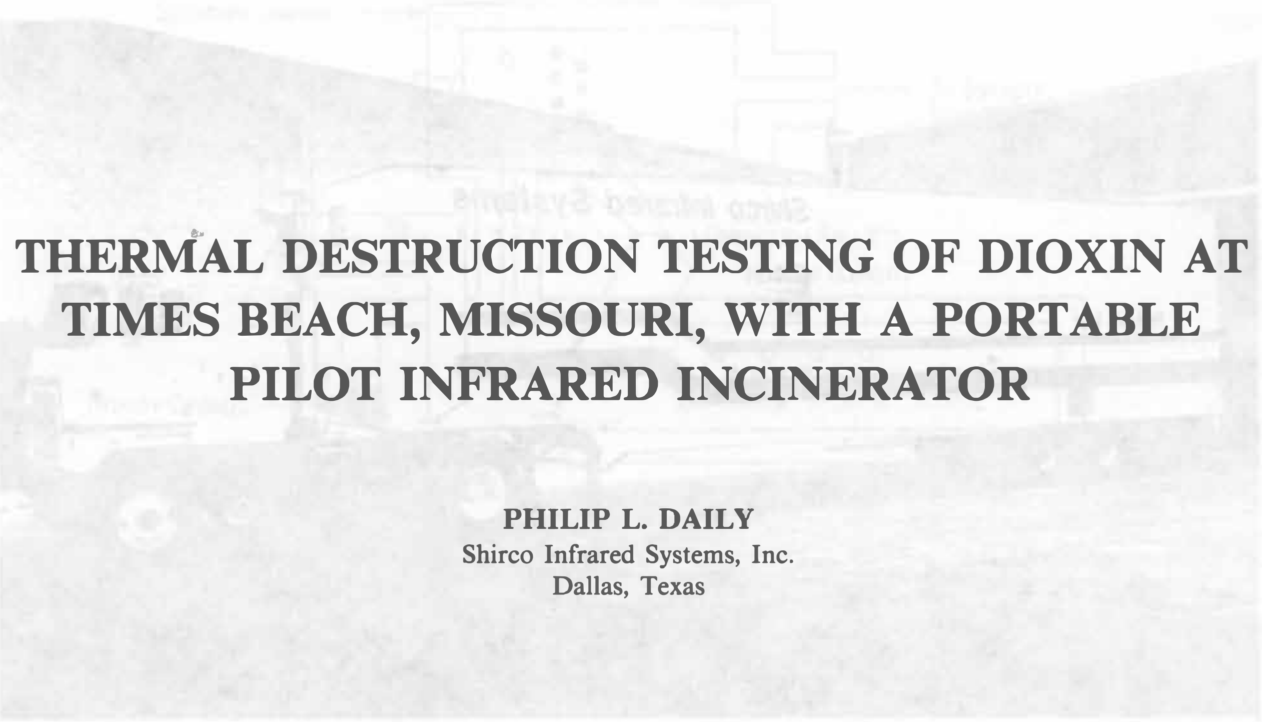

THERMAL DESTRUCTION TESTING OF DIOXIN AT TIMES BEACH, MISSOURI, WITH A PORTABLE PILOT INFRARED INCINERATOR

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INTRODUCTION

The U. S. EPA Hazardous Waste Management Regulations made transporting of hazardous materials to testing and destruction facilities difficult and expensive. A definite need existed for a trailer-mounted waste treatment system which could be brought to waste-producing or waste-storage sites for thermal process testing. In response to this situation, a Portable Pilot Test Unit was built (Fig. 1) and a series of tests were performed to demonstrate the unit's capabilities. The most significant of those tests to-date was the decontamination of soil containing dioxin. The construction of the Portable Unit and the results from the thermal testing of dioxin-laden soil will be reviewed.

PORTABLE UNIT CONSTRUCTION

The Portable Pilot Test Unit is designed to demonstrate the performance of the infrared furnace in a variety of thermal processing applications. The construction and process functions of the trailer-mounted furnace are identical to a full-scale infrared furnace. The system consists of a feed metering system, infrared primary chamber, a gas-fired secondary chamber, heating element power centers (HEPC's), and offgas handling, data acquisition, and control systems. The primary and secondary chambers are schematically depicted in Fig. 2. All equipment is enclosed in a 45 ft (13.7 m) van trailer.

Feed Metering System

Material for processing is fed by bucket or inclined conveyor onto a metering conveyor located at the feed end of the furnace. The feed end is located at the trailer's rear door to provide ease of access. The metering belt is synchronized with the furnace conveyor to control the material feed rate and has a clutch to provide automatic feed shut off, should process conditions require. The metering system includes a hopper mounted over a conveyor belt. The conveyor is shrouded and has rubber skirts to minimize inleakage of air or escape of furnace gases. An adjustable guillotine-type gate is provided at the conveyor discharge to distribute the material across the width of the metering belt. Final feed area sealing is provided by an additional adjustable knife gate in the feed chute at the point where the material enters into the furnace.

Primary Chamber

The primary chamber is a rectangular cross section box of carbon steel with nominal external dimensions

FIG. 1 PORTABLE PILOT UNIT

of 2.5 ft (0.8 m) wide × 9 ft (2.7 m) long × 7 ft (2.1 m) high, and has an installed weight of 3000 lb (1361 kg). The inner chamber is lined with multiple layers of ceramic fiber blanket insulation mounted on stainless steel studs, and retained with ceramic fasteners. The feed material is conveyed through the furnace on a woven, alloy steel, wire belt which is supported on high-temperature alloy shafts. The shafts are supported by external flange-mounted bearings. A friction drive system is used to pull the belt through the furnace. When the material reaches the discharge end of the furnace, it drops off of the belt into an enclosed hopper. The hopper contains a residue sampling drawer for collection of samples of ash during processing. A discharge screw conveyor is located at the bottom of the tapered hopper and transports the discharge material out of the van into a sealed collection drum. The primary chamber top can be arranged so that the gas flow within the chamber is either countercurrent or cocurrent. Infrared energy is provided by transversely mounted heating elements, equally spaced along the length of the furnace. The elements are silicon carbide rods, with external electrical connections. Access to the connections is gained by removing wireway covers. The heating elements are grouped into two control zones, with each zone being powered by a 10 kVA heating element power center (HEPC). The processing capabilities include up to a 1850°F (1010°C) process temperature, with material residence time variable between 10 and 180 min. Oxidizing, reducing, or neutral atmospheres can be provided.

Secondary Chamber

The secondary chamber is a rectangular carbon steel box with external dimensions of 3 ft (0.9 m) wide × 9 ft (2.7 m) long × 3 ft (0.9 m) high, and has a weight of 1500 lb (680 kg). The chamber is lined with ceramic fiber blanket insulation. A propane-fired burner is used to ignite combustible gases present in the exhaust, and maintain them at a predetermined setpoint temperature. An array of silicon carbide heating elements are installed to provide gas turbulence. A power center will be installed at a later date, to allow the chamber to serve as an electric infrared afterburner. The chamber is sized to provide the required combustion residence time for the gases at the setpoint temperature (typically 1.5–2.2 sec). The process temperature capability is 2300°F (1260°C), with a 2.2 sec gas residence time and up to 100% excess air. The burner is mounted in the chamber end plate, with the flame pattern in-

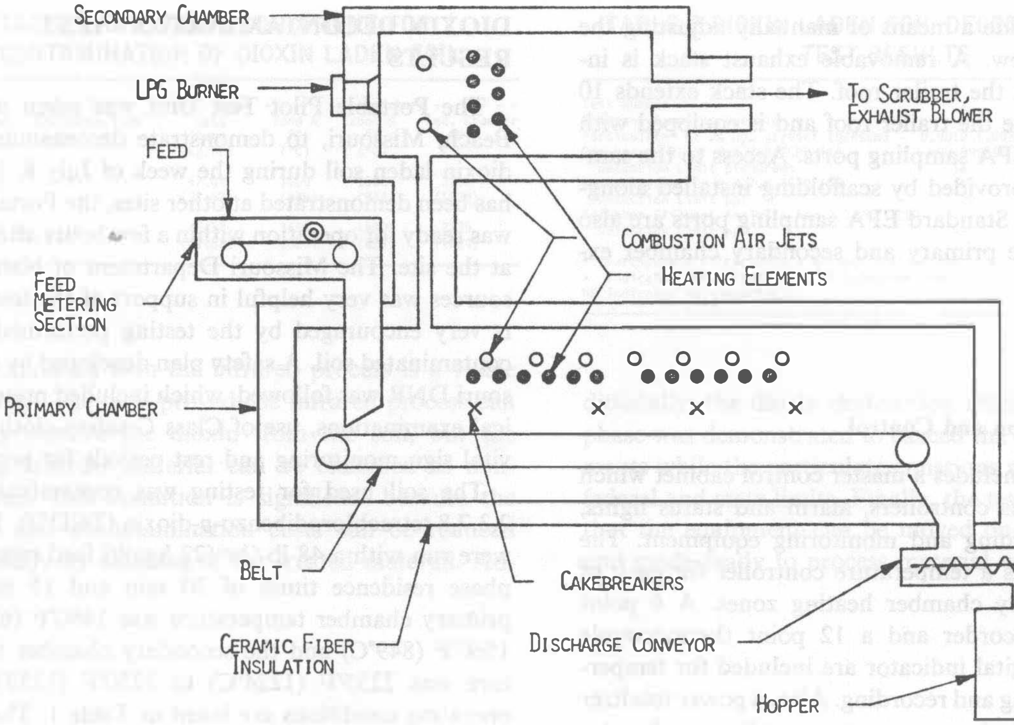

FIG. 2 ELECTRIC INFRARED INCINERATOR

tersecting incoming primary chamber exhaust gases at a 90 deg. angle. A pilot and electronic flame monitoring are provided.

Combustion Air

Combustion air for the primary and secondary chambers is supplied by a blower with manual adjustment of airflow rate. A splitter manifold with dampers at the blower outlet allows control of airflow to both chambers. In the primary chamber, air is injected at 10 points along the length of the chamber through a manifold system. Adjustment of the flow to any injection point is by means of manual blast gate valves. In the secondary chamber, air is injected through two offset jets on either side of the chamber, directed at the interface of the burner flame and exhaust gas inlet flow, providing a swirl to the gases. Adjustment of air flowrate is by means of a blast gate valve and the burner air registers.

Off Gas Handling

Exhaust gases from the secondary chamber pass through a venturi scrubber with a sump tank. This system consists of an adjustable venturi section containing liquid sprays, and a separator tower. A manually-adjustable, cone-type damper is located in the venturi section and is used to control scrubber pressure drop. The sprays in the venturi inject a fine liquid mist into the exhaust stream to agglomerate particulate grains as they pass through the sprays. The larger and heavier liquid-covered particulate grains are then removed in the separator tower by gravity, centrifugal force, and additional liquid sprays. The scrubber also cools the gases from their incoming temperature [1000°F (538°C)–2300°F (1260°C)], depending on processing requirements, to saturation temperature, usually about 180°F (83°C). Subcooling to a lower temperature can be performed, but consumes substantially more liquid. A recirculation pump is used to transport the liquid from the sump tank to the scrubber sprays. Reactive material, such as lime, can be added to the scrubber sump tank for acid removal. An induced draft exhaust blower is located on the discharge side of the scrubber. The blower is capable of exhausting the primary and secondary chambers, producing a slight draft on the system, while overcoming the 10.0 in. wc (254 mm wc) pressure drop of the scrubber. A butterfly damper is located on the outlet side of the blower to provide a means of manually adjusting the exhaust gas flow. A removable exhaust stack is installed through the trailer roof. The stack extends 10 ft (3.0 m) above the trailer roof and is equipped with two standard EPA sampling ports. Access to the sampling ports is provided by scaffolding installed alongside the trailer. Standard EPA sampling ports are also provided in the primary and secondary chamber exhaust ducts.

Data Acquisition and Control

The system includes a master control cabinet which contains process controllers, alarm and status lights, and data recording and monitoring equipment. The cabinet contains a temperature controller for each of the two primary chamber heating zones. A 6 point temperature recorder and a 12 point thermocouple switch with digital indicator are included for temperature monitoring and recording. Also, a power totalizer is installed for each power center as well as a voltmeter and ammeter for each phase to provide monitoring of electrical usage. A time totalizer accumulates operating time on the furnace. Additional process parameters monitored are primary chamber pressure, secondary chamber pressure, burner gas pressure, combustion air pressure, scrubber venturi liquid flow rate and pressure, scrubber separator liquid flowrate and pressure, scrubber tank liquid level, and scrubber differential pressure. The principal electrical components have lights to annunciate their status. Alarm lights are also installed in the cabinet to annunciate high primary chamber zone temperature, an open wireway cover, both low and high secondary chamber temperature, and high stack temperature.

Heating Element Power Centers

Heating elements in each of the two primary chamber zones are powered by a 10 kVA heating element power center to control the flow of electricity to the heating elements. Primary power input required for each power center is 3 phase, 60 Hz, 480 V at 12 kVA. A similar HEPC will be installed for the secondary chamber at a later date. Each power center consists of a silicon controlled rectifier (SCR) power controller driving the heating elements through a tapped step down transformer, mounted in a NEMA 3R (ventilated) enclosure.

DIOXIN DECONTAMINATION TEST RESULTS

The Portable Pilot Test Unit was taken to Times Beach, Missouri, to demonstrate decontamination of dioxin laden soil during the week of July 8, 1985. As has been demonstrated at other sites, the Portable Unit was ready for operation within a few hours after arrival at the site. The Missouri Department of Natural Resources was very helpful in support of the testing and is very encouraged by the testing performed on the contaminated soil. A safety plan developed by the Missouri DNR was followed, which included pretest physical examinations, use of Class C safety clothing, and vital sign monitoring and rest periods for personnel.

The soil used for testing was contaminated with 2,3,7,8 tetrachlorodibenzo-*p*-dioxin (TCDD). The tests were run with a 48 lb/hr (22 kg/h) feed rate at solid phase residence times of 30 min and 15 min. The primary chamber temperature was 1490°F (623°C) to 1560°F (849°C) and the secondary chamber temperature was 2235°F (1224°C) to 2250°F (1233°C). The operating conditions are listed in Table 1. The testing took place over a two day time period, followed by decontamination of the furnace and van. Emission samples were taken over a 7 hr period for the 30 minutes residence time case and over a 2.5 hr period for the 15 min case. Continuous samples were also taken of the thermally treated soil for each run condition. The sampling procedure was developed such that sufficient gas sample would be taken to confirm 99.9999% or greater destruction and removal efficiency (DRE) for the 2,3,7,8 TCDD isomer.

The test results, presented in Table 2, indicate that the treated residual material and the scrubber effluent were free of dioxin down to the detection limits listed. The DRE's for the dioxin isomer for both residence times exceeded 99.9999% when calculated at the detection limits. The detection limits were determined based on the size of the gas samples collected. Also, the particulate emissions were a small fraction of the 0.08 gr/dscf (0.18 g/dscm) EPA regulation requirement.

CONCLUSION

The Portable Pilot Test Unit was built to demonstrate the performance of thermal processing at the source of the material, rather than at some remote site of stationary equipment. The dioxin decontamination tests conducted at Times Beach, Missouri, demonstrated that on-site thermal processing of acute haz-

TABLE 1 OPERATING CONDITIONS FOR DECONTAMINATION OF DIOXIN LADEN SOIL

Test	TCDD in Feed (ng/g)	Solid Phase Residence Time (minutes)	Solid Feed Rate lb/hr (kg/hr)	Temperature		
				Zone A °F (°C)	Zone B °F (°C)	Sec. Chamber °F (°C)
1	227	30	47.68 (21.62)	1560 (849)	1550 (844)	2250 (1233)
2	156	15	48.12 (21.82)	1490 (623)	1490 (623)	2235 (1224)

TABLE 2 DIOXIN LADEN SOIL DECONTAMINATION TEST RESULTS

Test Number	1	2
Emissons Sampling Duration hr	7	2.5
Particulate* at 7% O_2 gr/dscf (g/dscm)	0.0010 (.0023)	0.0002 (.0005)
Gas Phase DRE of 2,3,7,8 TCDD (%)	>99.999996	>99.999989
Detection Limit picograms	14	8.4
Ash Analysis for 2,3,7,8 TCDD (%)	ND	ND
Detection Limit ppt	38	33
Scrubber Effluent Analysis for 2,3,7,8 TCDD	--	ND
Detection Limit ppb	--	1.0

* Particulate Filter Only - Without Train Rinse

\> Indicated DRE calculations at Detection Limit

ND Indicated Non-Detectable

ardous materials with the infrared process is a viable technology. The tests proved the infrared process can not only remove the dioxin from the soil, but the resulting residual material can be classified as non-hazardous. This condition is significant because the disposal and decontamination costs can be reduced substantially by delisting of the treated material. Additionally, the dioxin destruction efficiency in the gas phase was demonstrated to exceed the RCRA requirements while the particulate emissions remained within federal and state limits. Finally, the testing has proven that the equipment can be moved on-site, be set up, and made ready to process material very quickly.