LA-UR--83-3024

DE84 001737

CONF-8308106--22

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

TITLE: LOS ALAMOS CONTROLLED-AIR INCINERATION STUDIES

AUTHOR(S): R. A. Koenig
C. L. Warner

SUBMITTED TO: Fifth Annual DOE LLWMP Participant's Information Meeting,
August 30 - September 1, 1983, Denver, Colorado

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

By acceptance of this article the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution or to allow others to do so, for U.S. Government purposes.

The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

LOS ALAMOS CONTROLLED-AIR INCINERATION STUDIES

Ralph A. Koenig and Charles L. Warner
Los Alamos National Laboratory
Los Alamos, NM 87545

ABSTRACT

Current regulations of the Environmental Protection Agency (EPA) require that PCBs in concentrations greater than 500 ppm be disposed of in EPA-permitted incinerators. Four commercial incineration systems in the United States have EPA operating permits for receiving and disposing of concentrated PCBs, but none can accept PCBs contaminated with nuclear materials. The first section of this report presents an overview of an EPA-sponsored program for studying PCB destruction in the large-scale Los Alamos controlled air incinerator. A second major FY1983 program, sponsored by the Naval Weapons Support Center, Crane, Indiana, is designed to determine operating conditions that will destroy marker smoke compounds without also forming polycyclic aromatic hydrocarbons (PAHs), some of which are known or suspected to be carcinogenic. We discuss the results of preliminary trial burns in which various equipment and feed formulations were tested. We present qualitative analyses for PAHs in the incinerator off-gas as a result of these tests.

INTRODUCTION

In FY1972, the US Atomic Energy Commission initiated a multi-year program at Los Alamos to compile a history of radioactive waste incineration technology¹, examine current commercial incineration technology, and then design, assemble, and demonstrate a production-scale incineration system for the treatment of combustible solid TRU waste.^{2,3} The program progressed through several stages of development, addressing increased system safety, flexibility, and performance, and culminated with final trial burns in FY1979.

In the later stages of the TRU program, it became evident that the extensive effort expended in ventilation control and equipment sealing for TRU service resulted in an incineration system that would be exceptionally safe for studying the destruction of hazardous and toxic materials. Continuing programs

for studying treatment of these materials have been funded by the Environmental Protection Agency, the US Navy (Naval Weapons Support Center), the US Department of Defense (Defense Property Disposal Service), and the US Army (ARRCOM). To accommodate the requirements of these programs, we modified the incinerator to burn liquids and slurries. As a result, technology development at Los Alamos has been transferred to other national laboratories and to the nuclear fuel industry. Los Alamos technology is available from at least four commercial vendors and serves as the design model for the first mobile incinerator sold to a nuclear power utility.⁴

PROGRESS DESCRIPTION

As a result of early evaluations, Los Alamos chose an incinerator of the controlled-air type to serve as the principal element of the process. A high-energy aqueous offgas cleanup system was selected on the strength of such a system's performance, which remains high, regardless of acid gas and entrained particle composition. The aqueous offgas system is followed by a dry system using equipment frequently specified for conventional ventilation systems in radioactive service. A solid-waste feed preparation line was installed to screen incoming material. Later, a liquid and slurry preparation line was added. Continuous operation with solid feed became possible when Los Alamos engineers designed and installed a dry-medium ash removal and packaging system. Detailed descriptions of the process equipment are contained in references 5-7. Systems pertinent to FY1983 studies are briefly described here.

Incinerator

The incinerator is a controlled-air type (Figure 1), with two chambers in series. Each chamber has independent temperature and oxygen control loops; the primary chamber has a pressure control loop. Solid, liquid, and slurry wastes are injected into the primary chamber, which is designed to retain ash formed during combustion. The secondary chamber accepts the offgas from the primary chamber and completes the combustion reaction.

Aqueous Offgas Cleanup System

The offgas system consists of a quench tower that cools the exhaust from the secondary chamber to saturation temperature by evaporation of recirculated scrubber liquid. The quench tower is followed by a high-energy venturi scrubber designed to remove submicron-sized particles from the offgas, which uses recirculated liquid as the scrubbing medium. A differential-pressure-control loop varies the throat area in response to offgas flowrates. The next element is a packed-bed tower designed for

Figure 1. Controlled air incinerator.

removal of acid gases produced by the burning of certain wastes. The tower uses recirculated liquid as a scrubbing medium. Excess liquids from these three operations are combined, filtered, cooled, neutralized, and recirculated according to the requirements of the aqueous offgas cleanup system.

The final element in the aqueous system is a condenser/demister and superheater module. The condenser cools the saturated offgas, thereby reducing its water content. The demister removes water droplets entrained in the offgas, and the superheater dries the offgas by elevating the offgas temperature.

Dry Offgas Cleanup System

Exhaust from the aqueous system is routed through a high-efficiency particulated-air (HEPA) filter module, an activated carbon tower, and an induced draft blower. The HEPA filter module contains a fire screen, one bank of roughing filters, and two banks in series of high-capacity HEPA filters. The activated carbon tower was installed in later years as a final trap for any volatile radionuclides that may be present in the offgas. A bank of HEPA filters is installed at the tower outlet to trap entrained carbon fines. The incinerator and offgas systems are maintained at the desired negative pressure by parallel induced-draft blowers. The offgas system is illustrated in Figure 2.

Liquid and Slurry Feed Preparation Line

The liquid and slurry train consists of two parallel blending tanks fitted with agitators for various liquid and slurry formulations. The resulting mixtures are pumped by a progressing cavity pump to either a vortex-type burner on the primary chamber or to an atomizing nozzle for direct injection into the primary chamber. Liquid or slurry wastes with heating value greater than 2500 g-cal/g, are fed through the liquid burner. The preparation line is illustrated in Figure 3.

INCINERATION STUDIES

FY1983 programs have concentrated on studying of the destruction of PCBs in a controlled-air incinerator and on destruction of Navy marker smoke compounds by incineration.

PCB INCINERATION

The FY1983 PCB studies were the culmination of an FY1982 program. The PCB work was sponsored by the Environmental Protection Agency (EPA), Industrial Environmental Research Laboratory, under DOE/EPA Interagency Agreement No. AD-89-F-1-539-0.

Figure 2. Offgas cleanup system.

Figure 3. Liquid and slurry feed preparation line.

Background

Federal regulations ban the manufacture and use of PCBs and specify disposal requirements. All PCBs in concentrations greater than 500 ppm must be disposed of by incineration at EPA-approved facilities. Currently, four commercial incinerators in the United States are permitted to receive and dispose of PCBs. Although adequate destruction efficiency has been demonstrated frequently in high-temperature, long-residence-time incinerators, few useful data are available for prescribing minimum conditions for PCB destruction. The EPA-sponsored program at Los Alamos was designed to develop a data base for certain less-than-normal temperature conditions. A trial burn permit was obtained from EPA Region VI for burning transformer oil, analyzed as 61 wt% Aroclor 1260 and 39 wt% trichlorobenzene drained from Los Alamos equipment.

Process Equipment

Process components used in the PCB tests include the incinerator and offgas cleanup system described earlier. PCB mixtures were injected through an internal-mix steam/liquid atomizer into a high-energy vortex-type burner mounted on the side of the primary chamber. The PCB mixture was blended with #2 fuel oil, as required, to produce mixtures from 24-61 wt% PCB. Blends were prepared using the liquid and slurry preparation line.

Sampling

Samples and their location are shown in Figures 2 and 3. Samples collected at locations marked HZ (hot zone), OG (offgas), and CI (carbon bed inlet) were analyzed for PCBs, trichlorobenzene, chlorinated dibenzodioxins and dibenzofurans. For this discussion, results of only PCB analyses are presented. Sampling at the first two locations was done by a modified EPA Method 5 train using distilled water, Florisil chromatographic resin (Floridin Company), and XAD-2 resin (Rohm and Haas Company). Sampling at these high-temperature locations was accomplished by a water-cooled probe. The carbon-bed inlet was sampled by a similar train except that of 1N sodium hydroxide was used instead of distilled water.

Results

Results of PCB analyses for six runs⁸ are presented in Tables 1 and 2. To study the effects on PCB destruction the temperature was varied in the primary chamber. The conditions in the secondary chamber were held at a temperature, oxygen concentration, and residence time known to destroy PCBs. The results in Table 2 illustrate a high PCB destruction efficiency

for this combination of burner and incinerator. Destruction efficiencies less than 99.999% in the primary chamber occurred only at conditions of low temperature [844°C (1550°F)] with PCB concentrations of 61%. As expected, the conditions in the secondary chamber resulted in higher destruction efficiencies.

Future Plans

There is an identified need within the DOE for chemical processes that can treat PCBs that are also contaminated with nuclear materials. DOE contractors have developed several promising PCB treatments such as the Goodyear Atomic Liquid Sodium process⁹ and the Union Carbide Solvent Extraction process.¹⁰ Incineration also will provide a proven method for handling a wide range of mixed materials that commercial incinerator operators cannot accept. To this end, Los Alamos has presented results of the PCB trial burns to EPA Region VI with a request for a permit to routinely accept and dispose of PCBs. A final decision on the permit request is expected this calendar year.

NAVY SOLID SMOKE COMPOUND INCINERATION

The US Navy has developed pyrotechnic smoke compounds of varying colors that are used for signaling and/or markers. The Navy must dispose of many tons of these materials, which have become obsolete or unserviceable, in an economical safe, and environmentally acceptable manner. To that end, the Navy conducted small-scale incineration studies with the solid material which demonstrated incineration was technically feasible. However, these tests also revealed that under certain conditions, incineration produces polycyclic aromatic hydrocarbons (PAHs), some of which are considered to be carcinogenic. As a result, the Navy smoke program, sponsored by the Naval Weapons Center at Crane, Indiana, began in FY1982 and continued through FY1983. The program objectives were to develop waste forms suitable for conventional incinerators and to determine operating conditions for destroying smoke compounds without producing PAHs.

After we made several small-scale tests with the solid material, we decided to concentrate on developing a liquid waste form that can be directly injected into the primary chamber or through a burner. Extensive laboratory-scale tests resulted in a candidate liquid form that is easy to mix and pump, resists phase separation, and has a heating value greater than 2500 g-cal/g. The formulation, shown in Table 3, has the consistency and appearance of latex paint.

TABLE 1. INCINERATOR OPERATING CONDITIONS, PCB STUDIES

SAMPLE PERIOD	PCB, ^a WT%	FEED RATES, kg/h			ATOM. STEAM, kg/kg FEED	PRIMARY CHAMBER			SECONDARY CHAMBER		
		FUEL OIL	WASTE ^b	TOTAL		TEMP., °C (°F)	O ₂ , %		TEMP., °C (°F)	O ₂ , %	
1	0	18.82	0	18.82	1.48	1021(1870)MIN	4.3 MIN		1188(2170)MIN	8.1 MIN	
						1060(1940)MAX	4.8 MAX		1188(2170)MAX	8.8 MAX	
						1059(1939)AVG	4.53 AVG		1188(2170)AVG	8.58 AVG	
2	25.64	16.09	11.66	27.76	1.20	921(1690)MIN	5.0 MIN		1188(2170)MIN	6.0 MIN	
						1010(1850)MAX	6.4 MAX		1188(2170)MAX	6.5 MAX	
						994(1822)AVG	5.39 AVG		1188(2170)AVG	6.21 AVG	
3	23.80	15.52	9.93	25.45	1.23	885(1625)MIN	4.3 MIN		1188(2170)MIN	6.0 MIN	
						1027(1880)MAX	5.7 MAX		1193(2180)MAX	6.7 MAX	
						999(1830)AVG	5.17 AVG		1188(2171)AVG	6.38 AVG	
4	24.15	16.28	10.67	26.95	1.25	993(1820)MIN	5.3 MIN		1188(2170)AVG	6.6 MIN	
						1010(1850)MAX	5.6 MAX		1188(2170)AVG	6.85 MAX	
						1008(1847)AVG	5.4 AVG		1188(2170)AVG	6.71 AVG	
5	24.67	16.36	11.11	27.47	1.21	1010(1850)MIN	4.4 MIN		1188(2170)MIN	6.6 MIN	
						1043(1910)MAX	5.6 MAX		1188(2170)MAX	6.7 MAX	
						1036(1897)AVG	4.57 AVG		1188(2170)AVG	6.68 AVG	
6	61.0	0	43.43	43.43	0.74	677(1250)MIN	6.1 MIN		1182(2160)MIN	6.5 MIN	
						899(1650)MAX	9.1 MAX		1188(2170)MAX	8.2 MAX	
						844(1552)AVG	7.85 AVG		1186(2166)AVG	7.58 AVG	
7	61.0	0	42.44	42.44	0.78	838(1540)MIN	8.4 MIN		1188(2170)MIN	8.4 MIN	
						871(1600)MAX	8.9 MAX		1188(2170)MAX	8.7 MAX	
						844(1551)AVG	8.54 AVG		1188(2170)AVG	8.54 AVG	

^a PCB concentration in burner feed, percent by weight.

^b Refers to PCB/TCB mixture.

TABLE 2. INCINERATOR PERFORMANCE, PCB STUDIES

Sample Period	Residence Times, s		Analytical Lab	PCB Destruction Efficiencies, %		
	Primary ^a Chamber	Secondary ^b Chamber		HZ	OG	CI
2	4.24	2.71	1	99.99996	99.99898	-----
			2	>99.99995	99.99812	>99.99992
			3	>99.99997	>99.99991	>99.99995
3	4.26	2.75	1	99.99997	99.99950	-----
			2	>99.99986	99.99905	>99.99988
			3	99.99989	99.99996	>99.99992
4	4.21	2.76	1	99.99995	>99.99996	-----
			2	>99.99988	>99.99984	>99.99986
			3	>99.99992	>99.99990	>99.99991
5	4.13	2.84	1	99.99974	>99.99996	-----
			2	>99.99987	>99.99986	>99.99987
			3	99.99987	99.99970	>99.99992
6	4.86	2.60	1	99.97213	99.99999	99.99999
			2	99.95067	>99.99998	>99.99999
			3	99.97443	99.99998	99.99999
7	4.76	2.51	1	99.99757	99.99995	-----
			2	99.97592	>99.99996	>99.99996
			3	99.99017	99.99995	>99.99997

a Residence time based on total volume of primary chamber.

b Residence time based on volume between HZ and OG sample location.

TABLE 3. NAVY SMOKE LIQUID FEED FORMULATION

<u>Component</u>	<u>Fraction (wt%)</u>
Smoke compound	15.2
polycyclic dye	
potassium chlorate	
sugar	
sodium bicarbonate	
diatomaceous earth	
silica	
graphite	
Fuel oil (#2)	15.7
Water	68.9
Wetting agent ^a	0.2

^a Lonzest SML (Lonza Company)

Process Equipment

Process components used in preliminary incineration tests include the incinerator and offgas cleanup system described earlier. The smoke formulation was mixed in small batches and pumped to either a liquid injector or high-energy vortex burner. The liquid injector, designed to accommodate a two-fluid atomizer, provides for direct injection of the atomized liquid into the lower chamber. The vortex burner, mounted on the side of the primary chamber, is designed to accommodate similar atomizers.

Sampling

For the purpose of these equipment checkout tests, grab samples were collected at the OG (offgas) sample location at the exit from the secondary chamber for quick qualitative analysis at a local contract laboratory (see Figure 3). Each gas sample was conditioned with toluene and examined under long wave UV light and compared with a similarly prepared standard mixture of 10 PAHs

Results

The qualitative results of seven combinations of injector, nozzle type, atomizing medium, and temperature are presented in Table 4.

TABLE 4. RESULTS OF QUALITATIVE PAH TESTS

<u>Nozzle Type</u>	<u>Atomizing Medium</u>	<u>Injector</u>	<u>Temp. °C</u>	<u>Grab Sample Result</u>
Sonic 1	Air	Direct	982	Bad
Sonic 2	Air	Direct	982	Bad
Sonic 3	Steam	Direct	982	Better
External	Steam	Direct	1093	Much Better
External	Steam	Direct	982	Better Still
External	Steam	Burner	1093	Best
External	Steam	Burner	982	Best

Laboratory tests revealed that potassium chlorate readily decomposes to potassium chloride during combustion of the mixture. There is some concern that this alkali material may attack the ceramic refractory that lines most conventional incinerators. Laboratory tests of the effects of decomposing and oxidizing smoke compounds on sample refractory materials have been inconclusive. As a check on full-scale gross effects, refractory samples have been placed in the primary chamber to receive direct contact with some of the burning mixture. Preliminary full-scale tests have revealed no sign of refractory deterioration.

Future Plans

The final test series is scheduled for the second week in September. Nine compounds will be tested at various temperatures and excess air conditions. Sampling will be conducted by one contract sampling company and a second company will provide quality assurance. Analyses of split samples will be conducted by two Navy laboratories and three contract laboratories. A final program report will be issued by the end of the calendar year.

FY1984 INCINERATOR PROGRAM

Navy Smoke

The Navy smoke program will continue through the first quarter of FY1984. Efforts will then be directed toward developing a safe and effective method for treating demilitarized pyrotechnic signal flare compounds. These compounds differ from the Navy marker smoke compounds in their very high heat release.

Army Smoke

The US Army (AERCOM), Rock Island, Illinois, is sponsoring an FY1984 program similar in scope to the Navy program. Although the program objectives are the same and it's very similar to that of the Navy study, the Army smoke compositions are significantly different. Preliminary laboratory-scale tests indicate that methods developed for the Navy study are not directly transferable to the Army compounds.

Production Incineration

Economic analysis indicates that incineration offers a clear advantage to conventional operations in the case of newly generated TRU wastes. An extended demonstration run on 1000-nCi/g TRU wastes will be conducted in FY1984.

REFERENCES

1. B. L. Perkins, "Incineration Facilities for Treatment of Radioactive Wastes: A Review," Los Alamos Scientific Laboratory report LA-6252 (February 1976).
2. R. A. Koenig, "Design Considerations for Incineration of Transuranic-Contaminated Solid Wastes," Los Alamos Scientific Laboratory document LA-UR-77-415 (March 1977).
3. W. J. Whitty, "An Evaluation Procedure for Radioactive Waste Treatment Processes," Los Alamos Scientific Laboratory report LA-8052-MS, November 1979.
4. "Technical Description of a Mobile Radwaste Incinerator," unpublished document, Aerojet Energy Conversion Company, P.O. Box 13222, Sacramento, California 95813 (June 1982).
5. A. S. Neuls, W. E. Draper, R. A. Koenig, J. M. Newmyer, and C. L. Warner, "The Los Alamos Controlled Air Incinerator for Radioactive Waste, Volume I: Rationale, Process, Equipment, Performance and Recommendations," Los Alamos National Laboratory report LA-9427, Vol. I (August 1982).
6. R. A. Koenig, W. E. Draper, J. M. Newmyer, and C. L. Warner, "The Los Alamos Controlled Air Incinerator for Radioactive Waste, Volume II, Engineering Design Reference Manual," Los Alamos National Laboratory document LA-9427, Vol. II (October 1982).
7. L. A. Stretz and J. S. Vavruska, "Hazardous Waste Incineration Research at the Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-82-126 (March 1982).
8. J. S. Vavruska, "Research Incineration of Poly chlorinated Biphenyls at the Los Alamos National Laboratory," unreleased Los Alamos report.
9. Representative of Goodyear Atomic Corp., Piketon, Ohio.
10. Representative of Union Carbide Corp., Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.