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Project Summary

PCB Trial Burn Report for the U.S. EPA Combustion Research Facility Liquid Injection Incinerator System

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This report describes a trial burn of polychlorinated biphenyl (PCB) laden oil and No. 2. fuel oil injected into the liquid incinerator at the U.S. EPA Combustion Research Facility in Jefferson, Arkansas. Destruction Rate Efficiencies (DREs) in excess of 99.99999 percent (40CFR 761.70) were achieved in all test cases, far exceeding the requirement of 99.9999 for the PCB (Aroclor). Hydrochloric acid removal efficiencies generally exceeded 99.9 percent. Other emission rates of organic compounds listed in Appendix VIII of the Resource Conservation and Recovery Act (RCRA) were tested and reported.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

During March 5 through March 11, 1986, a trial burn was performed on the liquid injection incinerator at EPA's Combustion Research Facility in Jefferson, Arkansas. The trial burn was performed to fulfill the requirements of the RCRA Part B permit application (40 CFR 270.62) for a new facility and to demonstrate compliance with performance standards specified under the Toxic Substance Control Act (TSCA) (40 CFR 761.70) for burning PCB-laden wastes.

The specific objectives of the trial burn tests were as follows:

- To establish the incinerator's ability to achieve 99.9999-percent destruction and removal efficiencies (DRE) of the PCB in the waste; attain particulate emissions of less than 180 mg/dscm corrected to 7-percent O_2; and attain HCl emissions less than the greater of 0.5 kg/hr or 0.5 percent of the total Cl (as HCl) in the stack.
- To serve as a test vehicle to validate the experimental Marine Incineration Biological Assessment Sampler (MIBAS) developed under EPA's program for incineration at sea. The MIBAS measures the toxicity of sea water to aquatic organisms after the sea water has been exposed to PCB incineration combustion by-products.
- To obtain information on the volatile chlorinated organic products of incomplete combustion (PICs) from PCB incineration.

Waste Description

The waste feed to the liquid injection incinerator was prepared by mixing PCB-laden oil and No. 2 fuel oil on a one-to-one volume basis. The PCB was identified as Aroclor 1260. Several polychlorinated benzenes were also detected by gas chromatography in the PCB oil. Table 1 summarizes the analytical results of the two batches of waste feed used in the tests.

Facility Description and Operation

The liquid injection incinerator system illustrated in Figure 1 consists of a primary combustion chamber and an afterburner chamber. The hot combustion gas leaving

the afterburner chamber is cooled in the liquid-sprayed quench chamber prior to particulate and HCl removal in downstream air pollution control devices (APCD). The APCD system consists of Venturi, packed, and ionized scrubbers in series followed by additional particulate and organic emission control in the carbon bed and high efficiency particulate (HEPA) filters. The incinerator is rated at 586 kW (2 x 10^6 Btu/hr) heat input. The combined 5.19 m^3 (183 ft^3) volume of the primary chamber, afterburner chambers, and transition duct provides a nominal gas residence time of approximately 4.3 sec at a firing rate of 500 kW (1.7 x 10^6 Btu/hr) and 10-percent excess oxygen.

Seven tests were performed over seven consecutive days with nominally identical incinerator operation. Table 2 summarizes the key operating data for the incinerator. Total firing rate in the main combustion chamber averaged 519 kW (1.77x10^6 Btu/hr). The PCB waste oil supplied 86 percent of the total heat input, with propane accounting for the remainder. No fuel or PCB oil was fired in the afterburner chamber. The average gas temperatures in the main and afterburner chambers were 1,240°C (2,265°F) and 1,026°C (1,880°F), respectively, for the seven test days. Excess oxygen measured at the afterburner exit typically ranged between 6 and 17 percent with an average of 12 percent for the seven tests.

Table 1. Chemical Analysis of the Feed Waste

	Waste feed mixture	
	Batch 1	Batch 2
Date used	3-5-86 to 3-7-86	3-8-86 to 3-11-86
Component	Concentration (wt%)	
1,4-Dichlorobenzene	0.535	0.509
1,2-Dichlorobenzene	0.598	0.553
1,2,4-Trichlorobenzene	24.2	22.0
1,2,3-Trichlorobenzene	14.2	13.0
1,2,3,5 + 1,2,4,5-Tetrachlorobenzene	1.050	0.824
1,2,3,4-Tetrachlorobenzene	0.508	0.389
Aroclor 1260	42.1	36.0
Chlorine (Theoretical)	49.4	43.5
High Heating Value Kcal/kg (Btu/lb)	7604 (13688)	8093 (14567)

Sampling and Analysis Protocols

A detailed sampling and analysis (S&A) protocol was undertaken to evaluate emissions of hazardous organic and criteria pollutants at several sample locations in the incinerator system. Table 3 summarizes the S&A protocol used during these trial burn tests.

Test Results

Table 4 summarizes the DRE results for Aroclor 1260 (PCB). The DREs exceeded 99.99999 percent in all test cases; as a result they were well above the requirements specified in 40 CFR 761.70. Two of the three tests showed higher PCB emissions at the afterburner exit than those measured at the stack, possibly indicating some scrubbing of unburned PCB in the APCD system. HCl scrubbing efficiencies, shown in Table 5, generally exceeded 99.99 percent on the basis of HCl measurements at the stack using EPA Method 5. HCl concentration in the gas was also measured at the inlet to the carbon bed filter. These results showed concentrations in the range of 1 to 20 ppm corresponding to scrubbing efficiencies of approximately 99.9 percent. Particulate mass emissions were measured at the stack during four test days. These results, summarized in Table 6,

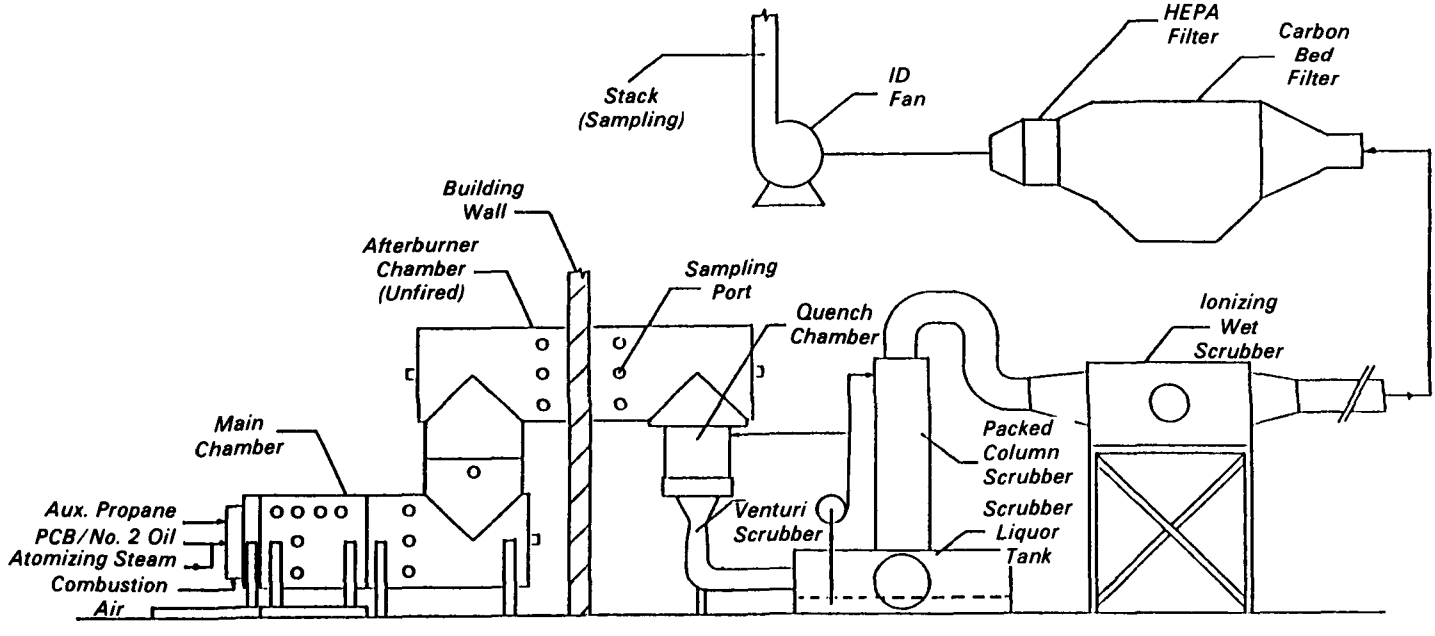

Figure 1. Simplified schematic of the USEPA Combustion Research Facility liquid injection incinerator system.

Table 2. *Liquid Injection Incinerator Operating Conditions During Tests*

Date	Test duration	PCB waste feedrate kg/hr (lb/hr)	PCB waste heat release kW (x10³ Btu/hr)	Propane flowrate scm/hr (SCFH)	Propane heat release kW (x10³ Btu/hr)	Total heat release rate kW (x10³ Btu/hr)	Combustion air flowrate scm/min (SCFM)	Afterburner oxygen percent dry	Main chamber temperature °C (°F)	Afterburner chamber temperature °C (°F)	Stack temperature °C (°F)
		48	421	3.4	86		9.0		1262	982	71
3-5-86	11:04 -	36 - 62	321 - 557	2.6 - 3.9	66 - 100	506	8.6 - 9.1	9.0	1262-1301	912-1067	68 - 71
	17:02	(105)	(1437)	(119)	(292)		(318)	3.0 - 15.3	(2303)	(1799)	(159)
		(80 - 136)	(1095 - 1902)	(92 - 139)	(225 - 341)	(1729)	(302 - 320)		(2016-2374)	(1671-1953)	(155 - 160)
		50	441	2.7	69		8.9		1195	943	69
3-6-86	11:06 -	27 - 67	241 - 593	2.6 - 3.0	66 - 75	510	8.8 - 9.2	11.6	1088-1195	873-1060	66 - 71
	16:50	(110)	(1506)	(96)	(235)		(315)	11.5 - 16.0	(2183)	(1730)	(156)
		(60 - 148)	(821 - 2025)	(92 - 105)	(225 - 257)	(1741)	(309 - 326)		(1990-2447)	(1604-1940)	(150 - 160)
		50	441	2.7	69		9.1		1239	1012	67
3-7-86	09:50 -	36 - 64	321 - 561	2.6 - 3.0	67 - 75	510	9.0 - 9.1	13.0	1178-1270	973-1044	64 - 70
	14:30	(110)	(1506)	(96)	(235)		(320)	12.0 - 14.9	(2262)	(1854)	(153)
		(80 - 140)	(1095 - 1916)	(93 - 105)	(228 - 257)	(1741)	(319 - 321)		(2152-2317)	(1782-1912)	(148 - 158)
		45	427	2.8	71		8.8		1216	1064	71
3-8-86	09:45 -	40 - 53	376 - 474	2.4 - 3.0	62 - 75	498	8.6 - 9.1	13.5	1181-1257	1045-1105	71 - 72
	13:23	(100)	(1457)	(99)	(243)		(310)	13.0 - 15.0	(2220)	(1948)	(160)
		(88 - 111)	(1282 - 1617)	(86 - 105)	(211 - 257)	(1700)	(303 - 322)		(2158-2295)	(1913-2021)	(159 - 161)
		52	491	2.9	73		8.8		1270	1056	71
3-9-86	09:15 -	47 - 58	444 - 446	2.8 - 2.9	72 - 75	564	8.1 - 9.3	11.0	1177-1363	1005-1106	70 - 72
	12:45	(115)	(1675)	(102)	(250)		(310)	8.0 - 12.0	(2318)	(1932)	(160)
		(104 - 128)	(1515 - 1865)	(100 - 104)	(245 - 255)	(1925)	(287 - 330)		(2150-2485)	(1841-2024)	(158 - 162)
		51	478	2.9	73		9.1		1267	1064	72
3-10-86	10:08 -	44 - 55	410 - 512	2.9 - 2.9	73 - 75	551	9.0 - 9.2	11.0	1239-1305	1033-1096	71 - 72
	14:45	(112)	(1632)	(102)	(250)		(320)	6.0 - 16.9	(2312)	(1948)	(161)
		(96 - 120)	(1398 - 1748)	(101 - 104)	(248 - 255)	(1882)	(318 - 323)		(2262-2384)	(1891-2004)	(160 - 162)
		45	427	2.9	73		8.9		1239	1063	71
3-11-86	09:03 -	18 - 54	171 - 504	2.7 - 2.9	69 - 74	500	8.8 - 9.0	14.0	1208-1270	1043-1070	70 - 71
	13:32	(100)	(1457)	(101)	(248)		(314)	10.5 - 17.8	(2263)	(1945)	(159)
		(40 - 118)	(583 - 1719)	(96 - 103)	(235 - 252)	(1705)	(310 - 319)		(2206-2318)	(1909-1958)	(158 - 160)

indicate concentrations in the range of 130 to 330 mg/dscm. The 225 mg/dscm average for the four tests is above the regulatory requirement of 180 mg/dscm.

Table 7 summarizes the measured emission rates of other RCRA listed (Appendix VIII) organic compounds detected in the gas samples at the stack and afterburner exit. The table lists the highest concentration measured for each compound and the average concentration (shown in parenthesis) calculated from all samples. With the exception of methylene chloride, chloroform, bromoform, and 1,2-dichloroethane (plus methylethyl ketone) all other compounds showed average concentrations less than 10 μg/dscm. Concentrations of all semivolatile compounds were higher at the afterburner exit than at the stack, indicating some scrubbing of these compounds in the APCD system.

Conclusions and Recommendations

Trial burn tests using PCB-laden oil in the liquid injection incinerator at the Combustion Research Facility in Jefferson, Arkansas, indicated PCB DREs in excess of 99.9999 percent with efficient HCl scrubbing. Average particulate emission, however, exceeded the requirements specified under RCRA and TSCA regulations. Additional research is recommended to determine the impact of incinerator operating conditions on PCB DRE and PIC emissions. Specifically, tests should be undertaken to evaluate the effect of waste firing in the afterburner section as well as operation at lower gas residence times approaching the minimum requirements specified under TSCA regulations.

Table 3. *Sampling and Analysis Program*

Test method	Sample location	Analyses
VOST	Afterburner exit Stack	Volatile organic compounds
Modified EPA Method 5 (MM5)	Afterburner exit Stack	Semivolatile organics
EPA Method 5 (M5)	Stack only	Particulate, HCl
Continuous monitors	Afterburner exit Carbon bed inlet Stack	O_2, CO_2, NO, NO_x, HCl

Analyses were performed with standard EPA methods (3, 4, 5).

Table 4. Destruction and Removal Efficiencies of Aroclor 1260 in the CRF Liquid Injection Incinerator

						Based on flue gas velocity data		
Date	Sample location	Total amount of waste feed (kg)	Total amount of Aroclor 1260 fed[a] units (kg)	Sampling period duration (min)	Flue gas Aroclor 1260 concentration (μg/dscm)	Flue gas flowrate (dscm/min)	Total Aroclor 1260 emitted (mg)	DRE (percent)
3-5-86	Afterburner	256.4	107.9	316	0.41	21.16[b]	2.74[c]	>99.999997[d]
	Stack	250.3	105.4	310	0.46	21.16	3.02	99.999997
3-7-86	Afterburner	189.2	79.7	241	0.27	22.32[b]	1.45[c]	>99.999998[d]
	Stack	196.6	82.8	249	0.15	22.32	0.82	99.9999990
3-10-86	Afterburner	198.7	71.5	240	0.23	18.61[b]	1.03[c]	>99.999999[d]
	Stack	200.0	72.0	243	0.079	18.61	0.36	99.9999995

[a] During corresponding sampling periods.
[b] Flue gas flowrate not measurable at this location, hence assumed to be equal to that at stack.
[c] Calculated based on footnote b above.
[d] Actual DREs will be higher than these indicated DREs because of the above approximation (see footnote b). Calculated Aroclor emissions are high because higher than actual flue flowrates were used.

Table 5. Scrubber Efficiency and HCl Emissions

		Method 5 at stack			CEA analyzer at carbon bed inlet		
Date	Inlet chlorine flowrate[a] kg/hr	Concentration range mg/dscm	Outlet chlorine flowrate kg HCl/hr	Scrubber efficiency percent	Concentration range ppm average min — max	Outlet chlorine flowrate kg HCl/hr average min — max	Scrubber efficiency percent average min — max
3-5-87	24.4	<1.6	<0.002	>99.99	6.5 1.2 — 14.8	0.012 0.002 — 0.028	99.95 99.99 — 99.88
3-7-86	25.4	<2.39	<0.003	>99.988	10.8 3.3 — 19.5	0.022 0.007 — 0.039	99.91 99.97 — 99.84
3-10-86	22.8	<1.76	<0.002	>99.99	12.2 4.5 — 17.1	0.021 0.008 — 0.029	99.91 99.97 — 99.87
3-11-86	20.1	<1.61	<0.002	>99.99	—	—	—

[a] As HCl.

Table 6. Particulate Emissions at the Stack

	Probe rinse			Filter paper			Total		
Date	Weight (mg)	Particulate concentration in sample gas (mg/dscm)	Emission rate (kg/hr)	Weight (mg)	Particulate concentration in sample gas (mg/dscm)	Emission rate (kg/hr)	Weight (mg)	Particulate concentration in sample gas (mg/dscm)	Emission rate (kg/hr)
3-5-86	174.9	306.0	0.388	15.9	27.8	0.035	190.8	334	0.423
3-7-86	133.7	166.2	0.165	9.5	8.8	0.012	143.2	132	0.177
3-10-86	136.7	225.2	0.251	15.7	25.6	0.029	152.4	251	0.280
3-11-86	100.9	166.2	0.174	11.9	19.6	0.021	112.8	186	0.195

Table 7. Organic Emissions, μg/dscm

Organic pollutant	March 5		March 7		March 10 and 11		Average for all tests	
	Stack	Afterburner exit	Stack	Afterburner exit	Stack	Afterburner exit	Stack	Afterburner exit
Volatile organics[a]								
Methylene chloride	>290 (>98)[c]	>290 (>145)	>300 (170)	155 (114)	97 (58)	B	>110	>78
1,1-dichloroethylene	4.8 (2.6)	13 (5.9)	2.2 (1.9)	24 (8.0)	0.54 (0.18)	3.7 (2.2)	1.6	5.1
1,1-dichloroethane	B	B	42 (19)	7.2 (2.4)	B	B	6.3	0.72
t-1,2-dichloroethylene	1.7 (0.81)	10 (4.8)	B	B	1.0 (0.5)	18 (4.5)	0.44	3.2
Chloroform	>100 (45)	32 (21)	18 (10)	36 (29)	14 (8.0)	11 (10)	21	19
1,2-dichloroethane and 2-butanone*	79 (64)	45 (26)	B	61 (27)	31 (28)	8.3 (3.6)	31	20
1,1,1-trichloroethane	B	B	B	B	0.61 (0.40)	B	0.13	B
Carbon tetrachloride	11 (4.7)	B	9.3 (3.1)	B	B	B	2.6	B
Bromodichloromethane	B	B	32 (11)	2.3 (1.8)	15 (13)	21 (11)	8.0	4.9
1,2-dichloropropane	12 (4.0)	7.4 (3.0)	2.6 (1.5)	B	B	B	1.8	0.90
T-1,3-dichloropropene	5.9 (2.0)	>116 (>69)	12 (4.1)	B	B	B	2.6	>21
Trichloroethylene	28 (13)	16 (5.3)	>62 (>22)	15 (12)	0.72 (0.64)	9.4 (7.6)	>12	8.2
Benzene	59 (53)	2.3 (0.77)	B	B	22 (20)	2.6 (1.7)	24	0.91
1,1,2-trichloroethane and chlorodibromomethane*	B	55 (18)	B	5.9 (2.0)	B	B	B	6.0
Bromoform	54 (21)	B	25 (15)	>88 (31)	13 (12)	>83 (>21)	16	>18
Tetrachloroethylene and 1,1,2,2-tetrachloroethane*	14 (7.1)	B	B	B	11 (8.8)	B	5.3	B
Toluene and hepane	15 (5.0)	4.5 (1.5)	14 (4.6)	8.0 (5.8)	15 (14)	6.4 (4.4)	7.9	3.9
Chlorobenzene	0.8 (0.27)	35 (14)	B	9.9 (6.0)	0.56 (0.53)	8.5 (5.9)	0.27	8.4
Semivolatile organics[b]								
1,3-dichlorobenzene	B	B	B	B	B	B	B	B
1,2-dichlorobenzene	0.05	0.59	B	B	B	6.3	0.017	2.3
1,4-dichlorobenzene	B	1.1	B	B	B	0.58	B	0.56
1,2,3-trichlorobenzene	0.03	0.36	B	B	0.010	0.29	0.013	0.22
1,2,4-trichlorobenzene	0.41	0.97	B	B	0.078	0.52	0.14	0.50
1,2,3,4-tetrachlorobenzene	0.004	0.85	0.048	0.082	0.004	0.68	0.019	0.54
1,2,3,5/4,5-tetrachlorobenzene	B	0.13	B	B	0.003	0.11	0.001	0.08

day.
*Compounds elute at the same retention time.
B — Below quantitation limit (typically <1 μg/dscm).
> — Greater than calibration range of gas chromatograph.

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The complete report entitled "PCB Trial Burn Report for the U.S. EPA Combustion Research Facility Liquid Injection Incinerator System," (Order No. PB 87-208 799/AS; Cost: $18.95, subject to change) will be available only from:
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