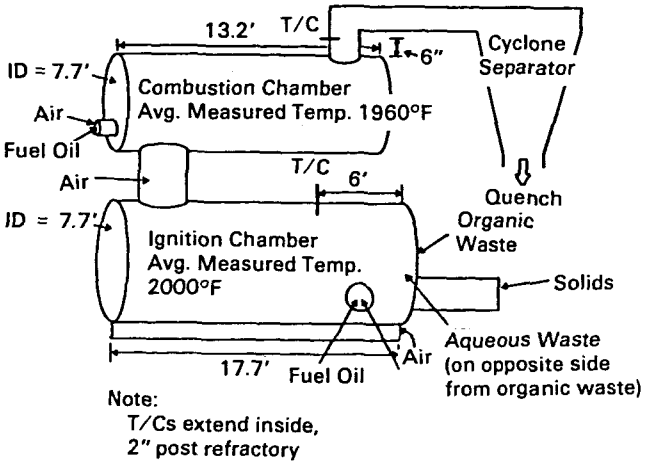
Comments: The TWI incinerator was more thoroughly tested than any of the other seven incinerators in this EPA test series. The fuel oil used at TWI was analyzed and found to contain 8 of the 10 POHC's tested. For 4 of the 8 POHC's, the fuel oil accounted for a significant percentage of the total POHC input; in one run, fuel oil accounted for 73% of the total POHC input.

Naphthalene is treated as a POHC in Run 4 because of its presence in the waste feed in concentrations >100 μg/g; in Runs 1-3, it was treated as a PIC because its waste concentration was <100 μg/g.

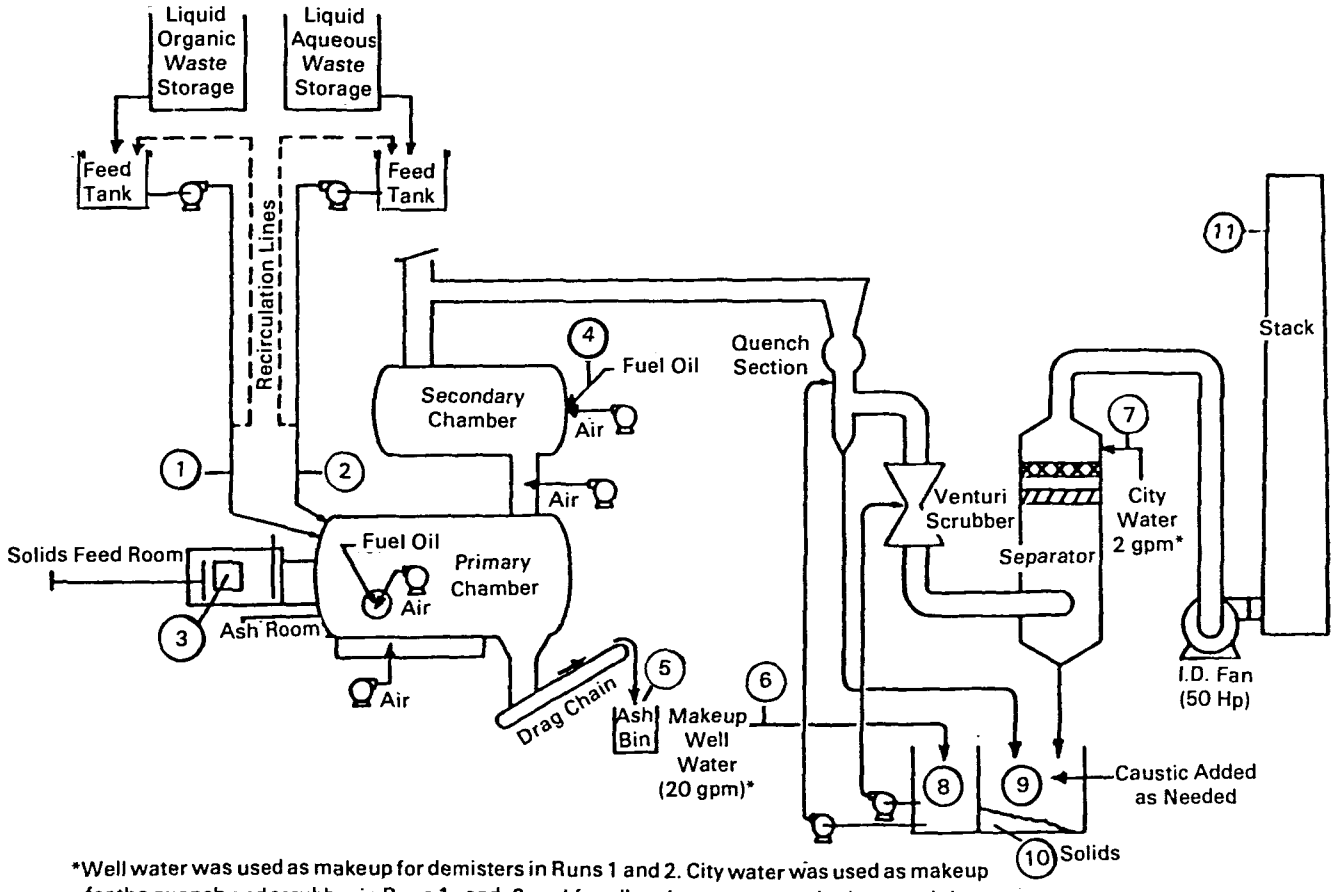
Runs 1-4 were apparently conducted under normal operating conditions. Particulate and chlorine emissions from Runs 1-4 were within RCRA standards. The average temperature of Run 4 was lower than that of Runs 1-3. The waste feed rates of Runs 6-8 were increased and combustion air altered in a deliberate attempt to increase the CO and THC emissions. Runs 6, 7, 8A, and 8B were only 20 minutes long, and no MM5 sampling was done. Run 5 was not reported.

PROCESS FLOW DIAGRAM

Combustion chamber diagram.



Summary of sampling locations and schematic of entire system.



*Well water was used as makeup for demisters in Runs 1 and 2. City water was used as makeup for the quench and scrubber in Runs 1 and 2 and for all makeup purposes in the remaining runs.

Date of Test: February 2-5, 1983

Run No.: 2

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private ___
Capacity: 11.08 x 10^6 Btuh during test run
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 3.5 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid (ink sludge) wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 28.0 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 4,450 Btu/lb
Ash content: 32.3%
Chlorine content: 1.34%
Moisture content: 38.9%

Operating Conditions:

Temperature: Average - 2030°F (Primary chamber); 2000°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil (3.1 lb/min)

Excess air: 13.0% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %[a]	DRE, %			
		Fast VOST	Slow VOST	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	0.00762[b]	99.71	99.930	99.48	-
Chloroform	0.00283[b]	98.2	97.4	97.8	-
Methylene bromide	0.126	99.9956	99.9948	>99.9995	-
1,1,1-trichloroethane	0.0110	99.81	99.72	>99.951	-
Carbon tetrachloride	0.228	>99.9983	99.9984	>99.9995	-
Trichloroethylene	0.212	99.9945	99.9938	>99.985	-
Benzene	1.18	99.989	99.9938	>99.99924	-
Tetrachloroethylene	0.00636[b]	99.78	99.74	>99.963	-
Toluene	4.08	99.9908	99.9964	>99.99975	-
Chlorobenzene	0.0102	99.70	99.74	>99.9928	-
Semivolatiles					
Hexachlorocyclopentadiene	0.00786[b]	-	-	-	>99.99
Bis-(2-ethylhexyl)-phthalate	0.00511[b]	-	-	-	99.960
Chlordane	0.660	-	-	-	>99.9999
Naphthalene	<0.000786[b]	-	-	-	c
Hexachlorobutadiene	<0.000786[b]	-	-	-	c

[a]Includes POHC input from the fuel oil.

[b]<100 µg/g

[c]Not reported.

HCl: 0.355 lb/h
Particulate: 0.1270 gr/dscf @ 7% O_2
THC: 1.9 ppm, avg.
CO: 0.9 ppm, avg.
Other: O_2: 13.0% avg. CO_2: 6.2% avg.
Metals: See comments
PIC's:

PIC	Emissions, g/min			
	Fast VOST, avg.	Slow VOST, avg.	Gas bag[a]	Modified Method 5
Volatiles				
Bromochloromethane	0.00084	0.0007	0.00030	-
Bromodichloromethane	0.00058	0.0016	0.00039	-
Dibromochloromethane	0.00029	0.0011	0.000093	-
Bromoform	0.0020	0.0044	0.00054	-
Semivolatiles				
Naphthalene	-	-	-	0.0017

[a]Grab sample.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 3

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private ___
Capacity: 12.08 x 10^6 Btuh during test run
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 3.5 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid (ink sludge) wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 23.0 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

Btu content: 4,380 Btu/lb
Ash content: 35.7%
Chlorine content: 1.25%
Moisture content: 37.0%

Operating Conditions:

Temperature: Average - 2070°F (Primary chamber); 2030°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil (5.2 lb/min)

Excess air: 13.2% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %[a]	DRE, %			
		Fast VOST	Slow VOST	Gas bag	Modified Method 5
Volatiles					
Methylene chloride	0.0210	99.88	99.87	>99.88	-
Chloroform	0.00201[b]	97.8	97.4	>99.68	-
Methylene bromide	0.172	99.964	99.975	99.9949	-
1,1,1-Trichloroethane	0.0105	99.86	99.82	>99.943	-
Carbon Tetrachloride	0.277	>99.9987	99.9988	>99.99930	-
Trichloroethylene	0.277	99.9917	99.9978	>99.9932	-
Benzene	1.43	99.984	99.9911	99.9966	-
Tetrachloroethylene	0.0124	99.88	99.88	>99.930	-
Toluene	9.56	99.9963	<99.998	99.99912	-
Chlorobenzene	0.00956[b]	99.956	99.940	>99.986	-
Semivolatiles					
Hexachlorocyclopentadiene	0.00956[b]	-	-	-	>99.99
Bis-(2-ethylhexyl)-phthalate	0.00574[b]	-	-	-	99.940
Chlordane	0.736	-	-	-	>99.9999
Naphthalene	<0.000956[b]	-	-	-	c
Hexachlorobutadiene	<0.000956[b]	-	-	-	c

[a]Includes POHC input from the fuel oil.

[b]<100 μg/g in the waste.

[c]Not reported.

HCl: 0.553 lb/h
Particulate: 0.0479 gr/dscf @ 7% O_2
THC: 1.7 ppm, avg.
CO: 1.2 ppm, avg.
Other: O_2: 13.2% avg. CO_2: 6.1% avg.
Metals: See comments
PIC's:

PIC	Emissions, g/min			
	Fast VOST, avg.	Slow VOST, avg.	Gas bag[a]	Modified Method 5
Volatiles				
Bromochloromethane	0.0010	0.00085	<0.00005	-
Bromodichloromethane	0.0012	0.0012	<0.0001	-
Dibromochloromethane	0.0011	0.001	<0.0001	-
Bromoform	0.010	0.008	0.00022	-
Semivolatiles				
Naphthalene	-	-	-	0.00058

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 4

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private __
Capacity: 9.98 x 10^6 Btuh during test run
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 3.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid (ink sludge) wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 16.8 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 6,920 Btu/lb
Ash content: 15.9%
Chlorine content: 3.41%
Moisture content: 38.4%

Operating Conditions:

Temperature: Average - 1810°F (Primary chamber); 1770°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil (2.6 lb/min)

Excess air: 15.6% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %[a]	DRE, %			
		Fast VOST	Slow VOST	Gas bag	Modified Method 5
Volatiles					
Methylene Chloride	0.0116	99.63	d	>99.05	-
Chloroform	0.00654[b]	99.78	d	99.49	-
Methylene Bromide	0.159	99.982	d	99.968	-
1,1,1-Trichloroethane	0.06510	99.82	d	>99.51	-
Carbon Tetrachloride	0.379	>99.99903	d	>99.9988	-
Trichloroethylene	0.353	>99.9989	d	>99.9937	-
Benzene	0.889	99.988	d	99.982	-
Tetrachloroethylene	0.0183	99.982	d	>99.936	-
Toluene	6.01	99.9922	d	99.985	-
Chlorobenzene	0.00470[b]	99.966	d	>99.90	-
Semivolatiles					
Hexachlorocyclopentadiene	0.693	-	-	-	>99.9996
Bis-(2-ethylhexyl)-phthalate	0.00261[b]	-	-	-	99.88
Chlordane	<0.00131[b]	-	-	-	c
Naphthalene	0.379	-	-	-	99.996
Hexachlorobutadiene	0.0144	-	-	-	>99.98

[a]Includes POHC input from the fuel oil.
[b]<100 µg/g
[c]Not reported.
[d]Slow VOST not used in this run.

HCl: 0.216 lb/h
Particulate: 0.0443 gr/dscf @ 7% O_2
THC: <1 ppm avg.
CO: <1 ppm avg.
Other: O_2: 15.6% avg. CO_2: 3.9% avg.
PIC's:

PIC	Emissions, g/min			
	Fast VOST, avg.	Slow VOST, avg.	Gas bag[a]	Modified Method 5
Volatiles				
Bromochloromethane	0.0011	a	0.0020	-
Bromodichloromethane	0.00059	a	0.0011	-
Dibromochloromethane	0.00037	a	0.0012	-
Bromoform	0.0016	a	0.0090	-
Semivolatiles				
Naphthalene	-	-	-	b

[a]Slow VOST not used in this run.
[b]Not reported.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 6

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private __
Capacity: Not reported
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 3.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous and liquid organic wastes. No solids were fed during this run.

Length of burn: 20 min
Total amount of waste burned: Not reported; total heat input from waste feed was 9.0×10^6 Btuh
Waste feed rate: 25.3 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 5,930 Btu/lb
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Average - 2230°F (Primary chamber); 2110°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil

Excess air: 13.1% O_2

Monitoring Methods: See Run 1

TRADE WASTE

Emission and DRE Results:

POHC's:

POHC	Concentration in waste feed, wt. %[a]	DRE, % Slow VOST	DRE, % Gas bag
Methylene Chloride	0.013	99.51	>99.50
Chloroform	0.0082[b]	99.10	99.69
Methylene Bromide	0.322	99.974	99.9942
1,1,1-Trichloroethane	0.016	99.88	>99.935
Carbon Tetrachloride	0.209	99.9926	99.9973
Trichloroethylene	0.956	99.989	>99.9924
Benzene	2.52	99.990	>99.9910
Tetrachloroethylene	0.0041[b]	99.64	>99.77
Toluene	8.52	<99.9979	99.9970
Chlorobenzene	0.0174	99.60	99.79

[a] Includes POHC input from the fuel oil.
[b] <100 μg/g

HCl: Not tested
Particulate: Not tested
THC: 2 ppm, avg.
CO: 2 ppm, avg.
Other: O_2: 13.1% avg. CO_2: 5.9% avg.
PIC's:

PIC	Emissions, g/min Slow VOST	Emissions, g/min Gas bag[a]
Bromochloromethane	0.00029	0.00024
Bromodichloromethane[a]	0.00098	0.0019
Dibromochloromethane[a]	0.0012	0.0016
Bromoform	0.039	0.0079

[a] These compountds may have been stripped from the scrubber water.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 7

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private ___
Capacity:
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 3.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous and liquid organic wastes. No solids were fed during this run.

Length of burn: 20 min
Total amount of waste burned: Not reported. Total heat input from waste feed was 10.9×10^6 Btuh
Waste feed rate: 30.3 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 6,000 Btu/lb
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Average - 2020°F (Primary chamber); 2050°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil

Excess air: 12.4% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*[a]	*DRE, %* Slow VOST[c]	*DRE, %* Gas bag[c]
Methylene Chloride	0.0109	99.53	>99.66
Chloroform	0.00478[b]	99.02	>99.986
Methylene Bromide	0.319	99.9936	99.9989
1,1,1-Trichloroethane	0.00870[b]	99.84	>99.72
Carbon Tetrachloride	0.377	>99.9987	>99.99958
Trichloroethylene	0.290	99.9926	99.9938
Benzene	2.54	99.9950	99.9932
Tetrachloroethylene	0.00377[b]	99.81	>99.84
Toluene	8.55	<99.9976	99.9990
Chlorobenzene	0.0152	99.73	99.64

[a]Includes POHC input from the fuel oil.
[b]<100 µg/g
[c]Slow VOST data only; other sampling methods not used in this run.

HCl: Not tested
Particulate: Not tested
THC: 2 ppm, avg.
CO: 23 ppm, avg.
Other: O_2: 12.4% avg. CO_2: 6.4% avg.
PIC's:

PIC	*Emissions, g/min* Slow VOST	*Emissions, g/min* Gas bag
Bromochloromethane	0.00053	0.000058
Bromodichloromethane[a]	0.00056	<0.0002
Dibromochloromethane[a]	0.00053	0.000083
Bromoform	0.040	0.0046

[a]These compounds may have been stripped from the scrubber water.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 8A

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private ___
Capacity:
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 2.8 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid high-Btu ink sludge wastes

Length of burn: 20 min
Total amount of waste burned: Not reported. Total heat input from waste feed was 8.8×10^6 Btuh.
Waste feed rate: 20.3 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 7,220 Btu/lb
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Average - 2050°F (Primary chamber); 2120°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil

Excess air: 14.2% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*[a]	*DRE, %* *Slow VOST*[c]
Methylene Chloride	0.00832[b]	>99.83
Chloroform	0.00443[b]	>99.88
Methylene Bromide	0.292	99.99981
1,1,1-Trichloroethane	0.0162	99.47
Carbon Tetrachloride	0.530	99.9966
Trichloroethylene	0.670	>99.99921
Benzene	3.24	99.99952
Tetrachloroethylene	b	b
Toluene	11.03	99.99959
Chlorobenzene	0.0184	99.978

[a]Includes POHC input from the fuel oil.
[b]Waste feed concentration was <100 μg/g.
[c]Slow VOST data only; other sampling methods not used in this run.

HCl: Not tested
Particulate: Not tested
THC: 2 ppm, avg.
CO: 63 ppm, avg.
Other: O_2: 14.2% avg. CO_2: 5.7% avg.
PIC's:

PIC	*Emissions, g/min*[a]
Bromochloromethane	<0.00006
Bromodichloromethane	<0.0001
Dibromochloromethane	<0.0001
Bromoform	0.0028

[a]Data from Slow VOST only; gas bags not used.
[b]These compounds may have been stripped from scrubber water.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Date of Test: February 2-5, 1983

Run No.: 8B

Equipment information:

Type of unit: Incinerator - Primary and secondary chambers
Commercial X Private ___
Capacity:
Pollution control system: Venturi scrubber and mist eliminator (packed bed scrubber)

Waste feed system: Liquids pumped from storage tanks; solids are fed with a ram

Residence time: 2.8 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Aqueous, liquid organic, and solid high-Btu ink sludge wastes

Length of burn: 20 min
Total amount of waste burned: Not reported. Total heat input from waste feed was 9.9×10^6 Btuh
Waste feed rate: 25.1 lb/min
POHC's selected and concentration in waste feed:

Name	*Concentration*

SEE EMISSION AND DRE RESULTS

Btu content: 6,570 Btu/lb
Ash content:
Chlorine content:
Moisture content:

Operating Conditions:

Temperature: Average - 2040°F (Primary chamber); 2140°F (Secondary chamber)
Auxiliary fuel used: Fuel Oil

Excess air: 13.5% O_2

Monitoring Methods: See Run 1

Emission and DRE Results:

POHC's:

POHC	*Concentration in waste feed, wt. %*[a]	*DRE, %* *Slow VOST*[c]
Methylene Chloride	0.00881[b]	>99.90
Chloroform	0.00476[b]	>99.92
Methylene Bromide	0.326	>99.99992
1,1,1-Trichloroethane	0.0123	99.87
Carbon Tetrachloride	0.440	99.9951
Trichloroethylene	0.555	>99.99924
Benzene	2.91	>99.99979
Tetrachloroethylene	0.00440[b]	99.966
Toluene	9.87	99.99988
Chlorobenzene	0.0167	>99.9949

[a]Includes POHC input from the fuel oil.
[b]Waste feed concentration was <100 µg/g.
[c]Slow VOST data only; other sampling methods not used in this run.

HCl: Not tested
Particulate: Not tested
THC: 2 ppm, avg.
CO: 120 ppm, avg.
Other: O_2: 13.5% avg. CO_2: 6.7% avg.
PIC's:

PIC	*Emissions, g/min*[a]
Bromochloromethane	0.00077
Bromodichloromethane[b]	<0.0001
Dibromochloromethane[b]	<0.0001
Bromoform	<0.0001

[a]Data from Slow VOST only; gas bags not used.
[b]These compounds may have been stripped from scrubber water.

Reference(s): See Run 1

Comments: See Run 1

Process Flow Diagram: See Run 1

Summary of Test Data for Union Carbide
South Charleston, West Virginia

Date of Trial Burn: April 3-18, 1984

Run No.: 1

Test Sponsor: Union Carbide

Equipment information:

Type of unit: Incinerator - special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11 x 10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.84 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 273 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 598 lb
Waste feed rate: Ignitable - 91 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 191 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	74.6 lb
Tetrachloroethylene (TCE)	16.7 lb
1,2 DCB (DCB)	58.2 lb
Monochlorobenzene (MCB)	16.3 lb

Btu content: 9172 Btu/lb
Ash content:
Chlorine content: 0.56%
Moisture content:

Operating Conditions: 3rd chamber
Temperature: Range 1590° to 1630°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 13.8% O_2
Other:

Monitoring Methods:
POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

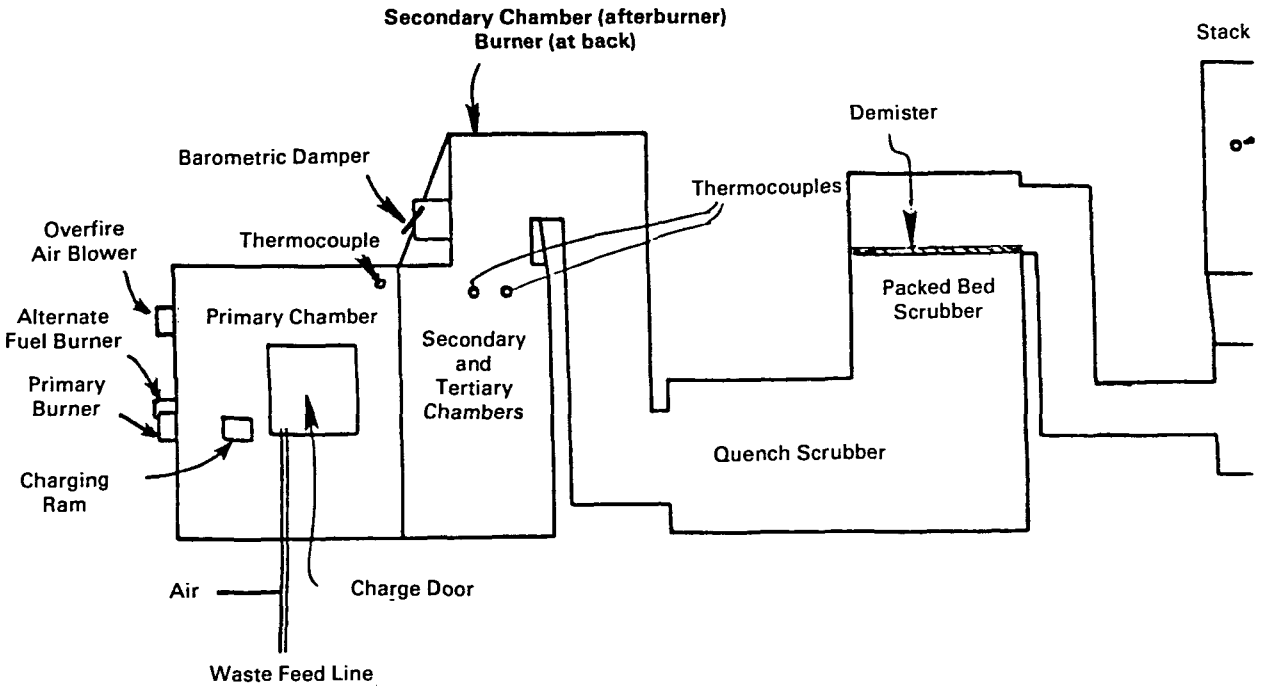
POHC's:	DRE:
Monochlorobenzene (MCB)	99.99961%
Tetrachloroethylene (TCE)	>99.99972%
1,2DCB (DCB)	99.99923%
Hexachloroethane (HCE)	99.999973%

HCl: HCl = 13.7 mg/dscm @ 98.15% removal
Particulate: 0.0943 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.95%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

PROCESS FLOW DIAGRAM



Date of Trial Burn: April 3-18, 1984

Run No.: 2

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.70 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 2.16 hours
Total amount of waste burned: Ignitable - 373 lb, Bottle - 122 lb, Air aspir. - 83.3 lb, Drum - 415 lb
Waste feed rate: Ignitable - 173 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 192 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	19.5 lb
Tetrachloroethylene (TCE)	19.6 lb
1,2 DCB (DCB)	15.3 lb
Monochlorobenzene (MCB)	19.1 lb

Btu content: 9,165 Btu/lb
Ash content: 0.055%
Chlorine content: 0.22%
Moisture content:

Operating Conditions:

Temperature: Range 1584° to 1616°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 13.6% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99962%
Tetrachloroethylene (TCE)	-	>99.99975%
1,2DCB (DCB)	-	>99.9999%
Hexachloroethane (HCE)	-	>99.9999%

HCl: HCl = 13.5 mg/dscm @ 98.10% removal
Particulate: 0.0729 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.7%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 3

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial __ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.57 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 666 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 613 lb
Waste feed rate: Ignitable - 222 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 204 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	28.8 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	28.1 lb

Btu content: 9,129 Btu/lb
Ash content: 0.055%
Chlorine content: 0.41%
Moisture content:

Operating Conditions:

Temperature: Range 1774° to 1835°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 12.7% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99979%
Tetrachloroethylene (TCE)	-	>99.99984%
1,2DCB (DCB)	-	99.99986%
Hexachloroethane (HCE)	-	>99.9999%

HCl: HCl = 16.9 mg/dscm @ 97.91% removal
Particulate: 0.0698 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.4%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 4

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.77 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 669 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 608 lb
Waste feed rate: Ignitable - 223 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 203 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	28.6 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	27.9 lb

Btu content: 9,365 Btu/lb
Ash content:
Chlorine content: 0.12%
Moisture content:

Operating Conditions:

Temperature: Range 1780° to 1823°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 13.2% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99952%
Tetrachloroethylene (TCE)	-	>99.99977%
1,2DCB (DCB)	-	99.99933%
Hexachloroethane (HCE)	-	>99.9999%

HCl: HCl = 13.9 mg/dscm @ 98.16% removal
Particulate: 0.0707 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.8%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 5

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.88 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 819 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 595 lb
Waste feed rate: Ignitable - 273 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 198 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	28.1 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	27.4 lb

Btu content: 9,300 Btu/lb
Ash content: 0.003%
Chlorine content: 0.15%
Moisture content:

Operating Conditions:

Temperature: Range 1763° to 1815°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 12.6% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99935%
Tetrachloroethylene (TCE)	-	>99.99977%
1,2DCB (DCB)	-	99.99957%
Hexachloroethane (HCE)	-	>99.9999%

HCl: HCl = 13.4 mg/dscm @ 98.26% removal
Particulate: 0.0611 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.7%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 6

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.81 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 537 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 535.9 lb
Waste feed rate: Ignitable - 179 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 194 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.5 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	26.9 lb

Btu content: 9,300 Btu/lb
Ash content:
Chlorine content: 0.31%
Moisture content:

Operating Conditions:

Temperature: Range 1792° to 1815°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 12.8% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:	DRE:
Monochlorobenzene (MCB)	99.99949%
Tetrachloroethylene (TCE)	>99.99986%
1,2DCB (DCB)	99.999923%
Hexachloroethane (HCE)	>99.9999%

HCl: HCl = 13.8 mg/dscm @ 98.19% removal
Particulate: 0.0746 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.5%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 7

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.89 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 189 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 543.3 lb
Waste feed rate: Ignitable - 63 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 196 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.8 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	27.2 lb

Btu content: 9,301 Btu/lb
Ash content:
Chlorine content: 0.39%
Moisture content:

Operating Conditions:

Temperature: Range 1591° to 1607°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 14.5% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99907%
Tetrachloroethylene (TCE)	-	>99.99966%
1,2DCB (DCB)	-	99.999944%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 8.0 mg/dscm (98.92% removal efficiency)
Particulate: 0.0659 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 17.5%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

UNION CARBIDE

Date of Trial Burn: April 3-18, 1984

Run No.: 8

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.82 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 159 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 542.2 lb
Waste feed rate: Ignitable - 53 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 196 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.8 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	27.1 lb

Btu content: 10,143 Btu/lb
Ash content: 0.046%
Chlorine content: 0.62%
Moisture content:

Operating Conditions:

Temperature: Range 1592° to 1615°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 14.1% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99907%
Tetrachloroethylene (TCE)	-	>99.99984%
1,2DCB (DCB)	-	99.99985%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 8.5 mg/dscm (98.87% removal efficiency)
Particulate: 0.0475 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 17.1%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 9

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.66 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 198 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 544.2 lb
Waste feed rate: Ignitable - 66 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 197 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.9 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	27.2 lb

Btu content: 10,171 Btu/lb
Ash content:
Chlorine content: 0.22%
Moisture content:

Operating Conditions:

Temperature: Range 1596° to 1618°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 14.3% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.9988%
Tetrachloroethylene (TCE)	-	>99.99979%
1,2DCB (DCB)	-	99.99985%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 11.2 mg/dscm (98.54% removal efficiency)
Particulate: 0.0567 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.9%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 10

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.73 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 966 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 528.6 lb
Waste feed rate: Ignitable - 322 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 191 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.2 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	26.5 lb

Btu content: 10,905 Btu/lb
Ash content:
Chlorine content: 1.00%
Moisture content:

Operating Conditions:

Temperature: Range 1774° to 1820°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 12.8% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.9987%
Tetrachloroethylene (TCE)	-	>99.99977%
1,2DCB (DCB)	-	99.99921%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 13.2 mg/dscm (98.48% removal efficiency)
Particulate: 0.0559 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.4%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 11

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial __ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.76 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 495 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 519.3 lb
Waste feed rate: Ignitable - 165 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 188 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	26.8 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	26.2 lb

Btu content: 10,870 Btu/lb
Ash content: 0.0304%
Chlorine content: 0.85%
Moisture content:

Operating Conditions:

Temperature: Range 1588° to 1603°F
Average 1600°F
Auxiliary fuel used: Natural gas

Excess air: 14.4% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99959%
Tetrachloroethylene (TCE)	-	>99.99983%
1,2DCB (DCB)	-	>99.9999%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 10.8 mg/dscm (98.64% removal efficiency)
Particulate: 0.0546 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 17%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Date of Trial Burn: April 3-18, 1984

Run No.: 12

Equipment information:

Type of unit: Special design - 1°, 2° & 3° chambers - Brule Model FG4-T20
Commercial ___ Private X
Capacity: 6×10^6 Btu/h but operated at 8 to 11×10^6 Btu/h
Pollution control system: Quenching and packed-bed scrubber (counterflow)

Waste feed system: 3 mechanisms: smaller bottles of waste fed by ram; larger containers are aspirated by nozzles; drum-sized material is pumped by nozzles

Residence time: 1.74 seconds

Test Conditions:

Waste feed data:

Type of waste(s) burned: Wide variety, but classed D001 and P&U wastes. Spent solvents constitute a large portion of waste

Length of burn: 3 hours
Total amount of waste burned: Ignitable - 762 lb, Bottle - 173 lb, Air aspir. - 120 lb, Drum - 536.8 lb
Waste feed rate: Ignitable - 254 lb/h, Bottle - 57.6 lb/h, Air aspir. - 40 lb/h, Drum - 194 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Hexachloroethane (HCE)	27.7 lb
Tetrachloroethylene (TCE)	27.6 lb
1,2 DCB (DCB)	21.6 lb
Monochlorobenzene (MCB)	26.9 lb

Btu content: 11,874 Btu/lb
Ash content:
Chlorine content: 0.68%
Moisture content:

Operating Conditions:

Temperature: Range 1783° to 1813°F
Average 1800°F
Auxiliary fuel used: Natural gas

Excess air: 13.3% O_2
Other:

Monitoring Methods:

POHC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
Other: CO - Ecolyzer (electro-chemical cell) and Beckman NDIR

Emission and DRE Results:

POHC's:		DRE:
Monochlorobenzene (MCB)	-	99.99979%
Tetrachloroethylene (TCE)	-	>99.99985%
1,2DCB (DCB)	-	>99.9999%
Hexachloroethane (HCE)	-	>99.9999%

HCl: 13.6 mg/dscm (98.39% removal efficiency)
Particulate: 0.0642 gr/dscf @ 7% O_2
THC:
CO: Approximately 5 ppm
Other: O_2 - 16.6%
PIC's: Benzene

Reference(s): Union Carbide trial burn dated July 17, 1984
Contact J.K. Petros in South Charleston, West Virginia, (304) 747-5209 (in-house test)

Comments: 70 to 80% of heat load from drums pumped via spray nozzles, 10 to 15% from air aspiration of bottles, the remainder from smaller bottles

Process Flow Diagram: See Data Sheet for Run No. 1

Summary of Test Data for the Upjohn Company
Laporte, Texas

Date of Test: August 12-13, 1982

Run No.: 2 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - liquid/gaseous
Commercial __ Private X
Capacity: 15 x 10^6 Btuh (design)
Pollution control system: Water quench followed by packed bed scrubber

Waste feed system: Liquid is fed from pressurized tanks; gas is vented directly from the process

Residence time: 5.2 s calculated
3-4 s design

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gaseous production wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 293 lb/h (liquid); 262 scfm (gas)
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

	Liquid	*Gas*
Btu content:	10,230 Btu/lb	Not reported
Ash content:	0.17%	Not reported
Chlorine content:	21.4%	376 mg/l
Moisture content:	Not reported	Not reported
Phosgene content:	0	534 mg/l
Isocyanate content:	190,000 µg/g	0

Operating Conditions:

Temperature: Average - 2040°F (2000°F is considered typical)
Auxiliary fuel used: Natural gas (22.2 scfm)

Excess air: 8.4% O_2

Monitoring Methods:

Waste Feed: One composite per run made up of grab samples taken every 15 minutes during run.
Combustion Emissions:
Volatile POHC's and PIC's: Gas bags and VOST (Fast)
Semivolatile POHC's and PIC's: Modified Method 5
HCl: Modified Method 5
Particulate: Modified Method 5
CO_2 and O_2: Gas bag for Orsat analysis

Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
HC - Beckman Model 402 (FID)

Dioxins and furans (tetra- and penta-chlorinated only): Modified Method 5
Phosgene: Midget impinger trains (2)
Isocyanates: Midget impinger trains (2)

Emission and DRE Results:

POHC's:

Name	Waste feed concentration		DRE, %		
	Liquid, μg/g	Gas, μg/l	Gas bag	Fast VOST	Modified Method 5
Volatiles					
Carbon tetrachloride	36,000	2.0	99.9940	99.25	-
Trichloroethylene	33,000	0.10	99.9983	>99.22	-
Chlorobenzene	7,200	<0.005	e	99.937	-
Chloromethane	>2,000	<0.005	>99.9986	99.990	-
Semivolatiles					
m-Dichlorobenzene	2,100	c	-	-	99.922
o-Dichlorobenzene	40,000	c	-	-	99.9990
p-Dichlorobenzene	56,000	c	-	-	99.9990
1,2,4-Trichlorobenzene	270	c	-	-	99.65
Bis(ethylhexyl)phthalate	500[f]	c	-	-	99.98
Chlorophenyl isocyanate	23,000	c	-	-	g
Phenyl isocyanate	170,100	c	-	-	>99.99992
Aniline	a	c	-	-	a
Phosgene	b	534,000[d]	-	-	99.9985

[a]Result not determinable due to interferences; concentration <100 μg/g.
[b]Highly unlikely as a waste constituent; therefore, not analyzed in sample.
[c]Vent gas samples not analyzed for semivolatiles.
[d]Separate sampling and analysis conducted for phosgene.
[e]Not measured.
[f]Poor recovery of spike from waste feed; DRE may be biased low.
[g]Not reported.

HCl: 0.93 lb/h
Particulate: 0.0948 gr/dscf @ 7% O_2
THC: 8.8 ppm
CO: 9.5 ppm
Other: Phosgene - 0.058 g/min; isocyanate - <0.005 g/min

PIC's:

PIC[a]	Gas bag, g/min	Fast VOST (avg.) g/min
Volatiles		
Chloroform	0.15	0.19
Benzene	0.0028	0.0022
Tetrachloroethylene	0.00029	0.00013
Toluene	0.0020	0.0047
Methylene chloride	0.0013	0.00093
Methyl ethyl ketone	0.00031	0.000064
Bromodichloromethane	0.014	0.0039
Dibromochloromethane	0.0017	0.0021

Semivolatiles	Modified Method 5, g/min
Phenol	0.00048
Naphthalene	0.000069
2,6-Toluene diisocyanate	<0.0002
Diethyl phthalate	0.00050
Hexachlorobenzene	0.000032
o-Chlorophenol	0.00016
2,4,6-Trichlorophenol	0.0050
Pentachlorophenol	0.00045
o-Nitrophenol	0.00053

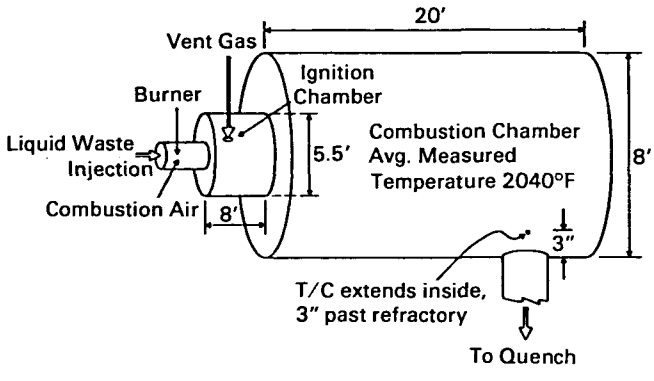
[a]Not blank corrected

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerators. Final Report, Volumes II and IV. EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, Missouri. Mr. Don Oberacker, Project Officer. EPA Hazardous Waste Engineering Research Laboratory, Cincinnati, OH 45268. November 1984.

Comments: Upjohn Run 1 was aborted due to sampling problems. Unit was operated during Runs 2-4 at less than half its rated capacity (6 MM Btuh versus 15 MM Btuh), but within the normal operating range. All parameters appeared normal and steady. Volatile results are questionable due to abnormally high recovery rates of spikes; as a result, DRE's may be biased high (See Reference Volume II, p. 101). Also due to sampling and analysis difficulties (i.e. poor recoveries of spikes), DRE's for bis(ethylhexyl)-phthalate and aniline may be biased (See Reference Volume II, p. 102). Tests for furans in stack emissions were positive (0.005 to 0.0068 ng/L) but tests for dioxin were negative (<0.0001 ng/L). Metals were not analyzed during any of the runs at Upjohn. Up to 1 ppm of phosgene was found in the stack gas.

PROCESS FLOW DIAGRAM

Combustion chamber diagram.



Date of Test: August 12-13, 1982

Run No.: 3

Equipment information:

Type of unit: Incinerator - liquid/gaseous injection

Commercial __ Private X

Capacity: 15 x 10^6 Btuh (design)

Pollution control system: Water quench followed by packed bed scrubber

Waste feed system: Liquid is fed from pressurized tanks; gas is vented directly from the process

Residence time: 5.2 s calculated
3-4 s design

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gaseous production wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 243 lb/h (liquid); 278 scfm (gas)
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

	Liquid	*Gas*
Btu content:	10,110 Btu/lb	Not reported
Ash content:	0.19%	Not reported
Chlorine content:	22.1%	
Moisture content:	Not reported	Not reported
Phosgene content:	0	508 mg/l
Isocyanate content:	180,000 µg/g	0

Operating Conditions:

Temperature: Average - 2040°F (2000°F is considered typical)

Auxiliary fuel used: Natural gas (30.5 scfm)

Excess air: 7.9% O_2

Monitoring Methods: See Run 2

Emission and DRE Results:

POHC's:

Name	Waste feed concentration		DRE, %		
	Liquid, μg/g	Gas, μg/l	Gas bag	Fast VOST	Modified Method 5
Volatiles					
Carbon tetrachloride	44,000	5.7	99.9931	99.971	-
Trichloroethylene	40,000	0.045	99.9989	99.9914	-
Chlorobenzene	4,100	<0.005	99.86	99.910	-
Chloromethane	>1,200	<0.005	>99.9952	>99.9916	-
Semivolatiles					
m-Dichlorobenzene	2,300	b	-	-	99.905
o-Dichlorobenzene	46,000	b	-	-	99.993
p-Dichlorobenzene	59,000	b	-	-	99.995
1,2,4-Trichlorobenzene	290	b	-	-	98.6
Bis(ethylhexyl)phthalate[d]	500	b	-	-	99.95
Phenyl isocyanate	160,000	b	-	-	>99.99990
Chlorophenyl isocyanate	21,000	b	-	-	e
Aniline	14,000	b	-	-	99.9988
Phosgene	a	508,000[c]	-	-	99.9930

[a]Highly unlikely as a waste constituent; therefore, not analyzed in sample.
[b]Vent gas samples not analyzed for semivolatiles.
[c]Separate sampling and analysis conducted for phosgene.
[d]Poor recovery of spike from waste; DRE may be biased low.
[e]Not reported.

HCl: 1.2 lb/h
Particulate: 0.0796 gr/dscf @ 7% O_2
THC: 5.8 ppm
CO: 10.1 ppm
Other: Phosgene - 0.28 g/min; isocyanate - 0.033 g/min

Reference(s): See Run 2

Comments: See Run 2

Process Flow Diagram: See Run 2

PIC's:

PIC[a]	Gas bag, g/min	Fast VOST (avg.) g/min
Volatiles		
Chloroform	0.034	0.022
Benzene	0.0012	0.0058
Tetrachloroethylene	0.00015	0.00013
Toluene	0.00069	0.0016
Methylene chloride	0.0012	0.00041
Methyl ethyl ketone	0.000095	0.00026
Bromodichloromethane	0.0023	0.0015
Dibromochloromethane	0.00016	0.0060

Semivolatiles	Modified Method 5, g/min
Phenol	0.00016
Naphthalene	0.00038
2,6-Toluene diisocyanate	0.00020
Diethyl phthalate	0.00036
Hexachlorobenzene	<0.00002
o-Chlorophenol	0.0012
2,4,6-Trichlorophenol	0.0067
Pentachlorophenol	0.00029
o-Nitrophenol	0.0023

[a]Not blank corrected

Date of Test: August 12-13, 1982

Run No.: 4

Equipment information:

Type of unit: Incinerator - liquid/gaseous
Commercial __ Private X
Capacity: 15 x 10^6 Btuh (design)
Pollution control system: Water quench followed by packed bed scrubber

Waste feed system: Liquid is fed from pressurized tanks; gas is vented directly from the process

Residence time: 5.2 s calculated
3-4 s design

Test Conditions:

Waste feed data:

Type of waste(s) burned: Liquid and gaseous production wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported
Waste feed rate: 243 lb/h (liquid); 272 scfm (gas)
POHC's selected and concentration in waste feed:

Name	*Concentration*
SEE EMISSION AND DRE RESULTS	

	Liquid	*Gas*
Btu content:	10,320 Btu/lb	Not reported
Ash content:	0.21%	Not reported
Chlorine content:	21.1%	
Moisture content:	Not reported	Not reported
Phosgene content:	0	202 mg/l
Isocyanate content:	240,000 μg/g	0

Operating Conditions:

Temperature: Average 2040°F (2000°F is considered typical)
Auxiliary fuel used: Natural gas (28.2 scfm)

Excess air: 8.0% O_2

Monitoring Methods: See Run 2

Emission and DRE Results:

POHC's:

Name	Waste feed concentration		DRE, %		
	Liquid, μg/g	Gas, μg/l	Gas bag	Fast VOST	Modified Method 5
Volatiles					
Carbon tetrachloride	44,000	4.3	99.9954	99.988	-
Trichloroethylene	40,000	0.11	>99.99956	99.9914	-
Chlorobenzene	6,800	<0.005	99.945	99.956	-
Chloromethane	>1,900	<0.005	>99.9975	>99.9903	-
Semivolatiles					
m-Dichlorobenzene	3,100	b	-	-	99.932
o-Dichlorobenzene	64,000	b	-	-	99.9990
p-Dichlorobenzene	80,000	b	-	-	99.9990
1,2,4-Trichlorobenzene	390	b	-	-	99.75
Bis(ethylhexyl)phthalate[d]	1,300	b	-	-	99.98
Phenyl isocyanate	210,000	b	-	-	>99.99992
Chlorophenyl isocyanate	28,000	b	-	-	e
Aniline	19,000	b	-	-	99.9991
Phosgene	a	202,000[c]	-	-	99.981

[a]Highly unlikely as a waste constituent; therefore, not analyzed in sample.
[b]Vent gas samples not analyzed for semivolatiles.
[c]Separate sampling and analysis conducted for phosgene.
[d]Poor recovery of spike from waste; DRE may be biased low.
[e]Not reported.

HCl: 1.7 lb/h
Particulate: 0.0126 gr/dscf @ 7% O_2
THC: 3.5 ppm
CO: 8.5 ppm
Other: Phosgene - 0.30 g/min; isocyanate - 0.27 g/min

Reference(s): See Run 2

Comments: See Run 2

Process Flow Diagram: See Run 2

PIC's:

PIC[a]	Gas bag, g/min	Fast VOST (avg.) g/min
Volatiles		
Chloroform	0.017	0.016
Benzene	0.0019	0.0036
Tetrachloroethylene	0.000097	0.00019
Toluene	0.00037	0.0020
Methylene chloride	0.0023	0.00097
Methyl ethyl ketone	0.00021	0.00022
Bromodichloromethane	0.00077	0.0011
Dibromochloromethane	0.000065	0.00048

Semivolatiles	Modified Method 5, g/min
Phenol	<0.00004
Naphthalene	0.00035
2,6-Toluene diisocyanate	<0.0002
Diethyl phthalate	0.00028
Hexachlorobenzene	0.000016
o-Chlorophenol	0.000076
2,4,6-Trichlorophenol	0.0059
Pentachlorophenol	0.00028
o-Nitrophenol	0.0012

[a]Not blank corrected

Summary of Test Data for Zapata Industries Inc.
Butner, North Carolina

Date of Test: September 28-30, 1982

Run No.: 1 ***Test Sponsor:*** EPA

Equipment information:

Type of unit: Incinerator - primary (pyrolytic) chamber followed by a secondary chamber (thermal reactor)
Commercial __ Private X
Capacity: Approximately 1.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid wastes are fed from a feed tank (presumably pumped)

Residence time: 0.069 s (calculated, secondary chamber); design residence time is 0.22 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Varnish and lacquer wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported; calculated heat input 1.4 x 10^6 Btuh (waste only)
Waste feed rate: 87 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Methylene chloride (CH_2Cl_2)	0.0064%
Carbon tetrachloride (CCl_4)	1.2%
Trichloroethylene (TCE)	1.1%
Toluene	0.11%
Chlorobenzene	0.78%

Btu content: 16,150 Btu/lb
Ash content: 0.018%
Chlorine content: 2.7%
Moisture content: 0.68%

Operating Conditions:

Temperature: Average - 1240°F (Primary chamber); 1570°F (Secondary chamber)
Auxiliary fuel used: Natural gas (385 scf/h)

Excess air: 8.2% O_2

Monitoring Methods:

Waste Feed: One composite per run made up of grab samples taken every 15 minutes during run
Combustion emissions:
Volatile POHC's and PIC's: Gas bags (all runs) and VOST (fast) (Runs 1, 2, and 3 only)
Semivolatile POHC's and PIC's: Not monitored
HCl: Modified Method 5
Particulate: Modified Method 5
Metals: Not monitored
CO_2 and O_2: Gas bag for Orsat analysis
Continuous monitors:
CO_2 - Horiba Model PIR-2000S (NDIR)
CO - Beckman Model 215A (NDIR)
O_2 - Beckman Model 742 (polarographic sensor)
HC - Beckman Model 402 (FID)
Dioxins and furans: Not monitored

Emission and DRE Results:

POHC's:

POHC	*Gas bag*[a]
CH_2Cl_2	b
CCl_4	99.978%
TCE	>99.979%
Toluene	>99.952%
Chlorobenzene	>99.9956%

[a]VOST sample not analyzed for this run.
[b]<0.01% in waste feed.

HCl: 2.23 lb/h
Particulate: 0.0301 gr/dscf @ 7% O_2
THC: 71 ppm
CO: 1275 ppm
Other:
PIC's:[a]

Chloroform	0.000036 g/min
1,1,1-trichloroethane	0.000038 g/min
Benzene	0.00072 g/min
Tetrachloroethylene	0.000042 g/min

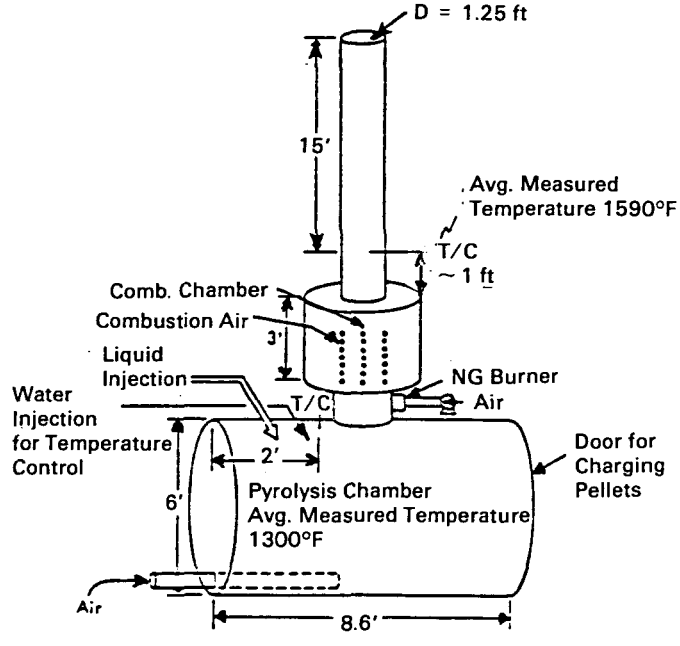
[a]Not blank corrected; values from gas bag sample.

Reference(s): Trenholm, A., P. Gorman, and G. Jungclaus. Performance Evaluation of Full-Scale Hazardous Waste Incinerators. Final Report, Volumes II and IV (Appendix F). EPA Contract No. 68-02-3177 to Midwest Research Institute, Kansas City, MO. Mr. Don Oberacker, EPA Project Officer, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH.

Comments: Only volatile POHC's were analyzed in this test since no semivolatiles were expected in the waste feed. Carbon tetrachloride, trichloroethylene, and chlorobenzene were spiked into the waste. Both particulate and chlorine emissions were within regulatory limits. Total calculated heat input from waste during Runs 3 and 4 may be low due to problems in waste feed sampling. The water content of the waste feed samples taken in Runs 3 and 4 was believed to be disproportionately high and not representative of the true waste feed composition. The sampling port used in Runs 2 through 4 was further away from the secondary chamber outlet than that used in Run 1. VOST sample from Run 1 was not analyzed; VOST was not collected in Run 4. Correction factors were used to adjust the POHC input rates to compensate for the apparent non-representativeness of the feed samples. These adjustments apparently carry forward into the DRE values calculated and reported. Metals were not monitored during this test program.

PROCESS FLOW DIAGRAM

Combustion chamber diagram.



Note:
T/C in stack extends inside 6"
T/C in chamber extends 3" post refractory

Date of Test: September 28-30, 1982

Run No.: 2

Equipment information:

Type of unit: Incinerator - primary pyrolytic chamber followed by reactor (secondary chamber)
Commercial __ Private X
Capacity: Approximately 1.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid wastes are fed from a feed tank (presumably pumped)

Residence time: 0.067 s (calculated, secondary chamber); design residence time is 0.22 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Varnish and lacquer wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported; calculated heat input (waste only) 1.6 x 10^6 Btuh
Waste feed rate: 101 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Methylene chloride (CH_2Cl_2)	0.017%
Carbon tetrachloride (CCl_4)	0.73%
Trichloroethylene (TCE)	0.71%
Toluene	0.33%
Chlorobenzene	0.76%

Btu content: 16,300 Btu/lb
Ash content: 0.013%
Chlorine content: 1.6%
Moisture content: 0.63%

Operating Conditions:

Temperature: Average - 1330°F (Primary chamber); 1594°F (Secondary chamber)
Auxiliary fuel used: Natural gas (350 scf/h)

Excess air: 12.0% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's:

POHC	*Gas bag*	*Fast VOST*
CH_2Cl_2	99.84%	>99.906
CCl_4	>99.9957%	99.99911
TCE	>99.987%	99.9979
Toluene	>99.985%	>99.9914
Chlorobenzene	>99.9963%	>99.9953

HCl: 1.39 lb/h
Particulate: 0.0219 gr/dscf @ 7% O_2
THC: 1.9 ppm
CO: 22.2 ppm
Other:
PIC's:[a]

	Gas bag, g/min	*Fast VOST, g/min*
Chloroform	0.000035	0.000056 avg.
1,1,1-trichloroethane	0.000052	0.0000120 avg.
Benzene	0.0013	0.000860 avg.
Tetrachloroethylene	0.000022	0.000014

[a]Not blank corrected.

Reference(s): Same as Run 1

Comments: Same as Run 1

Process Flow Diagram: See Run 1

ZAPATA

Date of Test: September 28-30, 1982

Run No.: 3

Equipment information:

Type of unit: Incinerator - primary pyrolytic chamber; thermal reactor (secondary)
Commercial ___ Private X
Capacity: Approximately 1.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid wastes are fed from a feed tank (presumably pumped)

Residence time: 0.066 s calculated (secondary chamber); design residence time 0.22 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Varnish and lacquer wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported; calculated heat input 1.0 x 10^6 Btuh (waste only - see comments)
Waste feed rate: 103 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Methylene chloride (CH_2Cl_2)	<0.0005%
Carbon tetrachloride (CCl_4)	0.61%
Trichloroethylene (TCE)	0.52%
Toluene	0.073%
Chlorobenzene	0.79%

Btu content: 9,800 Btu/lb
Ash content: 0.0098%
Chlorine content: 1.3%
Moisture content: 37%

Operating Conditions:

Temperature: Average - 1360°F (Primary chamber); 1553°F (Secondary chamber)
Auxiliary fuel used: Natural gas (375 scf/h)

Excess air: 11.8% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's:

POHC	*Gas bag*	*Fast VOST*
CH_2Cl_2	a	a
CCl_4	99.943%	99.9990
TCE	>99.976%	99.9985
Toluene	>99.965%	>99.9932
Chlorobenzene	99.9927%	>99.9974

[a]<0.01% in waste feed.

HCl: 2.75 lb/h
Particulate: 0.0357 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 4.7 ppm
Other:
PIC's:[a]

	Gas bag, g/min	*Fast VOST, g/min*
Chloroform	0.000035	0.000062 avg.
1,1,1-trichloroethane	0.000027	0.000020 avg.
Benzene	0.00016	0.00002 avg.
Tetrachloroethylene	0.000022	

[a]Not blank corrected.

Reference(s): Same as Run 1

Comments: Same as Run 1

Process Flow Diagram: See Run 1

Date of Test: September 28-30, 1982

Run No.: 4

Equipment information:

Type of unit: Incinerator - primary pyrolytic chamber, secondary thermal reactor
Commercial __ Private X
Capacity: Approximately 1.5 x 10^6 Btuh
Pollution control system: None

Waste feed system: Liquid wastes are fed from a feed tank (presumably pumped)

Residence time: 0.063 s (secondary chamber); 0.22 s design

Test Conditions:

Waste feed data:

Type of waste(s) burned: Varnish and lacquer wastes

Length of burn: 2 h (sampling time)
Total amount of waste burned: Not reported; calculated heat input 0.67 x 10^6 Btuh (waste only - see comments)
Waste feed rate: 102 lb/h
POHC's selected and concentration in waste feed:

Name	*Concentration*
Methylene chloride (CH_2Cl_2)	<0.0005%
Carbon tetrachloride (CCl_4)	0.28%
Trichloroethylene (TCE)	0.29%
Toluene	0.42%
Chlorobenzene	0.40%

Btu content: 6,550 Btu/lb
Ash content: 0.14%
Chlorine content: 0.74%
Moisture content: 54%

Operating Conditions:

Temperature: Average - 1274°F (Primary chamber); 1661°F (Secondary chamber)
Auxiliary fuel used: Natural gas (360 scf/h)

Excess air: 11.9% O_2

Monitoring Methods: Same as Run 1

Emission and DRE Results:

POHC's:

POHC	*Gas bag*[a]
CH_2Cl_2	b
CCl_4	>99.9972%
TCE	>99.9946%
Toluene	>99.9956%
Chlorobenzene	>99.9983%

[a]VOST sample not collected in this run.
[b]<0.01% in waste feed.

HCl: 3.30 lb/h
Particulate: 0.0168 gr/dscf @ 7% O_2
THC: <1 ppm
CO: 8.8 ppm
Other:
PIC's:[a]

Chloroform	0.000031 g/min
1,1,1-trichloroethane	0.000026 g/min
Benzene	0.00066 g/min
Tetrachloroethylene	0.000022 g/min

[a]Not blank corrected. Values from gas bag sample; VOST sample not collected.

Reference(s): Same as Run 1

Comments: Same as Run 1

Process Flow Diagram: See Run 1

Table B-1. Summary Tabulation of Incinerator Test Results by Compound

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h	TSP, gr/dscf[b]	TEST No.	SPONSOR
McDONNELL DGLS	1,1,1 trichloroethane	71	99.99999	1800	0.8	0.032	2	Private
McDONNELL DGLS	1,1,1 trichloroethane	70	99.99999	1800	0.74	0.032	4	Private
McDONNELL DGLS	1,1,1 trichloroethane	62	99.99999	1800	1.64	0.044	3	Private
McDONNELL DGLS	1,1,1 trichloroethane	59	99.99999	1800	1.67	0.047	1	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.88	99.99998	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.87	99.99998	1830	99.9	0.002	6	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.82	99.99998	1830	99.9	0.0009	4	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.83	99.99998	1830	99.9	0.003	5	Private
ROSS INCINERATION	1,1,1 trichloroethane	2.55	99.99952	2110	0.1	0.061	1	EPA
ROSS INCINERATION	1,1,1 trichloroethane	0.91	99.999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	1,1,1 trichloroethane	0.58	99.999	2040	0.3	0.061	3	EPA
DOW CHEMICAL	1,1,1 trichloroethane		99.998	1810	99.9		10212-2	Private
DOW CHEMICAL	1,1,1 trichloroethane		99.996	1820	99.9		10212-1	Private
TWI	1,1,1 trichloroethane[g]	0.00792	99.966	2080	0.3	0.075	1	EPA
DUPONT-LA	1,1,1 trichloroethane[g]	0.001	99.932	2640	0.5	0.015	1	EPA
TWI	1,1,1 trichloroethane[g,k]	0.016	99.88	2230	h	h	6	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0123	99.87	2140	h	h	8B	EPA
TWI	1,1,1 trichloroethane[g]	0.0105	99.86	2070	0.6	0.048	3	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0087	99.84	2050	h	h	7	EPA
TWI	1,1,1 trichloroethane[g]	0.0051	99.82	1810	0.2	0.044	4	EPA
TWI	1,1,1 trichloroethane[g]	0.011	99.81	2030	0.4	0.127	2	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0162	99.47	2120	h	h	8A	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.038	99.99999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.035	99.99999	2110	0.1	0.061	1	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.028	99.99999	2090	0.3	0.077	2	EPA
3M	1,1,2 trichloroethane	1.631	99.999	1890	0.8	0.08	10	Private
3M	1,1,2 trichloroethane	1.566	99.999	1985	0.2	0.091	4	Private
3M	1,1,2 trichloroethane	1.304	99.999	1905	0.3	0.047	6	Private
3M	1,1,2 trichloroethane	1.066	99.999	1885	0.4	0.048	7	Private
3M	1,1,2 trichloroethane	0.937	99.999	1915	0.5	0.047	5	Private
3M	1,1,2 trichloroethane	1.771	99.998	1930	1.2	0.154	8	Private
3M	1,1,2 trichloroethane	1.3	99.998	1925	0.7	0.078	9	Private
3M	1,1,2 trichloroethane	1.225	99.998	2030	0.44	0.0848	3	Private
3M	1,1,2 trichloroethane	0.548	99.994	1985	0.9	0.0623	1	Private
3M	1,1,2 trichloroethane	1.239	99.99	1950	0.48	0.112	2	Private
UNION CARBIDE	1,2 dichlorobenzene	2.1	99.99994	1600	98.9	0.066	7	Private
UNION CARBIDE	1,2 dichlorobenzene	1.6	99.99992	1800	98.2	0.075	6	Private
UNION CARBIDE	1,2 dichlorobenzene	1.7	99.9999	1600	98.6	0.055	11	Private
UNION CARBIDE	1,2 dichlorobenzene	1.5	99.9999	1600	98.1	0.073	2	Private
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.9999	1800	98.4	0.064	12	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.99986	1800	97.9	0.07	3	Private
UNION CARBIDE	1,2 dichlorobenzene	2.2	99.99985	1600	98.9	0.048	8	Private
UNION CARBIDE	1,2 dichlorobenzene	2.1	99.99985	1600	98.5	0.057	9	Private
UNION CARBIDE	1,2 dichlorobenzene	1.3	99.99957	1800	98.3	0.061	5	Private
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.99933	1800	98.2	0.071	4	Private
UNION CARBIDE	1,2 dichlorobenzene	5	99.99923	1600	98.2	0.094	1	Private
UNION CARBIDE	1,2 dichlorobenzene	1.2	99.99921	1800	98.5	0.056	10	Private
UPJOHN	1,2,4 trichlorobenzene	0.027	99.65	2040	0.9	0.094	2	EPA
UPJOHN	1,2,4 trichlorobenzene	0.039	99.75	2040	1.7	0.013	4	EPA
UPJOHN	1,2,4 Trichlorobenzene	0.029	98.6	2040	1.2	0.08	3	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.071	99.9994	2040	0.3	0.061	3	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.02	99.9992	2110	0.1	0.061	1	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.02	99.999	2090	0.3	0.077	2	EPA
AMERICAN CYANAMID	aniline[c,e]	60	99.99999	1198	0.007	0.069	3	EPA
AMERICAN CYANAMID	aniline[c,e]	53	99.99999	1198	0.007	0.175	5	EPA
AMERICAN CYANAMID	aniline[c,e]	55	99.99999	1240	0.004	0.075	2	EPA
AMERICAN CYANAMID	aniline[c,e]	0.8	99.9997	1254	0.007	0.007	4	EPA
UPJOHN	aniline[c]	c	99.9988	2040	1.2	0.08	3	EPA
ROSS INCINERATION	aniline	0.026	99.998	2110	0.1	0.061	1	EPA
ROSS INCINERATION	aniline	0.026	99.998	2040	0.3	0.061	3	EPA
ROSS INCINERATION	aniline	0.021	99.998	2090	0.3	0.077	2	EPA
UPJOHN	aniline[c]	c	99.9988	2040	1.2	0.08	3	EPA
UPJOHN	aniline[c]	c	99.981	2040	1.7	0.013	4	EPA
STAUFFER CHEMICAL	benzene	4.68	100	1830	99.9	0.003	5	Private
STAUFFER CHEMICAL	benzene	4.53	100	1830	99.9	0.002	6	Private
STAUFFER CHEMICAL	benzene	4.47	100	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	benzene	4.65	99.99999	1830	99.9	0.0009	4	Private
TWI	benzene[k]	2.91	99.99979	2140	h	h	8B	EPA
TWI	benzene[k]	3.24	99.99952	2120	h	h	8A	EPA
TWI	benzene	1.52	99.9983	2080	0.3	0.075	1	EPA
TWI	benzene[k]	2.54	99.995	2050	h	h	7	EPA
TWI	benzene[k]	2.52	99.99	2230	h	h	6	EPA
TWI	benzene	1.18	99.989	2030	0.4	0.127	2	EPA
TWI	benzene	0.889	99.988	1810	0.2	0.044	4	EPA
MITCHELL SYSTEMS	benzene[g]	0.0116	99.986	2000	4.9	0.313	2	EPA
TWI	benzene	1.43	99.984	2070	0.6	0.048	3	EPA
MITCHELL SYSTEMS	benzene[g]	0.0067	99.82	2050	f	f	3	EPA
DUPONT-LA	benzyl chloride	0.233	99.9996	2640	0.6	0.004	2	EPA
DUPONT-LA	benzyl chloride	0.211	99.9996	2640	0.5	0.015	1	EPA
DUPONT-LA	benzyl chloride	0.219	99.9994	2640	0.9	0.011	3	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
MITCHELL SYSTEMS	bis(ethyl hexy)phthalate[c]	0.192	99.9985	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	bis(ethyl hexy)phthalate[c]	0.416	99.996	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	bis(ethyl hexy)phthalate[c]	0.169	99.993	2000	4.9	0.313	2	EPA
TWI	bis(ethyl hexy)phthalate[c,g]	0.00511	99.96	2030	0.4	0.127	2	EPA
TWI	bis(ethyl hexy)phthalate[c,g]	0.00429	99.951	2080	0.3	0.075	1	EPA
TWI	bis(ethyl hexy)phthalate[c,g]	0.00574	99.94	2070	0.6	0.048	3	EPA
TWI	bis(ethyl hexy)phthalate[c,g]	0.00261	99.88	1810	0.2	0.044	4	EPA
UPJOHN	bis(ethyl hexy)phthalate[c]	0.05	99.98	2040	0.9	0.094	2	EPA
UPJOHN	bis(ethyl hexy)phthalate[c]	0.13	99.98	2040	1.7	0.013	4	EPA
UPJOHN	bis(ethyl hexy)phthalate[c]	0.05	99.95	2040	1.2	0.08	3	EPA
CINCINNATI MSD	bromodichloromethane	0.4	99.995	2400	60.9	0.444	9	EPA
CINCINNATI MSD	bromodichloromethane	0.28	99.97	1650	5	0.107	7	EPA
ROSS INCINERATION	butyl benzyl phthalate	0.1	99.9996	2110	0.1	0.061	1	EPA
ROSS INCINERATION	butyl benzyl phthalate	0.027	99.999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	butyl benzyl phthalate[g]	0.017	99.998	2090	0.3	0.077	2	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate	0.169	99.995	2000	4.9	0.313	2	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.0227	99.9938	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.0149	99.9923	1952	4.47	0.161	3	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate[g]	0.00758	99.992	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate[g]	0.0064	99.973	1975	3.8	0.378	4	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.00416	99.92	1952	1.83	0.187	2	EPA
STAUFFER CHEMICAL	carbon tetrachloride	0.89	99.99998	1830	99.9	0.002	6	Private
McDONNELL DGLS	carbon tetrachloride	8.9	99.99998	1800	1.64	0.044	3	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.82	99.99998	1830	99.9	0.0009	4	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.85	99.99998	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.84	99.99998	1830	99.9	0.003	5	Private
McDONNELL DGLS	carbon tetrachloride	7.5	99.99997	1800	0.8	0.032	2	Private
McDONNELL DGLS	carbon tetrachloride	8.1	99.99996	1800	1.67	0.047	1	Private
DUPONT-DE	carbon tetrachloride	9.4	99.99994	1831	2.6	f	3	Private
DUPONT-DE	carbon tetrachloride	9.2	99.99994	1842	1.3	f	7	Private
DUPONT-DE	carbon tetrachloride	9.3	99.99993	1864	1.2	0.079	6	Private
McDONNELL DGLS	carbon tetrachloride	8.9	99.99992	1800	0.74	0.032	4	Private
DUPONT-DE	carbon tetrachloride	8.7	99.99992	1833	0.6	0.08	4	Private
DUPONT-DE	carbon tetrachloride	7.5	99.99992	1906	0.1	0.055	2	Private
DUPONT-DE	carbon tetrachloride	8.8	99.99991	1826	1.7	f	5	Private
CINCINNATI MSD	carbon tetrachloride	0.26	99.9999	2400	6.1	f	3	EPA
DUPONT-LA	carbon tetrachloride	5.38	99.99988	2640	0.6	0.004	2	EPA
DUPONT-LA	carbon tetrachloride	6.16	99.99986	2640	0.5	0.015	1	EPA
DUPONT-LA	carbon tetrachloride	5.27	99.99981	2640	0.9	0.011	3	EPA
DUPONT-DE	carbon tetrachloride	7.7	99.9994	1857	1.1	0.071	1	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
ZAPATA INDUSTRIES	carbon tetrachloride	0.73	99.99911	1600	1.4	0.022	2	EPA
TWI	carbon tetrachloride[c]	0.379	99.99903	1810	0.2	0.044	4	EPA
3M	carbon tetrachloride	1.068	99.999	1985	0.2	0.091	4	Private
3M	carbon tetrachloride	1.031	99.999	1950	0.48	0.112	2	Private
3M	carbon tetrachloride	1.021	99.999	1890	0.8	0.08	10	Private
3M	carbon tetrachloride	0.99	99.999	1930	1.2	0.154	8	Private
3M	carbon tetrachloride	0.868	99.999	2030	0.44	0.0848	3	Private
3M	carbon tetrachloride	0.623	99.999	1905	0.3	0.047	6	Private
ZAPATA INDUSTRIES	carbon tetrachloride	0.61	99.999	1550	2.8	0.036	3	EPA
3M	carbon tetrachloride	0.596	99.999	1885	0.4	0.048	7	Private
3M	carbon tetrachloride	0.482	99.999	1915	0.5	0.047	5	Private
CINCINNATI MSD	carbon tetrachloride	0.16	99.999	1650	3.7	f	4	EPA
DOW CHEMICAL	carbon tetrachloride		99.999	1860	99.4		11302-2	Private
TWI	carbon tetrachloride[c,k]	0.377	99.9987	2050	h	h	7	EPA
TWI	carbon tetrachloride[c]	0.277	99.9987	2070	0.6	0.048	3	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.243	99.9984	1975	3.8	0.378	4	EPA
TWI	carbon tetrachloride[c]	0.198	99.9984	2080	0.3	0.075	1	EPA
TWI	carbon tetrachloride[c]	0.228	99.9983	2030	0.4	0.127	2	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.263	99.9981	2000	4.9	0.313	2	EPA
3M	carbon tetrachloride	0.881	99.998	1925	0.7	0.078	9	Private
3M	carbon tetrachloride	0.524	99.998	1985	0.86	0.0623	1	Private
ZAPATA INDUSTRIES	carbon tetrachloride	0.28	99.9972	1660	3.3	0.017	4	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.242	99.997	1930	4.1	0.491	1	EPA
TWI	carbon tetrachloride[c,k]	0.53	99.9966	2120	h	h	8A	EPA
ROSS INCINERATION	carbon tetrachloride	0.16	99.9964	2110	0.1	0.061	1	EPA
ROSS INCINERATION	carbon tetrachloride	0.21	99.9961	2090	0.3	0.077	2	EPA
DOW CHEMICAL	carbon tetrachloride		99.996	1830	99.7		11302-3	Private
ROSS INCINERATION	carbon tetrachloride	0.2	99.9959	2040	0.3	0.061	3	EPA
UPJOHN	carbon tetrachloride	4.4	99.9954	2040	1.7	0.013	4	EPA
TWI	carbon tetrachloride[c,k]	0.44	99.9951	2140	h	h	8B	EPA
CINCINNATI MSD	carbon tetrachloride	0.22	99.995	1650	1.9	f	1	EPA
UPJOHN	carbon tetrachloride	3.6	99.994	2040	0.9	0.094	2	EPA
UPJOHN	carbon tetrachloride	4.4	99.9931	2040	1.2	0.08	3	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.132	99.9928	1952	1.83	0.187	2	EPA
TWI	carbon tetrachloride[c,k]	0.209	99.9926	2230	h	h	6	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.223	99.984	2050	f	f	3	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.163	99.984	1952	0.64	f	1	EPA
ZAPATA INDUSTRIES	carbon tetrachloride	1.2	99.978	1570	2.2	0.03	1	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.142	99.976	1952	4.47	0.161	3	EPA
CINCINNATI MSD	carbon tetrachloride	0.11	99.96	2000	7.8	0.056	5	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
CONFIDENTIAL SITE B	carbon tetrachloride[c,l]	0.12	99.949	1776	h	h	4	EPA
CINCINNATI MSD	carbon tetrachloride	0.23	99.9	2400	89.7	f	6	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c,l]	0.118	99.63		h	h	5	EPA
TWI	chlordane	0.736	99.9999	2070	0.6	0.048	3	EPA
TWI	chlordane	0.66	99.9999	2030	0.4	0.127	2	EPA
TWI	chlordane	0.462	99.9998	2080	0.3	0.075	1	EPA
UNION CARBIDE	chlorobenzene	1.8	99.99979	1800	97.9	0.07	3	Private
UNION CARBIDE	chlorobenzene	1.7	99.99979	1800	98.4	0.064	12	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9997	1800	99.9	0.21	1	Private
UNION CARBIDE	chlorobenzene	1.9	99.99962	1600	98.1	0.073	2	Private
UNION CARBIDE	chlorobenzene	1.4	99.99961	1600	98.2	0.094	1	Private
UNION CARBIDE	chlorobenzene	2	99.99959	1600	98.6	0.055	11	Private
UNION CARBIDE	chlorobenzene	1.8	99.99952	1800	98.2	0.071	4	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9995	1800	99.9	0.14	3	Private
UNION CARBIDE	chlorobenzene	1.6	99.99949	1800	98.2	0.075	6	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9994	1800	99.9	0.2	2	Private
UNION CARBIDE	chlorobenzene	1.6	99.99935	1800	98.3	0.061	5	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9992	1800	99.9	0.19	4	Private
UNION CARBIDE	chlorobenzene	2.7	99.99907	1600	98.9	0.066	7	Private
UNION CARBIDE	chlorobenzene	2.7	99.99907	1600	98.9	0.048	8	Private
UNION CARBIDE	chlorobenzene	2.6	99.9988	1600	98.5	0.057	9	Private
UNION CARBIDE	chlorobenzene	1.5	99.9987	1800	98.5	0.056	10	Private
ZAPATA INDUSTRIES	chlorobenzene	0.4	99.9983	1660	3.3	0.017	4	EPA
CIBA-GEIGY	chlorobenzene	29.52	99.998	1800	99.9	0.14	5	Private
ZAPATA INDUSTRIES	chlorobenzene	0.79	99.9974	1550	2.8	0.036	3	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.78	99.9956	1570	2.2	0.03	1	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.76	99.9953	1600	1.4	0.022	2	EPA
TWI	chlorobenzene[g,k]	0.0167	99.9949	2140	h	h	8B	EPA
TWI	chlorobenzene[g,k]	0.0184	99.978	2120	h	h	8A	EPA
TWI	chlorobenzene[g]	0.0047	99.966	1810	0.2	0.044	4	EPA
TWI	chlorobenzene[g]	0.00858	99.965	2080	0.3	0.075	1	EPA
TWI	chlorobenzene[g]	0.00956	99.956	2070	0.6	0.048	3	EPA
UPJOHN	chlorobenzene	0.68	99.945	2040	1.7	0.013	4	EPA
UPJOHN	chlorobenzene	0.41	99.86	2040	1.2	0.08	3	EPA
TWI	chlorobenzene[g,k]	0.0152	99.73	2050	h	h	7	EPA
TWI	chlorobenzene[g]	0.0102	99.7	2030	0.4	0.127	2	EPA
TWI	chlorobenzene[g,k]	0.0174	99.6	2230	h	h	6	EPA
SMITH KLINE CHEM	chloroform	1.21	99.99999	1640	0.6	0.057	6	Private
SMITH KLINE CHEM	chloroform	1.1	99.99999	1620	0.2	0.027	7	Private
SMITH KLINE CHEM	chloroform	0.93	99.99999	1710	0.6	0.03	8	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
CINCINNATI MSD	chloroform	1.32	99.9997	1650	3.7	f	4	EPA
CINCINNATI MSD	chloroform	1.72	99.9995	2400	6.1	0.123	3	EPA
CINCINNATI MSD	chloroform	1.09	99.9989	2000	7.8	0.056	5	EPA
CINCINNATI MSD	chloroform	1.8	99.998	2400	89.7	f	6	EPA
CINCINNATI MSD	chloroform	1.2	99.998	1650	1.9	f	1	EPA
DUPONT-LA	chloroform	0.33	99.9938	2640	0.5	0.015	1	EPA
DUPONT-LA	chloroform	0.404	99.9914	2640	0.9	0.011	3	EPA
DUPONT-LA	chloroform	0.229	99.987	2640	0.6	0.004	2	EPA
TWI	chloroform[c,g]	0.00224	99.944	2080	0.3	0.075	1	EPA
TWI	chloroform[c,g,k]	0.00476	99.92	2140	h	h	8B	EPA
TWI	chloroform[c,g,k]	0.00443	99.88	2120	h	h	8A	EPA
CONFIDENTIAL SITE B	chloroform[c,g]	0.0074	99.86	1952	1.83	0.187	2	EPA
TWI	chloroform[c,g]	0.00201	99.8	2070	0.6	0.048	3	EPA
TWI	chloroform[c,g]	0.00654	99.78	1810	0.2	0.044	4	EPA
CONFIDENTIAL SITE B	chloroform[c,g]	0.0154	99.7	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	chloroform[c,g,l]	0.00428	99.69	1776	h	h	4	EPA
CONFIDENTIAL SITE B	chloroform[c,g]	0.0102	99.66	1952	4.47	0.161	3	EPA
TWI	chloroform[c,g,k]	0.0082	99.1	2230	h	h	6	EPA
TWI	chloroform[c,g,k]	0.00478	99.02	2050	h	h	7	EPA
TWI	chloroform[c,g]	0.00283	98.2	2030	0.4	0.127	2	EPA
CONFIDENTIAL SITE B	chloroform[c,g,l]	0.00725	97.9		h	h	5	EPA
UPJOHN	chloromethane[c]	>0.2	99.9986	2040	0.9	0.094	2	EPA
UPJOHN	chloromethane[c]	>0.19	99.9975	2040	1.7	0.013	4	EPA
UPJOHN	chloromethane[c]	>0.12	99.9952	2040	1.2	0.08	3	EPA
UPJOHN	chlorophenyl isocyanate	2.8	99.9991	2040	1.7	0.013	4	EPA
DUPONT-LA	cis-dichlorobutene	1.76	99.99998	2640	0.9	0.011	3	EPA
DUPONT-LA	cis-dichlorobutene	1.39	99.99998	2640	0.6	0.004	2	EPA
DUPONT-LA	cis-dichlorobutene	1.63	99.9999	2640	0.5	0.015	1	EPA
ROSS INCINERATION	cresol(s)	0.12	99.9993	2110	0.1	0.061	1	EPA
ROSS INCINERATION	cresol(s)	0.091	99.9991	2040	0.3	0.061	3	EPA
ROSS INCINERATION	cresol(s)	0.074	99.999	2090	0.3	0.077	2	EPA
TWI	dibromomethane[k]	0.326	99.99992	2140	h	h	8B	EPA
TWI	dibromomethane[k]	0.292	99.99981	2120	h	h	8A	EPA
TWI	dibromomethane	0.0244	99.9987	2080	0.3	0.075	1	EPA
TWI	dibromomethane[k]	0.319	99.9936	2050	h	h	7	EPA
TWI	dibromomethane	0.159	99.982	1810	0.2	0.044	4	EPA
TWI	dibromomethane[k]	0.322	99.974	2230	h	h	6	EPA
TWI	dibromomethane	0.172	99.964	2070	0.6	0.048	3	EPA
TWI	dibromomethane	0.126	99.956	2030	0.4	0.127	2	EPA
OLIN	dichlordifluormethane	5	99.99	2088	0.7	0.052	2a,b,c	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
OLIN	dichlordifluormethane	5	99.99	2095	1.2	0.031	3a,b,c	Private
CINCINNATI MSD	dichlorobenzene	0.11-0.17	99.998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	dichlorobenzene	0.09-0.15	99.996	1650	5	0.107	7	EPA
CINCINNATI MSD	dichlorobenzene	0.05-0.15	99.99	2000	16	0.68	8	EPA
PENNWALT	dichlorofluoroethane	17.6	99.999	2320	1.3	0.006	22-3	Private
PENNWALT	dichlorofluoroethane	15.1	99.999	2370	1.4	0.006	23-2	Private
PENNWALT	dichlorofluoroethane	15	99.999	2260	0.72	0.044	22-4	Private
PENNWALT	dichlorofluoroethane	14.5	99.999	2340	1	0.007	23-3	Private
PENNWALT	dichlorofluoroethane	9.2	99.999	2380	0.9	0.005	23-1	Private
PENNWALT	dichlorofluoroethane	8.9	99.997	2340	1.1	0.036	22-1	Private
PENNWALT	dichlorofluoroethane	10.2	99.995	2350	1	0.014	22-2	Private
DUPONT-DE	dichloromethane	6.7	99.9999	1864	1.2	0.079	6	Private
DUPONT-DE	dichloromethane	6.1	99.9998	1826	1.7	f	5	Private
DUPONT-DE	dichloromethane	8	99.9997	1833	0.6	0.08	4	Private
DUPONT-DE	dichloromethane	7.1	99.9997	1831	2.6	f	3	Private
DUPONT-DE	dichloromethane	5.6	99.9997	1906	0.1	0.055	2	Private
DUPONT-DE	dichloromethane	4.6	99.9997	1842	1.3	f	7	Private
DUPONT-LA	dichloromethane	1.71	99.99941	2640	0.5	0.015	1	EPA
DUPONT-LA	dichloromethane	1.61	99.9991	2640	0.6	0.004	2	EPA
DUPONT-DE	dichloromethane	7.7	99.999	1857	1.1	0.071	1	Private
DUPONT-LA	dichloromethane	1.89	99.9988	2640	0.9	0.011	3	EPA
ROSS INCINERATION	dichloromethane[c]	0.67	99.989	2090	0.3	0.077	2	EPA
ROSS INCINERATION	dichloromethane[c]	0.36	99.978	2040	0.3	0.061	3	EPA
ROSS INCINERATION	dichloromethane[c]	0.23	99.968	2110	0.1	0.061	1	EPA
TWI	dichloromethane[g]	0.00627	99.918	2080	0.3	0.075	1	EPA
ZAPATA INDUSTRIES	dichloromethane	0.017	99.906	1600	1.4	0.022	2	EPA
TWI	dichloromethane[g,k]	0.00881	99.9	2140	h	h	8B	EPA
TWI	dichloromethane	0.021	99.88	2070	0.6	0.048	3	EPA
TWI	dichloromethane[g,k]	0.00832	99.83	2120	h	h	8A	EPA
TWI	dichloromethane[g]	0.00762	99.71	2030	0.4	0.127	2	EPA
TWI	dichloromethane[g]	0.0116	99.63	1810	0.2	0.044	4	EPA
TWI	dichloromethane[g,k]	0.0109	99.53	2050	h	h	7	EPA
TWI	dichloromethane[g,k]	0.013	99.51	2230	h	h	6	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0572	99.974	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0524	99.962	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.037	99.943	1952	1.83	0.187	2	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.58	99.9992	1198	0.007	0.069	3	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.54	99.9992	1198	0.007	0.175	5	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.62	99.999	1240	0.004	0.075	2	EPA
AKZO CHEMICAL	formaldehyde	10.03	99.998	1650	d	0.052	3-18	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
DUPONT-WV	formaldehyde	9.7	99.998	1701	h	0.017	DIES-4	Private
DUPONT-WV	formaldehyde	10	99.997	1729	h	0.017	DIES-3	Private
AKZO CHEMICAL	formaldehyde	10.01	99.996	1620	d	0.037	1-18	Private
AKZO CHEMICAL	formaldehyde	10.24	99.995	1830	d	0.041	1-20	Private
DUPONT-WV	formaldehyde	7.5	99.995	1735	h	0.018	DIES-2	Private
AKZO CHEMICAL	formaldehyde	10.2	99.993	1830	d	0.043	3-20	Private
AKZO CHEMICAL	formaldehyde	10.14	99.993	1780	d	0.04	2-19	Private
AKZO CHEMICAL	formaldehyde	10.01	99.993	1830	d	0.04	2-20	Private
AKZO CHEMICAL	formaldehyde	10.09	99.992	1780	d	0.048	1-19	Private
AKZO CHEMICAL	formaldehyde	10.09	99.992	1780	d	0.04	3-19	Private
AKZO CHEMICAL	formaldehyde	10.05	99.992	1630	d	0.03	2-18	Private
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.016	99.993	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.01	99.993	1650	3.7	f	4	EPA
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.016	99.99	2000	0.8	0.123	2	EPA
CINCINNATI MSD	hexachlorobenzene[g]	0.01-0.026	99.99	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachlorobenzene[g]	0.01	99.99	1650	1.9	f	1	EPA
CINCINNATI MSD	hexachlorobenzene[g]	0.01	99.99	2000	7.8	0.056	5	EPA
TWI	hexachlorobutadiene[g]	0.0144	99.98	1810	0.2	0.044	4	EPA
TWI	hexachlorocyclopentadiene	0.693	99.9996	1810	0.2	0.044	4	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.37-0.56	99.999	1650	1.9	f	1	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.24-1.6	99.998	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.25-0.71	99.996	2000	7.8	0.056	5	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.069-0.76	99.996	2000	0.8	0.123	2	EPA
TWI	hexachlorocyclopentadiene[g]	0.00956	99.99	2070	0.6	0.048	3	EPA
TWI	hexachlorocyclopentadiene[g]	0.00786	99.99	2030	0.4	0.127	2	EPA
TWI	hexachlorocyclopentadiene[g]	0.0066	99.99	2080	0.3	0.075	1	EPA
CINCINNATI MSD	hexachlorocyclopentadiene[g]	0.01-1.2	99.97	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachlorocyclopentadiene[g]	0.009-0.31	99.96	1650	3.7	f	4	EPA
UNION CARBIDE	hexachloroethane	6.4	99.99997	1600	98.2	0.094	1	Private
UNION CARBIDE	hexachloroethane	2.8	99.9999	1600	98.9	0.048	8	Private
UNION CARBIDE	hexachloroethane	2.7	99.9999	1600	98.9	0.066	7	Private
UNION CARBIDE	hexachloroethane	2.7	99.9999	1600	98.5	0.057	9	Private
UNION CARBIDE	hexachloroethane	2.1	99.9999	1600	98.6	0.055	11	Private
UNION CARBIDE	hexachloroethane	2	99.9999	1600	98.1	0.073	2	Private
UNION CARBIDE	hexachloroethane	2	99.9999	1800	98.2	0.075	6	Private
UNION CARBIDE	hexachloroethane	1.8	99.9999	1800	97.9	0.07	3	Private
UNION CARBIDE	hexachloroethane	1.8	99.9999	1800	98.2	0.071	4	Private
UNION CARBIDE	hexachloroethane	1.7	99.9999	1800	98.4	0.064	12	Private
UNION CARBIDE	hexachloroethane	1.6	99.9999	1800	98.3	0.061	5	Private
UNION CARBIDE	hexachloroethane	1.5	99.9999	1800	98.5	0.056	10	Private

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
CINCINNATI MSD	hexachloroethane	0.21-0.47	99.9997	2400	60.9	0.444	9	EPA
CINCINNATI MSD	hexachloroethane	0.22-0.77	99.9996	1650	5	0.107	7	EPA
CINCINNATI MSD	hexachloroethane	0.14-0.75	99.999	2000	16	0.68	8	EPA
CIBA-GEIGY	hexachloroethane	4.87	99.998	1800	99.9	0.21	1	Private
CIBA-GEIGY	hexachloroethane	4.87	99.997	1800	99.9	0.2	2	Private
CIBA-GEIGY	hexachloroethane	4.87	99.997	1800	99.9	0.14	3	Private
CIBA-GEIGY	hexachloroethane	4.87	99.995	1800	99.9	0.19	4	Private
CINCINNATI MSD	hexachloroethane[g]	0.01-0.023	99.994	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.019	99.993	2000	0.8	0.123	2	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.014	99.992	1650	3.7	f	4	EPA
CIBA-GEIGY	hexachloroethane	4.87	99.992	1800	99.9	0.14	5	Private
CINCINNATI MSD	hexachloroethane	0.011-0.020	99.99	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.018	99.99	2000	7.8	0.056	5	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.015	99.99	1650	1.9	f	1	EPA
DUPONT-LA	hexachloroethane[g]	0.045	99.99	2640	0.6	0.004	2	EPA
DUPONT-LA	hexachloroethane	0.044	99.99	2640	0.5	0.015	1	EPA
DUPONT-LA	hexachloroethane	0.0395	99.99	2640	0.9	0.011	3	EPA
UPJOHN	m-dichlorobenzene	2.1	99.922	2040	0.9	0.094	2	EPA
UPJOHN	m-dichlorobenzene	3.1	99.932	2040	1.7	0.013	4	EPA
UPJOHN	m-dichlorobenzene	2.3	99.905	2040	1.2	0.08	3	EPA
AMERICAN CYANAMID	m-dinitrobenzene[e]	0.31	99.99	1254	0.007	0.007	4	EPA
ROSS INCINERATION	MEK	0.86	99.99967	2110	0.1	0.061	1	EPA
ROSS INCINERATION	MEK	1.64	99.99932	2040	0.3	0.061	3	EPA
ROSS INCINERATION	MEK	0.79	99.9993	2090	0.3	0.077	2	EPA
MITCHELL SYSTEMS	MEK	0.273	99.9965	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	MEK	0.422	99.9952	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	MEK		99.988	2050	f	f	3	EPA
MITCHELL SYSTEMS	MEK	0.284	99.987	1975	3.8	0.378	4	EPA
ROSS INCINERATION	methyl pyridine	0.042	99.998	2090	0.3	0.077	2	EPA
ROSS INCINERATION	methyl pyridine	0.041	99.998	2040	0.3	0.061	3	EPA
ROSS INCINERATION	methyl pyridine	0.025	99.998	2110	0.1	0.061	1	EPA
AMERICAN CYANAMID	mononitrobenzene[e]	64	99.99991	1254	0.007	0.007	4	EPA
ROSS INCINERATION	N,N dimethylacetamide	1.9	99.9999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	N,N dimethylacetamide	1.82	99.9999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	N,N dimethylacetamide	0.83	99.9998	2110	0.1	0.061	1	EPA
TWI	naphthalene	0.379	99.996	1810	0.2	0.044	4	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0395	99.986	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0148	99.98	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0192	99.96	1930	4.1	0.491	1	EPA
DUPONT-LA	naphthalene[c,g]	0.009	99.1	2640	0.6	0.004	2	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
DUPONT-LA	naphthalene[c,g]	0.011	98	2640	0.5	0.015	1	EPA
DUPONT-LA	naphthalene[c,g]	0.006	97.4	2640	0.9	0.011	3	EPA
GULF OIL	naphthalene		99.998	1310	0.12	0.027	1	Private
GULF OIL	naphthalene		99.998	1320	0.12	0.053	2	Private
GULF OIL	naphthalene		99.998	1320	0.19	0.026	3	Private
ROSS INCINERATION	naphthalene[c]	0.036	99.994	2090	0.3	0.077	2	EPA
ROSS INCINERATION	naphthalene[c]	0.032	99.994	2110	0.1	0.061	1	EPA
ROSS INCINERATION	naphthalene[c]	0.024	99.991	2040	0.3	0.061	3	EPA
CONFIDENTIAL SITE B	naphthalene[c,g]	0.0177	99.927	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	naphthalene[c,g]	0.0174	99.85	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	naphthalene[c,g]	0.0118	99.81	1952	1.83	0.187	2	EPA
UPJOHN	o-dichlorobenzene	4	99.999	2040	0.9	0.094	2	EPA
UPJOHN	o-dichlorobenzene	6.4	99.999	2040	1.7	0.013	4	EPA
UPJOHN	o-dichlorobenzene	4.6	99.993	2040	1.2	0.08	3	EPA
UPJOHN	p-dichlorobenzene	5.6	99.999	2040	0.9	0.094	2	EPA
UPJOHN	p-dichlorobenzene	8	99.999	2040	1.7	0.013	4	EPA
UPJOHN	p-dichlorobenzene	5.9	99.995	2040	1.2	0.08	3	EPA
SCA CHEMICAL SER	PCB	27.5	99.99994	2212	2.5	f	19	Private
SCA CHEMICAL SER	PCB	26.7	99.99982	2231	1.4	0.075	17	Private
SCA CHEMICAL SER	PCB	19	99.9998	2225	3.4	f	21	Private
SCA CHEMICAL SER	PCB	22.1	99.99949	2247	2.2	f	20	Private
CINCINNATI MSD	pentachloroethane	0.42-0.81	99.9998	1650	5	0.107	7	EPA
CINCINNATI MSD	pentachloroethane	0.42-0.81	99.9998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	pentachloroethane	0.27-0.83	99.9994	2000	16	0.68	8	EPA
MITCHELL SYSTEMS	phenol[c]	1.9	99.99996	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	phenol[c]	2.73	99.9985	1930	4.1	0.491	1	EPA
ROSS INCINERATION	phenol[c,g]	0.012	99.997	2110	0.1	0.061	1	EPA
MITCHELL SYSTEMS	phenol[c]	1.72	99.996	1975	3.8	0.378	4	EPA
GULF OIL	phenol		99.996	1320	0.12	0.053	2	Private
ROSS INCINERATION	phenol[c,g]	0.006	99.993	2090	0.3	0.077	2	EPA
GULF OIL	phenol		99.993	1320	0.19	0.026	3	Private
ROSS INCINERATION	phenol[c,g]	0.005	99.992	2040	0.3	0.061	3	EPA
GULF OIL CORP.	phenol		99.991	1310	0.12	0.027	1	Private
CONFIDENTIAL SITE B	phenol[c]	0.169	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	phenol[c]	0.148	99.979	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	phenol[c]	0.249	99.976	1952	4.47	0.161	3	EPA
UPJOHN	phenyl isocyanate	17	99.99992	2040	0.9	0.094	2	EPA
UPJOHN	phenyl isocyanate	21	99.99992	2040	1.7	0.013	4	EPA
UPJOHN	phenyl isocyanate	16	99.9999	2040	1.2	0.08	3	EPA
AMERICAN CYANAMID	phenylene diamine	0.53	99.9992	1198	0.007	0.069	3	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
AMERICAN CYANAMID	phenylene diamine[e]	0.46	99.999	1198	0.007	0.175	5	EPA
AMERICAN CYANAMID	phenylene diamine[e]	0.23	99.997	1240	0.004	0.075	2	EPA
UPJOHN	phosgene	53.4	99.9985	2040	0.9	0.094	2	EPA
UPJOHN	phosgene	50.8	99.993	2040	1.2	0.08	3	EPA
UPJOHN	phosgene	20.2	99.981	2040	1.7	0.013	4	EPA
ROSS INCINERATION	phthalic anhydride[g]	0.008	99.99	2090	0.3	0.077	2	EPA
ROSS INCINERATION	phthalic anhydride[g]	0.007	99.99	2040	0.3	0.061	3	EPA
CINCINNATI MSD	tetrachloroethane	0.27	99.9998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	tetrachloroethane	0.128	99.9997	1650	5	0.107	7	EPA
SMITH KLINE CHEM	tetrachloroethene	1.32	99.99999	1620	0.2	0.027	7	Private
SMITH KLINE CHEM	tetrachloroethene	0.98	99.99999	1710	0.6	0.03	8	Private
SMITH KLINE CHEM	tetrachloroethene	1.36	99.99997	1640	0.6	0.057	6	Private
CINCINNATI MSD	tetrachloroethene	0.38	99.999	2400	6.1	f	3	EPA
CINCINNATI MSD	tetrachloroethene	0.24	99.999	1650	1.9	f	1	EPA
CIBA-GEIGY	tetrachloroethene	5.03	99.997	1800	99.9	0.21	1	Private
CINCINNATI MSD	tetrachloroethene	0.26	99.997	1650	3.7	f	4	EPA
CIBA-GEIGY	tetrachloroethene	5.03	99.995	1800	99.9	0.2	2	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.995	1800	99.9	0.14	3	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.991	1800	99.9	0.19	4	Private
CINCINNATI MSD	tetrachloroethene	0.26	99.99	2000	7.8	0.056	5	EPA
CIBA-GEIGY	tetrachloroethene	5.03	99.982	1800	99.9	0.14	5	Private
CINCINNATI MSD	tetrachloroethene	0.34	99.97	2400	89.7	f	6	EPA
UNION CARBIDE	tetrachloroethylene	1.6	99.99986	1800	98.2	0.075	6	Private
UNION CARBIDE	tetrachloroethylene	1.7	99.99985	1800	98.4	0.064	12	Private
UNION CARBIDE	tetrachloroethylene	2.8	99.99984	1600	98.9	0.048	8	Private
UNION CARBIDE	tetrachloroethylene	1.8	99.99984	1800	97.9	0.07	3	Private
UNION CARBIDE	tetrachloroethylene	2.1	99.99983	1600	98.6	0.055	11	Private
UNION CARBIDE	tetrachloroethylene	2.7	99.99979	1600	98.5	0.057	9	Private
UNION CARBIDE	tetrachloroethylene	1.8	99.99977	1800	98.2	0.071	4	Private
UNION CARBIDE	tetrachloroethylene	1.6	99.99977	1800	98.3	0.061	5	Private
UNION CARBIDE	tetrachloroethylene	1.5	99.99977	1800	98.5	0.056	10	Private
UNION CARBIDE	tetrachloroethylene	2	99.99975	1600	98.1	0.073	2	Private
UNION CARBIDE	tetrachloroethylene	1.4	99.99972	1600	98.2	0.094	1	Private
DUPONT-LA	tetrachloroethylene	0.852	99.99972	2640	0.6	0.004	2	EPA
UNION CARBIDE	tetrachloroethylene	2.7	99.99966	1600	98.9	0.066	7	Private
DUPONT-LA	tetrachloroethylene	1.06	99.99948	2640	0.5	0.015	1	EPA
DUPONT-LA	tetrachloroethylene	0.834	99.99926	2640	0.9	0.011	3	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.398	99.99918	1952	4.47	0.161	3	EPA
ROSS INCINERATION	tetrachloroethylene	1.67	99.99912	2040	0.3	0.061	3	EPA
ROSS INCINERATION	tetrachloroethylene	0.78	99.9986	2110	0.1	0.061	1	EPA

Table B-1. *(continued)*

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
McDONNELL DGLS	tetrachloroethylene	0.6	99.99779	1800	1.67	0.047	1	Private
ROSS INCINERATION	tetrachloroethylene	0.69	99.9977	2090	0.3	0.077	2	EPA
McDONNELL DGLS	tetrachloroethylene	0.57	99.9977	1800	0.8	0.032	2	Private
McDONNELL DGLS	tetrachloroethylene	0.64	99.99763	1800	1.64	0.044	3	Private
McDONNELL DGLS	tetrachloroethylene	0.64	99.9971	1800	0.74	0.032	4	Private
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.582	99.9968	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.347	99.9966	1952	1.83	0.187	2	EPA
MITCHELL SYSTEMS	tetrachloroethylene[g]	0.00861	99.9929	2050	f	f	3	EPA
TWI	tetrachloroethylene[g]	0.0183	99.982	1810	0.2	0.044	4	EPA
TWI	tetrachloroethylene[g,k]	0.0044	99.966	2140	h	h	8B	EPA
TWI	tetrachloroethylene[g]	0.00567	99.965	2080	0.3	0.075	1	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c,i]	0.235	99.948	1776	h	h	4	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c,j]	0.29	99.937		h	h	5	EPA
TWI	tetrachloroethylene[g]	0.0124	99.88	2070	0.6	0.048	3	EPA
TWI	tetrachloroethylene[g,k]	0.00377	99.81	2050	h	h	7	EPA
TWI	tetrachloroethylene[g]	0.00636	99.78	2030	0.4	0.127	2	EPA
TWI	tetrachloroethylene[g,k]	0.0041	99.64	2230	h	h	6	EPA
DUPONT-LA	toluene	20.2	99.99993	2640	0.6	0.004	2	EPA
TWI	toluene[k]	9.87	99.99988	2140	h	h	8B	EPA
DUPONT-LA	toluene	21.9	99.99986	2640	0.9	0.011	3	EPA
DUPONT-LA	toluene	21.54	99.99986	2640	0.5	0.015	1	EPA
TWI	toluene[k]	11.03	99.99959	2120	h	h	8A	EPA
SMITH KLINE CHEM	toluene	3.86	99.99953	1620	0.2	0.027	7	Private
TWI	toluene	7.92	99.99946	2080	0.3	0.075	1	EPA
CIBA-GEIGY	toluene	60.58	99.9994	1800	99.9	0.21	1	Private
CONFIDENTIAL SITE B	toluene[c]	2.47	99.99923	1952	0.64	f	1	EPA
CIBA-GEIGY	toluene	60.58	99.9992	1800	99.9	0.2	2	Private
CIBA-GEIGY	toluene	60.58	99.9992	1800	99.9	0.14	3	Private
ROSS INCINERATION	toluene	4.04	99.99904	2110	0.1	0.061	1	EPA
ROSS INCINERATION	toluene	2.87	99.9987	2090	0.3	0.077	2	EPA
SMITH KLINE CHEM	toluene	3.2	99.9982	1710	0.6	0.03	8	Private
CIBA-GEIGY	toluene	60.58	99.998	1800	99.9	0.19	4	Private
TWI	toluene[k]	8.52	99.9979	2230	h	h	6	EPA
ROSS INCINERATION	toluene	2.74	99.9978	2040	0.3	0.061	3	EPA
TWI	toluene[k]	8.55	99.9976	2050	h	h	7	EPA
CIBA-GEIGY	toluene	60.58	99.997	1800	99.9	0.14	5	Private
SMITH KLINE CHEM	toluene	4.53	99.997	1640	0.6	0.057	6	Private
TWI	toluene	9.56	99.9963	2070	0.6	0.048	3	EPA
ZAPATA INDUSTRIES	toluene	0.42	99.9956	1660	3.3	0.017	4	EPA
CONFIDENTIAL SITE B	toluene[c,i]	0.748	99.994	1776	h	h	4	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
ZAPATA INDUSTRIES	toluene	0.073	99.9932	1550	2.8	0.036	3	EPA
CONFIDENTIAL SITE B	toluene[c]	1.62	99.9923	1952	4.47	0.161	3	EPA
TWI	toluene	6.01	99.9922	1810	0.2	0.044	4	EPA
ZAPATA INDUSTRIES	toluene	0.33	99.9914	1600	1.4	0.022	2	EPA
TWI	toluene	4.08	99.9908	2030	0.4	0.127	2	EPA
CONFIDENTIAL SITE B	toluene[c]	1.317	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	toluene[c,l]	1.3	99.982		h	h	5	EPA
MITCHELL SYSTEMS	toluene[c]	0.0618	99.979	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	toluene[c]	0.0738	99.966	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	toluene[c]	0.0957	99.957	2050	f	f	3	EPA
ZAPATA INDUSTRIES	toluene	0.11	99.952	1570	2.2	0.03	1	EPA
MITCHELL SYSTEMS	toluene[c]	0.105	99.941	2000	4.9	0.313	2	EPA
DUPONT-LA	trans-dichlorobutene	5.27	99.99992	2640	0.9	0.011	3	EPA
DUPONT-LA	trans-dichlorobutene	4.48	99.9999	2640	0.6	0.004	2	EPA
DUPONT-LA	trans-dichlorobutene	4.4	99.9999	2640	0.5	0.015	1	EPA
OLIN	trichlorfluormethane	14.85	99.9999	2095	1.2	0.031	3a,b,c	Private
OLIN	trichlorfluormethane	10.97	99.9998	2088	0.7	0.052	2a,b,c	Private
DOW CHEMICAL	trichlorobenzenes		99.995	1800	99.7		10272-1	Private
DOW CHEMICAL	trichlorobenzenes		99.992	1820	99.8		10272-2	Private
CINCINNATI MSD	trichloroethane	3.1	99.999	2400	60.9	0.444	9	EPA
CINCINNATI MSD	trichloroethane	0.96	99.985	1650	5	0.107	7	EPA
McDONNELL DGLS	trichloroethylene	18	99.99999	1800	1.64	0.044	3	Private
McDONNELL DGLS	trichloroethylene	21	99.99998	1800	1.67	0.047	1	Private
McDONNELL DGLS	trichloroethylene	9.5	99.99995	1800	0.8	0.032	2	Private
DUPONT-LA	trichloroethylene	0.277	99.99984	2640	0.5	0.015	1	EPA
ROSS INCINERATION	trichloroethylene	1.04	99.99963	2110	0.1	0.061	1	EPA
UPJOHN	trichloroethylene	4	99.99956	2040	1.7	0.013	4	EPA
McDONNELL DGLS	trichloroethylene	0.5	99.9995	1800	0.74	0.032	4	Private
TWI	trichloroethylene[k]	0.555	99.99924	2140	h	h	8B	EPA
TWI	trichloroethylene[k]	0.67	99.99921	2120	h	h	8A	EPA
DUPONT-LA	trichloroethylene	0.309	99.999	2640	0.6	0.004	2	EPA
UPJOHN	trichloroethylene	4	99.9989	2040	1.2	0.08	3	EPA
TWI	trichloroethylene	0.353	99.9989	1810	0.2	0.044	4	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.52	99.9985	1550	2.8	0.036	3	EPA
UPJOHN	trichloroethylene	3.3	99.9983	2040	0.9	0.094	2	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.71	99.9979	1600	1.4	0.022	2	EPA
ROSS INCINERATION	trichloroethylene	0.83	99.9969	2040	0.3	0.061	3	EPA
ROSS INCINERATION	trichloroethylene	0.47	99.9965	2090	0.3	0.077	2	EPA
TWI	trichloroethylene	0.178	99.9962	2080	0.3	0.075	1	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.202	99.9959	2050	f	f	3	EPA

Table B-1. (continued)

SITE	COMPOUND	CONC,%	DRE,%	TEMP, °F	HCL, lb/h	TSP, gr/dscf	TEST No.	SPONSOR
DUPONT-LA	trichloroethylene	0.198	99.9951	2640	0.9	0.011	3	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.29	99.9946	1660	3.3	0.017	4	EPA
TWI	trichloroethylene	0.212	99.9945	2030	0.4	0.127	2	EPA
TWI	trichloroethylene[k]	0.29	99.9926	2050	h	h	7	EPA
TWI	trichloroethylene	0.277	99.9917	2070	0.6	0.048	3	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.232	99.991	2000	4.9	0.313	2	EPA
TWI	trichloroethylene	0.956	99.989	2230	h	h	6	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.222	99.985	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.223	99.984	1975	3.8	0.378	4	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.136	99.983	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.166	99.981	1952	0.64	f	1	EPA
ZAPATA INDUSTRIES	trichloroethylene	1.1	99.979	1570	2.2	0.03	1	EPA
CONFIDENTIAL SITE B	trichloroethylene[c,i]	0.124	99.949	1776	h	h	4	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.147	99.8	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	trichloroethylene[c,j]	0.123	99.8		h	h	5	EPA

[a]For those runs in which a range of waste feed concentrations were tested, only the lowest reported DRE is listed.
[b]HCl values for Dow, Stauffer Chemical, and Upjohn are listed as % removal, not lb/h.
[c]*Sampling and/or analytical problems; data suspect.*
[d]None detected; limit of detection unknown.
[e]Temperature reading suspect—may be low by 300°F.
[f]Not reported.
[g]Low concentration (200 ppm or less) in waste feed.
[h]Not measured.
[i]Abnormal operating conditions—low temperature.
[j]Abnormal operating conditions—unspecified.
[k]Abnormal operating conditions—waste feed rate increased and combustion air distribution changed in attempt to increase CO and THC emissions.

Table B-2. Summary Tabulation of Incinerator Test Results by Site

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
3M	1,1,2 trichloroethane	1.566	99.999	1985	0.2	0.091	4	Private
3M	1,1,2 trichloroethane	0.937	99.999	1915	0.5	0.047	5	Private
3M	1,1,2 trichloroethane	1.304	99.999	1905	0.3	0.047	6	Private
3M	1,1,2 trichloroethane	1.066	99.999	1885	0.4	0.048	7	Private
3M	1,1,2 trichloroethane	1.631	99.999	1890	0.8	0.08	10	Private
3M	1,1,2 trichloroethane	1.225	99.998	2030	0.44	0.0848	3	Private
3M	1,1,2 trichloroethane	1.771	99.998	1930	1.2	0.154	8	Private
3M	1,1,2 trichloroethane	1.3	99.998	1925	0.7	0.078	9	Private
3M	1,1,2 trichloroethane	0.548	99.994	1985	0.9	0.0623	1	Private
3M	1,1,2 trichloroethane	1.239	99.99	1950	0.48	0.112	2	Private
3M	carbon tetrachloride	1.031	99.999	1950	0.48	0.112	2	Private
3M	carbon tetrachloride	0.868	99.999	2030	0.44	0.0848	3	Private
3M	carbon tetrachloride	1.068	99.999	1985	0.2	0.091	4	Private
3M	carbon tetrachloride	0.482	99.999	1915	0.5	0.047	5	Private
3M	carbon tetrachloride	0.623	99.999	1905	0.3	0.047	6	Private
3M	carbon tetrachloride	0.596	99.999	1885	0.4	0.048	7	Private
3M	carbon tetrachloride	0.99	99.999	1930	1.2	0.154	8	Private
3M	carbon tetrachloride	1.021	99.999	1890	0.8	0.08	10	Private
3M	carbon tetrachloride	0.524	99.998	1985	0.86	0.0623	1	Private
3M	carbon tetrachloride	0.881	99.998	1925	0.7	0.078	9	Private
AKZO CHEMICAL	formaldehyde	10.03	99.998	1650	d	0.052	3-18	Private
AKZO CHEMICAL	formaldehyde	10.01	99.996	1620	d	0.037	1-18	Private
AKZO CHEMICAL	formaldehyde	10.24	99.995	1830	d	0.041	1-20	Private
AKZO CHEMICAL	formaldehyde	10.14	99.993	1780	d	0.04	2-19	Private
AKZO CHEMICAL	formaldehyde	10.01	99.993	1830	d	0.04	2-20	Private
AKZO CHEMICAL	formaldehyde	10.2	99.993	1830	d	0.043	3-20	Private
AKZO CHEMICAL	formaldehyde	10.05	99.992	1630	d	0.03	2-18	Private
AKZO CHEMICAL	formaldehyde	10.09	99.992	1780	d	0.048	1-19	Private
AKZO CHEMICAL	formaldehyde	10.09	99.992	1780	d	0.04	3-19	Private
AMERICAN CYANAMID	aniline[c,e]	60	99.99999	1198	0.007	0.069	3	EPA
AMERICAN CYANAMID	aniline[c,e]	53	99.99999	1198	0.007	0.175	5	EPA
AMERICAN CYANAMID	aniline[c,e]	55	99.99999	1240	0.004	0.075	2	EPA
AMERICAN CYANAMID	aniline[c,e]	0.8	99.9997	1254	0.007	0.007	4	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.58	99.9992	1198	0.007	0.069	3	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.54	99.9992	1198	0.007	0.175	5	EPA
AMERICAN CYANAMID	diphenyl amine[e]	0.62	99.999	1240	0.004	0.075	2	EPA
AMERICAN CYANAMID	m-dinitrobenzene[e]	0.31	99.99	1254	0.007	0.007	4	EPA
AMERICAN CYANAMID	monoinitrobenzene[e]	64	99.99991	1254	0.007	0.007	4	EPA
AMERICAN CYANAMID	phenylene diamine[e]	0.53	99.9992	1198	0.007	0.069	3	EPA
AMERICAN CYANAMID	phenylene diamine[e]	0.46	99.999	1198	0.007	0.175	5	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
AMERICAN CYANAMID	phenylene diamine[e]	0.23	99.997	1240	0.004	0.075	2	EPA
CIBA-GEIGY	chlorobenzene	29.52	99.9997	1800	99.9	0.21	1	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9995	1800	99.9	0.14	3	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9994	1800	99.9	0.2	2	Private
CIBA-GEIGY	chlorobenzene	29.52	99.9992	1800	99.9	0.19	4	Private
CIBA-GEIGY	chlorobenzene	29.52	99.998	1800	99.9	0.14	5	Private
CIBA-GEIGY	hexachloroethane	4.87	99.998	1800	99.9	0.21	1	Private
CIBA-GEIGY	hexachloroethane	4.87	99.997	1800	99.9	0.2	2	Private
CIBA-GEIGY	hexachloroethane	4.87	99.997	1800	99.9	0.14	3	Private
CIBA-GEIGY	hexachloroethane	4.87	99.995	1800	99.9	0.19	4	Private
CIBA-GEIGY	hexachloroethane	4.87	99.992	1800	99.9	0.14	5	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.997	1800	99.9	0.21	1	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.995	1800	99.9	0.2	2	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.995	1800	99.9	0.14	3	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.991	1800	99.9	0.19	4	Private
CIBA-GEIGY	tetrachloroethene	5.03	99.982	1800	99.9	0.14	5	Private
CIBA-GEIGY	toluene	60.58	99.9994	1800	99.9	0.21	1	Private
CIBA-GEIGY	toluene	60.58	99.9992	1800	99.9	0.2	2	Private
CIBA-GEIGY	toluene	60.58	99.9992	1800	99.9	0.14	3	Private
CIBA-GEIGY	toluene	60.58	99.998	1800	99.9	0.19	4	Private
CIBA-GEIGY	toluene	60.58	99.997	1800	99.9	0.14	5	Private
CINCINNATI MSD	bromodichloromethane	0.4	99.995	2400	60.9	0.444	9	EPA
CINCINNATI MSD	bromodichloromethane	0.28	99.97	1650	5	0.107	7	EPA
CINCINNATI MSD	carbon tetrachloride	0.26	99.9999	2400	6.1	f	3	EPA
CINCINNATI MSD	carbon tetrachloride	0.16	99.999	1650	3.7	f	4	EPA
CINCINNATI MSD	carbon tetrachloride	0.22	99.995	1650	1.9	f	1	EPA
CINCINNATI MSD	carbon tetrachloride	0.11	99.96	2000	7.8	0.056	5	EPA
CINCINNATI MSD	carbon tetrachloride	0.23	99.9	2400	89.7	f	6	EPA
CINCINNATI MSD	chloroform	1.32	99.9997	1650	3.7	f	4	EPA
CINCINNATI MSD	chloroform	1.72	99.9995	2400	6.1	0.123	3	EPA
CINCINNATI MSD	chloroform	1.09	99.9989	2000	7.8	0.056	5	EPA
CINCINNATI MSD	chloroform	1.2	99.998	1650	1.9	f	1	EPA
CINCINNATI MSD	chloroform	1.8	99.998	2400	89.7	f	6	EPA
CINCINNATI MSD	dichlorobenzene	0.11-0.17	99.998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	dichlorobenzene	0.09-0.15	99.996	1650	5	0.107	7	EPA
CINCINNATI MSD	dichlorobenzene	0.05-0.15	99.99	2000	16	0.68	8	EPA
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.01	99.993	1650	3.7	f	4	EPA
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.016	99.993	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachlorobenzene[g]	0.01	99.99	1650	1.9	f	1	EPA
CINCINNATI MSD	hexachlorobenzene[g]	<0.01-0.016	99.99	2000	0.8	0.123	2	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
CINCINNATI MSD	hexachlorobenzene[g]	0.01-0.026	99.99	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachlorobenzene[g]	0.01	99.99	2000	7.8	0.056	5	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.37-0.56	99.999	1650	1.9	f	1	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.24-1.6	99.998	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.069-0.76	99.996	2000	0.8	0.123	2	EPA
CINCINNATI MSD	hexachlorocyclopentadiene	0.25-0.71	99.996	2000	7.8	0.056	5	EPA
CINCINNATI MSD	hexachlorocyclopentadiene[g]	0.01-1.2	99.97	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachlorocyclopentadiene[g]	0.009-0.31	99.96	1650	3.7	f	4	EPA
CINCINNATI MSD	hexachloroethane	0.21-0.47	99.9997	2400	60.9	0.444	9	EPA
CINCINNATI MSD	hexachloroethane	0.22-0.77	99.9996	1650	5	0.107	7	EPA
CINCINNATI MSD	hexachloroethane	0.14-0.75	99.999	2000	16	0.68	8	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.023	99.994	2400	89.7	f	6	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.019	99.993	2000	0.8	0.123	2	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.014	99.992	1650	3.7	f	4	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.015	99.99	1650	1.9	f	1	EPA
CINCINNATI MSD	hexachloroethane[g]	0.011-0.020	99.99	2400	6.1	f	3	EPA
CINCINNATI MSD	hexachloroethane[g]	0.01-0.018	99.99	2000	7.8	0.056	5	EPA
CINCINNATI MSD	pentachloroethane	0.42-0.81	99.9998	1650	5	0.107	7	EPA
CINCINNATI MSD	pentachloroethane	0.42-0.81	99.9998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	pentachloroethane	0.27-0.83	99.9994	2000	16	0.68	8	EPA
CINCINNATI MSD	tetrachloroethane	0.27	99.9998	2400	60.9	0.444	9	EPA
CINCINNATI MSD	tetrachloroethane	0.128	99.9997	1650	5	0.107	7	EPA
CINCINNATI MSD	tetrachloroethene	0.24	99.999	1650	1.9	f	1	EPA
CINCINNATI MSD	tetrachloroethene	0.38	99.999	2400	6.1	f	3	EPA
CINCINNATI MSD	tetrachloroethene	0.26	99.997	1650	3.7	f	4	EPA
CINCINNATI MSD	tetrachloroethene	0.26	99.99	2000	7.8	0.056	5	EPA
CINCINNATI MSD	tetrachloroethene	0.34	99.97	2400	89.7	f	6	EPA
CINCINNATI MSD	trichloroethane	3.1	99.999	2400	60.9	0.444	9	EPA
CINCINNATI MSD	trichloroethane	0.96	99.985	1650	5	0.107	7	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.0227	99.9938	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.0149	99.9923	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	butyl benzyl phthalate[g]	0.00416	99.92	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.132	99.9928	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.163	99.984	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c]	0.142	99.976	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c,i]	0.12	99.949	1776	h	h	4	EPA
CONFIDENTIAL SITE B	carbon tetrachloride[c,i]	0.118	99.63		h	h	5	EPA
CONFIDENTIAL SITE B	chloroform[c,g]	0.0074	99.86	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	chloroform[c,g]	0.0154	99.7	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	chloroform[c,g,i]	0.00428	99.69	1776	h	h	4	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
CONFIDENTIAL SITE B	chloroform[c,g]	0.0102	99.66	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	chloroform[c,g,j]	0.00725	97.9		h	h	5	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0572	99.974	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.0524	99.962	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	diethyl phthalate	0.037	99.943	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	naphthalate[c,g]	0.0177	99.927	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	naphthalate[c,g]	0.0174	99.85	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	naphthalate[c,g]	0.0118	99.81	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	phenol[c]	0.169	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	phenol[c]	0.148	99.979	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	phenol[c]	0.249	99.976	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.398	99.99918	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.582	99.9968	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c]	0.347	99.9966	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c,i]	0.235	99.948	1776	h	h	4	EPA
CONFIDENTIAL SITE B	tetrachloroethylene[c,j]	0.29	99.937		h	h	5	EPA
CONFIDENTIAL SITE B	toluene[c]	2.47	99.99923	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	toluene[c,i]	0.748	99.994	1776	h	h	4	EPA
CONFIDENTIAL SITE B	toluene[c]	1.62	99.9923	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	toluene[c]	1.317	99.989	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	toluene[c,j]	1.3	99.982		h	h	5	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.136	99.983	1952	1.83	0.187	2	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.166	99.981	1952	0.64	f	1	EPA
CONFIDENTIAL SITE B	trichloroethylene[c,i]	0.124	99.949	1776	h	h	4	EPA
CONFIDENTIAL SITE B	trichloroethylene[c]	0.147	99.8	1952	4.47	0.161	3	EPA
CONFIDENTIAL SITE B	trichloroethylene[c,j]	0.123	99.8		h	h	5	EPA
DOW CHEMICAL	1,1,1 trichloroethane		99.998	1810	99.9		10212-2	Private
DOW CHEMICAL	1,1,1 trichloroethane		99.996	1820	99.9		10212-1	Private
DOW CHEMICAL	carbon tetrachloride		99.999	1860	99.4		11302-2	Private
DOW CHEMICAL	carbon tetrachloride		99.996	1830	99.7		11302-3	Private
DOW CHEMICAL	trichlorobenzenes		99.995	1800	99.7		10272-1	Private
DOW CHEMICAL	trichlorobenzenes		99.992	1820	99.8		10272-2	Private
DUPONT-DE	carbon tetrachloride	9.4	99.99994	1831	2.6	f	3	Private
DUPONT-DE	carbon tetrachloride	9.2	99.99994	1842	1.3	f	7	Private
DUPONT-DE	carbon tetrachloride	9.3	99.99993	1864	1.2	0.079	6	Private
DUPONT-DE	carbon tetrachloride	7.5	99.99992	1906	0.1	0.055	2	Private
DUPONT-DE	carbon tetrachloride	8.7	99.99992	1833	0.6	0.08	4	Private
DUPONT-DE	carbon tetrachloride	8.8	99.99991	1826	1.7	f	5	Private
DUPONT-DE	carbon tetrachloride	7.7	99.9994	1857	1.1	0.071	1	Private
DUPONT-DE	dichloromethane	6.7	99.9999	1864	1.2	0.079	6	Private

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
DUPONT-DE	dichloromethane	6.1	99.9998	1826	1.7	f	5	Private
DUPONT-DE	dichloromethane	5.6	99.9997	1906	0.1	0.055	2	Private
DUPONT-DE	dichloromethane	7.1	99.9997	1831	2.6	f	3	Private
DUPONT-DE	dichloromethane	8	99.9997	1833	0.6	0.08	4	Private
DUPONT-DE	dichloromethane	4.6	99.9997	1842	1.3	f	7	Private
DUPONT-DE	dichloromethane	7.7	99.999	1857	1.1	0.071	1	Private
DUPONT-LA	1,1,1 trichloroethane[g]	0.001	99.932	2640	0.5	0.015	1	EPA
DUPONT-LA	benzyl chloride	0.211	99.9996	2640	0.5	0.015	1	EPA
DUPONT-LA	benzyl chloride	0.233	99.9996	2640	0.6	0.004	2	EPA
DUPONT-LA	benzyl chloride	0.219	99.9994	2640	0.9	0.011	3	EPA
DUPONT-LA	carbon tetrachloride	5.38	99.99988	2640	0.6	0.004	2	EPA
DUPONT-LA	carbon tetrachloride	6.16	99.99986	2640	0.5	0.015	1	EPA
DUPONT-LA	carbon tetrachloride	5.27	99.99981	2640	0.9	0.011	3	EPA
DUPONT-LA	chloroform	0.33	99.9938	2640	0.5	0.015	1	EPA
DUPONT-LA	chloroform	0.404	99.9914	2640	0.9	0.011	3	EPA
DUPONT-LA	chloroform	0.229	99.987	2640	0.6	0.004	2	EPA
DUPONT-LA	cis-dichlorobutene	1.39	99.99998	2640	0.6	0.004	2	EPA
DUPONT-LA	cis-dichlorobutene	1.76	99.99998	2640	0.9	0.011	3	EPA
DUPONT-LA	cis-dichlorobutene	1.63	99.9999	2640	0.5	0.015	1	EPA
DUPONT-LA	dichloromethane	1.71	99.99941	2640	0.5	0.015	1	EPA
DUPONT-LA	dichloromethane	1.61	99.9991	2640	0.6	0.004	2	EPA
DUPONT-LA	dichloromethane	1.89	99.9988	2640	0.9	0.011	3	EPA
DUPONT-LA	hexachloroethane	0.044	99.99	2640	0.5	0.015	1	EPA
DUPONT-LA	hexachloroethane	0.045	99.99	2640	0.6	0.004	2	EPA
DUPONT-LA	hexachloroethane	0.0395	99.99	2640	0.9	0.011	3	EPA
DUPONT-LA	naphthalene[c,g]	0.009	99.1	2640	0.6	0.004	2	EPA
DUPONT-LA	naphthalene[c,g]	0.011	98	2640	0.5	0.015	1	EPA
DUPONT-LA	naphthalene[c,g]	0.006	97.4	2640	0.9	0.011	3	EPA
DUPONT-LA	tetrachloroethylene	0.852	99.99972	2640	0.6	0.004	2	EPA
DUPONT-LA	tetrachloroethylene	1.06	99.99948	2640	0.5	0.015	1	EPA
DUPONT-LA	tetrachloroethylene	0.834	99.99926	2640	0.9	0.011	3	EPA
DUPONT-LA	toluene	20.2	99.99993	2640	0.6	0.004	2	EPA
DUPONT-LA	toluene	21.9	99.99986	2640	0.9	0.011	3	EPA
DUPONT-LA	toluene	21.54	99.99986	2640	0.5	0.015	1	EPA
DUPONT-LA	trans-dichlorobutene	5.27	99.99992	2640	0.9	0.011	3	EPA
DUPONT-LA	trans-dichlorobutene	4.4	99.9999	2640	0.5	0.015	1	EPA
DUPONT-LA	trans-dichlorobutene	4.48	99.9999	2640	0.6	0.004	2	EPA
DUPONT-LA	trichloroethylene	0.277	99.99984	2640	0.5	0.015	1	EPA
DUPONT-LA	trichloroethylene	0.309	99.999	2640	0.6	0.004	2	EPA
DUPONT-LA	trichloroethylene	0.198	99.9951	2640	0.9	0.011	3	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
DUPONT-WV	formaldehyde	9.7	99.998	1701	h	0.017	DIES-4	Private
DUPONT-WV	formaldehyde	10	99.997	1729	h	0.017	DIES-3	Private
DUPONT-WV	formaldehyde	7.5	99.995	1735	h	0.018	DIES-2	Private
GULF OIL	naphthalene		99.998	1310	0.12	0.027	1	Private
GULF OIL	naphthalene		99.998	1320	0.12	0.053	2	Private
GULF OIL	naphthalene		99.998	1320	0.19	0.026	3	Private
GULF OIL	phenol		99.996	1320	0.12	0.053	2	Private
GULF OIL	phenol		99.993	1320	0.19	0.026	3	Private
GULF OIL CORP.	phenol		99.991	1310	0.12	0.027	1	Private
McDONNELL DGLS	1,1,1 trichloroethane	70	99.99999	1800	0.74	0.032	4	Private
McDONNELL DGLS	1,1,1 trichloroethane	71	99.99999	1800	0.8	0.032	2	Private
McDONNELL DGLS	1,1,1 trichloroethane	62	99.99999	1800	1.64	0.044	3	Private
McDONNELL DGLS	1,1,1 trichloroethane	59	99.99999	1800	1.67	0.047	1	Private
McDONNELL DGLS	carbon tetrachloride	8.9	99.99998	1800	1.64	0.044	3	Private
McDONNELL DGLS	carbon tetrachloride	7.5	99.99997	1800	0.8	0.032	2	Private
McDONNELL DGLS	carbon tetrachloride	8.1	99.99996	1800	1.67	0.047	1	Private
McDONNELL DGLS	carbon tetrachloride	8.9	99.99992	1800	0.74	0.032	4	Private
McDONNELL DGLS	tetrachloroethylene	0.6	99.99779	1800	1.67	0.047	1	Private
McDONNELL DGLS	tetrachloroethylene	0.57	99.9977	1800	0.8	0.032	2	Private
McDONNELL DGLS	tetrachloroethylene	0.64	99.99763	1800	1.64	0.044	3	Private
McDONNELL DGLS	tetrachloroethylene	0.64	99.9971	1800	0.74	0.032	4	Private
McDONNELL DGLS	trichloroethylene	18	99.99999	1800	1.64	0.044	3	Private
McDONNELL DGLS	trichloroethylene	21	99.99998	1800	1.67	0.047	1	Private
McDONNELL DGLS	trichloroethylene	9.5	99.99995	1800	0.8	0.032	2	Private
McDONNELL DGLS	trichloroethylene	0.5	99.9995	1800	0.74	0.032	4	Private
MITCHELL SYSTEMS	benzene[g]	0.0116	99.986	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	benzene[g]	0.0067	99.82	2050	f	f	3	EPA
MITCHELL SYSTEMS	bis(ethyl hexyl)phthalate[c]	0.192	99.9985	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	bis(ethyl hexyl)phthalate[c]	0.416	99.996	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	bis(ethyl hexyl)phthalate[c]	0.169	99.993	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate	0.169	99.995	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate[g]	0.00758	99.992	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	butyl benzyl phthalate[g]	0.0064	99.973	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.243	99.9984	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.263	99.9981	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.242	99.997	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	carbon tetrachloride[c]	0.223	99.984	2050	f	f	3	EPA
MITCHELL SYSTEMS	MEK	0.273	99.9965	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	MEK	0.422	99.9952	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	MEK		99.988	2050	f	f	3	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
MITCHELL SYSTEMS	MEK	0.284	99.987	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0395	99.986	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0148	99.98	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	naphthalene[c,g]	0.0192	99.96	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	phenol[c]	1.9	99.99996	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	phenol[c]	2.73	99.9985	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	phenol[c]	1.72	99.996	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	tetrachloroethylene[g]	0.00861	99.9929	2050	f	f	3	EPA
MITCHELL SYSTEMS	toluene[c]	0.0618	99.979	1975	3.8	0.378	4	EPA
MITCHELL SYSTEMS	toluene[c]	0.0738	99.966	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	toluene[c]	0.0957	99.957	2050	f	f	3	EPA
MITCHELL SYSTEMS	toluene[c]	0.105	99.941	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.202	99.9959	2050	f	f	3	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.232	99.991	2000	4.9	0.313	2	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.222	99.985	1930	4.1	0.491	1	EPA
MITCHELL SYSTEMS	trichloroethylene[c]	0.223	99.984	1975	3.8	0.378	4	EPA
OLIN	dichlordifluormethane	5	99.99	2088	0.7	0.052	2a,b,c	Private
OLIN	dichlordifluormethane	5	99.99	2095	1.2	0.031	3a,b,c	Private
OLIN	trichlorfluormethane	14.85	99.9999	2095	1.2	0.031	3a,b,c	Private
OLIN	trichlorfluormethane	10.97	99.9998	2088	0.7	0.052	2a,b,c	Private
PENNWALT	dichlorofluoroethane	17.6	99.999	2320	1.3	0.006	22-3	Private
PENNWALT	dichlorofluoroethane	15	99.999	2260	0.72	0.044	22-4	Private
PENNWALT	dichlorofluoroethane	9.2	99.999	2380	0.9	0.005	23-1	Private
PENNWALT	dichlorofluoroethane	15.1	99.999	2370	1.4	0.006	23-2	Private
PENNWALT	dichlorofluoroethane	14.5	99.999	2340	1	0.007	23-3	Private
PENNWALT	dichlorofluoroethane	8.9	99.997	2340	1.1	0.036	22-1	Private
PENNWALT	dichlorofluoroethane	10.2	99.995	2350	1	0.014	22-2	Private
ROSS INCINERATION	1,1,1 trichloroethane	2.55	99.99952	2110	0.1	0.061	1	EPA
ROSS INCINERATION	1,1,1 trichloroethane	0.91	99.999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	1,1,1 trichloroethane	0.58	99.999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.035	99.99999	2110	0.1	0.061	1	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.028	99.99999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	1,1,2 trichloroethane	0.038	99.99999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.071	99.9994	2040	0.3	0.061	3	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.02	99.9992	2110	0.1	0.061	1	EPA
ROSS INCINERATION	2,4 dimethylphenol	0.02	99.999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	aniline	0.026	99.998	2110	0.1	0.061	1	EPA
ROSS INCINERATION	aniline	0.021	99.998	2090	0.3	0.077	2	EPA
ROSS INCINERATION	aniline	0.026	99.998	2040	0.3	0.061	3	EPA
ROSS INCINERATION	butyl benzl phthalate	0.1	99.9996	2110	0.1	0.061	1	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
ROSS INCINERATION	butyl benzyl phthalate	0.027	99.999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	butyl benzyl phthalate[g]	0.017	99.998	2090	0.3	0.077	2	EPA
ROSS INCINERATION	carbon tetrachloride	0.16	99.9964	2110	0.1	0.061	1	EPA
ROSS INCINERATION	carbon tetrachloride	0.21	99.9961	2090	0.3	0.077	2	EPA
ROSS INCINERATION	carbon tetrachloride	0.2	99.9959	2040	0.3	0.061	3	EPA
ROSS INCINERATION	cresol(s)	0.12	99.9993	2110	0.1	0.061	1	EPA
ROSS INCINERATION	cresol(s)	0.091	99.9991	2040	0.3	0.061	3	EPA
ROSS INCINERATION	cresol(s)	0.074	99.999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	dichloromethane[c]	0.67	99.989	2090	0.3	0.077	2	EPA
ROSS INCINERATION	dichloromethane[c]	0.36	99.978	2040	0.3	0.061	3	EPA
ROSS INCINERATION	dichloromethane[c]	0.23	99.968	2110	0.1	0.061	1	EPA
ROSS INCINERATION	MEK	0.86	99.99967	2110	0.1	0.061	1	EPA
ROSS INCINERATION	MEK	1.64	99.99932	2040	0.3	0.061	3	EPA
ROSS INCINERATION	MEK	0.79	99.9993	2090	0.3	0.077	2	EPA
ROSS INCINERATION	methyl pyridine	0.025	99.998	2110	0.1	0.061	1	EPA
ROSS INCINERATION	methyl pyridine	0.042	99.998	2090	0.3	0.077	2	EPA
ROSS INCINERATION	methyl pyridine	0.041	99.998	2040	0.3	0.061	3	EPA
ROSS INCINERATION	N,N dimethylacetamide	1.82	99.9999	2090	0.3	0.077	2	EPA
ROSS INCINERATION	N,N dimethylacetamide	1.9	99.9999	2040	0.3	0.061	3	EPA
ROSS INCINERATION	N,N dimethylacetamide	0.83	99.9998	2110	0.1	0.061	1	EPA
ROSS INCINERATION	naphthalene[c]	0.032	99.994	2110	0.1	0.061	1	EPA
ROSS INCINERATION	naphthalene[c]	0.036	99.994	2090	0.3	0.077	2	EPA
ROSS INCINERATION	naphthalene[c]	0.024	99.991	2040	0.3	0.061	3	EPA
ROSS INCINERATION	phenol[c,g]	0.012	99.997	2110	0.1	0.061	1	EPA
ROSS INCINERATION	phenol[c,g]	0.006	99.993	2090	0.3	0.077	2	EPA
ROSS INCINERATION	phenol[c,g]	0.005	99.992	2040	0.3	0.061	3	EPA
ROSS INCINERATION	phthalic anhydride[g]	0.008	99.99	2090	0.3	0.077	2	EPA
ROSS INCINERATION	phthalic anhydride[g]	0.007	99.99	2040	0.3	0.061	3	EPA
ROSS INCINERATION	tetrachloroethylene	1.67	99.99912	2040	0.3	0.061	3	EPA
ROSS INCINERATION	tetrachloroethylene	0.78	99.9986	2110	0.1	0.061	1	EPA
ROSS INCINERATION	tetrachloroethylene	0.69	99.9977	2090	0.3	0.077	2	EPA
ROSS INCINERATION	toluene	4.04	99.99904	2110	0.1	0.061	1	EPA
ROSS INCINERATION	toluene	2.87	99.9987	2090	0.3	0.077	2	EPA
ROSS INCINERATION	toluene	2.74	99.9978	2040	0.3	0.061	3	EPA
ROSS INCINERATION	trichloroethylene	1.04	99.99963	2110	0.1	0.061	1	EPA
ROSS INCINERATION	trichloroethylene	0.83	99.9969	2040	0.3	0.061	3	EPA
ROSS INCINERATION	trichloroethylene	0.47	99.9965	2090	0.3	0.077	2	EPA
SCA CHEMICAL SER	PCB	27.5	99.99994	2212	2.5	f	19	Private
SCA CHEMICAL SER	PCB	26.7	99.99982	2231	1.4	0.075	17	Private
SCA CHEMICAL SER	PCB	19	99.9998	2225	3.4	f	21	Private

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
SCA CHEMICAL SER	PCB	22.1	99.99949	2247	2.2	f	20	Private
SMITH KLINE CHEM	chloroform	1.21	99.99999	1640	0.6	0.057	6	Private
SMITH KLINE CHEM	chloroform	1.1	99.99999	1620	0.2	0.027	7	Private
SMITH KLINE CHEM	chloroform	0.93	99.99999	1710	0.6	0.03	8	Private
SMITH KLINE CHEM	tetrachloroethene	1.32	99.99999	1620	0.2	0.027	7	Private
SMITH KLINE CHEM	tetrachloroethene	0.98	99.99999	1710	0.6	0.03	8	Private
SMITH KLINE CHEM	tetrachloroethene	1.36	99.99997	1640	0.6	0.057	6	Private
SMITH KLINE CHEM	toluene	3.86	99.99953	1620	0.2	0.027	7	Private
SMITH KLINE CHEM	toluene	3.2	99.9982	1710	0.6	0.03	8	Private
SMITH KLINE CHEM	toluene	4.53	99.997	1640	0.6	0.057	6	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.88	99.99998	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.87	99.99998	1830	99.9	0.002	6	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.82	99.99998	1830	99.9	0.0009	4	Private
STAUFFER CHEMICAL	1,1,1 trichloroethane	0.83	99.99998	1830	99.9	0.003	5	Private
STAUFFER CHEMICAL	benzene	4.47	100	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	benzene	4.53	100	1830	99.9	0.002	6	Private
STAUFFER CHEMICAL	benzene	4.68	100	1830	99.9	0.003	5	Private
STAUFFER CHEMICAL	benzene	4.65	99.99999	1830	99.9	0.0009	4	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.89	99.99998	1830	99.9	0.002	6	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.82	99.99998	1830	99.9	0.0009	4	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.85	99.99998	1830	99.9	0.001	7	Private
STAUFFER CHEMICAL	carbon tetrachloride	0.84	99.99998	1830	99.9	0.003	5	Private
TWI	1,1,1 trichloroethane[g]	0.00792	99.966	2080	0.3	0.075	1	EPA
TWI	1,1,1 trichloroethane[g,k]	0.016	99.88	2230	h	h	6	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0123	99.87	2140	h	h	8B	EPA
TWI	1,1,1 trichloroethane[g]	0.0105	99.86	2070	0.6	0.048	3	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0087	99.84	2050	h	h	7	EPA
TWI	1,1,1 trichloroethane[g]	0.0051	99.82	1810	0.2	0.044	4	EPA
TWI	1,1,1 trichloroethane[g]	0.011	99.81	2030	0.4	0.127	2	EPA
TWI	1,1,1 trichloroethane[g,k]	0.0162	99.47	2120	h	h	8A	EPA
TWI	benzene[k]	2.91	99.99979	2140	h	h	8B	EPA
TWI	benzene[k]	3.24	99.99952	2120	h	h	8A	EPA
TWI	benzene	1.52	99.9983	2080	0.3	0.075	1	EPA
TWI	benzene[k]	2.54	99.995	2050	h	h	7	EPA
TWI	benzene[k]	2.52	99.99	2230	h	h	6	EPA
TWI	benzene	1.18	99.989	2030	0.4	0.127	2	EPA
TWI	benzene	0.889	99.988	1810	0.2	0.044	4	EPA
TWI	benzene	1.43	99.984	2070	0.6	0.048	3	EPA
TWI	bis(ethyl hexyl)phthalate[c,g]	0.00511	99.96	2030	0.4	0.127	2	EPA
TWI	bis(ethyl hexyl)phthalate[c,g]	0.00429	99.951	2080	0.3	0.075	1	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
TWI	bis(ethyl hexyl)phthalate[c,g]	0.00574	99.94	2070	0.6	0.048	3	EPA
TWI	bis(ethyl hexyl)phthalate[c,g]	0.00261	99.88	1810	0.2	0.044	4	EPA
TWI	carbon tetrachloride[c]	0.379	99.99903	1810	0.2	0.044	4	EPA
TWI	carbon tetrachloride[c]	0.277	99.9987	2070	0.6	0.048	3	EPA
TWI	carbon tetrachloride[c,k]	0.377	99.9987	2050	h	h	7	EPA
TWI	carbon tetrachloride[c]	0.198	99.9984	2080	0.3	0.075	1	EPA
TWI	carbon tetrachloride[c]	0.228	99.9983	2030	0.4	0.127	2	EPA
TWI	carbon tetrachloride[c,k]	0.53	99.9966	2120	h	h	8A	EPA
TWI	carbon tetrachloride[c,k]	0.44	99.9951	2140	h	h	8B	EPA
TWI	carbon tetrachloride[c,k]	0.209	99.9926	2230	h	h	6	EPA
TWI	chlordane	0.66	99.9999	2030	0.4	0.127	2	EPA
TWI	chlordane	0.736	99.9999	2070	0.6	0.048	3	EPA
TWI	chlordane	0.462	99.9998	2080	0.3	0.075	1	EPA
TWI	chlorobenzene[g,k]	0.0167	99.9949	2140	h	h	8B	EPA
TWI	chlorobenzene[g,k]	0.0184	99.978	2120	h	h	8A	EPA
TWI	chlorobenzene[g]	0.0047	99.966	1810	0.2	0.044	4	EPA
TWI	chlorobenzene[g]	0.00858	99.965	2080	0.3	0.075	1	EPA
TWI	chlorobenzene[g]	0.00956	99.956	2070	0.6	0.048	3	EPA
TWI	chlorobenzene[g,k]	0.0152	99.73	2050	h	h	7	EPA
TWI	chlorobenzene[g]	0.0102	99.7	2030	0.4	0.127	2	EPA
TWI	chlorobenzene[g,k]	0.0174	99.6	2230	h	h	6	EPA
TWI	chloroform[c,g]	0.00224	99.944	2080	0.3	0.075	1	EPA
TWI	chloroform[c,g,k]	0.00476	99.92	2140	h	h	8B	EPA
TWI	chloroform[c,g,k]	0.00443	99.88	2120	h	h	8A	EPA
TWI	chloroform[c,g]	0.00201	99.8	2070	0.6	0.048	3	EPA
TWI	chloroform[c,g]	0.00654	99.78	1810	0.2	0.044	4	EPA
TWI	chloroform[c,g,k]	0.0082	99.1	2230	h	h	6	EPA
TWI	chloroform[c,g,k]	0.00478	99.02	2050	h	h	7	EPA
TWI	chloroform[c,g]	0.00283	98.2	2030	0.4	0.127	2	EPA
TWI	dibromomethane[k]	0.326	99.99992	2140	h	h	8B	EPA
TWI	dibromomethane[k]	0.292	99.99981	2120	h	h	8A	EPA
TWI	dibromomethane	0.0244	99.9987	2080	0.3	0.075	1	EPA
TWI	dibromomethane[k]	0.319	99.9936	2050	h	h	7	EPA
TWI	dibromomethane	0.159	99.982	1810	0.2	0.044	4	EPA
TWI	dibromomethane[k]	0.322	99.974	2230	h	h	6	EPA
TWI	dibromomethane	0.172	99.964	2070	0.6	0.048	3	EPA
TWI	dibromomethane	0.126	99.956	2030	0.4	0.127	2	EPA
TWI	dibromomethane[g]	0.00627	99.918	2080	0.3	0.075	1	EPA
TWI	dibromomethane[g,k]	0.00881	99.9	2140	h	h	8B	EPA
TWI	dibromomethane	0.021	99.88	2070	0.6	0.048	3	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
TWI	dichloromethane[g,k]	0.00832	99.83	2120	h	h	8A	EPA
TWI	dibromomethane[g]	0.00762	99.71	2030	0.4	0.127	2	EPA
TWI	dibromomethane[g]	0.0116	99.63	1810	0.2	0.044	4	EPA
TWI	dibromomethane[g,k]	0.0109	99.53	2050	h	h	7	EPA
TWI	dibromomethane[g,k]	0.013	99.51	2230	h	h	6	EPA
TWI	hexachlorobutadiene[g]	0.0144	99.98	1810	0.2	0.044	4	EPA
TWI	hexachlorocyclopentadiene	0.693	99.9996	1810	0.2	0.044	4	EPA
TWI	hexachlorocyclopentadiene[g]	0.0066	99.99	2080	0.3	0.075	1	EPA
TWI	hexachlorocyclopentadiene[g]	0.00786	99.99	2030	0.4	0.127	2	EPA
TWI	hexachlorocyclopentadiene[g]	0.00956	99.99	2070	0.6	0.048	3	EPA
TWI	naphthalene	0.379	99.996	1810	0.2	0.044	4	EPA
TWI	tetrachloroethylene[g]	0.0183	99.982	1810	0.2	0.044	4	EPA
TWI	tetrachloroethylene[g,k]	0.0044	99.966	2140	h	h	8B	EPA
TWI	tetrachloroethylene[g]	0.00567	99.965	2080	0.3	0.075	1	EPA
TWI	tetrachloroethylene[g]	0.0124	99.88	2070	0.6	0.048	3	EPA
TWI	tetrachloroethylene[g,k]	0.00377	99.81	2050	h	h	7	EPA
TWI	tetrachloroethylene[g]	0.00636	99.78	2030	0.4	0.127	2	EPA
TWI	tetrachloroethylene[g,k]	0.0041	99.64	2230	h	h	6	EPA
TWI	toluene[k]	9.87	99.99988	2140	h	h	8B	EPA
TWI	toluene[k]	11.03	99.99959	2120	h	h	8A	EPA
TWI	toluene	7.92	99.99946	2080	0.3	0.075	1	EPA
TWI	toluene[k]	8.52	99.9979	2230	h	h	6	EPA
TWI	toluene[k]	8.55	99.9976	2050	h	h	7	EPA
TWI	toluene	9.56	99.9963	2070	0.6	0.048	3	EPA
TWI	toluene	6.01	99.9922	1810	0.2	0.044	4	EPA
TWI	toluene	4.08	99.9908	2030	0.4	0.127	2	EPA
TWI	trichloroethylene[k]	0.555	99.99924	2140	h	h	8B	EPA
TWI	trichloroethylene[k]	0.67	99.99921	2120	h	h	8A	EPA
TWI	trichloroethylene	0.353	99.9989	1810	0.2	0.044	4	EPA
TWI	trichloroethylene	0.178	99.9962	2080	0.3	0.075	1	EPA
TWI	trichloroethylene	0.212	99.9945	2030	0.4	0.127	2	EPA
TWI	trichloroethylene[k]	0.29	99.9926	2050	h	h	7	EPA
TWI	trichloroethylene	0.277	99.9917	2070	0.6	0.048	3	EPA
TWI	trichloroethylene	0.956	99.989	2230	h	h	6	EPA
UNION CARBIDE	1,2 dichlorobenzene	2.1	99.99994	1600	98.9	0.066	7	Private
UNION CARBIDE	1,2 dichlorobenzene	1.6	99.99992	1800	98.2	0.075	6	Private
UNION CARBIDE	1,2 dichlorobenzene	1.5	99.9999	1600	98.1	0.073	2	Private
UNION CARBIDE	1,2 dichlorobenzene	1.7	99.9999	1600	98.6	0.055	11	Private
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.9999	1800	98.4	0.064	12	Private
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.99986	1800	97.9	0.07	3	Private

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
UNION CARBIDE	1,2 dichlorobenzene	2.2	99.99985	1600	98.9	0.048	8	Private
UNION CARBIDE	1,2 dichlorobenzene	2.1	99.99985	1600	98.5	0.057	9	Private
UNION CARBIDE	1,2 dichlorobenzene	1.3	99.99957	1800	98.3	0.061	5	Private
UNION CARBIDE	1,2 dichlorobenzene	1.4	99.99933	1800	98.2	0.071	4	Private
UNION CARBIDE	1,2 dichlorobenzene	5	99.99923	1600	98.2	0.094	1	Private
UNION CARBIDE	1,2 dichlorobenzene	1.2	99.99921	1800	98.5	0.056	10	Private
UNION CARBIDE	chlorobenzene	1.8	99.99979	1800	97.9	0.07	3	Private
UNION CARBIDE	chlorobenzene	1.7	99.99979	1800	98.4	0.064	12	Private
UNION CARBIDE	chlorobenzene	1.9	99.99962	1600	98.1	0.073	2	Private
UNION CARBIDE	chlorobenzene	1.4	99.99961	1600	98.2	0.094	1	Private
UNION CARBIDE	chlorobenzene	2	99.99959	1600	98.6	0.055	11	Private
UNION CARBIDE	chlorobenzene	1.8	99.99952	1800	98.2	0.071	4	Private
UNION CARBIDE	chlorobenzene	1.6	99.99949	1800	98.2	0.075	6	Private
UNION CARBIDE	chlorobenzene	1.6	99.99935	1800	98.3	0.061	5	Private
UNION CARBIDE	chlorobenzene	2.7	99.99907	1600	98.9	0.066	7	Private
UNION CARBIDE	chlorobenzene	2.7	99.99907	1600	98.9	0.048	8	Private
UNION CARBIDE	chlorobenzene	2.6	99.9988	1600	98.5	0.057	9	Private
UNION CARBIDE	chlorobenzene	1.5	99.9987	1800	98.5	0.056	10	Private
UNION CARBIDE	hexachloroethane	6.4	99.99997	1600	98.2	0.094	1	Private
UNION CARBIDE	hexachloroethane	2	99.9999	1600	98.1	0.073	2	Private
UNION CARBIDE	hexachloroethane	1.8	99.9999	1800	97.9	0.07	3	Private
UNION CARBIDE	hexachloroethane	1.8	99.9999	1800	98.2	0.071	4	Private
UNION CARBIDE	hexachloroethane	1.6	99.9999	1800	98.3	0.061	5	Private
UNION CARBIDE	hexachloroethane	2	99.9999	1800	98.2	0.075	6	Private
UNION CARBIDE	hexachloroethane	2.7	99.9999	1600	98.9	0.066	7	Private
UNION CARBIDE	hexachloroethane	2.8	99.9999	1600	98.9	0.048	8	Private
UNION CARBIDE	hexachloroethane	2.7	99.9999	1600	98.5	0.057	9	Private
UNION CARBIDE	hexachloroethane	1.5	99.9999	1800	98.5	0.056	10	Private
UNION CARBIDE	hexachloroethane	2.1	99.9999	1600	98.6	0.055	11	Private
UNION CARBIDE	hexachloroethane	1.7	99.9999	1800	98.4	0.064	12	Private
UNION CARBIDE	tetrachloroethylene	1.6	99.99986	1800	98.2	0.075	6	Private
UNION CARBIDE	tetrachloroethylene	1.7	99.99985	1800	98.4	0.064	12	Private
UNION CARBIDE	tetrachloroethylene	1.8	99.99984	1800	97.9	0.07	3	Private
UNION CARBIDE	tetrachloroethylene	2.8	99.99984	1600	98.9	0.048	8	Private
UNION CARBIDE	tetrachloroethylene	2.1	99.99983	1600	98.6	0.055	11	Private
UNION CARBIDE	tetrachloroethylene	2.7	99.99979	1600	98.5	0.057	9	Private
UNION CARBIDE	tetrachloroethylene	1.8	99.99977	1800	98.2	0.071	4	Private
UNION CARBIDE	tetrachloroethylene	1.6	99.99977	1800	98.3	0.061	5	Private
UNION CARBIDE	tetrachloroethylene	1.5	99.99977	1800	98.5	0.056	10	Private
UNION CARBIDE	tetrachloroethylene	2	99.99975	1600	98.1	0.073	2	Private

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
UNION CARBIDE	tetrachloroethylene	1.4	99.99972	1600	98.2	0.094	1	Private
UNION CARBIDE	tetrachloroethylene	2.7	99.99966	1600	98.9	0.066	7	Private
UPJOHN	1,2,4 trichlorobenzene	0.027	99.65	2040	0.9	0.094	2	EPA
UPJOHN	1,2,4 trichlorobenzene	0.039	99.75	2040	1.7	0.013	4	EPA
UPJOHN	1,2,4 Trichlorobenzene	0.029	98.6	2040	1.2	0.08	3	EPA
UPJOHN	aniline[c]	c	99.9988	2040	1.2	0.08	3	EPA
UPJOHN	aniline[c]	c	99.9988	2040	1.2	0.08	3	EPA
UPJOHN	aniline[c]	c	99.981	2040	1.7	0.013	4	EPA
UPJOHN	bis(ethyl hexyl)phthalate[c]	0.05	99.98	2040	0.9	0.094	2	EPA
UPJOHN	bis(ethyl hexyl)phthalate[c]	0.13	99.98	2040	1.7	0.013	4	EPA
UPJOHN	bis(ethyl hexyl)phthalate[c]	0.05	99.95	2040	1.2	0.08	3	EPA
UPJOHN	carbon tetrachloride[c]	4.4	99.9954	2040	1.7	0.013	4	EPA
UPJOHN	carbon tetrachloride[c]	3.6	99.994	2040	0.9	0.094	2	EPA
UPJOHN	carbon tetrachloride[c]	4.4	99.9931	2040	1.2	0.08	3	EPA
UPJOHN	chlorobenzene[c]	0.68	99.945	2040	1.7	0.013	4	EPA
UPJOHN	chlorobenzene[c]	0.41	99.86	2040	1.2	0.08	3	EPA
UPJOHN	chloromethane[c]	>0.2	99.9986	2040	0.9	0.094	2	EPA
UPJOHN	chloromethane[c]	>0.19	99.9975	2040	1.7	0.013	4	EPA
UPJOHN	chloromethane[c]	>0.12	99.9952	2040	1.2	0.08	3	EPA
UPJOHN	chlorophenyl isocyanate	2.8	99.9991	2040	1.7	0.013	4	EPA
UPJOHN	m-dichlorobenzene	2.1	99.922	2040	0.9	0.094	2	EPA
UPJOHN	m-dichlorobenzene	3.1	99.932	2040	1.7	0.013	4	EPA
UPJOHN	m-dichlorobenzene	2.3	99.905	2040	1.2	0.08	3	EPA
UPJOHN	o-dichlorobenzene	4	99.999	2040	0.9	0.094	2	EPA
UPJOHN	o-dichlorobenzene	6.4	99.999	2040	1.7	0.013	4	EPA
UPJOHN	o-dichlorobenzene	4.6	99.993	2040	1.2	0.08	3	EPA
UPJOHN	p-dichlorobenzene	5.6	99.999	2040	0.9	0.094	2	EPA
UPJOHN	p-dichlorobenzene	8	99.999	2040	1.7	0.013	4	EPA
UPJOHN	p-dichlorobenzene	5.9	99.995	2040	1.2	0.08	3	EPA
UPJOHN	phenyl isocyanate	17	99.99992	2040	0.9	0.094	2	EPA
UPJOHN	phenyl isocyanate	21	99.99992	2040	1.7	0.013	4	EPA
UPJOHN	phenyl isocyanate	16	99.9999	2040	1.2	0.08	3	EPA
UPJOHN	phosgene	53.4	99.9985	2040	0.9	0.094	2	EPA
UPJOHN	phosgene	50.8	99.993	2040	1.2	0.08	3	EPA
UPJOHN	phosgene	20.2	99.981	2040	1.7	0.013	4	EPA
UPJOHN	trichloroethylene[c]	4	99.99956	2040	1.7	0.013	4	EPA
UPJOHN	trichloroethylene[c]	4	99.9989	2040	1.2	0.08	3	EPA
UPJOHN	trichloroethylene[c]	3.3	99.9983	2040	0.9	0.094	2	EPA
ZAPATA INDUSTRIES	carbon tetrachloride	0.73	99.99911	1600	1.4	0.022	2	EPA
ZAPATA INDUSTRIES	carbon tetrachloride	0.61	99.999	1550	2.8	0.036	3	EPA

Table B-2. (continued)

SITE	COMPOUND	CONC,%[a]	DRE,%[a]	TEMP, °F	HCL, lb/h[b]	TSP, gr/dscf	TEST No.	SPONSOR
ZAPATA INDUSTRIES	carbon tetrachloride	0.28	99.9972	1660	3.3	0.017	4	EPA
ZAPATA INDUSTRIES	carbon tetrachloride	1.2	99.978	1570	2.2	0.03	1	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.4	99.9983	1660	3.3	0.017	4	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.79	99.9974	1550	2.8	0.036	3	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.78	99.9956	1570	2.2	0.03	1	EPA
ZAPATA INDUSTRIES	chlorobenzene	0.76	99.9953	1600	1.4	0.022	2	EPA
ZAPATA INDUSTRIES	dichloromethane	0.017	99.906	1600	1.4	0.022	2	EPA
ZAPATA INDUSTRIES	toluene	0.42	99.9956	1660	3.3	0.017	4	EPA
ZAPATA INDUSTRIES	toluene	0.073	99.9932	1550	2.8	0.036	3	EPA
ZAPATA INDUSTRIES	toluene	0.33	99.9914	1600	1.4	0.022	2	EPA
ZAPATA INDUSTRIES	toluene	0.11	99.952	1570	2.2	0.03	1	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.52	99.9985	1550	2.8	0.036	3	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.71	99.9979	1600	1.4	0.022	2	EPA
ZAPATA INDUSTRIES	trichloroethylene	0.29	99.9946	1660	3.3	0.017	4	EPA
ZAPATA INDUSTRIES	trichloroethylene	1.1	99.979	1570	2.2	0.03	1	EPA

[a]For those runs in which a range of waste feed concentrations were tested, only the lowest reported DRE is listed.
[b]HCl values for Dow, Stauffer Chemical, and Upjohn are listed as % removal, not lb/h.
[c]Sampling and/or analytical problems; data suspect.
[d]None detected; limit of detection unknown.
[e]Temperature reading suspect—may be low by 300°F.
[f]Not reported.
[g]Low concentration (200 ppm or less) in waste feed.
[h]Not measured.
[i]Abnormal operating conditions—low temperature.
[j]Abnormal operating conditions—unspecified.
[k]Abnormal operating conditions—waste feed rate increased and combustion air distribution changed in attempt to increase CO and THC emissions.

Appendix C

BOILER TEST SUMMARIES

Summary of Test Data for Site A

Date of Test: ***1982***

Run No.: 4 tests. Test 1 was baseline while tests 2, 3, and 4 included creosote sludge

Test Sponsor: EPA

Equipment information:

Type of unit: Keeler type CP water tube steam generator (Boiler)
Commercial __ Private X
Capacity: 10,000 lb/h of saturated steam @ 250 psig (308 HP)
Pollution control system: Multiclone

Waste feed system: Creosote waste sludge fed onto belt convey or carrying wood waste. The mixture was fed into furnace through two injectors equipped with variable speed augers.

Residence time: 1.2 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Creosote waste sludge (about 40% of total heat input)

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 3,440 lb/test
Waste feed rate: 430 lb/h of creosote sludge and 1,770 to 1,970 lb/h wood waste.
POHC's selected and concentration in waste feed:

	Concentration, % by wt.		
Name	***Test 2***	***Test 3***	***Test 4***
Phenol	0.13	0.08	0.058
Pentachlorophenol	0.6	0.22	0.22
2,4-dimethylphenol	0.13	0.036	0.03
Naphthalene	1.9	0.60	0.54
Fluorene	0.76	0.50	0.044

Btu content: 8518 Btu/lb avg.
Ash content: 0.82% avg.
Chlorine content: 0.15 to 0.21%
Moisture content: 40.4% avg.

Operating Conditions:

Temperature: Not reported
Primary fuel used: Wood chips, bark and sawdust

Excess air: High excess air
Other:
Had ambient underfire, overfire and reinjection air. Boiler efficiency = 63%
Total heat input = 17.2 to 18.7 x 10^6 Btu/h
Volumetric heat release rate = 72 x 10^3 Btu/ft^3-h

Monitoring Methods:

Waste Feed: One composite sample for each co-fired test
POHC's: Tenax sorbent trap
HCl: Not sampled
Particulate: EPA Modified Method 5
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

BOILER SITE A

Emission and DRE Results:

POHC's:

POHC	DRE, %					
	Without background correction			*With background correction*		
	Test 2	*Test 3*	*Test 4*	*Test 2*	*Test 3*	*Test 4*
Phenol	>99.999	99.994	99.938	>99.999	>99.999	>99.997
Pentachlorophenol	99.985	99.975	99.996	99.985	99.975	99.996
Fluorene	99.997	99.986	>99.999	99.997	99.986	>99.999
Naphthalene	99.986	99.988	99.946	99.988	99.997	99.955
2,4-dimethyl-phenol	>99.995	>99.982	>99.979	>99.995	>99.982	>99.979

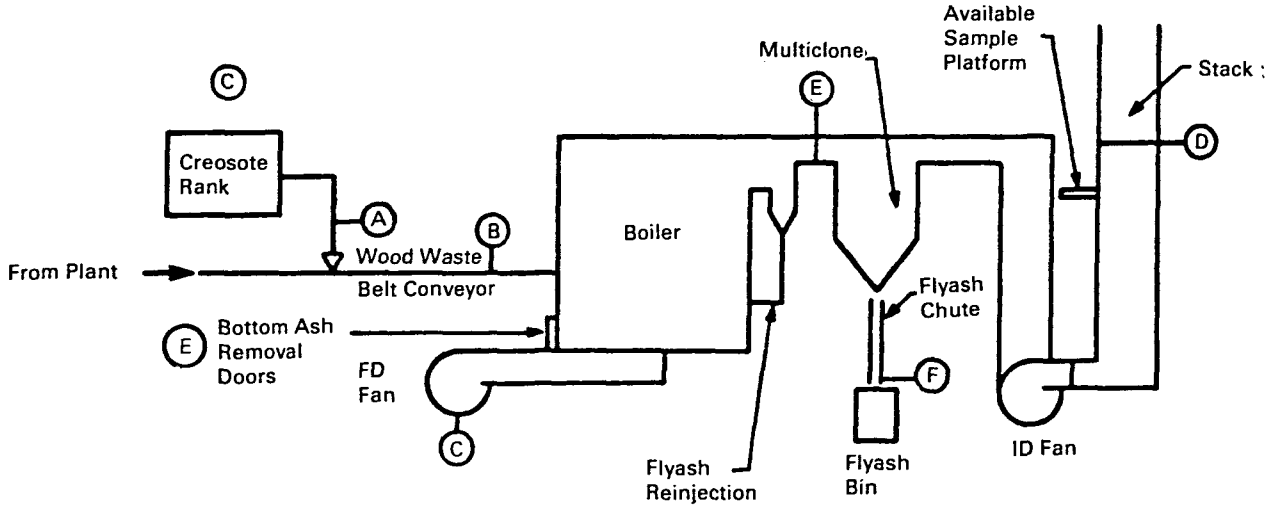
HCl: Not sampled
Particulate: 1.0 g/s (average)
THC: Not reported
CO: 1200, 977, 900 ppm
Other: NO_x - 210, 171, 180 ppm
PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1985.

Comments: Operation appeared normal but there were large fluctuations in CO_2, O_2, and CO. Although not measured, boiler steam load probably varied significantly.

PROCESS FLOW DIAGRAM

Site layout—site A.



Summary of Test Data for Site B

Date of Test: *1982*

Run No.: 4 tests. Test 1 was baseline while tests 2, 3, and 4 included alkyde wastewater from paint manufacturing.

Test Sponsor: EPA

Equipment information:

Type of unit: Cleaver-Brooks fire tube steam boiler
Commercial __ Private X
Capacity: 8400 lb/h of saturated steam @ 150 psig (250 HP)
Pollution control system: None

Waste feed system: Air atomized oil burner centered in the single ring burner used to find natural gas

Residence time: 0.8 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Alkyde resin wastewater from paint manufacturing containing toluene, xylenes and acids

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 283, 259, and 254 gallons
Waste feed rate: 0.59, 0.54, 0.53 gal/min for 3 waste runs
POHC's selected and concentration in waste feed:

	Concentration, % by wt.		
Name	*Test 2*	*Test 3*	*Test 4*
Naphthalene	0.0007	0.00002	0.00009
Pentachlorophenol	0.0002	0.00002	0.00002
Toluene	13	0.0004	0.02

Btu content: 90,900, 113, 491 Btu/gal
Ash content: Not reported
Chlorine content: Not reported
Moisture content: 28, 99.9, 99.6%

Operating Conditions:

Temperature: Not reported
Primary fuel used: Natural gas

Excess air: 5.3, 5.7, 5.0% oxygen in outlet
Other:
Boiler efficiency = 63%, heat input = 2.5 to >2.9 x 10^6 Btu/h
Volumetric heat release rate = 72 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's: Tenax sorbent trap
HCl: Not reported
Particulate: Not reported
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

BOILER SITE B

Emission and DRE Results: (see comments)

POHC's:

POHC	DRE, %					
	Without background correction			With background correction		
	Run 2	Run 3	Run 4[a]	Run 2	Run 3	Run 4[b]
Phenol	99.3%	81%	13/96%	>99.9	>99.7	>98.77 - >99.95
Pentachlorophenol	>99.6%	NA	>70/>98.9%	>99.6	NA	>70 - >98.9
Toluene	>99.999%	NA	84/99.99%	>99.999	NA	>98 - >99.999

[a]High and low values are based upon analyses of three waste samples. Single value indicated only one value reported above detection limit.
[b]Two numbers indicate high and low values depending on which of three waste analyses was used. Single value indicates only one waste concentration.

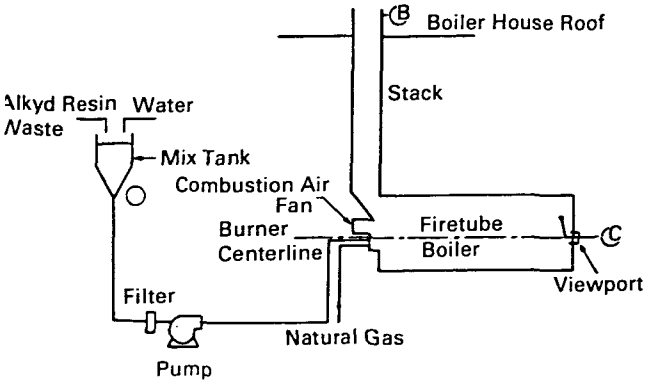
HCl: Not reported
Particulate: Not reported
THC: 89, 85, 47 ppm
CO: 47, 47, 88 ppm
Other: NO_x - 44, 65, 40 ppm
PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: During cofiring, several nonsteady-state conditions and operational upsets were recorded. These were primarily caused by waste feed problems due to insufficient mixing of the alkyd resin wastewater. There were several waste feed cutoffs due to pluggage of strainers.

Note, all POHC concentrations were extremely low except for toluene in Test 2

PROCESS FLOW DIAGRAM



Summary of Test Data for Site C

Date of Test: 1982

Run No.: 4 tests. Test 1 was baseline while tests 2, 3, and 4 included phenolic wastes

Test Sponsor: EPA

Equipment information:

Type of unit: Babcock & Wilcox wall-fired steam generator
Commercial __ Private X
Capacity: 230,000 lb/h @ 250 psig and 516°F
Pollution control system: None

Waste feed system: Fed into furnace through oil guns and is steam atomized

Residence time: 2.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: o-methyl stryene dimers and phenolic and benzene residues including phenol, methylene-bisphenol and cumene, phenolic wastes

Length of burn: Approximately 8 h
Total amount of waste burned: estimated 2048, 1904, 1928 gallons
Waste feed rate: 256, 238, 241 gal/h
POHC's selected and concentration in waste feed:

	Concentration, % by wt.		
Name	*Test 2*	*Test 3*	*Test 4*
Phenol	5.6	4.7	5.3
Bis (2-ethylhexyl) phthalate	0.006	0.004	0.003
Dibutylphthalate	NA	NA	0.012

Btu content: 16,498; 16,525; 16,799 Btu/lb
Ash content: 0.08, 0.08, 0.07%
Chlorine content: 0.02, 0.03, 0.07%
Moisture content: 0.45, 0.50, 0.60%

Operating Conditions:

Temperature: Not reported
Primary fuel used: Natural gas

Excess air: 9.7, 10.5, 10.7% oxygen in outlet
Other:
Boiler efficiency - 81%, heat input - 83.4 to 88.3 x 10^6 Btu/h
Volumetric heat release rate - 7.5 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's: Tenax sorbent trap
HCl: Not reported
Particulate: Not reported
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

BOILER SITE C

Emission and DRE Results: (see comments)

POHC's:

POHC	DRE, % Test 2	Test 3	Test 4
Phenol	99.9998%	>99.999%	>99.999%
Bis (2-ethylhexyl) phthalate[a]	99.1%	98.3%	96%
Dibutylphthalate[a]	NA	NA	99.3%

[a]The concentrations of bis (2-ethylhexyl) phthalate and dibutylphthalate in the waste were very low (<120 ppm)

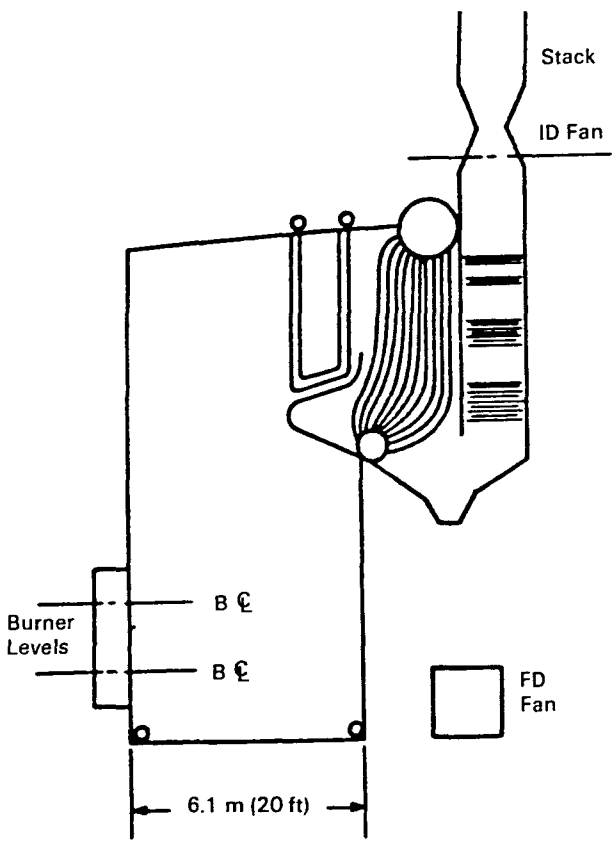
HCl: Not reported
Particulate: Not reported
THC: 0, 0, 0 ppm
CO: 21, 20, 18 ppm
Other: Opacity - 16, 15, 15% during tests; 10% during baseline
NO_x - 61, 74, 66 ppm
PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: The boiler operated at very low loads during the test which resulted in high excess air levels in the range of 80 to 95 percent (10 to 11 percent oxygen) to promote good air fuel mixing.

PROCESS FLOW DIAGRAM

Schematic of site C boiler.



a. Side View

Summary of Test Data for Site D

Date of Test: Early 1983

Run No.: 2, 3, 4, 5, 6, and 7 (Test 1 was baseline)

Test Sponsor: EPA

Equipment information:

Type of unit: B&W field erected water tube boiler - multi-burner
Commercial ___ Private X
Capacity: 90,000 lb/h @ 260 psig
Pollution control system: Essentially no controls for particulate. Multiclone has been removed to leave a settling chamber.

Waste feed system: Waste solvent was injected into boiler with steam atomization through burners.

Residence time: 1.1 to 1.3 s

Test Conditions:

Waste feed data:

Type of waste(s) burned:
2 solvent waste streams (#3 and #6);
#3 = mixture of methanol, xylenes and TCE
#6 = mixture of toluene and bis (2-chloroethyl) ether

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 2010, 2090, 1960, 1430, 1430, 1460 gallons
Waste feed rate: 4.19, 4.35, 4.08, 2.97, 2.97, 3.04 gal/min
POHC's selected and concentration in waste feed:

	Concentration, % by wt.					
Name	*Test 2*	*Test 3*	*Test 4*	*Test 5*	*Test 6*	*Test 7*
Tetrachloroethylene (PCE)	29.5	16.3	6.96			
Dichloroethyl ether (BCEE)				4.10	4.02	4.02

Btu content: 12,645; 12,551; 8,866; 17,977; 16,669; 17,073 Btu/lb
Ash content: 0.11, 0.17, 0.10, 0.02, <0.01, <0.01%
Chlorine content: 22.0, 22.0, 3.9, 1.6, 2.4, 2.2%
Moisture content: 0.68, 7.8, 11.2, 0.2, 0.2, 0.09%

Operating Conditions:

Temperature: Not reported
Auxiliary fuel used: No. 6 fuel oil

Excess air: 3.5, 4.2, 4.0, 3.8, 4.4, 5.0% oxygen in outlet
Other:
Heat input - 49 to 95 x 10^6 Btu/h
Volumetric heat release rate = 23 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's and PIC's: Dual cold Tenax sorbent trap
HCl: EPA Modified Method 6
Particulate: EPA Modified Method 5
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

BOILER SITE D

Emission and DRE Results: (see comments)

POHC's:

	DRE, %					
POHC	***Test 2***	***Test 3***	***Test 4***	***Test 5***	***Test 6***	***Test 7***
Tetrachloroethylene	99.999	99.998	99.995	-	-	-
Dichloroethylether				>99.9999	99.9999	99.9999

HCl: #3 = 24.2 g/s, #6 = 4.9 g/s, or 320, 186, 69, 45, 32, 39 lb/h

Particulate: #3 = 1.3 g/s, #6 = 0.26 g/s, or 13.94, 8.84, 8.48, 1.88, 2.03, 2.12 lb/h

THC: Not reported

CO: 118, 88, 107, 107, 100, 127 ppm

Other: Opacity - 0 episodes during baseline but 4 during stream #3 and 3 during stream #6 (episode = over 20% opacity). NO_x - 250, 242, 231, 203, 202, 193 ppm

PIC's:

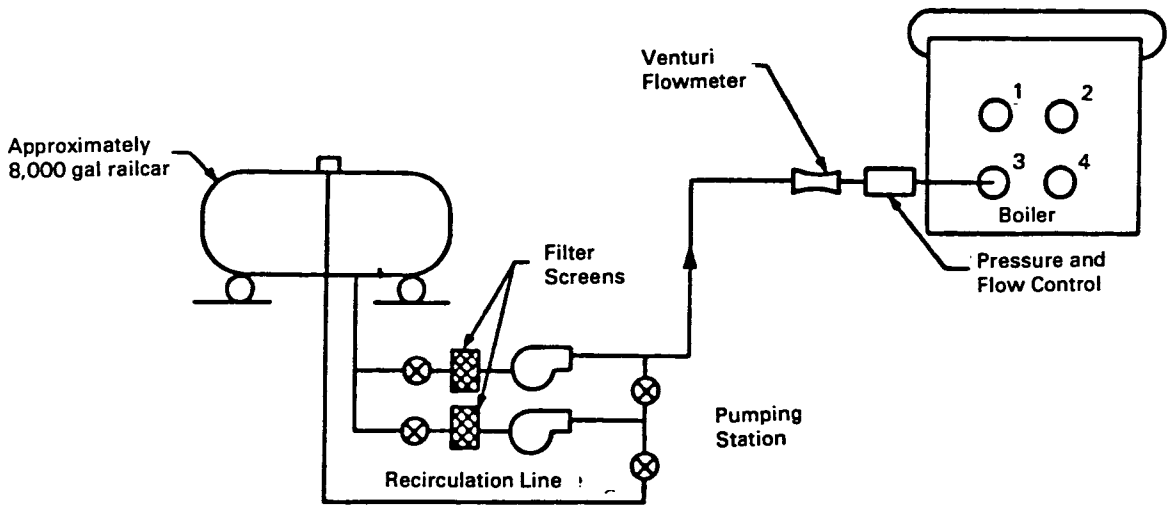
	Emissions, μg/s					
PIC	***Test 2***	***Test 3***	***Test 4***	***Test 5***	***Test 6***	***Test 7***
Benzene	680	570	220	0	50	150
Carbon tetrachloride	200	270	0	0	94	0
1,1,2-trichloroethane	110	150	0	0	47	0
Dichloromethane	2100	1600	6000	1800	860	0
Chloroform	360	290	120	410	160	210
Trichloroethylene	30	12	25	15	28	0
1,1,1-trichloroethane	260	160	140	110	200	46
1,2-dichloroethane	64	50	0	26	0	0
1,1-dichloroethylene	360	92	350	130	110	0

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: Operational upsets in some tests, particularly Test 2 (flame-outs). Waste solvent flow fluctuations noted throughout test program. Testing was stopped during most flame-out episodes but some testing took place during Test 2 and occasionally during Tests 3 and 6.

PROCESS FLOW DIAGRAM

Schematic of waste solvent feed system—site D.



BOILER SITE E

Summary of Test Data for Site E

Date of Test: Early 1983

Run No.: 8 runs total

Test Sponsor: EPA

Equipment information:

Type of unit: Forced draft CE Type 30-A - 12 packaged water tube boiler
Commercial __ Private X
Capacity: 110,000 lb/h @ 425 psig and 600°F
Pollution control system: No controls

Waste feed system: Waste steams filtered in mixing tank before injection by steam atomization through burners into furnace

Residence time: 0.5 to 1.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: 3 waste streams: #1 Methyl methacrylate - 1%, o-Hydroxy methyl isobutyrate - 11%, o-Hydroxy isobutyrate methyl ether - 7%, Fluxing oils - 81%, #2 Methyl methacrylate - 1%, o-Hydroxy methyl isobutyrate methyl ether - 10%, o-hydroxy isobutyrate methyl ether - 6%, CCl_4 - 2%, Cl - 2%, trichloroethylene - 2%, Fluxing oils - 77%, #3 Toluene - 80%, Methyl methacrylate - 20%

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 1490, 1800, 1980, 1910, 1990, 1900, 1970, 1800 gallons
Waste feed rate: 3.10, 3.75, 4.13, 3.97, 4.15, 3.96, 4.11, 3.74 gal/min
POHC's selected and concentration in waste feed:

	Concentration, % by wt.							
Name	***Test 2***	***Test 3***	***Test 4***	***Test 5***	***Test 6***	***Test 7***	***Test 8***	***Test 9***
Carbon tetrachloride	NA	2.77	2.87	2.91	2.91	3.34	2.69	0.009
Chlorobenzene	NA	1.65	1.59	1.61	1.79	1.91	1.45	NA
Trichloroethylene (TCE)	NA	2.87	2.94	2.89	2.81	3.1	2.39	0.009
Methyl methacrylate (MMA)	3.41	3.75	3.30	4.97	4.62	4.73	3.74	11.9
Methoxybutanone (MOB)	35.7	44.6	37.7	33.2	29.0	29.4	34.3	2.05
Methyl methoxybutanone	7.18	8.42	7.08	6.41	5.2	5.76	8.44	0.67

Btu content: 11,741, 10,975, 11,108, 10,546, 11,245, 11,076, 11,491, 15,941 Btu/lb
Ash content: 0.01, 0.05, 0.03, 0.03, 0.02, 0.02, 0.02, <0.01%
Chlorine content: 0.10, 1.80, 2.06, 1.53, 3.00, 3.35, 2.36, 0.16%
Moisture content: 1.73, 3.98, 2.71, 2.57, 2.5, 2.41, 1.33, 0.20%

Operating Conditions:

Temperature: Not reported
Primary fuel used: No. 6 oil and natural gas

Excess air: 15%
Other:
Boiler efficiency = 80.4, 89.1, 88, 89.4, 94.1, 85.5, 96.9, 88.9%
Heat input = 80.5, 68.9, 73.5, 70, 52.4, 107, 70.1, 58.6 x 10^6 Btu/h
Volumetric heat release rate = 50 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's and PIC's: Dual cold Tenax sorbent trap
Cl: Modified Method 6
Particulate: Modified Method 5
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results: (see comments)

POHC's:

POHC	DRE, %							
	Test 2	*Test 3*	*Test 4*	*Test 5*	*Test 6*	*Test 7*	*Test 8*	*Test 9*
Carbon tetrachloride	NA	99.9995	99.9998	99.9997	99.9990	99.9996	99.9998	NA
Trichloroethylene	NA	99.998	99.9995	99.9994	99.9993	99.994	99.9994	NA
Chlorobenzene	NA	99.995	99.99990	99.9993	99.998	99.998	99.9998	NA
Methylmethacrylate	99.997	99.95	99.98	99.997	99.994	99.993	99.992	99.9995
Methoxybutanone	>99.9999	99.9999	>99.9999	>99.9999	>99.9999	>99.9999	>99.9999	>99.9999
Methyl methoxybutanone	>99.9999	99.998	99.998	>99.9999	99.9996	>99.9999	99.9998	>99.9999

HCl: 0.08, 5 @ avg. of 8.6, 8.6, 0.05 g/s (1.5, 53, 51.6, 61.7, 81, 71.8, 68.3, 0.35 lb/h)

Particulate: 0.32, 5 @ avg. of 0.47, 0.09, 0.22 g/s (2.56, 3.23, 2.66, 2.55, 1.94, 7.94, 0.718, 1.77 lb/h)

THC: Not reported

CO: 97, 135, 129, 138, 115, 134, 83, 106 ppm

Other: Opacity - 0 episodes during baseline; #2 = 1, #3 = 8, #4 = 4, #5 = 3, #6 = 0, #7 = 3, #8 & 9 (but smoke present) = 0 (episode = 20% or greater)

NO_x - 278, 378, 431, 439, 413, 446, 359, 492, 164 ppm

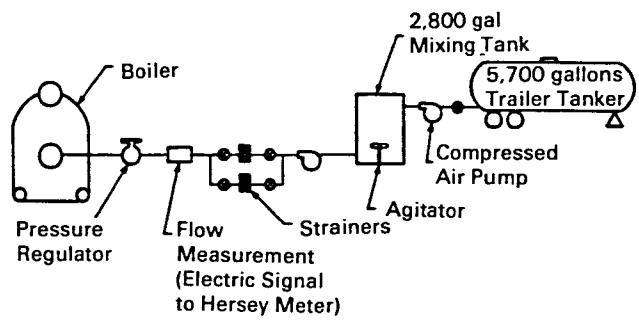
PIC's:

PIC	Emissions, µg/s							
	Test 2	*Test 3*	*Test 4*	*Test 5*	*Test 6*	*Test 7*	*Test 8*	*Test 9*
1,1,1-trichloroethane	280	-	52	200	170	800	77	320
Tetrachloroethylene	1100	500	630	800	870	9500	2200	2000
1,1,2,2-tetrachloroethane	130	-	70	-	-	180	-	-
Toluene	3400	1300	2000	1780	2000	12,000	4500	-
Benzene	76	180	200	480	410	3600	910	1000
Chloroform	34	-	45	73	200	21,000	5800	4200
Chloromethane	-	-	-	-	-	-	-	68

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: Some smoking occurred during all cofired testing. In test 3, smoke emissions prevalent due to surge in waste fuel flow. Higher excess air levels (15%) during tests 4 through 9.

PROCESS FLOW DIAGRAM



BOILER SITE F

Summary of Test Data for Site F

Date of Test: Summer 1983

Run No.: 4 tests. Test 1 was baseline and Tests 2, 3, and 4 were cofiring tests with spiked thinner.

Test Sponsor: EPA

Equipment information:

Type of unit: Balanced draft Babcock & Wilcox *Integral Furnace Water Tube Boiler*
Commercial __ Private X
Capacity: 60,000 lb/h @ 200 psig
Pollution control system: None

Waste feed system: Pressure-atomized oil gun

Residence time: 2.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Purge thinner with methyl esters, butyl cellosolve acetate, aromatic hydrocarbons, and aliphatic hydrocarbons. Spiked with chlorobenzene, TCE, and CCL_4.

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 216, 264, 232 gallons
Waste feed rate: 27, 33, 29 gal/h
POHC's selected and concentration in waste feed:

	Concentration, % by wt.		
Name	Test 2	Test 3	Test 4
Carbon tetrachloride	2.08	2.98	2.95
Trichloroethylene	0.78	4.86	4.92
Chlorobenzene	0.129	0.56	0.35
Toluene	1.02	1.18	0.46

Btu content: 14,359, 13,771, 13,351 Btu/lb
Ash content: 1.23, 1.07, 0.99%
Chlorine content: 1.75, 4.18, 6.40%
Moisture content: 0.44, 0.44, 0.45%

Operating Conditions:

Temperature: Not reported
Auxiliary fuel used: No. 2 and No. 6 oil, natural gas, propane

Excess air: 59, 63, 65%
Other:
Operated at 32,000 lb/h during testing; heat input = 35.5, 35.7, 32.6 x 10^6 Btu/h; boiler efficiency = 79, 78.7, 79.2%
Volumetric heat release rate = 11 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's and PIC's: VOST
HCl: EPA Modified Method 6
Particulate: EPA Modified Method 5
Other:
Heat input - 35.5, 35.7, 32.6 x 10^6 Btu/h
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results: (see comments)

POHC's:

	DRE, %		
POHC	Test 2	Test 3	Test 4
Carbon tetrachloride	99.98	99.998	99.9990
Trichloroethylene	99.98	99.994	99.998
Chlorobenzene	99.96	99.992	99.98
Toluene	99.90	99.97	99.97

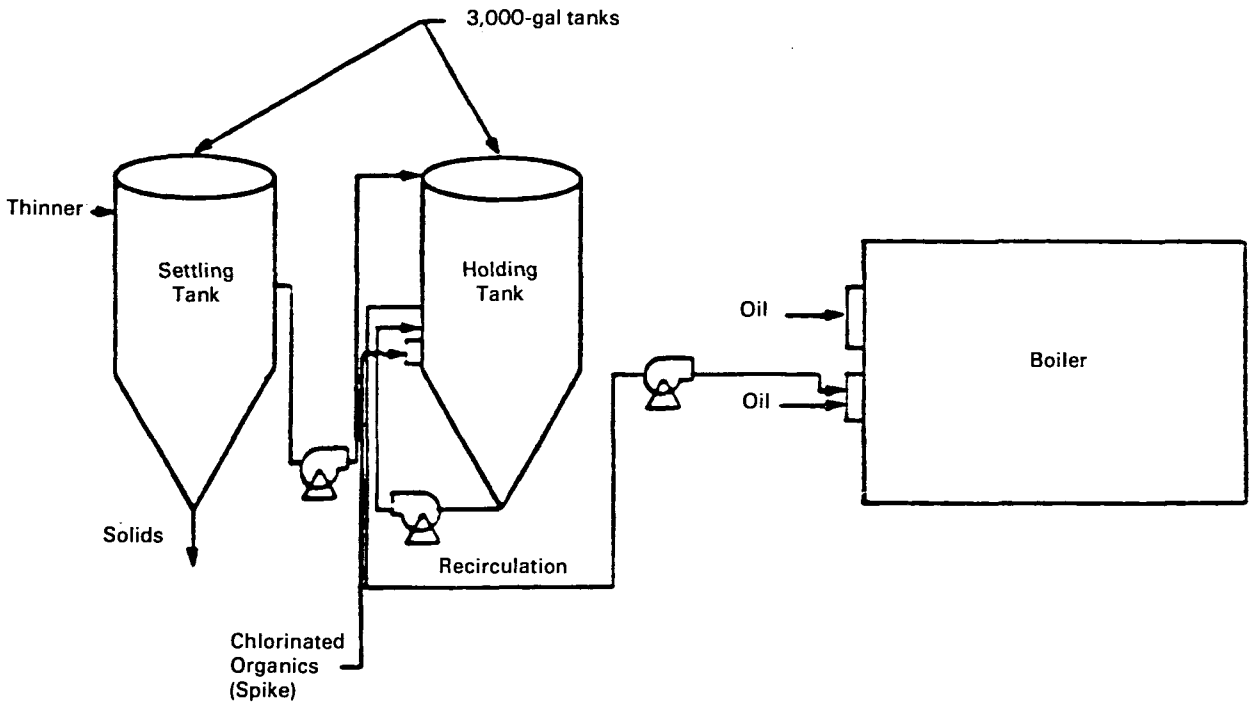
HCl: 3 @ avg. of 2.9 g/s (7.75, 21.5, 38.5 lb/h)
Particulate: 3 @ avg. of 0.41 g/s (0.0328, 0.0380, 0.0422 gr/dscf)
THC: 4, 1.48, 0.34, NA ppm
CO: 139, 109, NA ppm
Other: NO_x - 275, 299, 243 ppm
PIC's:

	Emissions µg/s		
PIC	Test 2	Test 3	Test 4
Tetrachloroethylene	3.0	5.0	1.4
Dichloromethane	580	9900	420
1,2-dichloroethane	-	-	5.9
1,2-dichloropropene	5.0	-	2.5
1,1,1-trichloroethane	110	1300	-
Benzene	1300	260	180
1,1,2,2-tetrachloroethane	22	-	-
Trans-1,3-dichloroethylene	21	1.0	-
Chloromethane	700	2000	270
Chloroform	650	9300	-
Trans-1,3-dichloropropene	-	-	31
Chloroethane	3.8	32	0.8

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: The waste fuel burner was misaligned during all tests. The boiler was shutdown after second test and the oil burner cleaned to prevent coking over of oil gun. The boiler operated at 50% of capacity during testing.

PROCESS FLOW DIAGRAM



BOILER SITE G

Summary of Test Data for Site G

Date of Test: Summer 1983

Run No.: 3 runs total. Tests 1, 2, and 3

Test Sponsor: EPA

Equipment information:

Type of unit: Johnson modified, 3-pass wet back scotch marine packaged fire-tube boiler (Thermal Heat Recovery Oxidizer or Throx)

Commercial __ Private X

Capacity: 50 x 10^6 Btu/h @ 250 psig (40,000 lb/h)

Pollution control system: 2 scrubber columns in series using caustic liquid

Waste feed system: Injected with a single-air atomized nozzle

Residence time: 0.3 to 0.5 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Mixture of chlorinated hydrocarbons containing mainly Bis (2-chloroisopropyl) ether, epichlorohydrin. Spiked with carbon tetrachloride

Length of burn: Approximately 8 h

Total amount of waste burned: Estimated 1650, 1650, 1630 gallons

Waste feed rate: 3.43, 3.43, 3.40 gal/min

POHC's selected and concentration in waste feed:

	Concentration, mg/ml		
Name	*Test 1*	*Test 2*	*Test 3*
Bis (2-Chloroisopropyl) ether	495	505	509
1-Chloro-2 propanol & t-1, 3-dichloropropylene	42.1	43.8	496
Epichlorohydrin	177	188	207
Carbon tetrachloride	44	45	47
Propionaldehyde	0.98	0.88	0.97
Cis-1-3-dichloropropylene	<1.0	<1.0	<1.0

Btu content: 9083, 8730, 9112 Btu/lb

Ash content: 0.002, 0.003, 0.004%

Chlorine content: 42.9, 45.03, 41.83%

Moisture content: 0.19, 0.019, 0.22%

Operating Conditions:

Temperature: Range 2400° to 2600°F

Auxiliary fuel used: Natural gas for startup only

Excess air: 7.9, 7.8, 9.1% oxygen in outlet (about 65% excess air)

Other:

Heat input = 17.8, 17.1, 17.9 x 10^6 Btu/h

Thermal efficiency = 81.9, 83.2, 83.1%

Volumetric heat release rate = 79 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's and PIC's:

Volatile - VOST

Semivolatile - Modified Method 5

HCl: EPA Method 6

Particulate: EPA Modified Method 5

Other:

CO-ANARAD NDIR

NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results:

POHC's:

	DRE, %		
POHC	*Test 1*	*Test 2*	*Test 3*
Carbon tetrachloride	99.990	99.9951	99.9989
Propionaldehyde[a]	99.963	>99.998	99.75
Epichlorohydrin	>99.9999	>99.9999	>99.9999
t-1,3-Dichloropropylene	>99.9999	>99.9999	>99.9999
1-Chloro-2-propanol	>99.9999	>99.9999	>99.9999
Bis (2-Chloroisopropyl) ether	>99.9999	>99.9999	>99.9999

[a]The concentration of propionaldehyde was less than 1000 ppm in the waste feed which may be related to DRE's less for this compound.

HCl: 3 @ avg. of 0.47 g/s (3.60, 3.43, 3.88 lb/h)

Particulate: 3 @ avg. of 0.4 g/s (6.91, 1.42, 1.70 lb/h)

THC: 0.7, 0.6, 0.3 ppm

CO: 170, 155, 146 ppm

Other: NO_x - 67, 67, 74 ppm

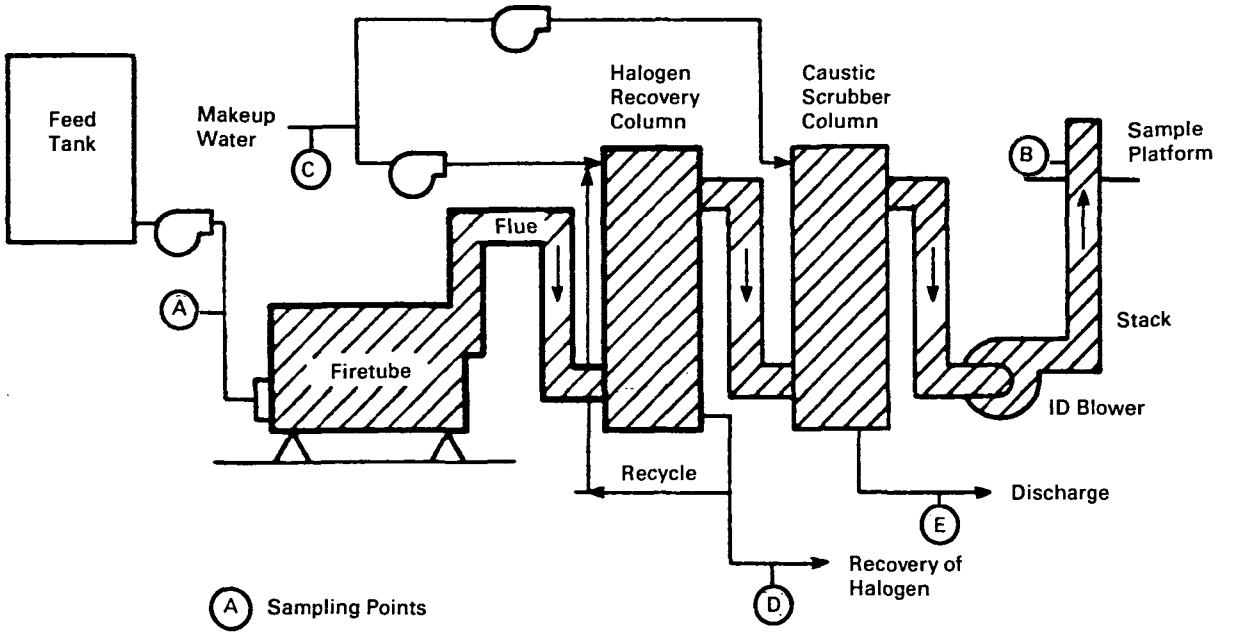
PIC's:

	Emissions, µg/s		
PIC	*Test 1*	*Test 2*	*Test 3*
Chloroform	6000	2300	280
Dichloromethane	180	250	-
Chloromethane	10	750	-
Chlorobenzene	390	140	12
1,2-dichloroethane	15	2400	100
Tetrachloroethylene	-	750	270
Dichlorobromomethane	660	170	160

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: The THROX unit operated normally during the tests.

PROCESS FLOW DIAGRAM



BOILER SITE H

Summary of Test Data for Site H

Date of Test: October 1983

Run No.: 3 runs total (Run Nos. 2, 3, 4)

Test Sponsor: EPA

Equipment information:

Type of unit: Combustion Engineering VU-40 pulverized coal-fired boiler
Commercial __ Private X
Capacity: 250,000 lb/h @ 600 psig and 740°F
Pollution control system: ESP (cold side)

Waste feed system: Injected by oil-burners

Residence time: 2.0 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Methyl acetate spiked with the POHC's listed below

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 1150, 2020, 1200 gallons
Waste feed rate: 2.4, 4.2, 2.5 gal/min
POHC's selected and concentration in waste feed:

	Concentration, % by wt.		
Name	Test 2	Test 3	Test 4
Carbon tetrachloride (CCl_4)	2.69	4.41	4.95
Chlorobenzene	2.62	3.03	4.87
1,1,1-trichloroethane	2.03	3.60	3.95

Btu content: 6630, 6565, 7171 Btu/lb
Ash content: 0.0009, 0.0018, 0.0007%
Chlorine content: 5.67, 9.65, 9.75%
Moisture content: 13.3, 5.3, 9.35%

Operating Conditions:

Temperature: Not reported
Auxiliary fuel used: Pulverized coal

Excess air: 3.5, 3.4, 3.4% oxygen in outlet
Other:
Heat input = 319, 319, 317 x 10^6 Btu/h
Boiler efficiency = 87.4, 87.4, 86.8%
Volumetric heat release rate = 17 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's and PIC's: VOST
HCl: Not reported
Particulate: Not reported
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results: (see comments)

POHC's:

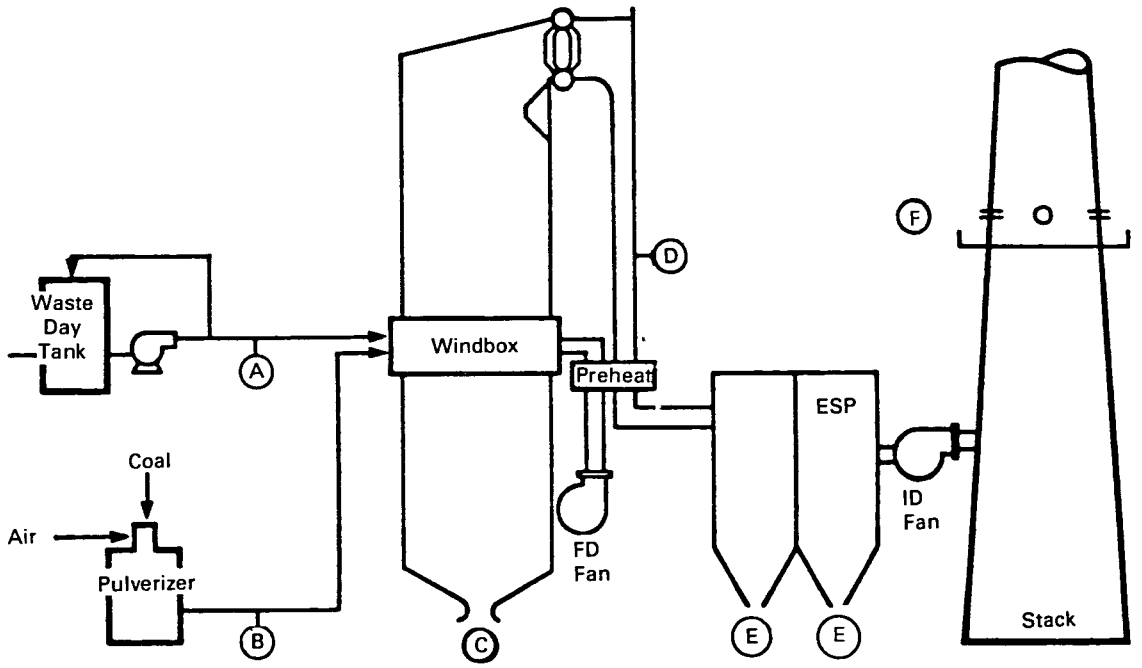
	DRE, %		
POHC	Test 2	Test 3	Test 4
CCl_4	99.9994	99.9990	99.97
1,1,1 trichloroethane	99.9996	99.9990	99.97
Chlorobenzene	99.992	99.997	99.990

HCl: Not reported
Particulate: Not reported
THC: 1.0, 0.5, <0.5 ppm
CO: 157, 144, 142 ppm
Other: NO_x - 394, 393, 427 ppm
PIC's: PIC's were measured at Plant H but not reported for each test. Total chlorinated PIC's ranged from 4,000 to 12,000 μg/s and averaged 6,900 μg/s. Approximately 92% of these PIC's was chloromethane.

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: The boiler operated normally during the tests. Boiler operating conditions during Test 4 included occasional surges in excess air levels with excess O_2 as high as 12%. Chlorobenzene was detected during baseline tests and its presence as a PIC from coal combustion may have decreased DRE's for this compound.

PROCESS FLOW DIAGRAM



(A) Sampling Point

BOILER SITE I

Summary of Test Data for Site I

Date of Test: *1983*

Run No.: 2 tests while burning wastes (2 and 4) and two baseline tests

Test Sponsor: EPA

Equipment information:

Type of unit: Foster Wheeler type AG252, forced draft, bent water-tube boiler
Commercial __ Private X
Capacity: 62,000 lb/h @ 175 psi
Pollution control system: No controls

Waste feed system: Waste fed through 2 parallel, circular burner ports. Liquid waste mixed with solvents in tank prior to firing

Residence time: 1.8 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Waste fuel gas (methane) and small amounts of organic liquid aniline waste. Liquid waste containing nitrobenzene, aniline, and benzene. Spiked with CCl_4, TCE, chlorobenzene, and toluene.

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 288, 288 gallons
Waste feed rate: 0.6, 0.6 gal/min
POHC's selected and concentration in waste feed:

	Concentration, % by wt.	
Name	*Test 2*	*Test 4*
CCl_4	1.7	1.8
TCE	1.7	1.8
Nitrobenzene	82.9	83.9
Aniline	2.6	2.1
Benzene	1.7	1.8
Toluene	3.4	3.5

Btu content: 10,620, 10,630 Btu/lb
Ash content: Not reported
Chlorine content: Not reported
Moisture content: Not reported

Operating Conditions:

Temperature: Not reported
Primary fuel used: Natural gas

Excess air: 2.6, 2.6% oxygen in outlet
Other:
Operated at: 40,000 lb/h
Heat input = 47, 46.9 x 10^6 Btu/h
Volumetric heat release rate = 33 to 34 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's: VOST
HCl: EPA Modified Method 5
Particulate: Not reported
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results: (see comments)

POHC's:

	DRE, %	
POHC	*Run 2*	*Run 4*
CCl_4	99.9993	99.9990
TCE	99.99990	99.99992
Chlorobenzene	99.997	99.9990
Toluene	99.998	99.998
Benzene	99.97	99.98

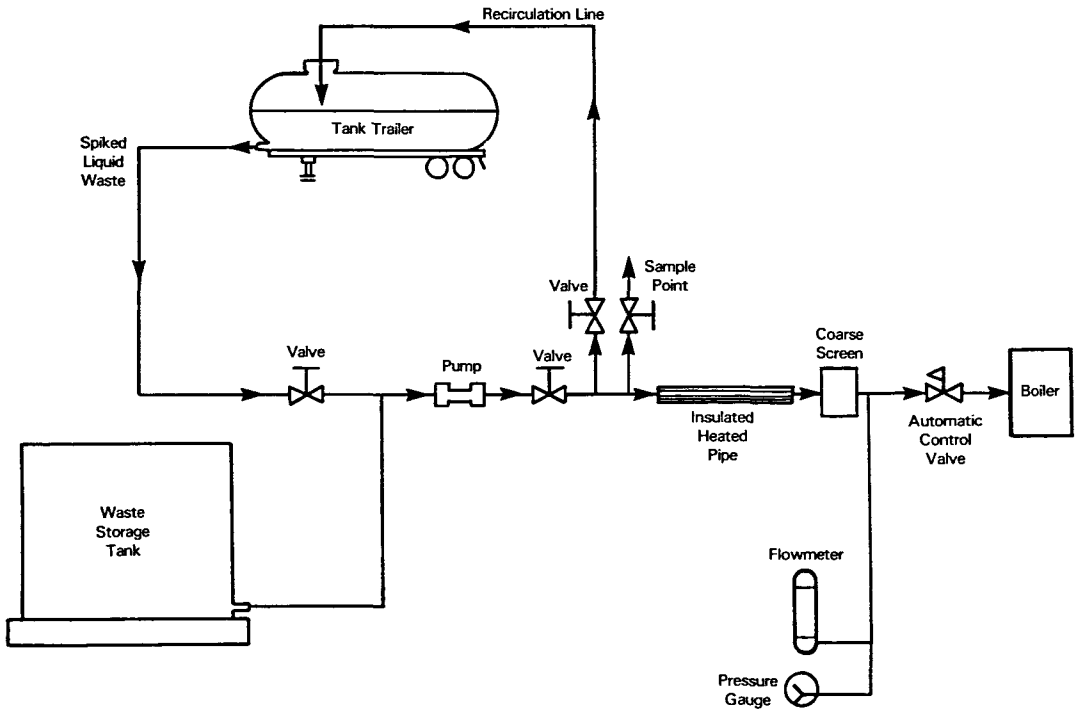
Aniline = 99.9995 (99.9994 - 99.9996%)
Nitrobenzene = 99.99996% (99.99990 - 99.99998%)

HCl: 2.5 g/s avg. (2.3 - 2.9 g/s)
Particulate:
THC: 6.3, 5.2 ppm
CO: 175, 63 ppm
Other: NO_x - 410, 1125 ppm
PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: Test 4 used unstaged combustion (equal amounts of combustion air through top and bottom burners) and Test 2 used staged combustion [more combustion air (65%) through upper burner than lower burners (35%)]. Staged combustion reduced NO_x emissions but increased CO emissions. The boiler operated normally during the tests.

PROCESS FLOW DIAGRAM



BOILER SITE J

Summary of Test Data for Site J

Date of Test: 1983

Run No.: 6 tests total (Test Nos. 1, 2, 3, 4, 5, 6)

Test Sponsor: EPA

Equipment information:

Type of unit: North American Model 3200X, three-pass firetube packaged boiler
Commercial __ Private X
Capacity: 8.4 x 10^6 Btu/h @ 150 psig (200 HP)
Pollution control system: None

Waste feed system: Waste fuels added to tank; pump moves waste to air-atomized compressor that forces waste through nozzles. Storage tank is agitated

Residence time: 0.58, 0.32, 0.55, 0.32, 0.67, 0.32 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: 2 blends:
#1 - 0.5% carbon tetrachloride (CCl_4), 1.0% trichloroethylene (TCE) and 0.5% chlorobenzene in toluene (98%)
#2 - the same except TCE was 2% and toluene was reduced to 97%

Length of burn: Approximately 8 h
Total amount of waste burned: Estimated 254, 498, 274, 435, 202, 515 gallons
Waste feed rate:
#1 blend = 31.7, 62.2, 54.4 and 25.2 gal/h for Runs 1, 2, 4, and 5 respectively
#2 blend = 34.2 and 64.4 gal/h for Runs 3 and 6 respectively
POHC's selected and concentration in waste feed:

	Concentration, % by wt.					
Name	*Test 1*	*Test 2*	*Test 3*	*Test 4*	*Test 5*	*Test 6*
Toluene	97.88	97.91	97.01	97.99	97.94	96.97
Carbon tetrachloride (CCl_4)	0.53	0.52	0.48	0.50	0.5	0.50
TCE	1.07	1.05	2.00	1.01	1.01	1.99
Chlorobenzene	0.52	0.52	0.51	0.50	0.55	0.54

Btu content: 17,960; 17,970; 17,950; 17,940; 17,780; 17,770 Btu/lb
Ash content: Not reported
Chlorine content: 1.52, 1.49, 2.60, 1.45, 2.22, 2.24%
Moisture content: Not reported

Operating Conditions:

Temperature: Range 2400° to 2500°F
Primary fuel used: None

Excess air: 37.0, 21.8, 33.9, 40.2, 52.9, 16.9%
Other:
Heat input = 4.3, 8.3, 4.6, 7.3, 3.4, 8.7 x 10^6 Btu/h
Volumetric heat release rate = 66.5 to 170 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's: VOST
HCl: Modified Method 6
Particulate: Not reported
Other:
CO-ANARAD NDIR
NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results: (see comments)
POHC's:

POHC	DRE, %					
	Test 1	*Test 2*	*Test 3*	*Test 4*	*Test 5*	*Test 6*
CCl_4	99.997	99.9990	99.9990	99.9998	99.9992	99.9991
TCE	99.9998	99.9998	99.998	99.99990	99.9990	99.99993
Chlorobenzene	99.95	99.94	99.97	99.8	99.97	99.97
Toluene	99.9997	99.9990	99.9992	99.9996	99.9993	99.9991

HCl: 0.51 g/s avg.
Particulate: Not reported
THC: 2 ppm, NA for the remaining runs
CO: 129, 135, 12, 108, 120, 20 ppm (corrected to 3% O_2, dry basis)
Other: NO_x - 203, 87, 185, 92, 175, 85 ppm (corrected to 3% O_2, dry basis)
PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: Fuel Blend No. 1 was used for Runs 1, 2, 4, and 5 while fuel Blend No. 2 was used for Runs 3 and 6. The boiler was run at half load during tests 1, 3, and 5 and a full load for Tests 2, 4, and 6. High excess air was used during tests 4 and 5.

Process Flow Diagram: No Diagram Available

Summary of Test Data for Site K

Date of Test: 1983

Run No.: 1 test on heavy oil and 1 test on light oil

Test Sponsor: EPA

Equipment information:

Type of unit: Combustion Engineering VU-10 balanced draft water tube boiler with a Peabody AT burner

Commercial __ Private X

Capacity: 75 x 10^6 Btu/h @ 60,000 lb/h @ 353°F and 125 psi

Pollution control system: No controls

Waste feed system: 4 burners: 2 for heavy oil which were steam atomized; 2 for light oil which were air atomized

Residence time: 1.8 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Light and heavy oil mixtures spiked with carbon tetrachloride (CCl_4), trichloroethylene, and chlorobenzene

Length of burn: Approximately 8 h

Total amount of waste burned: Estimated 1710, 1920 gallons

Waste feed rate: 214 gal/h, 240 gal/h

POHC's selected and concentration in waste feed:

	Concentration, % by wt.	
Name	*Heavy oil*	*Light oil*
CCl_4	0	1.0
Trichloroethylene	0	0.8
Chlorobenzene	0	0.9
Toluene	2.8	1.2
Benzene	0.2	0.1
m&p-Xylene	4.6	4.0
O-Xylene	0.7	0.6
Phenol	0	23

Btu content: 18,360, 17,100 Btu/lb

Ash content: 0.08, 0.06%

Chlorine content: 0.37, 1.79%

Moisture content: Not reported

Operating Conditions:

Temperature: Not reported

Primary fuel used: No. 6 fuel oil

Excess air: 3.8 and 4.0% oxygen in outlet

Other:

Heat input = 59.2 x 10^6 Btu/h

Volumetric heat release rate = 26 x 10^3 Btu/ft^3-h

Monitoring Methods:

POHC's:

Volatile - VOST

Semivolatile - Modified Method 5

HCl: Modified Method 6

Particulate: Not reported

Other:

CO-ANARAD NDIR

NO_x-Thermo Electron Chemiluminescence

Emission and DRE Results:

POHC's:

	DRE, %	
POHC	*Heavy oil*	*Light oil*
Volatiles		
CCL_4	NA	99.999
Trichloroethylene	NA	99.999
Chlorobenzene	NA	99.999
Toluene	99.985	99.999
Benzene	NA	99.977
Semivolatiles		
m and p-xylene	99.768	99.947
o-xylene	99.643	99.958
Phenol	NA	99.999

HCl: 2.6 g/s avg.

Particulate:

THC:

CO: 114 ppm

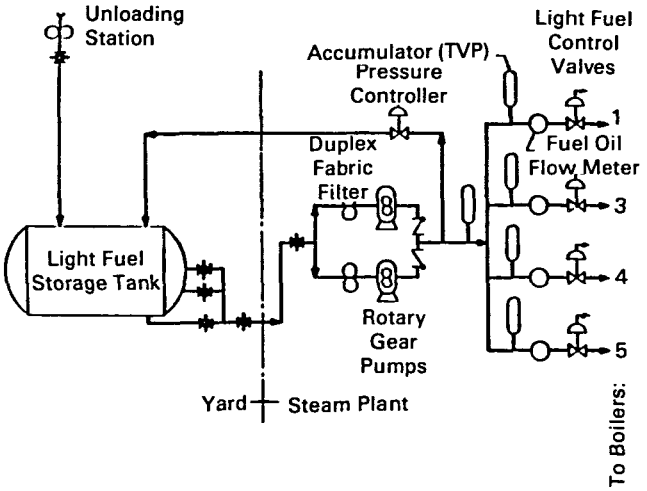
Other: NO_x - 154 ppm

PIC's: Not reported

Reference(s): Castaldini, C., et. al. Engineering Assessment Report - Hazardous Waste Cofiring in Industrial Boilers - Volumes I and II. Prepared by Acurex Corporation, Mountain View, California under Contract No. 68-02-3188, June 1984.

Comments: The boiler was operated normally but O_2 content was maintained as close as possible to the minimum value.

PROCESS FLOW DIAGRAM



Appendix D

KILN TEST SUMMARIES

Summary of Test Data for Florida Solite Corporation
Green Cove Springs, Florida

Date of Test: February 1983

Run No.: 1, 2, 3, 4, 5

Test Sponsor: EPA

Equipment information:

Type of unit: Aggregate kiln
Commercial __ Private X
Capacity: 60,000 tons/yr for 3 kilns
Pollution control system: Cyclone and horizontal cross-flow water scrubber

Waste feed system: Wastes blended from 10,000- to 20,000-gallon storage tank and stored in 20,000-gallon tank for testing; (normally stored in 300,000-gallon tank); fed to kiln through a burner separate from coal fuel

Residence time: Greater than 1.5 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Solvents, alcohols, ethers, still bottoms, chlorinated hydrocarbons

Length of burn: Five full test days
Total amount of waste burned: Not reported. The feed rate, however, is based on tank depth measurements at the beginning and end of each test day.
Waste feed rate: 274, 350, 224, 173, 218 gal/h
POHC's selected and concentration in waste feed:

	Concentration, %				
Name	*Test 1*	*Test 2*	*Test 3*	*Test 4*	*Test 5*
MEK	1.99	1.78	1.83	2.81	4.25
Methyl isobutyl ketone (MIBK)	1.53	1.70	1.41	1.12	3.90
Tetrachloroethylene	0.187	0.194	0.173	0.059	0.031
Toluene	8.38	9.27	8.21	7.99	7.54

Btu content: 12,550, 11,450, 12,740, 9,530, 12,670 Btu/lb
Ash content: 7.74, 7.28, 7.47, 15.5, 6.18%
Chlorine content: 1.08, 1.08, 1.04, 0.55, 0.55%
Moisture content: Not reported

Operating Conditions:

Temperature: Range Solids temperature of 2000° - 2100°F
Primary fuel used: Coal

Excess air: Not reported

Monitoring Methods:

POHC's: VOST
HCl: Impinger absorption in 0.5 m NaOAc (back half of EPA Method 5) and specific ion electrode analysis
Particulate: EPA Method 5

FLORIDA SOLITE

Emission and DRE Results: (see comments)
POHC's:

	DRE, %				
POHC	*Test 1*	*Test 2*	*Test 3*	*Test 4*	*Test 5*
MEK	VOID	99.999	99.992	99.999	99.999
MIBK	VOID	99.999	99.999	99.995	99.999
Tetrachloroethylene	VOID	99.999	99.999	99.997	99.995
Toluene	VOID	99.999	99.999	99.998	99.999

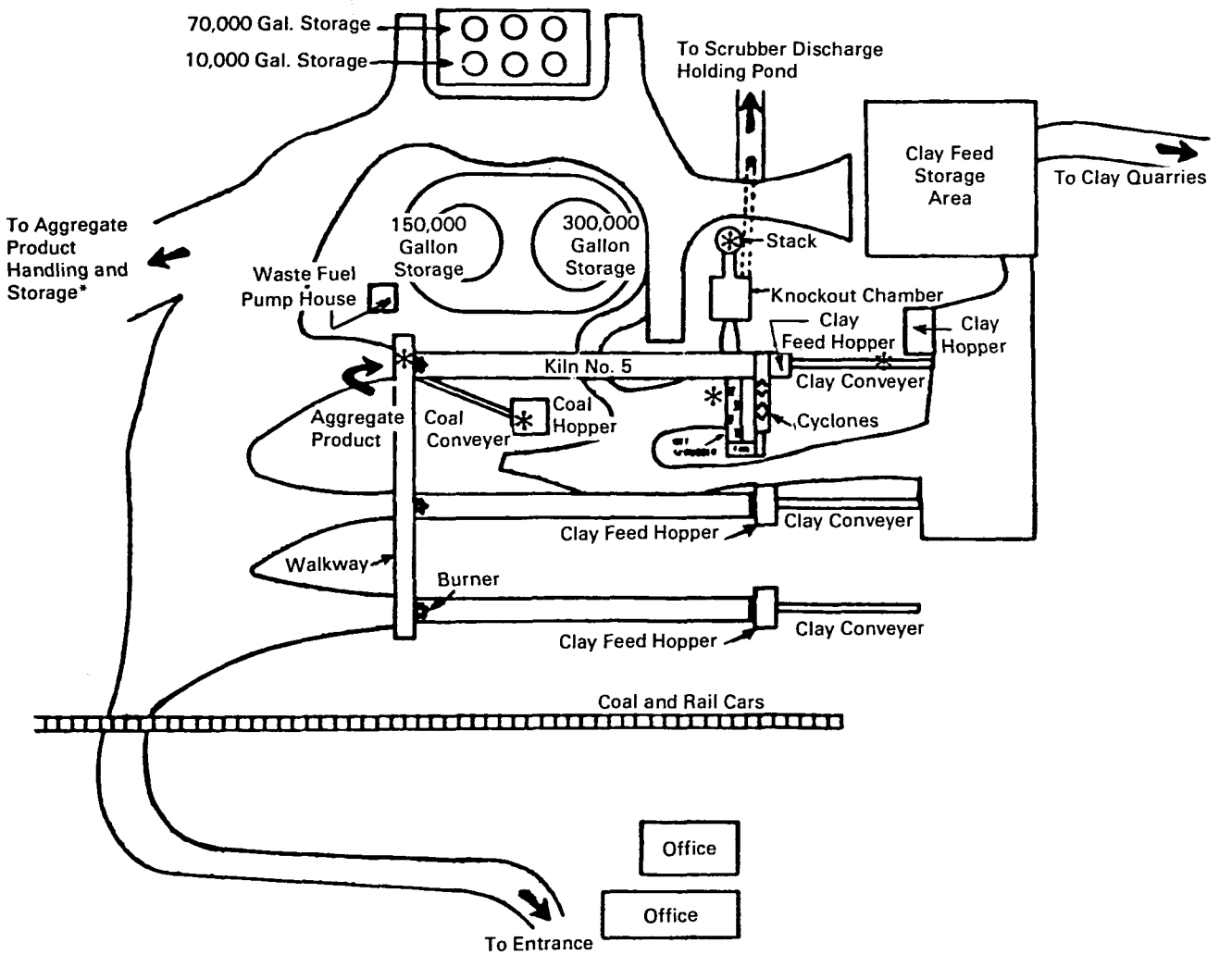
HCl: 0.45, NA, 0.15, 0.68, 0.68 ppm
Particulate: 0.071, NA, 0.102, 0.119, 0.0119, gr/scf
THC: Not reported
CO: Not reported
Other: SO_2 - 269.6, 1474, NA, 1192, 1439 ppm
PIC's: Not reported

Reference(s): Day, D. R. and L. A. Cox. Evaluation of Hazardous Waste Incineration in an Aggregate Kiln: Florida Solite Corporation. Prepared for U.S. Environmental Protection Agency by Monsanto Research Corporation under Contract No. 68-03-3025. 1984.

Comments: The kiln apparently operated normally during the test. The POHC results for Test 1 were voided in the field or during analysis. The trace metals of highest concentration on the particulates were sodium, lead, aluminum, iron, calcium, magnesium, and zinc.

PROCESS FLOW DIAGRAM

Florida Solite Site layout and sample locations (shown by asterisks).



GENERAL PORTLAND (CALIFORNIA)

Summary of Test Data for General Portland Cement
Los Robles, California

Date of Test: *1982*

Run No.: Complete test report not released by EPA Region IX

Test Sponsor: Private

Equipment information:
Type of unit: Dry cement kiln
Commercial __ Private X
Capacity: 1,750 ton/day
Pollution control system: Fabric filter

Waste feed system: Concentric burner firing. The hot coal and primary air are fed to the kiln through a burner pipe which contains a smaller waste fuel burner pipe down its center.

Residence time: Not reported

Test Conditions:
Waste feed data:
Type of waste(s) burned: Liquid waste containing POHC's listed below

Length of burn: Not reported
Total amount of waste burned: Not reported
Waste feed rate: Not reported
POHC's selected and concentration in waste feed:

Name	*Concentration*
Dichloromethane	Not reported
1,1,1-Trichloroethane	
1,3,5-Trimethylbenzene	
Xylene	

Btu content: Not reported
Ash content: Not reported
Chlorine content: Not reported
Moisture content: Not reported

Operating Conditions:
Temperature: Range not reported
Average: Not reported
Primary fuel used: Coal is primary fuel

Excess air: 0.5 to 1.3% O_2

Monitoring Methods: Not reported
POHC's:
HCl:
Particulate:

Emission and DRE Results: (see comments)
POHC's:

POHC	*DRE, %*	
Dichloromethane	>99.99	
1,1,1-Trichloroethane	99.99	
1,3,5-Trimethylbenzene	>99.95	(Not detectable in exhaust. DRE based on detection limit)
Xylene	>99.99	

HCl: 1.03 lb/h (over 99 percent removal)
Particulate: Not reported
THC: Not reported
CO: 25 to 100 ppm
Other: SO_2 - 27 ppm NO_x - 486 ppm
PIC's: During baseline tests (coal only) there were detectable quantities of benzene (120-530 ppb) and toluene (20-70 ppb) and trace quantities of trichloroethane and methylene chloride

Reference(s): Original test report not released by U.S. EPA Region IX

Branscome, M. et. al. Summary Report on Hazardous Waste Combustion in Calcining Kilns. Prepared for U.S. Environmental Protection Agency by Research Triangle Institute and Engineering Science Under Contract No. 68-02-3149. 1984.

Comments: No corrections were made for baseline levels or for the contribution from ambient air. The kiln apparently operated normally during the tests.

Process Flow Diagram: Not Available

Summary of Test Data for General Portland, Inc.
Paulding, Ohio

Date of Test: October 1983

Run No.: Tests 5, 6, 7, 8, 9 (Tests 1-4 were baseline)

Test Sponsor: EPA

Equipment information:

Type of unit: Wet process cement kiln
Commercial __ Private X
Capacity: 230,000 tons/yr for each kiln
Pollution control system: ESP and multicyclones

Waste feed system: Concentric burner firing. The hot coal and primary air are fed to the kiln through a burner pipe which contains a smaller waste fuel burner pipe down its center.

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Solvents, organic components, resins, paint wastes

Length of burn: Nine days of testing. Concurrent testing included POHCs (40 min/test), particulate (4 to 6 h/test), and combustion gases (4 to 7 h/day)
Total amount of waste burned: Not reported
Waste feed rate: 929 gal/h (59% waste fuel), 824 gal/h (43% waste), 1050 gal/h (61% waste), 538 gal/h (39% waste), 883 gal/h (58% waste)
POHC's selected and concentration in waste feed:

	Concentration, %				
Name	*Test 5*	*Test 6*	*Test 7*	*Test 8*	*Test 9*
Dichloromethane (CH_2Cl_2)	1.06	0.056	0.34	1.64	2.4
MEK	0.86	0.31	0.68	0.76	1.57
1,1,1-Trichloroethane	0.06	0.1	0.99	0.8	1.17
Toluene	1.3	0.64	1.87	1.66	3.6
Freon 113	0.013	0.002	0.12	0.81	1.32

Btu content: 12,500; 10,700; 13,700; 12,500; 12,500 Btu/lb
Ash content: 3.4, 5.3, 4.3, 3.0, 3.5, 3.5%
Chlorine content: 0.90, 0.59, 0.99, 3.58, 3.91%
Moisture content: Not reported

Operating Conditions:

Temperature: Range 2500° - 2600°F
Average: Not reported
Primary fuel used: Coal

Excess air: Not reported

Monitoring Methods:

POHC's: VOST
HCl: Impinger absorption with specific ion electrode analysis
Particulate: EPA Modified Method 5 (also used for collection of metals and PIC's)
Other: CO_2, NO_x, SO_2, CO, O_2, and total hydrocarbons were continuously monitored

GENERAL PORTLAND (OHIO)

Emission and DRE Results: (see comments)
POHC's:

POHC	DRE, %				
	Test 5	*Test 6*	*Test 7*	*Test 8*	*Test 9*
CH_2Cl_2	99.998	99.995	99.956	99.975	99.993
MEK	99.991	99.978	99.990	99.983	99.997
1,1,1-Trichloroethane	99.991	99.991	99.996	99.996	99.999
Toluene	99.952	99.940	99.974	99.951	99.988
Freon 113	>99.983	>99.840	>99.998	>99.999	>99.999

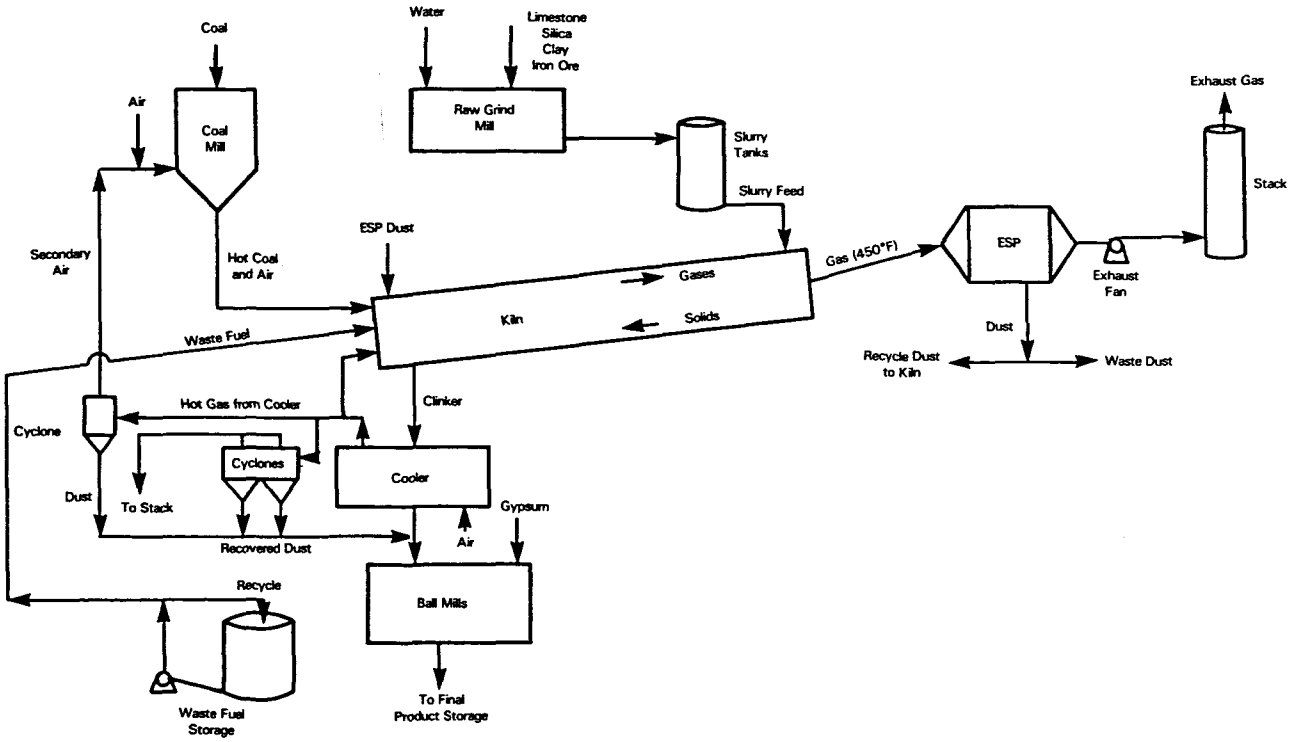
HCl:<8.7, 11.2, 12.9, 14.9, 43.6 ppm
Particulate: 0.0233, 0.034, 0.0274, 0.0254, 0.041 gr/dscf
THC: 28.1, 17.5, 24.5, 18.8, 15.9 ppm
CO: 130, 153, 337, 178, 152 ppm
Other: SO_2 - 105, 189, 274, 370, 388 ppm
PIC's: POHC were found in baseline analysis (i.e., MEK, toluene, and CH_2Cl_2). No difference in detected PIC formation between waste fuel and baseline

Reference(s): Research Triangle Institute and Engineering Science (RTI and ES). Evaluation of Waste Combustion in Cement Kilns at General Portland, Inc., Paulding, Ohio. Prepared for U.S. Environmental Protection Agency under Contract No. 68-02-3149, March 1984.

Branscome, M. Summary Report on Hazardous Waste Combustion in Calcining Kilns. Prepared for U.S. Environmental Protection Agency, Cincinnati, OH, by Research Triangle Institute. 1985.

Comments: No statistical difference in average POHC emission rate for the baseline (coal) and waste fuel burns. No difference in TSP emissions. Highest NO_x emissions occurred during highest DRE. No adjustments were made in the DRE calculations to account for POHC emissions during baseline tests. Note low waste concentration of Freon 113. DRE's are based on detection limit for Freon 113. The kiln apparently operated normally during the tests.

PROCESS FLOW DIAGRAM



Summary of Test Data for Lone Star Industries
Oglesby, Illinois

Date of Test: ***December 1983***

Run No.: 3, 4, 5 (Tests 1 and 2 were baseline with coal/coke firing only)

Test Sponsor: EPA

Equipment information:

Type of unit: Dry process cement kiln
Commercial __ Private X
Capacity: 1450 tons per day of clinker
Pollution control system: ESP (malfunctioning) and cyclone

Waste feed system: Burner nozzle installed under the main coal/coke burner. Low-pressure air injected around waste fuel line in a concentric pipe to provide protective cooling

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Solvents, organic compounds, resins, paint waste solids

Length of burn: Each test was run over a 6-hour period each day.
Total amount of waste burned: Not reported
Waste feed rate: 2.34, 3.28, 4.00 Mg/h
POHC's selected and concentration in waste feed:

	Concentration, %		
Name	*Test 3*	*Test 4*	*Test 5*
Freon 113	0.86	0.654	NA
Toluene	2.25	4.25	NA
MEK	0.926	2.19	NA
1,1,1-Trichloroethane	0.998	1.45	NA
Dichloromethane (CH_2Cl_2)	0.385	0.393	NA

Btu content: 12,470, 12,310, 12,170 Btu/lb
Ash content: 3.94, 4.27, 4.81%
Chlorine content: 2.15, 1.93, 1.64%
Moisture content: Not reported

Operating Conditions:

Temperature: Range 2500° - 2600°F avg. kiln operating temperature
Average: Not reported
Primary fuel used: Coal/coke

Excess air: Not reported

Monitoring Methods:

POHC's: VOST
HCl: Impinger absorption and ion chromatography (IC) analysis
Particulate: Method 5
Other: CO - HORIBA, NDIR

Emission and DRE Results: (see comments)

POHC's:

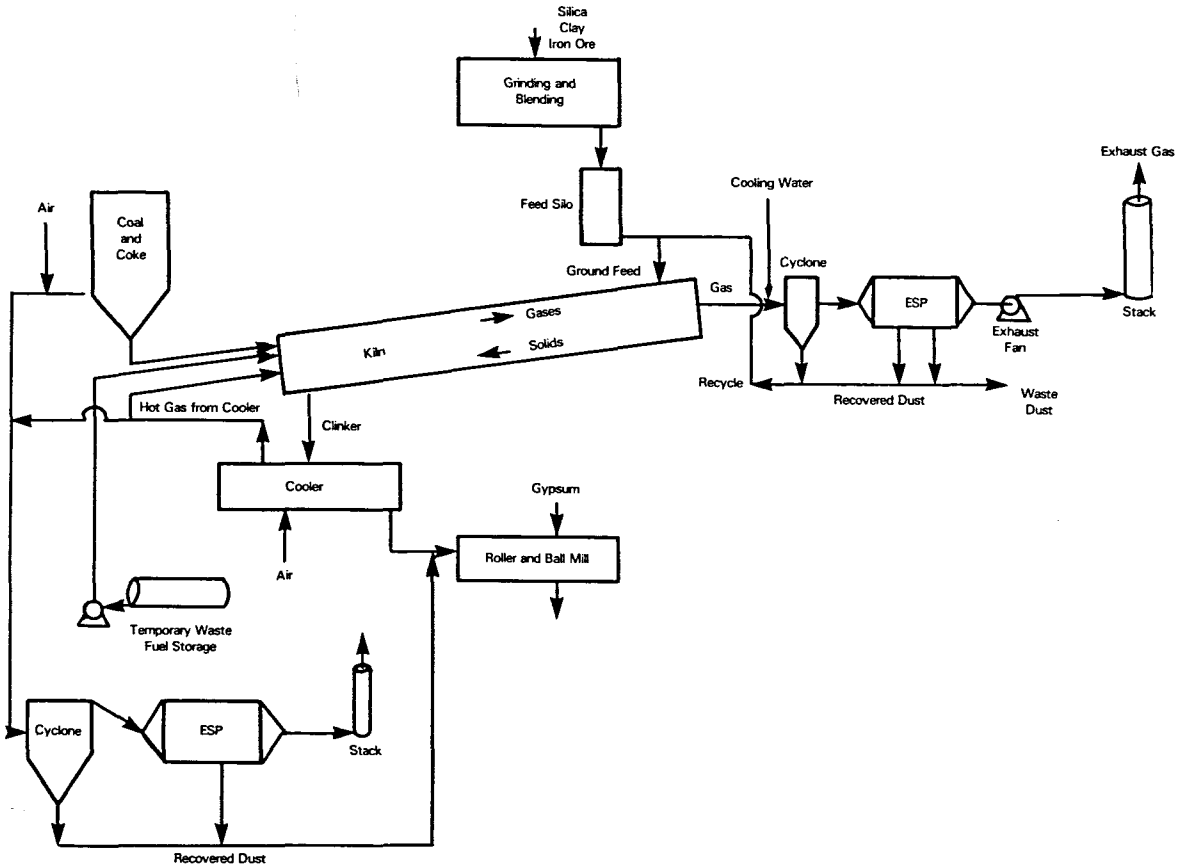
	DRE, %		
POHC	*Test 3*	*Test 4*	*Test 5*
Freon	99.999	99.999	Calculations
Toluene	99.992	99.998	not performed
MEK	99.998	99.999	- excessive
1,1,1 Trichloroethane	99.999	>99.999	sample
CH_2Cl_2	99.94	99.99	storage time

HCl: 4.85, 12.04, 58.86 ppm
Particulate: 768, 320, 502 lb/h
THC: 9.2, 4.8, 1.0 ppm
CO: 43, 49, 24 ppm
Other: SO_2 - 38, 13, 5 ppm
PIC's: Increases over baseline levels for several organic compounds (i.e., biphenyl, benzaldehyde, naphthalenes, and methyl naphthalenes)

Reference(s): Branscome, M., et. al. 1984. Evaluation of Waste Combustion in Dry-Process Cement Kiln at Lone Star Industries, Oglesby, Illinois. Prepared for U.S. Environmental Protection Agency by Research Triangle Institute and Engineering Science under Contract No. 68-02-3149.

Comments: Dibenzodioxins and dibenzofurans were not found in the stack gas at a detection limit of less than 1 ppb (by weight). Waste fuel replaced 25 percent of the primary fuel in Test 3, 37 percent in Test 4, and 42 percent in Test 5. Apparently the kiln operated normally during the tests.

PROCESS FLOW DIAGRAM



MARQUETTE CEMENT

Summary of Test Data for Marquette Cement
Oglesby, Illinois

Date of Test: October 1981

Run No.: 1, 2, 3

Test Sponsor: Private

Equipment information:

Type of unit: Dry process cement kiln
Commercial ___ Private X
Capacity: 450,000 tons/yr
Pollution control system: Cyclone and ESP

Waste feed system: Liquid waste pumped from storage tanker into the flame of the kiln through a specially designed delivery nozzle

Residence time: Less than 10 s

Test Conditions:

Waste feed data:

Type of waste(s) burned: Waste solvents from ink and paint manufacturing

Length of burn: 2 hours per test
Total amount of waste burned: Not reported
Waste feed rate: 12.8 percent of heat input
POHC's selected and concentration in waste feed:

	Concentration, %		
Name	*Test 1*	*Test 2*	*Test 3*
Dichloromethane	2.72	2.94	6.27
2-Butanone (MEK)	7.51	8.90	8.18
Trichloroethane	1.86	1.63	1.97
Toluene	11.79	8.54	11.84

Btu content: 12,210, 13,012, 11,823 Btu/lb
Ash content: 12.1, 7.8, 6.8 wt. %
Chlorine content: 1.75, 2.10, 1.78 wt. %
Moisture content: 10.7, 10.3, 11.8 wt. %

Operating Conditions:

Temperature: Range 2700° - 3000°F
Average: Not reported
Primary fuel used: Coal

Excess air: Not reported

Monitoring Methods:

POHC's: Integrated bag samples analyzed by FID (EPA Method 23)
HCl: Midget impinger train containing sodium hydroxide and analysis by mercuric nitrate titration
Particulate: EPA Method 5
Other: Total gaseous nonmethane organics (TGNMO) by EPA Method 25

Emission and DRE Results: (see comments)

POHC's:

	DRE, %		
POHC	*Test 1*	*Test 2*	*Test 3*
Dichloromethane	99.869	99.851	99.917
MEK	99.960	99.959	99.961
1,1,1-Trichloroethane	99.718	99.604	99.710
Toluene	99.968	99.947	99.968

HCl: 405, 232, 289 ppm
Particulate: 0.125, 0.101, 0.086 gr/scf
THC: 220, 800, and 390 ppm (total gaseous non-methane organics)
CO: Not reported
Other: SO_2 - 41, 8, 5 ppm
PIC's: Not measured

Reference(s):

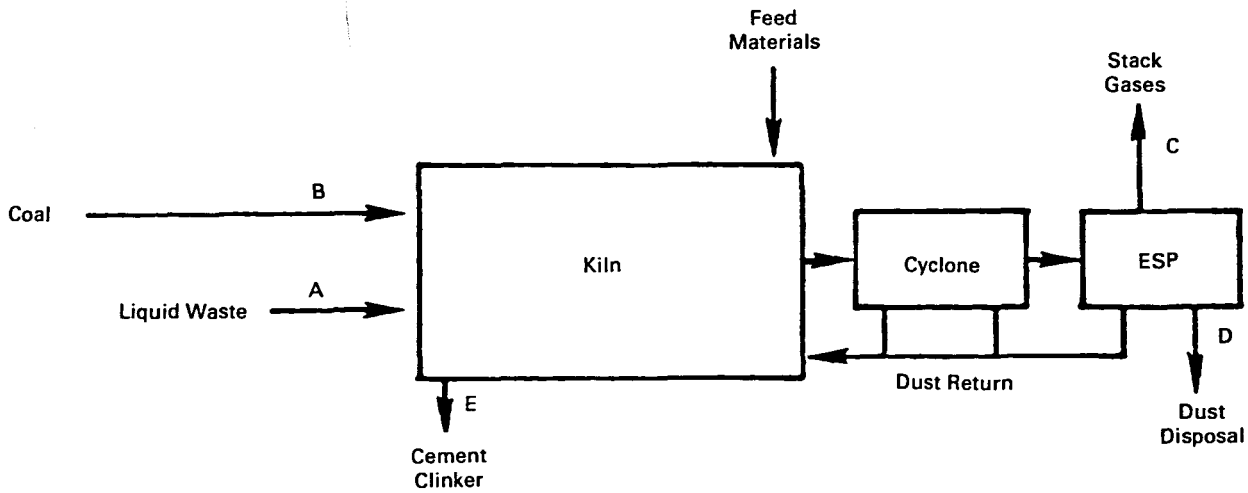
Higgins, G. M., and A. J. Helmstetter. Evaluation of Hazardous Waste Incineration in a Dry Process Cement Kiln. In: Incineration and Treatment of Hazardous Waste: Proceedings of the Eighth Annual Research Symposium, March 1982. EPA-600-9-83-003. 1983.

Branscome, M. Summary Report on Hazardous Waste Combustion in Calcining Kilns. Prepared for U.S. Environmental Protection Agency, Cincinnati, OH, by Research Triangle Institute. 1985.

Comments: None of the POHC's were detected in either baseline or waste feed tests. The DRE's are based on detection limits, therefore, the DRE values presented are minimum DRE's. TSP, HC, SO_2, NO_x, and HCl did not significantly increase from baseline tests. Slight increase in lead in the particulate. There were several periods of downtime during the tests.

PROCESS FLOW DIAGRAM

Marquette-Oglesby cement kiln schematic.



Summary of Test Data for Rockwell Lime
Rockwood, Wisconsin

Date of Test: April-May 1983

Run No.: 4, 5A, 6A, 7A, 8

Test Sponsor: EPA

Equipment information:
Type of unit: Lime kiln
Commercial __ Private X
Capacity: 8.5 tons/hour
Pollution control system: Baghouse

Waste feed system: Temporary 1-inch-diameter stainless steel pipe placed on the burner pipe and nozzle pointing into flame.

Residence time: Not reported

Test Conditions:
Waste feed data:
Type of waste(s) burned: Lacquer thinners, alcohols, still bottoms, paint wastes, chlorinated hydrocarbons

Length of burn: Five test days, 10 hours/day
Total amount of waste burned: 734, 581, 984, 1877, 1382 gal/day
Waste feed rate: Estimated 73.4, 58.1, 98.4, 188, 138 gal/h
POHC's selected and concentration in waste feed:

	Concentration, %				
Name	*Test 4*	*Test 5A*	*Test 6A*	*Test 7A*	*Test 8*
Dichloromethane (CH_2Cl_2)	0.20	0.10	0.11	0.24	0.12
MEK	5.0	2.75	2.48	6.34	2.59
1,1,1-Trichloroethane (CH_3CCl_3)	0.47	0.24	0.23	0.43	0.28
Trichloroethylene (TCE)	3.46	1.64	1.78	4.32	1.89
Tetrachloroethylene	4.34	2.02	2.05	4.98	2.56
Toluene	21.94	10.55	10.95	25.0	12.90

Btu content: 12,300; 12,084; 12,267; 13,612; 14,064 Btu/lb
Ash content: Not reported
Chlorine content: 3, 2.66, 3.04, 3.05, 3.51%
Moisture content: Not reported

Operating Conditions:
Temperature: Range not reported
Average: 2000°F process temperature
Primary fuel used: Petroleum coke and natural gas mixture

Excess air: "As low as possible" 1.8 to 10% (5.6% avg.) oxygen in outlet

Monitoring Methods:
POHC's: VOST
HCl: Impinger absorption in 0.5 m NaOAc (back half of EPA Method 5) and specific ion electrode analysis
Particulate: EPA Method 5
Other: CO - Beckman, NDIR, Spectro

Emission and DRE Results: (see comments)
POHC's:

POHC	DRE, %				
	Run 4	*Run 5A*	*Run 6A*	*Run 7A*	*Run 8*
CH_2Cl_2	99.9947	99.9947	99.9994	99.9985	99.9995
MEK	99.9994	99.9996	99.9997	99.9992	99.9997
CH_3CCl_3	99.9955	99.9982	99.9975	99.9962	99.9969
TCE	99.9998	99.9997	99.9998	99.9999	99.9998
Tetrachloroethylene	99.9998	99.9999	99.9999	99.9997	99.9997
Toluene	99.9998	99.9998	99.9998	99.9995	99.9997

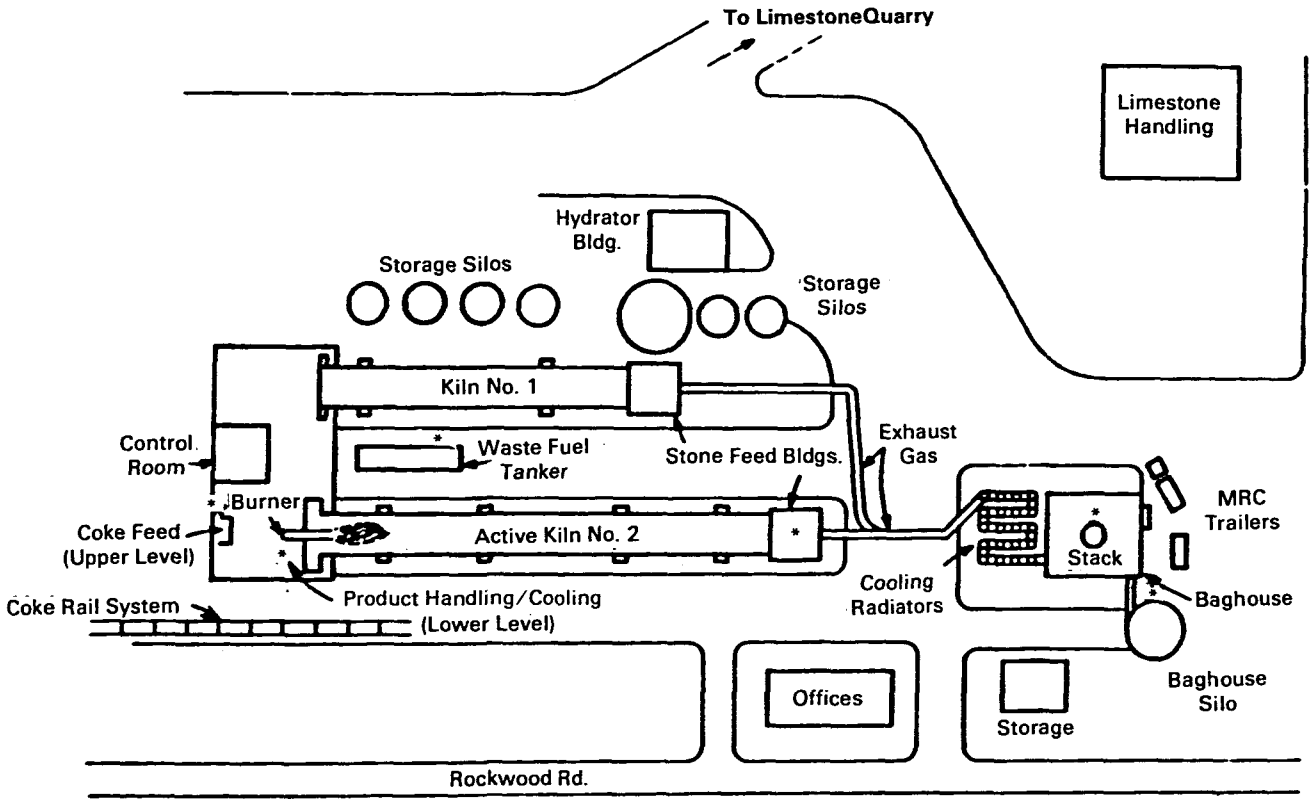
HCl: 2.54, 4.04, 4.79, 2.98, 4.73 ppm
Particulate: 0.012, 0.011, 0.016, 0.016, 0.021 gr/scf
THC: 3.9, 3.0, 3.5, 3.8, 3.6 ppm
CO: 32, 224, 557, 1060, 1357 ppm
Other: SO_2 - 492, 540, 637, 650, 672 ppm
PIC's: The 4 runs had DRE's less than 99.99%, which was suspected to have been caused by PIC's; 3 were CH_2Cl_2, the other was CH_3CCl_3. CH_2Cl_2 may have contaminated the lab. CH_3CCl_3 was in extremely low concentration.

Reference(s): Day, D. R., and L. A. Cox. Evaluation of Hazardous Waste Incineration in a Lime Kiln: Rockwell Lime Company. Prepared for U.S. Environmental Protection Agency by Monsanto Research Corporation under Contract No. 68-03-3025. June 1984.

Comments: CO emission fluctuated widely each day indicating incomplete combustion or kiln upset conditions at CO peaks. The temporary burner setup did not allow optimum mixing of coke and waste fuel. On a few occasions, lime product quality problems were encountered.

PROCESS FLOW DIAGRAM

Plan view of Rockwell Lime site in Rockwood, Wisconsin (not to scale). Sample locations shown by asterisk.



Summary of Test Data for San Juan Cement Company
Doradado, Puerto Rico

Date of Test: November 1981 to February 1982

Run No.: W1-1, W1-2, W2-1, W3-1, W3-2, W3-3 (Data for the following runs are presented on subsequent forms: W4-1, W4-2, W4-3, W4-4, W5-1, W5-2, W6-1, W4/6-1, W4/6-2, W4/6-3, W4/6-4, W4/6-5)

Test Sponsor: EPA

Equipment information:

Type of unit: Wet process cement kiln
Commercial __ Private X
Capacity: 450,000 tons/yr for 3 kilns
Pollution control system: Fabric filter

Waste feed system: Concentric burner nozzle. Waste fuel gun runs parallel to the fuel oil gun but slightly off the centerline where the fuel oil gun is located.

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Reclaimed solvents and degreasers

Length of burn:
Total amount of waste burned:
Waste feed rate: 180, 312, 300, 121, 219, 261 gal/h
POHC's selected and concentration in waste feed:

	Concentration, %					
Name	*Test W1-1*	*Test W1-2*	*Test W2-1*	*Test W3-1*	*Test W3-2*	*Test W3-3*
Dichloromethane	35	35.1	24.8	17.2	17.2	17.2
Trichloromethane (chloroform)	1.6	1.6	1.3	5.4	5.4	5.4
Carbon tetrachloride	1.4	1.4	1.1	2.4	2.4	2.4

Btu content: 11,188; 11,188; 11,198; 11,022; 11,022; 11,022 Btu/lb
Ash content: 0.30, 0.30, 0.20, 0.38, 0.38, 0.38 wt. %
Chlorine content: 32, 32, 22.9, 21.4, 21.4, 21.4 wt. %
Moisture content: <1.0, <1.0, 4.1, 4.3, 4.3, 4.3 volume %

Operating Conditions:

Temperature: Range 1800° - 2509°F
Average: 1900°, 1800°, 2495°, 2315°, 2469°, 2509°F
Primary fuel used: Fuel oil

Excess air: 13.0, 12.0, 12.0, 10.4, 10.6, 10.6% oxygen in outlet

Monitoring Methods:

POHC's: Integrated bag samples and on-site GC/EC and SASS train with off-site GC/MS analysis
HCl: Impinger train collection and specific ion electrode analysis
Particulate: EPA Method 5
Other: CO - Beckman 864, NDIR

SAN JUAN CEMENT

Emission and DRE Results: (see comments)
POHC's:

	DRE, %					
POHC	***Run W1-1***	***Run W1-2***	***Run W2-1***	***Run W3-1***	***Run W3-2***	***Run W3-3***
Dichloromethane	NA	>99.997	99.995	>99.991	99.960	99.659
Trichloromethane	NA	>99.842	>99.859	99.887	99.932	>99.960
Carbon tetrachloride	NA	99.309	>99.996	91.043	96.864	98.977

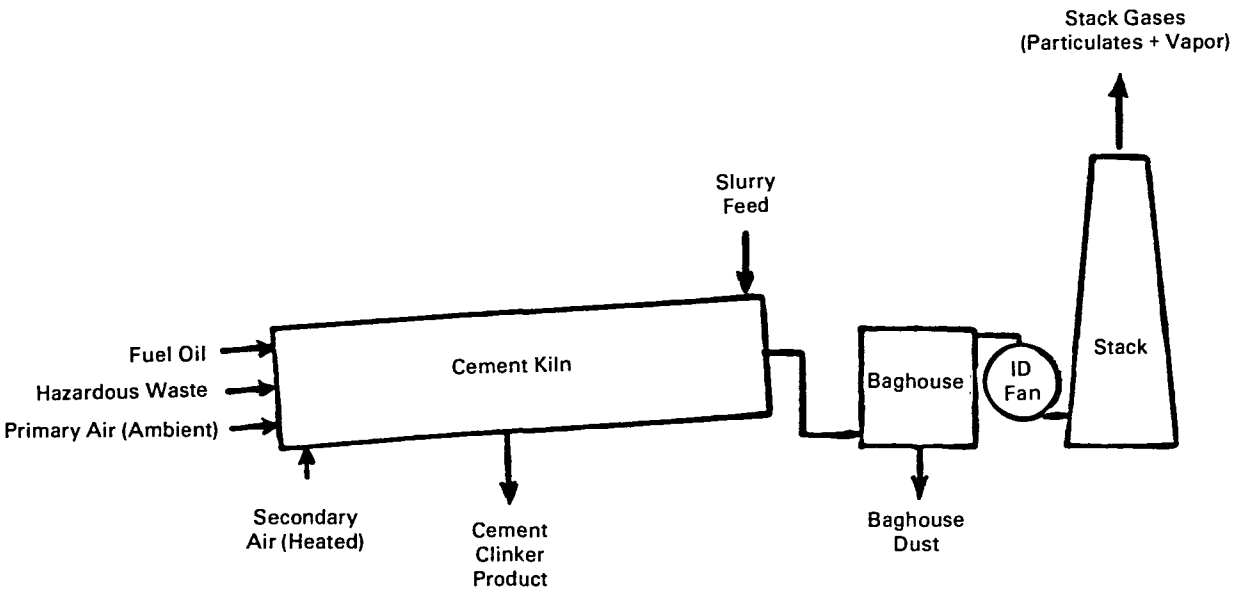
HCl: NA, 0.67, NA, 0.66, 1.63, 1.24 lb/h
Particulate: 0.0448, 0.0767, 0.2558, NA, 0.0294, 0.0257 gr/dscf
THC: 16.0, 11.8, 9.1, 12.3, 13.2, 14.7 ppm
CO: 378, 308, 260, 289, 289, NA ppm
Other: SO_2 - 874, 263, 350, NA, NA, 548 ppm
PIC's: Carbon tetrachloride may have been formed as a PIC from methylene chloride and chloroform. Also trichlorotrifluoroethane (F113) was probably introduced from air conditioners and trichloroethylene from chloromethanes. PIC of carbon tetrachloride may be responsible for lower DRE. Other compounds during waste burning did not lower DRE.

Reference(s): Peters, J. A., et. al. 1983. Evaluation of Hazardous Waste Incineration in Cement Kilns at San Juan Cement Company. Prepared for U.S. Environmental Protection Agency by Monsanto Research Corporation under Contract No. 68-03-3025, August 1983.

Comments: Problems with waste atomization through burner during many tests. The high chlorine content of the waste also believed to be a factor for low DRE's. TSP emissions - no difference in firing waste fuel. NO_x emissions - baseline is higher; HCl, THC, SO_2 emissions - higher during waste firing. Low DRE's because of lack of waste atomization and difficult incinerability of chlorinated monocarbons. Low concentration of POHC appeared to cause low DRE also.

PROCESS FLOW DIAGRAM

Schematic diagram of San Juan Cement kiln burning hazardous waste.



SAN JUAN CEMENT

Date of Test: November 1981 to February 1982

Run No.: W4-1, W4-2, W4-3, W4-4, W5-1, W5-2

Test Sponsor: EPA

Equipment information:

Type of unit: Wet process cement kiln
Commercial __ Private X
Capacity: 450,000 tons/yr for 3 kilns
Pollution control system: Baghouse

Waste feed system: Concentric burner nozzle. Waste fuel gun runs parallel to the fuel oil gun but slightly off the centerline where the fuel oil gun is located.

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Reclaimed solvents and degreasers

Length of burn:
Total amount of waste burned:
Waste feed rate: 105, 104, NA, NA, 87, 109 gal/h
POHC's selected and concentration in waste feed:

	Concentration, %					
Name	*Test W4-1*	*Test W4-2*	*Test W4-3*	*Test W4-4*	*Test W5-1*	*Test W5-2*
Dichloromethane	15.8	15.8	15.8	15.8	1.9	1.9
Trichloromethane (chloroform)	7.9	7.9	7.9	7.9	6.1	6.1
Carbon tetrachloride	16.1	16.1	16.1	16.1	12.7	12.7

Btu content: 10,099; 10,099; 10,099; 10,099; 4,546; 4,546; 4,546 Btu/lb
Ash content: 0.23, 0.23, 0.23, 0.23, 0.31, 0.31 wt. %
Chlorine content: 35.1, 35.1, 35.1, 35.1, 35.1, 35.1 wt. %
Moisture content: 8.9, 8.9, 8.9, 8.9, 23.0, 23.0 volume %

Operating Conditions:

Temperature: Range 2016° - 2561°F
Average: 2050°, 2016°, 2548°, 2561°, 2532°, 2495°F
Primary fuel used: Fuel oil

Excess air: NA, 11.3, 14.5, 12.3, NA, NA% oxygen in outlet

Monitoring Methods:

POHC's: Integrated bag samples and on-site GC/EC and SASS train with off-site GC/MS analysis
HCl: Impinger train collection and specific ion electrode analysis
Particulate: EPA Method 5
Other: CO - Beckman 864, NDIR

Emission and DRE Results:

POHC's:

POHC	DRE, %					
	Run W4-1	*Run W4-2*	*Run W4-3*	*Run W4-4*	*Run W5-1*	*Run W5-2*
Dichloromethane	98.237	99.418	99.461	99.984	93.292	96.663
Trichloromethane	98.592	99.470	99.283	98.475	98.388	96.099
Carbon tetrachloride	97.732	98.122	98.142	99.684	99.553	99.460

HCl: 1.18, 0.56, 0.99, <0.0272, NA, NA lb/h

Particulate: NA, 0.0326, 0.0631, NA, NA, NA gr/dscf

THC: 11.9, NA, NA, NA, NA, NA ppm

CO: NA, NA, NA, 492, 123, 305 ppm

Other: SO_2 - NA, 485, 191, NA, NA, NA ppm

PIC's: Carbon tetrachloride may have been formed as a PIC from dichloromethane and trichloromethane. Also trichlorotrifluoroethane (F113) was probably introduced from air conditioners and trichloroethylene from chloromethanes. PIC of carbon tetrachloride may be responsible for lower DRE. Other compounds during waste burning did not lower DRE.

Reference(s): Peters, J. A., et. al., 1983. Evaluation of Hazardous Waste Incineration in Cement Kilns at San Juan Cement Company. Prepared for U.S. Environmental Protection Agency by Monsanto Research Corporation under Contract No. 68-03-3025, August 1983.

Comments: Same as Tests W1, W2, and W3

Process Flow Diagram: Same as tests W1, W2, and W3

SAN JUAN CEMENT

Date of Test: November 1981 to February 1982

Run No.: W6-1, W4/6-1, W4/6-2, W4/6-3, W4/6-4, W4-6/5

Test Sponsor: EPA

Equipment information:

Type of unit: Wet process cement kiln
Commercial ___ Private X
Capacity: 450,000 tons/yr for 3 kilns
Pollution control system: Baghouse

Waste feed system: Concentric burner nozzle. Waste fuel gun runs parallel to the fuel oil gun but slightly off the centerline where the fuel oil gun is located.

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Reclaimed solvents and degreasers

Length of burn:
Total amount of waste burned:
Waste feed rate: 94, 217, 333, 80, 145, 355 gal/h
POHC's selected and concentration in waste feed:

	Concentration, %					
Name	*Test W6-1*	*Test W4/6-1*	*Test W4/6-2*	*Test W4/6-3*	*Test W4/6-4*	*Test W4/6-5*
Dichloromethane	7.6	7.8	7.8	7.8	7.8	7.8
Trichloromethane (chloroform)	0.17	1.5	1.5	1.5	1.5	1.5
Carbon tetrachloride	0.02	2.45	2.45	2.45	2.45	2.45

Btu content: 13,098, NA, NA, NA, NA, NA
Ash content: 0.046, NA, NA, NA, NA, NA wt. %
Chlorine content: 6.5, 10.1, 10.1, 10.1, 10.1, 10.1 wt. %
Moisture content: 2.0, NA, NA, NA, NA, NA volume %

Operating Conditions:

Temperature: Range 1550° - 2700°F
Average: 2526°, 2483°, 2310°, 2700°, 1550°, 2688°F
Primary fuel used: Fuel oil

Excess air: Not reported

Monitoring Methods:

POHC's: Integrated bag samples and on-site GC/EC and SASS train with off-site GC/MS analysis
HCl: Impinger train collection and specific ion electrode analysis
Particulate: EPA Method 5
Other: CO - Beckman 864, NDIR

Emission and DRE Results, %:

POHC's:

POHC	DRE, %					
	Run W6-1	*Run W4/6-1*	*Run W4/6-2*	*Run W4/6-3*	*Run W4/6-4*	*Run W4/6-5*
Dichloromethane	99.223	99.760	99.668	99.564	99.133	99.474
Trichloromethane		95.617	92.171	98.703	>99.737	99.515
Carbon tetrachloride		94.129	99.325	94.512	92.253	95.873

HCl: 0.14 lb/h

Particulate: Not reported

THC: Not reported

CO: 87, 738, 559, NA, 460, 205 ppm

PIC's: Carbon tetrachloride may have been formed as a PIC from dichloromethane and trichloromethane. Also trichlorotrifluoroethane (F113) was probably introduced from air conditioners and trichloroethylene from chloromethanes. PIC of carbon tetrachloride may be responsible for lower DRE. Other compounds during waste burning did not lower DRE.

Reference(s): Peters, J. A., et. al. 1983. Evaluation of Hazardous Waste Incineration in Cement Kilns at San Juan Cement Company. Prepared for U.S. Environmental Protection Agency by Monsanto Research Corporation under Contract No. 68-03-3025, August 1983.

Comments: Same as Tests W1, W2, and W3

Process Flow Diagram: Same as tests W1, W2, and W3

Summary of Test Data for St. Lawrence Cement Co.
Mississauga, Ontario

Date of Test: 1975/76

Run No.: 1-WBA, 2-WBA, 3-WBA, 1-WBB, 2-WBB, 3-WBB, 1-WBC, 2-WBC, 3-WBC

Test Sponsor: Environment Canada

Equipment information:

Type of unit: Rotary cement kilns with suspension preheaters

Commercial ___ Private X

Capacity: 2 wet, 1 dry kiln, each rated at 1050 tons/day

Pollution control system: ESP for wet and dry processes

Waste feed system: Concentric burners

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: chlorinated hydrocarbons; WBA = chlorinated aliphatics, WBB = WBA plus chlorinated aromatics and alicyclics, WBC = WBB plus PCB

Length of burn: 5550 min (all WBA), 4420 (all WBB), 3615 min (all WBC)

Total amount of waste burned: Aliphatic mixture = 5550 gallons (WBA tests); aromatic mixture = 5126 gallons (WBB tests); PCB mixture = 3262 gallons (WBC tests)

Waste feed rate: 1440, 1440, 2670, 1745, 1814, 620, 1210, 2808 gal/day

POHC's selected and concentration in waste feed:

Name	*Concentration, %*
Ethylene dichloride	Not reported
Chlorotoluene	
PCB	

Btu content: WBA - 12,750 Btu/lb; WBB - 9,530, 9,500, 8,820 Btu/lb; WBC - 12,070, 12,050, 12,000 Btu/lb

Moisture content: Not reported

Operating Conditions:

Temperature: Range NA

Average Approx. 2000°F where gas exits kiln into preheater

Primary fuel used: Coal

Excess air: Not reported

Monitoring Methods:

POHC's: Gaseous sampling train using Chromosorb 102 adsorbent and grab bag samples

HCl: Midget impingers containing 5% caustic soda and water solution

Particulate: U.S. EPA Method 5

Emission and DRE Results:

POHC's:

Waste		*DRE, %*
All WBA runs	=	99.990%
All WBB runs	=	99.989%
All WBC runs	=	99.986%

Cl: 0.31%, 0.31%, 0.63%, 0.45 to 0.71%, 0.31 to 0.51%, 0.79%, 0.06 to 0.14%, 0.13 to 0.33%, 0.61%

Particulate: 0.1458, 0.1524, 0.3415, 0.0821, 0.0731, 0.1019, 0.0785, 0.0652, 0.0892 gr/ft^2

THC: <10, <10, <10, NA, NA, NA, NA, NA, NA ppm

CO: 1500, 500, 300, NA, NA, NA, NA, NA, NA ppm

Other: SO_2 - 492, 540, 637, 650, 672 ppm

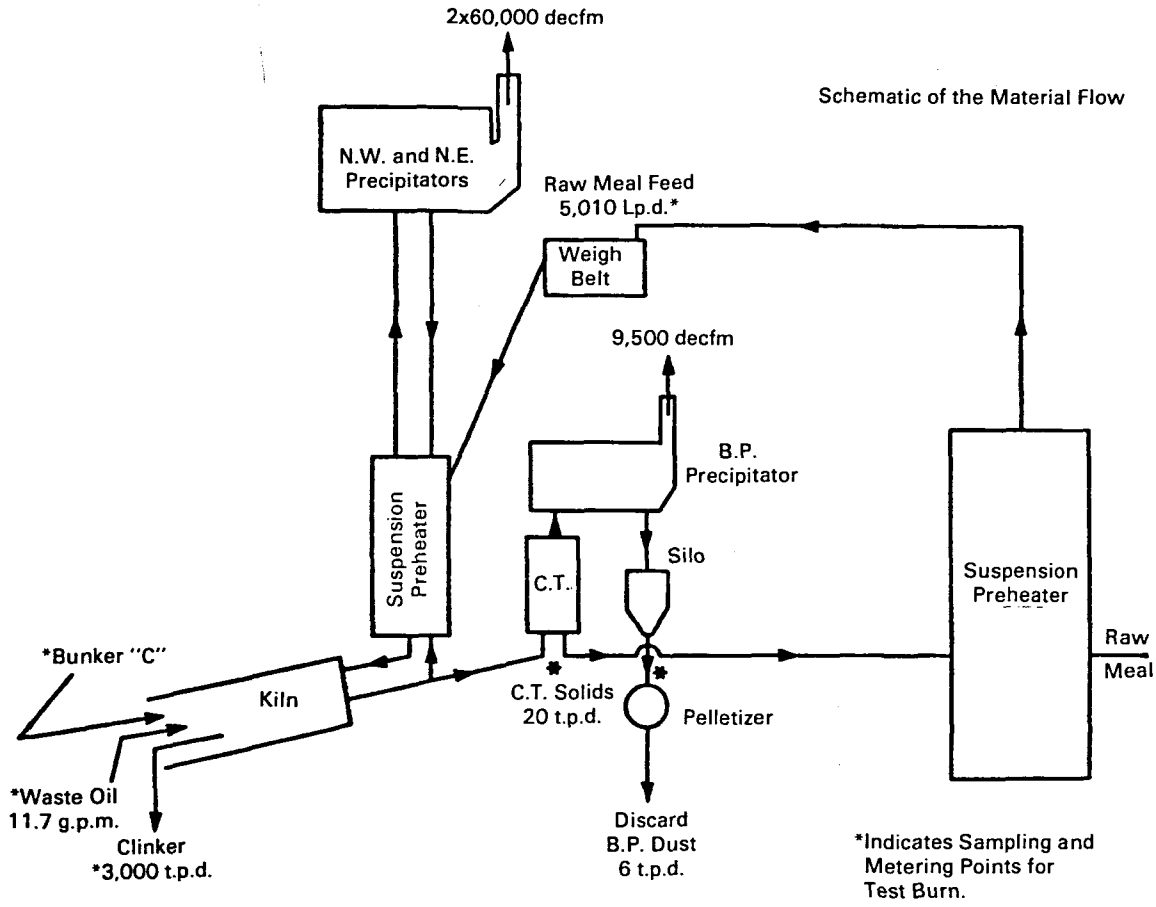
PIC's: 4 runs had DRE's less than 99.99%; 3 were CH_2Cl_2, the other was CH_3CCl_3. CH_2Cl_2 may have contaminated the lab. CH_3CCl_3 was in extremely low concentration.

Reference(s): MacDonald, L. P., et. al. 1977. Burning Waste Chlorinated Hydrocarbons in a Cement Kiln. Water Pollution Control Directorate, Environmental Protection Service, Fisheries and Environment Canada, Report No. EPS 4-WP-77-2.

Comments: No corrections were made for baseline levels of chlorinated compounds. DRE's based on total chlorinated organics instead of specific compounds. Waste fuel was formulated. Began test with dry process kiln, then switched to wet process. When chloride wastes were burned, TSP increased. During waste fuel burning, production dropped from 1038 to 1025 tons/day.

PROCESS FLOW DIAGRAM

Schematic of St. Lawrence Cement process flow.



Summary of Test Data for Site I
EPA Region IV

Date of Test: February/March 1984

Run No.: 1, 2, 3

Test Sponsor: EPA

Equipment information:
Type of unit: Rotary kiln clay dryer
Commercial __ Private X
Capacity: 40 tons/h
Pollution control system: Fabric filter

Waste feed system: Liquid wastes blended with virgin or reclaimed oil and fired through a single burner

Residence time: 2.5 s

Test Conditions:
Waste feed data:
Type of waste(s) burned: Blend of waste solvents and waste oil

Length of burn: 8- to 10-hour tests
Total amount of waste burned: Not reported
Waste feed rate: 200, 226, and 225 gal/h (25.4, 28.7, and 28.6 x 10^6 Btu/h)
POHC's selected and concentration in waste feed: Concentrations for most organics were extremely low. Compounds with concentrations less than 1000 ppm (1 mg/ml) are not usually considered POHC's

	Concentration, mg/ml		
Name	Test 1	Test 2	Test 3
1,1,1-Trichloroethane	0.364	0.346	0.355
Trichloroethylene	0.038	0.036	0.032
Benzene	0.037	0.057	0.046
Tetrachloroethylene	0.147	0.149	0.121
Toluene	0.925	0.912	0.825
Chlorobenzene	0.014	0.011	0.011
2-Butanone (MEK)	0.390	0.305	0.398
Trichlorotrifluoroethane (F113)	5.94	5.92	6.10

Btu content: 17,100; 17,148; 17,126 Btu/lb
Ash content: 0.70, 0.69, 0.66 wt. %
Chlorine content: 0.60, 0.64, 0.74 wt. %
Moisture content: 7.5, 7.05, 6.95 wt. %

Operating Conditions:
Temperature: Range 1100° - 1200°F
Average
Primary fuel used: None during tests; fuel oil when necessary

Excess air: 280%

Monitoring Methods:
POHC's: VOST
HCl: EPA Modified Method 6
Particulate: EPA Modified Method 5
Other: CO - ANARAD, NDIR

Emission and DRE Results: (see comments)
POHC's:

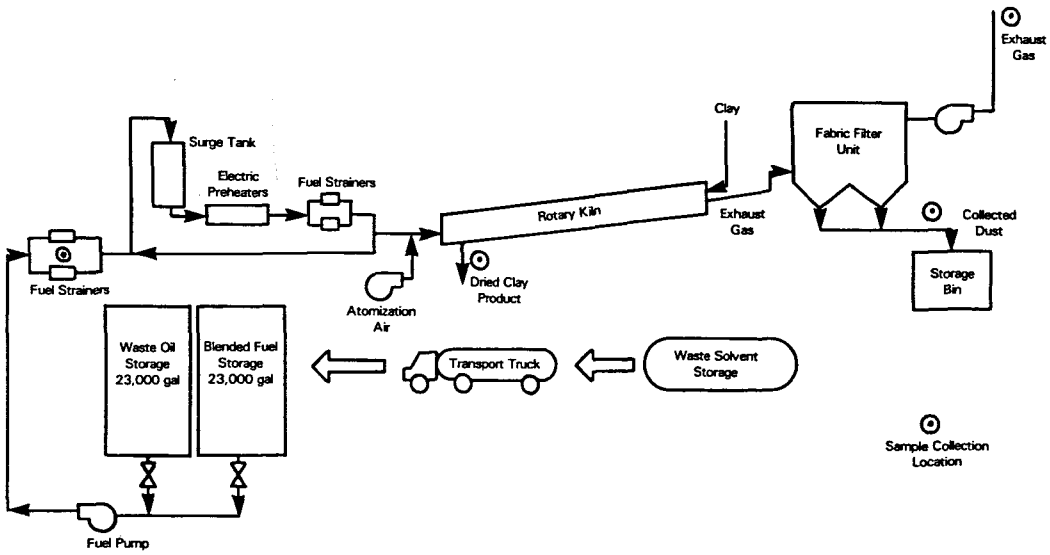
	DRE, %		
POHC	Test 1	Test 2	Test 3
1,1,1 Trichloroethane	99.92	99.95	99.988
Trichloroethylene	99.80	>99.994	>99.993
Benzene	82.5	98.5	98.8
Tetrachloroethylene	99.87	99.98	99.989
Toluene	99.7	99.90	99.89
Chlorobenzene	99.4	99.93	99.3
MEK	99.93	99.95	99.98
F113	99.988	99.998	99.998

HCl: 1.78, 2.32, 1.42 lb/h
Particulate: 0.0008, 0.0004, 9,9997, gr/dscf
THC: Not reported
CO: NA, 50, 57 ppm
Other: SO_2 - 23, 44, 13 ppm
PIC's: Some PIC's were POHC's and resulted in lower DRE's; unstable kiln conditions led to higher PIC levels

Reference(s): Wyss, A. W., C. Castaldini, and M. M. Murray. Field Evaluation of Resource Recovery of Hazardous Wastes. Prepared for U.S. Environmental Protection Agency by Acurex Corporation under Contract No. 68-02-3176. 1984.

Comments: Test 1 heat input was about 12% lower than Tests 2 and 3. Extremely low concentrations of organic compounds believed to be primary cause for DRE's less than 99.99%. F113 is also a common laboratory contaminant.

PROCESS FLOW DIAGRAM



Summary of Test Data for Site II
EPA Region IV

Date of Test: February/March 1984

Run No.: 1, 2, 3, 4

Test Sponsor: EPA

Equipment information:
Type of unit: Aggregate kiln
Commercial __ Private X
Capacity: 9 to 10 ton/h
Pollution control system: Multiple cyclone and wet scrubber

Waste feed system: Concentric burner nozzle

Residence time: 2.3 s

Test Conditions:
Waste feed data:
Type of waste(s) burned: Waste solvents

Length of burn: Not reported
Total amount of waste burned: Not reported
Waste feed rate: 230, 187, 300, and 302 gal/h (20.7, 17.1, 29.0, and 29.7 x 10^6 Btu/h)
POHC's selected and concentration in waste feed:

	Concentration, mg/ml			
Name	Test 1	Test 2	Test 3	Test 4
1,2-Dichloroethane	0.117	0.117	0.130	0.140
1,1,1-Trichloroethane	1.45	1.63	2.01	2.03
Carbon tetrachloride	0.059	0.065	0.083	0.082
Dichloromethane	3.99	4.28	4.96	4.92
Trichloroethylene	0.543	0.636	0.442	0.732
Benzene	0.094	0.111	0.078	0.131
Tetrachloroethylene	2.45	2.94	2.11	3.53
Toluene	36.8	37.8	26.6	43.7
Chlorobenzene	0.147	0.148	0.119	0.184
2-Butanone (MEK)	11.4	15.8	13.2	14.1
Trichlorotrifluoroethane (F113)	5.86	7.63	8.90	8.98

Btu content: 11,696; 12,208; 13,102; 13,400 Btu/lb
Ash content: 3.09, 2.98, 2.54, and 2.53%
Chlorine content: 1.55, 2.04, 2.27, 2.35 wt. %
Moisture content: 20.3, 18.3, 13.4, and 12.3 wt. %

Operating Conditions:
Temperature: Range 2050° - 2150°F
Average: Not reported
Primary fuel used: Coal in Tests 1 and 2, none in Tests 3 and 4

Excess air: 50-80%

Monitoring Methods:
POHC's: VOST
HCl: EPA Modified Method 6
Particulate: EPA Method 5
Other: CO - ANARAD, NDIR

Emission and DRE Results: (see comments)

POHC's:

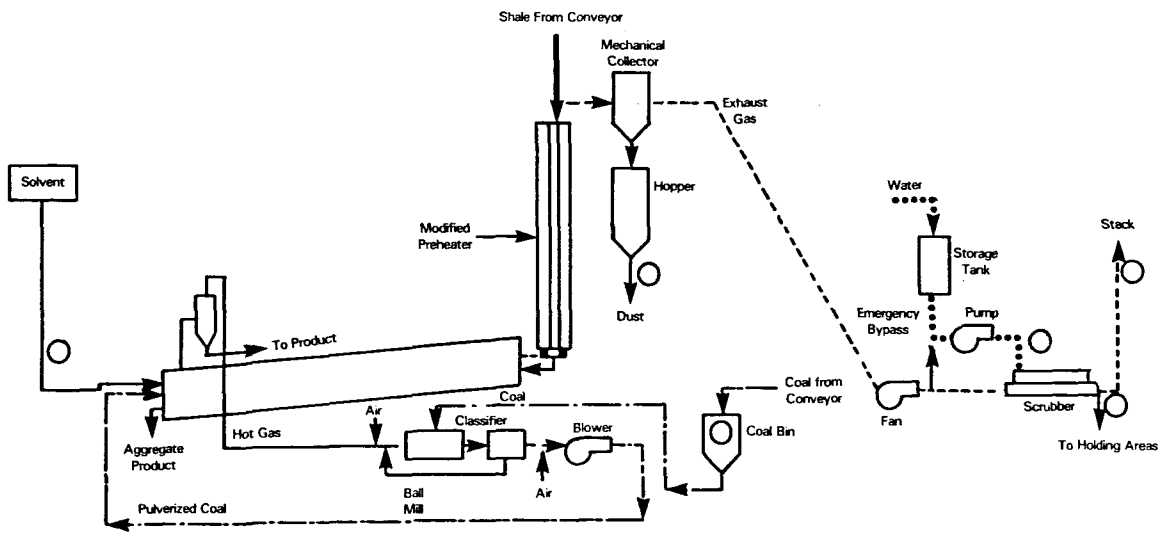
POHC	DRE, %			
	Test 1	*Test 2*	*Test 3*	*Test 4*
1,2-Dichloroethane	99.996	>99.9998	>99.9993	>99.9993
1,1,1-Trichloroethane	99.9998	>99.9999	>99.99995	>99.9997
Carbon tetrachloride	99.90	99.98	99.993	99.989
Dichloromethane	>99.9997	>99.99996	>99.99998	>99.99998
Trichloroethylene	99.998	99.9992	99.9988	99.9991
Benzene	99.82	99.88	99.84	99.90
Tetrachloroethylene	99.998	99.9996	99.9997	99.9998
Chlorobenzene	99.95	99.94	99.94	99.96
Toluene	99.9998	99.9997	99.998	99.9992
MEK	>99.9998	>99.99999	99.998	99.998
F113	99.99994	99.99995	99.99998	99.99994

HCl: 7.16, 8.63, 3.94, 5.55 lb/h
Particulate: 13.4, 4.4, 5.5, and 5.7 lb/h
THC: Not reported
CO: Not reported
Other: SO_2 - 922, 1480 ppm
PIC's: Nearly all PIC attributed to chloromethane

Reference(s): Wyss, A. W., C. Castaldini, and M. M. Murray. Field Evaluation of Resource Recovery of Hazardous Wastes. Prepared for U.S. Environmental Protection Agency by Acurex Corporation under Contract No. 68-02-3176. 1984.

Comments: Extremely low concentrations in waste feed of carbon tetrachloride (<100 ppm), benzene (<200 ppm), and chlorobenzene (<200 ppm) believed to be cause for measured DRE's less than 99.99%.

PROCESS FLOW DIAGRAM



STORA VIKA CEMENT

Summary of Test Data for Stora Vika Cement Plant
Stora Vika, Sweden

Date of Test: February 7-17, 1978

Run No.: One test series for each type of waste (i.e., chlorinated aliphatics, chlorophenols and phenoxyacids, polychlorinated biphenyl (PCB) and, trichlorotrifluoroethane (Freon 113)

Test Sponsor: Swedish Water and Air Pollution Research Institute

Equipment information:

Type of unit: Cement kiln - wet
Commercial __ Private X
Capacity: 620 ton/day
Pollution control system: Electrostatic precipitator

Waste feed system: Coal and waste fuel fed separately to kiln burner

Residence time: Not reported

Test Conditions:

Waste feed data:

Type of waste(s) burned: Chlorinated aliphatics, chlorophenols and phenoxyacids, PCB, and F113

Length of burn: Chlorinated aliphatics (100 h), chlorophenols and phenoxy acids (12 h), PCB mixed with oil (24 h), and F113 (3 h)
Total amount of waste burned: In above order: 50 m^3, 10 m^3, 16 m^3, 255 kg (given)
Waste feed rate: In above order: 0.5 m^3/h, 0.8 m^3/h, 0.7 m^3/h, 85 kg/h (calculated)
POHC's selected and concentration in waste feed:

Name	*Concentration*
Dichloromethane	22 to 37 wt. %
Trichloroethylene	1.5 to 2.7 wt. %
Freon 113	100%
Chlorinated phenols Phenoxy acids	100%
Polychlorinated biphenyls (PCB)	42 wt. % chlorine content

Btu content: Not reported
Ash content: Not reported
Chlorine content: Not reported
Moisture content: Not reported

Operating Conditions:

Temperature:
Range 1600°-1630°F, 1500°-1650°F, 1540°-1600°F, 1580°F-1600°F
Average 1610°F, 1610°F, 1580°F, 1590°F
Primary fuel used: Coal used as primary fuel

Excess air: Not reported

Monitoring Methods:

POHC's: Water sampling train followed by absorption column containing APIEZON M® and then through activated carbon column
HCl: None
Particulate: isokinetically on heated prefilters
Other: O_2, CO_2, CO grab samples
Total hydrocarbons analyzed continuously with IPM instrument

Emission and DRE Results:

POHC's:

POHC		*DRE, %*	
Dichloromethane	-	>99.95	measured during chlorinated aliphatics burn
Trichloroethylene	-	>99.9998	measured during chlorinated aliphatics burn
Chlorinated phenols	-	>99.99999	
Phenoxy acids	-	>99.99998	
PCB	-	>99.99998	
F113	-	>99.99986	

HCl: Not reported
Particulate:
72 mg/Nm³, - , 110 mg/Nm³, 110 mg/Nm³
<10 ppm, - , 10 ppm, <10 ppm
0.11 vol.%, 0.03 vol. %, 0.08 vol. %, 0.06 vol.%
THC: Not reported
CO: Not reported
Other: Not reported
PIC's: Not reported

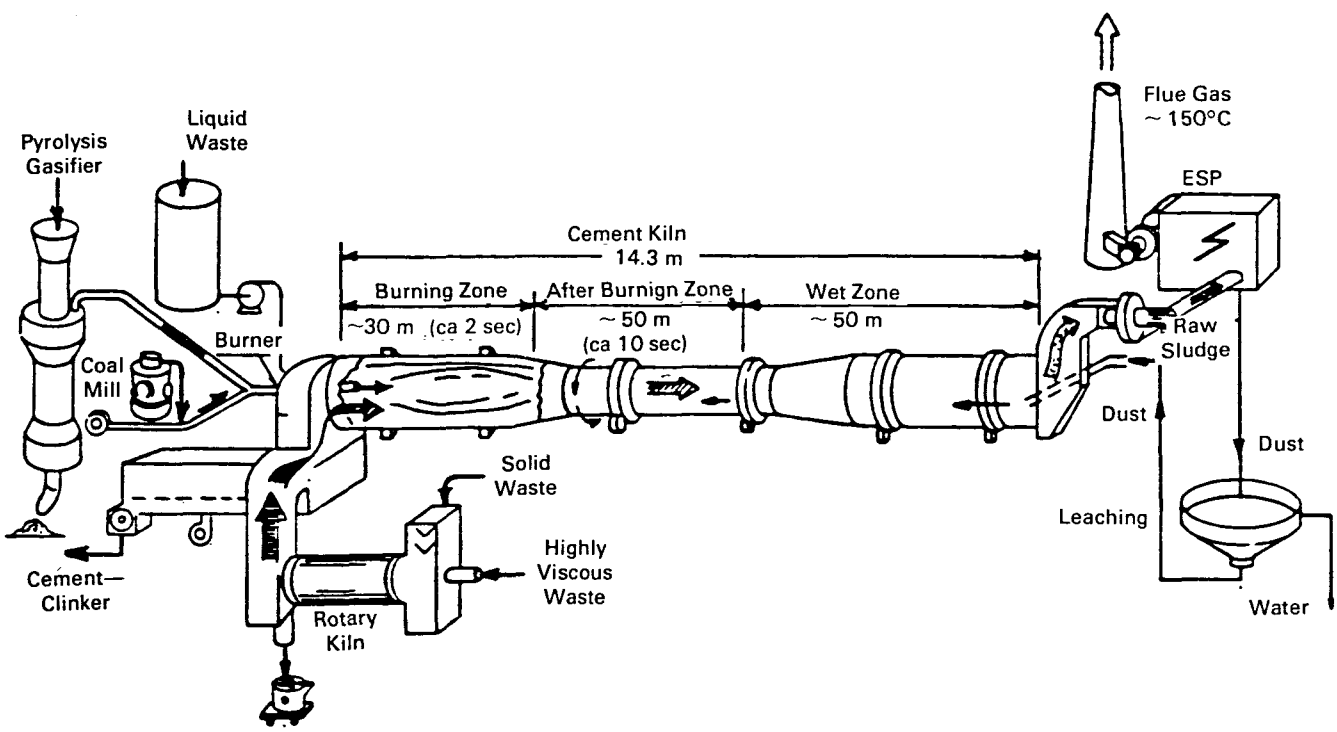
Reference(s): Ahling, Bengt. 1979. Combustion Test with Chlorinated Hydrocarbons in a Cement Kiln at Stora Vika Test Center, Swedish Water and Air Pollution Research Institute.

Branscome, M. 1985. Summary Report on Hazardous Waste Combustion in Calcining Kilns. Prepared for U.S. Environmental Protection Agency, Cincinnati, OH, by Research Triangle Institute.

Comments: No correction for baseline concentrations of organics when firing coal only.

PROCESS FLOW DIAGRAM

Schematic of the Stora Vika cement process with waste fuel feed. (Ahling 1979)



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