CONTROLLED AIR INCINERATION OF HAZARDOUS CHEMICAL WASTE AT THE LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT

An incineration system, originally demonstrated as a transuranic (TRU) waste volume-reduction process, is described. The production-scale controlled air incinerator using commercially available equipment and technology was modified for solid radioactive waste service. The same incinerator and offgas treatment system has been modified further for use in evaluating the destruction of hazardous liquid wastes such as polychlorinated biphenyls (PCBs) and hazardous solid wastes such as pentachlorophenol (PCP)-treated wood.

Results of a PCP-treated wood incineration test show a PCP destruction efficiency of greater than 99.99% in the primary chamber for the operating conditions investigated. Conditions and results for this test are described.

INTRODUCTION

Solid wastes, both radioactive and hazardous, which are contained in a combustible matrix often lend themselves to incineration as a viable method of treatment. In the case of radioactive wastes, incineration provides a means of volume reduction. For hazardous wastes, incineration not only reduces the total volume, but can render the waste nonhazardous by thermal destruction of the hazardous chemical constituents.

In 1973, the Los Alamos National Laboratory established a study program for the development, evaluation, and demonstration of production-scale (50 - 100 kg/hr) transuranic waste treatment processes. The initial process investigated was to be incineration-based and utilize commercially available technology for volume reduction and chemical stabilization of low-level activity TRU-contaminated combustible materials. Process evaluation resulted in selection and modification of a controlled air incinerator (CAI) system for the TRU solid waste incineration program at Los Alamos.

This system is equipped with sophisticated containment, safety, and offgas cleanup systems which makes it well suited to hazardous waste incineration studies. Recent additions to the Los Alamos system include a liquid waste feed system and a high intensity liquid burner. Initial consideration has been given to two hazardous waste types: solid pentachlorophenol (PCP)-treated wood, and liquid polychlorinated biphenyls (PCBs). A PCP-treated wood incineration test has been completed, and a PCB incineration test is awaiting a burn permit.

Incineration under improper conditions or open burning of wood which has been treated with PCP can result in the generation of toxic reaction products in the ash and the offgas stream. Various organochlorine compounds have been reported as potential incomplete combustion products from the burning of PCP-treated wood, including chlorinated dibenzo-furans and dibenzo-dioxins such as 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD).

The safe disposal of wood treated with PCP has become a significant problem for the Department of Defense, particularly in Korea. Ammunition crates are treated with PCP to prevent degradation of the wood during transportation and storage. Disposal of the empty crates is not allowed in Korea and has resulted in problems related to the PCP elsewhere. The amount of wood involved is such that shipment back to the United States is an expensive and unattractive option. Incineration of the crates in Korea appears to be the most feasible solution.

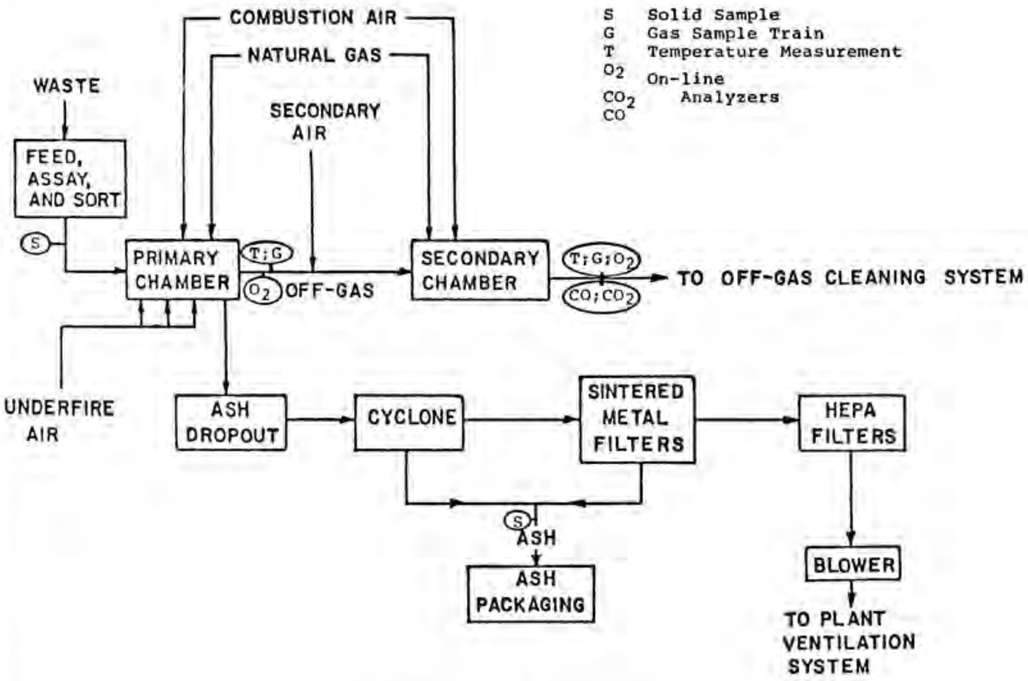
The Korean government has agreed to consider incineration of the material if testing assures that it will not create an additional and perhaps more severe problem than the PCP treated wood itself presents. DOD, through the Defense Property Disposal Service (DPDS), is attempting to secure operating data on PCP treated wood incineration that will demonstrate that an existing incinerator in Korea can safely dispose of the material.

In response to discussions with EPA staff and representatives of the Defense Property Disposal Service and with their support, an experimental evaluation of the thermal destruction of PCP on wood was performed at Los Alamos using the CAI system.

This paper reviews the design and modifications of the CAI system being used for the TRU and hazardous waste programs at Los Alamos. The as-built process is described, and operating experience from the experimental program is presented, along with future plans for incineration studies at Los Alamos.

PROCESS DESCRIPTION

The Los Alamos CAI process is an assemblage of modified commercially available equipment which has been incorporated into a continuous-system. The more important components of the installation are shown in Fig. 1, a simplified flowsheet of the CAI process. There are six subsystems comprising the process: a



Incinerator Sample Points

Fig. 1. Controlled Air Incinerator Process Showing Sampling and Monitoring Locations.

feed preparation and introduction train for solid wastes, a feed blending and metering station for liquid wastes, a dual chamber incinerator, an offgas cleanup system, a scrub solution recycle system, and an ash removal and packaging system. A brief description of selected equipment and the overall processing sequence for various waste forms is provided in the following paragraphs. More detailed descriptions of individual process components are given in earlier reports.[1,2,3,4]

Solid Waste Feed System

At Los Alamos, solid TRU wastes are packaged at their source in sealed plastic bags and contained in 0.3 m x 0.3 m x 0.6 m cardboard boxes. The boxes are loaded into the receiving slotbox of the CAI feed preparation line where the packages are assayed for TRU content. Assay is performed using a multiple energy gamma assay system (MEGAS), a nondestructive assay system developed by Los Alamos National Laboratory to analyze for TRU concentrations in low density solids at the 10 nCi/g activity level. The boxes are then passed through an x-ray assembly similar to airport security equipment, which scans for noncombustible materials such as bottles of liquid and large metal objects. Large noncombustibles generally pose no problem from an incineration standpoint, but tend to become stranded on the hearth requiring manual retrieval following a campaign. If necessary, the packages are opened in the sorting glovebox and these items are removed. Following inspection and necessary sorting, the waste packages are transported to the storage glovebox where enough waste is accumulated for about 5 hrs of incinerator operation. During incineration, waste packages are manually transferred from the storage box to the side ram feeder, which in turn loads the main ram feeder in preparation for waste introduction onto the incinerator hearth.

The same general precautions must be followed when preparing highly toxic hazardous solid wastes for incineration. Therefore, the feed preparation and introduction train described is ideally suited to the handling of hazardous solid wastes. The main function of the feed preparation line is to assure safe and acceptable waste configurations while providing radionuclide or toxic chemical containment and minimizing handling and potential worker exposure to such materials.

Liquid Waste Feed System

A liquid feed system is the most recent addition to the Los Alamos controlled air incineration process. A simplified schematic of the system is given as Fig. 2. The system consists of two 155-gallon KYNAR-lined tanks, each equipped with agitators mounted on removable heads. Positive displacement progressing cavity pumps mounted below each tank supply liquid to the burner. Desired feed composition can be achieved either by batchwise

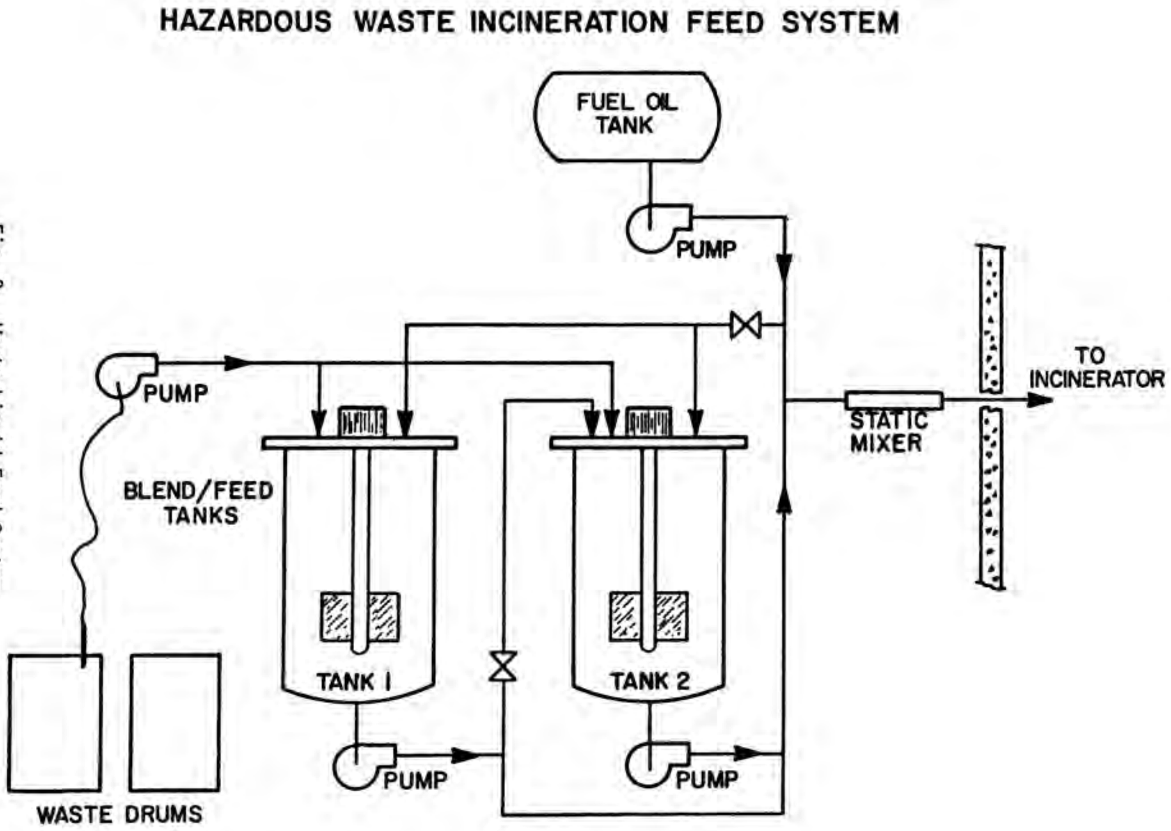


Fig. 2. Waste Liquid Feed System.

blending of waste liquid with fuel oil in one of the feed tanks, or by continuous blending of fuel oil and waste using an in-line static mixer unit. Precise metering of each stream is accomplished by d/p cells and control valves located in the fuel oil and waste feed lines upstream of the static mixer. Final flow of the blended feed stream to the incinerator is monitored by a mass flowmeter which provides a measure of instantaneous mass flowrate and totalized flow.

Incinerator

The incinerator is a conventional dual-chamber controlled-air design (Fig. 3), which has been modified to provide physical containment barriers around the combustion air fans, ash removal doors, and flanged connections to the offgas system ductwork. Similar unmodified models are frequently used for disposal of municipal, pathological, and industrial solid wastes. Both chambers are refractory-lined and natural gas is used for waste ignition and supplemental heat. Solid wastes are charged batchwise via the main ram feeder to the lower chamber where underfire air is used to support combustion under controlled conditions. Unburned volatile components and entrained particles exit the lower chamber through an interconnecting port where excess air is introduced to promote complete combustion. The secondary, or upper, chamber provides the needed residence time for completion of combustion reactions. Supplemental heat is supplied to the secondary chamber as needed. Normal operating temperatures are 870°C in the lower chamber and 1100°C in the upper chamber for TRU-containing wastes, and somewhat higher as required for halogenated organics such as PCBs. Combustion air supply rates are varied depending on waste combustion characteristics.

Addition of steam enhances the oxidation of carbon via the water gas shift reaction and also favors hydrochloric acid formation which is highly soluble in the scrub solution. Steam is also used as a snuffing medium should a fast shutdown of the process be required. To further promote carbon burnout, the secondary-air injection system was modified to provide more intimate mixing of the excess air with products of partial combustion leaving the lower chamber. More positive oxygen control was achieved by installing oxygen/combustibles analyzers at the exit of each chamber. The analyzers continuously monitor the offgas from each chamber and act to control the level of excess air in each; the lower by adjustment of the underfire air flow and the upper by variation of the secondary air flow.

For combustion of liquid and slurry wastes, a commercial high intensity vortex liquid burner is mounted on the side of the primary incinerator chamber firing downward at a 45° angle from horizontal directly into the chamber. The burner is equipped

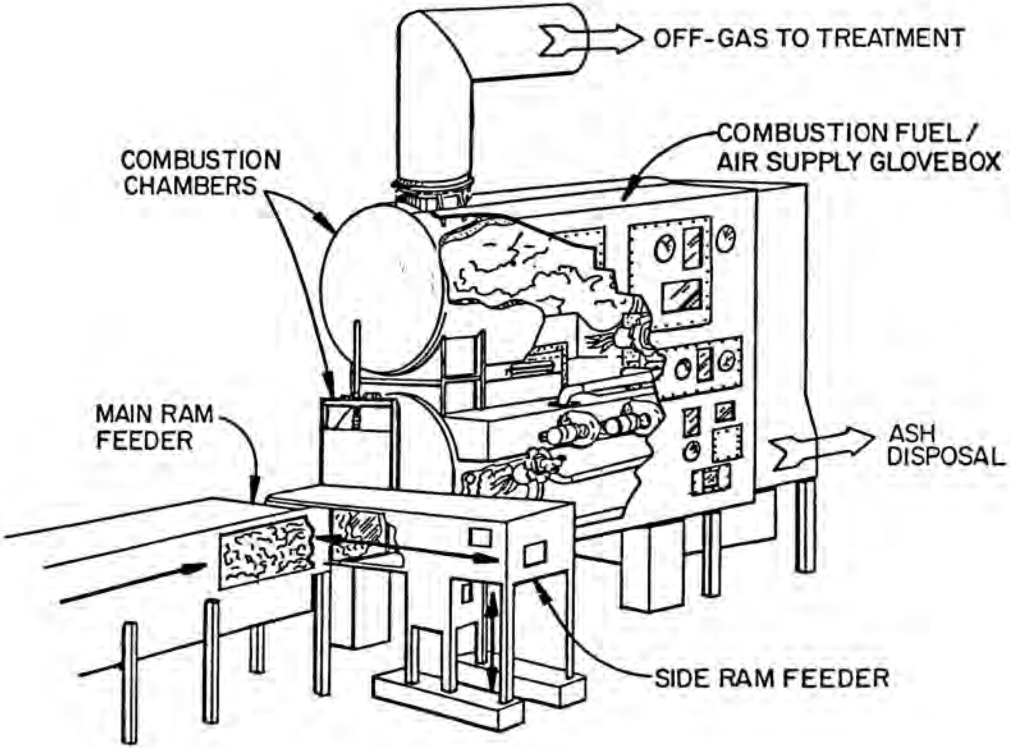


Fig. 3. Controlled Air Incinerator Module.

with its own natural gas pilot and natural gas supply for supplemental heat. Atomization media can be supplied through internally or externally mixed nozzle configurations. Nozzle penetration within the burner windbox can be varied to provide optimum flame stability for a given feed stream. The burner/nozzle arrangement can accept slurries as well as liquids. A schematic of the liquid burner arrangement is shown as Fig. 4.

Offgas Cleaning System

In addition to the combustion products carbon dioxide and water, exhaust from the CAI upper chamber contains both particulates and mineral acids which result from the combustion of halogenated waste feed streams. Removal of these chemical pollutants and potentially radioactive particulates is accomplished by the offgas cleaning system, which consists of a quench tower, a high-energy venturi scrubber, a packed-column absorber tower, a condenser, a mist eliminator, a reheater, High Efficiency Particulate Air (HEPA) filters, and an activated carbon adsorber (Fig. 5).

The quench tower is divided into an upper contacting section and a lower separating section. Combustion gases are cooled from the incinerator exit temperature to approximately 70°C by evaporation of recycled scrub solution. Excess solution collects in the separator while the saturated gas phase is routed to the inlet of the venturi scrubber.

The variable-throat venturi scrubber, located between the quench tower and the absorber tower, removes up to 99 wt% of the offgas particulates. The venturi assembly consists of converging and diverging cones with a clamp valve throat to allow the pressure drop to be varied. Venturi pressure drop normally is controlled to 12.45 kPa (50 in. WC). Scrub solution is injected through a nozzle located upstream of the throat. Mineral acids are removed from the gas phase by counter-current contact with process condensate, recycled scrub solution, or fresh water in the packed-column absorber tower.

The condenser, mist eliminator, and reheater are included to condition the process exhaust gases before final HEPA filtration. The condenser lowers offgas temperture, removing the bulk of water vapor from the scrubbed gas stream. The offgas is then reheated to approximately 17°C above saturation temperature to avoid condensation and attendant plugging of the HEPA filters and corrosion within the plenum, exit ducting, and offgas blowers. Functional parts of each of these subsystem components are commercial equipment, which are housed in enclosures specifically designed to withstand the 21.22 kPa (85.2 in. WC) pressure differential between this process and ambient conditions.

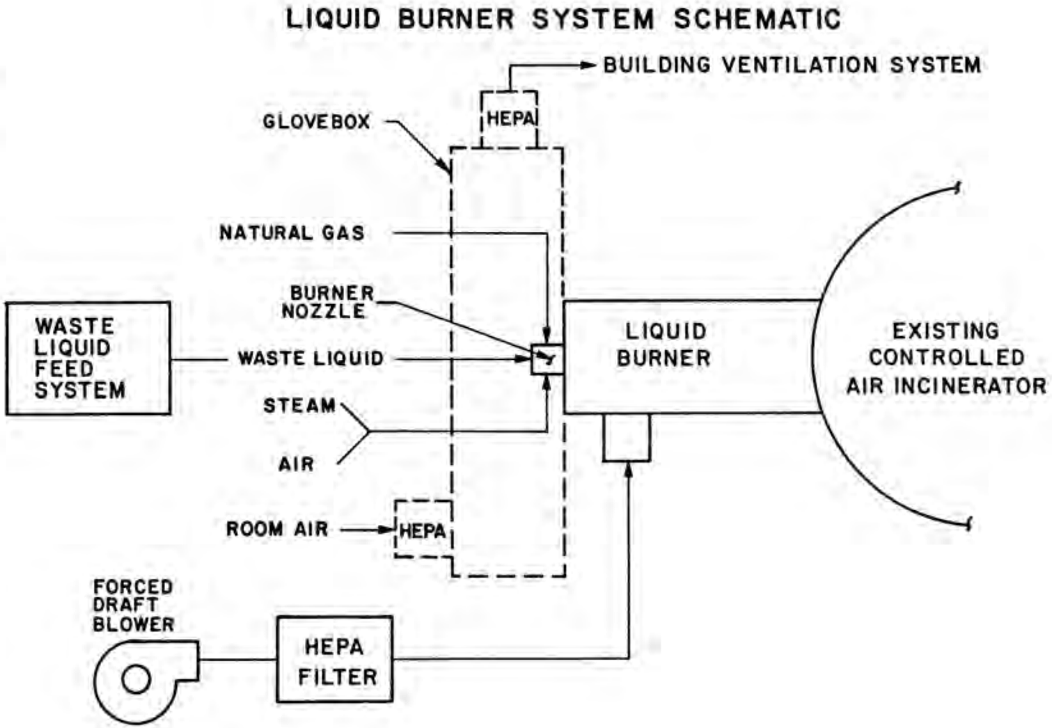
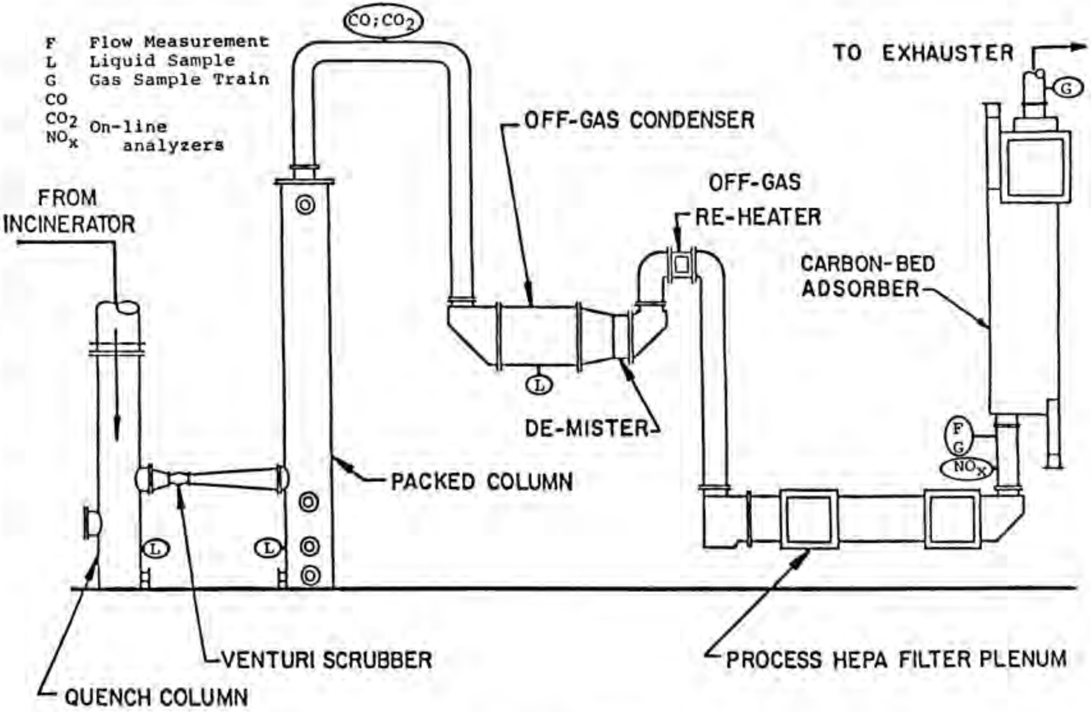


Fig. 4. High Intensity Liquid Burner System.



Offgas System Sample Points

Fig. 5. Offgas System Showing Sampling and Monitoring Locations.

HEPA filtration is required for final removal of particulates. The filter module houses two frames in series; the first consisting of a prefilter and two HEPA filters, the second being similar but without the prefilter. The filter housing is designed to withstand the 20.8 kPa (83.5 in. WC) pressure differential capability of the process and is fitted with hatches to access the bag-out doors and in-place filter testing ports.

The activated carbon bed adsorber serves as a final trap for radioiodine and trace organic compounds. The bed design permits a 0.5 s residence time and a superficial velocity of .152 m/s at maximum offgas flow.

The induced draft blower is capable of producing 57.2 kPa (230 in. WC) static pressure absolute at 0.90 m^3/s with a discharge pressure of 78.0 kPa (313 in. WC) absolute (to accomodate the 2255 m elevation at Los Alamos).

Scrub Solution Recycle System

A scrub solution recycle system is used to minimize liquid blowdown (waste to final treatment) from the offgas cleaning system. This system consists of full-flow cartridge liquid filters, a graphite heat exchanger, two evaporative cooling towers, a scrub solution receiver tank, a condensate receiver tank, and a caustic makeup tank. Excess liquid drains from the bottom of the quench tower and combines with scrub solution and venturi blowdown in the packed-column base. This solution is pumped through a 100 m cartridge filter and a primary heat exchanger to the receiver tank. Liquid requirements for the quench tower, venturi scrubber, and absorber tower are satisfied by recycle from the receiver tank. Solution recycling through the quench tower is refiltered to remove particulates down to 20 μm.

The graphite heat exchanger cools recycled solution from 85°C to 50°C. The process (tube) side is operated at a lower pressure than the coolant (shell) side to guarantee in-leakage in the event of tube failure. The shell side fluid from the primary heat exchanger is cooled by the secondary heat exchange loop, providing isolation from the environment.

To control scrub solution acidity, 20% caustic solution is added at the receiver tank inlet. The addition rate is controlled by a pH sensor on the outlet of the receiver tank.

Condensate from the condenser/mist eliminator drains into a condensate receiver tank. The level in this tank is maintained by addition of fresh water. The solution is then pumped either to the top of the packed-column scrubber or to the receiver tank.

The blowdown rate from the scrub solution receiver tank is controlled by level and specific gravity. If the specific gravity of the scrub solution exceeds a specified value (currently 1.05), or if the tank liquid level becomes excessive, the rate of blowdown sent to the liquid waste treatment plant is increased.

Process Sampling and Analysis

Sampling and analysis of all major streams during testing operations are essential to evaluate incinerator destruction and combustion efficiencies, evaluate offgas system performance, and to detect and quantify the presence of products of incomplete combustion or recombinant reactions.

The incinerator and offgas system configuration does not permit isokinetic sampling upstream of the quench and scrub system. To measure gas phase concentrations of products of incomplete combustion (PICs), samples are withdrawn from the hot zone between chambers and from the hot fluegas duct upstream of the quench column using modified EPA Method 5 sampling trains. Samples are also taken downstream of the HEPA filters and downstream of the activated carbon bed adsorber prior to discharge through the facility stack.

To obtain material balances for hazardous solid waste incineration, solid samples of the feed material and bottom ash are taken to provide data on waste fed to the incinerator and material remaining uncombusted in the ash. Bottom ash samples are collected at the ash packaging station following discharge from the incinerator and transfer to the collection system, providing a homogeneous ash sample from the test run.

Post run samples are collected of filter cake on scrub liquid filters and, if material is present, from the HEPA filters.

On-stream incinerator instrumentation includes gas phase oxygen and combustibles analysis between combustion chambers and at the secondary chamber discharge point. CO and CO_2 analysis of the secondary chamber and absorber tower exhaust streams and final gas flow rate at the HEPA filter plenum discharge are also measured on-line.

Locations for sampling of PICs, particulates, HCl, and scrub solution, and monitoring locations for NO_x, CO, CO_2, and O_2 throughout the incineration process are shown in Figs. 1 and 5.

Ash Removal

Ash generated primarily from the combustion of solid wastes is removed from the CAI by one of two methods. A gravity ash dropout system (GADOS) is used for ash removal during operation and a vacuum ash removal system is used for thorough cleanout of both chambers of the incinerator during shutdowns.

The GADOS consists of a refractory-lined pit and door in the floor of the CAI primary chamber. As new waste is fed to the incinerator, ash is pushed down the hearth until it drops into the ash removal pit. Periodically, the dropout door is opened for a brief time to allow ash to fall through a grate and delumper wheel into a collection hopper. The ash is then pneumatically transferred from the GADOS hopper and collected by a high-energy cyclone and sintered metal filter system into a second hopper for removal at the ash packaging station.

The vacuum system, which is capable of producing up to 26.7 kPa (107.2 in. WC) suction, also is used for vacuum ash cleanout during shutdown. This is achieved by manipulating a vacuum hose in the incinerator chambers through the access doors and gloveboxes on the ends of the chambers.

The ash packaging station consists of a bagout glovebox where ash is removed from the collection hopper through an interlocked isolation chamber. The chamber is first opened to the ash hopper and allowed to fill and is then isolated from the hopper and opened to drop contents into a collection bag.

After the ash is packaged it is stored for future studies or immobilization processing.

Control and Instrumentation

Design and specification of the CAI process control system received priority attention throughout the planning and construction phase. As the "nerve center" for the process, the controls not only assure effective component performance, but monitor performance data to assure the safety of continuing operations. Control design considerations started with the parameters affecting operation of the incinerator and primary offgas components. As the process design evolved, the considerations broadened to encompass the operation of ancillary equipment including backup utility supplies. A detailed description of the complete control system is well beyond the scope of this paper, however, the incinerator control features and a general overview of the total system design are described below.

Controls on the as-received incinerator were largely limited to pre-set conditions based on combustion experience for a particular waste composition. These controls were upgraded to accept a wider range of feed compositions and to minimize thermal cycling in the lower chamber. Both air and natural gas supplies are modulated to permit proportional rather than step response to demand. The air introduction rate for each stage is controlled by feedback from oxygen analyzers located at the exit of each chamber. The pressure differential between the incinerator interior and the operating area is maintained by a valve immediately upstream of the induced draft fan. Flow measuring elements and recorders monitor air, natural gas, and steam introduction rates for energy and material balance purposes.

For the offgas cleanup, conditioning, and filtration equipment downstream of the incinerator, the controlled variables are: venturi scrubber liquid feed rate and pressure drop; absorber tower liquid feed rate; condenser gas-phase temperature decrease; reheater gas-phase temperature increase; and HEPA filter pressure drop. The pressure drop and nominal temperature of each component is also monitored as an indication of normal versus deteriorating performance.

In the scrub solution recycle subsystem, a pH feedback arrangement controls neutralization of the liquid effluent from the primary offgas scrubbing components. Differential pressure is monitored across each liquid filter; process side temperatures are controlled in the graphite heat exchanger. Liquid level and specific gravity are controlled in the scrub solution receiver tank.

The primary variables as well as many other secondary variables and parameters are controlled and/or recorded at a central station. Variables considered critical to process operation and safety are tied into an alarm panel which positively identifies the off-range variable as an aid to trouble shooting. Off-range variables identified as vital to process safety will activate one of two automatic shutdown modes -- controlled or fast. Less critical variables require only operator response to correct off-range behavior.

A data acquisition system automatically records additional variable and parameter values generated during experimental CAI process runs.

Auxiliary Equipment

Backup utilities provide required services for an orderly process shutdown under abnormal circumstances. A diesel-powered generator, kept running during all incinerator operations, supplies standby power to high consumption equipment and vital motor-driven equipment. An on-line, floating battery system provides electrical power for process controls, data collection, and averting potential momentary power interruptions, which could result in control relay dropout. A two-hour auxiliary cooling water supply is stored in a pressurized container for release to the quenching system in the event of a recirculation pump failure because loss of cooling water constitutes an immediate threat of damage to process equipment. A backup air compressor and compressed nitrogen are available to supplement normal instrument air supply if required. Pneumatic actuators are designed to "fail safe" on loss of air pressure. Snuffing steam is injected into the primary chamber to extinguish burning waste in the event of a fast shutdown at high temperature to prevent uncontrolled burning and inefficient combustion, which can clog the offgas cleaning system with soot and heavy tars.

Radioisotope containment for the building is maintained by physical barriers and zoned ventilation. There are four separate ventilation zones. The pressure in each zone is regulated so that ventilation air moves from the highest pressure zone (atmospheric) toward the lowest pressure zone (the volume internal to the process). The interface between each zone is controlled by physical enclosures.

EXPERIMENTAL PROGRAM AND RESULTS

The CAI experimental program at Los Alamos is divided broadly into two areas by waste classification: radioactive and hazardous. The radioactive work consists of nonradioactive testing and development completed in late 1979, transuranic waste testing and demonstration which was completed in May 1980, and low-level beta-gamma waste testing which began in 1981. Modifications to the existing system have been completed to incorporate hazardous solid and liquid wastes into the CAI development program.

PCP-Treated Wood Testing

The purpose of the PCP-treated wood testing was to determine the destruction efficiency for PCP fed as a component on treated wood in the Los Alamos CAI at conditions simulating those obtainable in a potential disposal incinerator. It was also desirable to study the effects of feed rate, incineration, temperature, and excess air on the destruction efficiency for PCP. Operation was included with the conditions set to best model the incinerator proposed for final disposal of subject feed material. Details on the proposed disposal incinerator and operating conditions were not adequate for a comprehensive study.

PCP treated wood for testing was as similar as possible to the treated wood for which disposal options were being evaluated. Actual ammunition crate wood was supplied for use in the test run. Extracts from samples of the PCP-treated wood were analyzed and found to contain from 0.103 to 0.106% by weight PCP.

The ram feeder system on the CAI is designed to load 0.31 m x 0.31 m x 0.62 m boxes or bundles of waste. Slightly larger loading configurations are possible but modification of the system to alter the feed configuration significantly did not appear to be warranted. Therefore, the wood was packaged in the standard boxes at a density of 160.2 kg/m^3 (4.54 kg/box) and fed through the existing feed train.

The first phase of the test involved system startup and operation with untreated wood to verify that the system was functioning properly with no gross problems related to complete combustion of the wood. This phase was also to be used to obtain baseline samples for analysis. The second test phase involved testing with PCP treated wood at conditions specified to simulate the candidate system and to study the combustion characteristics of the PCP-treated wood.

The test conditions for the experimental program are summarized in Table I. Potential existed for studying the effect of feed rate, incinerator temperature and excess air (and, indirectly, residence time) on the destruction efficiency for PCP. Operating conditions included those which would best model the incinerator proposed for final disposal of subject feed material. Details of the proposed disposal incinerator and operating conditions were not adequate for a comprehensive study.

Results from analytical work on samples from the hot zone between the incinerator chambers and from the secondary chamber offgas are given in Table II. These samples were the samples of primary interest in the test burn and were analyzed both at Los Alamos and by Southwest Research Institute. Variation in reported amounts of PCP present in the samples by HPLC and GC/EC are most likely due to better component separation with the GC techniques.

No evidence of PCP, TCDD, or TCDF was found in any of the ash extracts. Samples taken downstream of the offgas system both before and after the carbon bed showed no evidence of unburned hydrocarbons.

The calculated destruction efficiency for PCP in the primary chamber was greater than 99.99% in all cases, based on the GC/ECD analytical information. The samples with reported PCP content by HPLC were taken during intervals involving upsets to normal operation. The actual destruction efficiency for PCP during normal operation is probably much better than 99.99% but the low concentration of PCP on the feed material and the difficult analysis for low levels of PCP in the offgas has precluded verification of the higher efficiency.

TABLE I. PCP-TREATED WOOD AVERAGE TEST CONDITIONS

Test Period*	Feed Rate kg/hr	Primary Chamber Temp °C	Primary Chamber Oxygen % vol	Secondary Chamber Temp °C	Secondary Chamber Oxygen % vol
1-1	27.2	921	6	1010	10
1-2	42.0	1000	6	1093	8
2-1	38.6	960	5	1102	8
2-2	30.6	932	6	1206	7
2-3	39.7	1029	5	1204	6
2-4	28.4	935	1	1192	8

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* Each test period consists of two sample periods of four hours each.

The results indicate that PCP-treated wood can be successfully incinerated at controlled conditions without creating an environmental hazard. The conditions in the primary chamber varied between approximately 910°C (1670°F) and 1025°C (1877°F) with excess air between 20% and 60%. Retention time for the gas phase in the primary chamber varied between 2.5 and 3.5 s based on waste pile burning on the hearth and effective use of 66.6% of the lower chamber volume.

A final report on this effort has been submitted to the Industrial Environmental Research Laboratory, EPA.

Future Plans

Future plans for hazardous waste incineration studies at Los Alamos include a proposed test on PCB materials. The proposed test will evaluate the destruction of high concentration (up to 50% PCB) feed at several operating conditions in the CAI.

Controlled air incineration is also being considered as a disposal method for other hazardous wastes. It is planned to utilize the test unit at Los Alamos for verification of incineration concept and evaluation of operating conditions for destruction of these wastes as they are identified.

SUMMARY

Modification of commercially available equipment and technology for radioactive service and production scale incineration of TRU-contaminated wastes were successfully demonstrated. Further modifications were made to incorporate incineration studies of hazardous solid and liquid wastes into the Los Alamos CAI development program. A recent incineration test demonstrated that

TABLE II. ANALYSIS OF INCINERATOR OFFGAS SAMPLES FOR PCP

Sample from:				Results* (in sample)		
Phase	Period	Location**	Interval	ppm PCP by GC/ECD	ppm PCP by HPLC	ppm PCP by GC/MS
1	1	HZ	1	ND+	ND	ND
1	1	HZ	2	ND	ND	ND
1	2	HZ	1	ND	ND	ND
1	2	HZ	2	ND	ND	ND
2	1	HZ	1	ND	1.64	ND
2	1	HZ	2	ND	ND	ND
2	2	HZ	1	ND	ND	ND
2	2	HZ	2	ND	ND	ND
2	3	HZ	1	ND	ND	ND
2	3	HZ	2	ND	ND	ND
2	4	HZ	1	ND	0.41	ND
2	4	HZ	2	ND	5.09	ND
1	1	OG	1	ND	ND	ND
1	1	OG	2	ND	ND	ND
1	2	OG	1	ND	ND	ND
1	2	OG	2	ND	ND	ND
2	1	OG	1	ND	ND	ND
2	1	OG	2	ND	ND	ND
2	2	OG	1	ND	ND	ND
2	2	OG	2	ND	ND	ND
2	3	OG	1	ND	ND	ND
2	2	OG	2	ND	ND	ND
2	4	OG	1	ND	ND	ND
2	4	OG	2	ND	ND	ND

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*GC/ECD by Los Alamos, detection limit 0.015 ppm in sample.

HPLC by Los Alamos, detection limit 0.5 ppm in sample for HZ samples.

HPLC by Los Alamos, detection limit 0.01 ppm in sample for OG samples.

GC/MS by Southwest Research Institute, detection limit 0.2 ppm in sample.

**Location: HZ = Hot Zone between primary and secondary incineration chambers; OG = Secondary chamber effluent.

+ND = below detection limits.

wood treated with pentachlorophenol can be successfully incinerated without creating an environmental hazard. Current efforts at Los Alamos include documentation of the CAI process design, operating procedures, and process data generated during te experimental campaigns. Technology transfer has and will remain an important object of the program.

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