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Project Summary

Facilities Evaluation of High Efficiency Boiler Destruction PCB Waste

J. E. Cotter and R. J. Johnson

A rendering plant by-product, yellow grease, was found to be contaminated by PCB's from a transformer leak. The PCB content (under 500 ppm) determines the method of disposal under 40 CFR Part 761. For this evaluation, destruction in a high-efficiency boiler was evaluated as an alternative to landfill disposal. The process steam boiler belonging to the waste owner, Seattle Rendering Works, was evaluated as a candidate site for waste destruction. The logistics and fuel handling requirements were found to be feasible to set up in a short time, and the boiler size and residence time were determined to be likely to allow high destruction efficiency. With 99.9% destruction of PCB's, the downwind concentration was estimated by diffusion modeling to be less than OSHA limits for industrial exposure. Fuel characteristics of the yellow grease were used to support the recommendation for 100% grease fired as fuel.

A second high-efficiency boiler candidate was also evaluated. The Shuffleton power plant, operated by Puget Sound Power & Light Company, operates three boilers from a common oil fuel supply system. The size and facilities at this site were determined to satisfy all the prerequisites for high-efficiency boilers (40 CFR Part 761), and to best be operated by blending the waste with the normal fuel oil supply. A 30% waste blend was evaluated and found to be completely miscible and feasible with respect to logistical support.

A verification test burn was recommended and outlined for either candidate site. Current EPA protocol and policy developments for PCB destruction were found to be appropriate for the preparation of a candidate facility test plan and an example public notice.

This report is submitted in fulfillment of Contract No. 68-02-3174, Work Assignment No. 11, by TRW Environmental Engineering Division, under sponsorship of the U.S. Environmental Protection Agency. This report covers the period January 10, 1980 to April 1, 1980, and work was completed as of July 1, 1980.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, 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

Source of Contaminated Waste

A quantity of tallow (yellow grease), produced from the rendering of chicken packing by-products, was contaminated by a transformer leak at a packing plant in Billings, MT. The incident occurred in 1979, and by mid-1979 the contamina-

ted yellow grease had already been sold to distributors who had combined the contaminated material with other stocks. Routine FDA inspections identified the PCB contamination, and subsequent analyses of blended stocks were carried out. The FDA notified the EPA Region X headquarters in September 1979 of the results of those analyses where the PCB content was greater than 50 ppm, and therefore subject to EPA jurisdiction.

All grease stocks containing more than 50 ppm of PCB were traced to two tanks at 2900 11th Avenue SW, Seattle, WA. The tanks contain (as of the date of this report) approximately 500,000 lbs and 600,000 lbs, or about 150,000 gallons total. FDA inspection of the grease revealed PCB concentrations ranging from 116 to 391 ppm, based on four samples taken from the tanks, and duplicate assays.

Disposal Options

The contaminated grease, having a PCB content of under 500 ppm, does not require destruction in an EPA-approved incinerator. The final ruling governing PCB disposal, 40 CFR Part 761, identifies destruction in high-efficiency boilers or disposal in chemical landfills as acceptable alternatives.

"High-efficiency" boilers are defined to include power generation boilers and industrial boilers that operate at a high combustion efficiency (99.9%) as defined by the percentage ratio of CO_2 to $CO+CO_2$ concentrations in the combustion gases. These boilers are assumed to be capable of achieving 99.9% or greater PCB destruction efficiency.

There are two approved locations in EPA Region X where PCB contaminated waste may be disposed. These chemical landfills are Chem-Nuclear Systems (Arlington, OR) and Wes-Con (Grand View, ID). It was estimated by Region X that landfilling would cost a waste owner around 8¢/lb.

Prerequisites for High-Efficiency Boiler Destruction

The Regional Administrator may grant approval for PCB thermal destruction in a boiler if a number of prerequisites are met:

1. The boileris rated at a minimum of 50 million Btu/hour.
2. The PCB contaminated waste comprises no more than 10% of the total volume of fuel.
3. The waste will not be added to the combustion chamber during boiler start-up or shut-down operations.
4. The combustion emissions will contain at least 3% excess oxygen and the carbon monoxide concentration will be less than 50 ppm for oil- or gas-fired boilers or 100 ppm for coal-fired boilers.
5. The combustion process will be monitored continuously or at least once each hour that the PCB contaminated wastes are being burned to determine the percentage of excess oxygen and the carbon monoxide level in the combustion emissions.
6. The primary fuel and waste feed rates are monitored at least every 15 minutes whenever burning the waste.
7. The carbon monoxide and excess oxygen levels are monitored at least once an hour, and if they fall below the levels specified, the flow of wastes to the boiler is stopped immediately.
8. Records are maintained that include the monitoring data in (5) and (6), above, and the quantities of PCB-contaminated waste burned each month. When burning PCB wastes, the boiler must operate at a level of output no less than the output at which the reported carbon monoxide and excess oxygen measurements were taken.

Candidate Sites for Waste Destruction

Two boiler/incinerator sites were selected for study in this report: the steam boiler at the Seattle Rendering Works plant in Seattle, WA, and the utility boilers at Puget Sound Power & Light's Shuffleton Plant in Renton, WA.

Seattle Rendering Works Analysis

Facility Operations Background

The Seattle Rendering Works, Inc., facility is located at 5795 S. 130th Place, Seattle, WA, adjacent to the Duwamish River and the Foster Golf Course. It is a dual-fuel (gas and/or No. 6 oil) water-tube Cleaver-Brooks model (Delta D-60) with a design capacity of 35,000 lbs steam/hr. The oil burner is a low-pressure air-atomizing type. The rated gas-fuel efficiency is 78%, so the design heat input is 46,000,000 Btu/hour. The furnace volume is 755 cu ft in the immediate combustion zone, excluding the upper radiant section. Typical stack temperatures at maximum firing are 550-560°F. The combustion zone temperatures are in excess of 2200°F at the back wall. A steam-heated preheater is capable of raising incoming oil temperatures of 100-240°F. The oil feed pressure is maintained by a gear pump, which is protected by a duplex 30-mesh strainer on the suction side.

The boiler operates at full modulation from a low- to high-fire position, regulated by steam pressure, which is directly affected by steam demand. Since a PCB destruction program would be required to operate at a steady rate of waste fuel consumption, there would be a change from normal boiler operating practice. If the fuel waste were consumed at maximum fuel feed rates, then some of the generated steam would have to be dumped when process demands dropped off. In the case of waste fuel consumption at some intermediate rate, auxiliary heating must be made up by firing natural gas simultaneously during high demand periods, and excess steam would have to be dumped at low demand conditions.

Recommendations on the Feasibility of Using the Seattle Rendering Boiler

Suitability of Yellow Grease as Boiler Fuel

The inspection of a grease sample from one of the contaminated shipments (Fujitsuki Maru No. 1, port tank 09-15-79) produced the results, shown

in Table 1; two grades of fuel oil are shown by comparison. These inspection results provide some confidence that the grease could be burned undiluted, since:

- The viscosity is between that of No. 5 and No. 6 fuel oil, so atomization should be good with a burner that is usually run with No. 6 oil.
- The fuel value of the grease is 93% of a No. 6 oil value.
- The ash content is low.

Furthermore, Pierce Packing* confirmed that they had burned 600,000 lbs of grease in their steam boiler, with good combustion characteristics.

Estimated Destruction Efficiency

The residence time of the PCB's in the furnace combustion zone has to be determined as part of the evaluation of destruction efficiency. At a waste feedrate of 6 gpm, the actual volumetric flowrate of combustion gases through the 755-cu ft furnace volume is 43,097 acfm, yielding a residence time of 1.1 seconds. The residence time will be twice as long at a feedrate of 3 gpm, since the gas volumetric rate is half as much.

The estimated destruction efficiencies under these conditions depend on a number of factors, including:

- Comparison of residence time and temperature to those specified in 40 CFR, Part 761, Subpart E: 1200°C (2191°F) @ 2 seconds, or 1600°C (2912°F) @ 1.5 seconds dwell: (these conditions are for waste incinerators, burning PCB wastes of any concentration).
- Estimated efficiency of the Cleaver-Brooks burner, and the ease of atomization of the grease fuel, as compared to No. 6 fuel oil.
- The likelihood of achieving high destruction efficiencies with PCB concentrations of a few hundred ppm, vs. percentage range concentrations found in some other wastes (it's always easier to remove high percentages of high concentrations). A 99.9% destruction efficiency is often obtained with high efficiency incinerators and high PCB concentrations.

The likelihood of achieving 99.9 + % PCB destruction is estimated to be very good at a 3 gpm feedrate, since the time and temperature relationships may approximate those of good incinerator practice. It is less certain that a 6 gpm feedrate would yield equivalent destruction efficiency, but the operation at 6 gpm would certainly be preferred for reducing the program length. Therefore, the verification test should determine the destruction efficiency and combustion temperature at both feedrates.

The boiler operation under automatic control will allow full modulation from low- to high-fire, regulated by steam pressure. High-fire fuel demand would be about 6 gpm, since the Btu content of grease and No. 6 oil are similar. Low-fire demand is about 25% of high fire, or about 1.5 gpm.

Although the Cleaver-Brooks boiler at Seattle Rendering does not meet the standard prerequisite of 50 million Btu/hr heat input (at full output), it comes close at 46 million Btu/hr.

It is recommended that the standard prerequisite of a maximum blend of 10% waste (with the remainder fuel oil) is less appropriate for the Seattle Rendering program than a 100% waste fuel choice. The 10% blend is based on the possibility of using any waste, including those with very low fuel value. As already noted, the Btu content of yellow grease is very close to No. 5 or No. 6 fuel oils, and the combustion characteristics are judged to be good. Furthermore, there are no facilities available for blending grease and fuel oil.

Environmental Impact

The anticipated impact of PCB waste burning at the Seattle Rendering facility was modeled with a point-source dispersion model, actual stack dimensions, and a range of local meteorological conditions, as reported from the PSAPCA* station at Tuckwila/South Center, about 2 miles south of the plant.

The flat-terrain dispersion model is only useful for impact analysis up to the point of a significant terrain change. The prevailing winds at the source location (35% of the time) are south to southwest, with neutral (Class "D") atmospheric stability.

There is a sharp terrain rise of 50 m only 400 m in a prevailing (SSW) direction from the rendering plant source. The calculated effective stack height is 40-65 m. Model predictions at 400 m of PCB concentrations at the plume centerline (which is a worst-case condition) are as follows:

Feed Rate gpm	*Wind Speed m/sec*	*No PCB Destruction μgm^3*	*99.9% PCB Destruction ng/m^3*
6	*10*	*6.4*	*6.4*
6	*4*	*16.4*	*16.0*
3	*10*	*1.6*	*1.6*
3	*4*	*4.0*	*4.0*

The modeling estimates are based on calculated emission quantities as follows:

- 6 gpm feedrate using worst-case of 400 ppm PCB's: 9110 scfm stack discharge, 0.12 g/sec uncontrolled, 0.12 mg/sec controlled emission rates.
- 3 gpm feedrate, using moderate-case of 175 ppm PCB's: 4555 scfm stack discharge, 0.03 g/sec uncontrolled, 0.03 mg/sec controlled emission rates.

The ground-level concentration of the plume under flat-terrain assumptions may be more realistic at 1.5 to 2 km downwind, after the plume has passed over the bluff. The atmospheric PCB concentrations for a 99.9% efficient destruction operation are in the range of 0.1 to 0.4 ng/m^3.

Techniques for ambient monitoring of these extemely low PCB concentrations are still being developed, but it is recommended that an attempt be made to make such a measurement at the most likely downwind position, in support of the verification test.

*Billings, MT.

*Puget Sound Air Pollution Control Agency.

An analysis of downwash concentrations of PCB's was also done, using the building as an area source. In a downwash model, dispersal of pollutants occurs in the immediate, ground level vicinity of a source, rather than through an elevated plume. Calculated atmospheric concentrations of PCB's were estimated to be around 0.2 ng/m^3 with 99.9% destruction. The OSHA limit for worker exposure to PCB's on an 8-hour day, 40-hour week basis is 1 mg/m^3 with 42% PCB chlorine content, so that the downwash concentration certainly does not threaten worker safety.

Shuffleton Power Plant Analysis

Facility Operation Background

The Shuffleton Power Plant, owned by the Puget Sound Power and Light Co., (PSPL), is located at 1101 Lake Washington Blvd., Renton, WA. Shuffleton is operated at a steady level of 330,000 lb/hr of steam in each of three oil-fired boilers. The Shuffleton boilers are balanced draft type (FD, ID fans); there are 16 Peabody mechanical burners in each boiler, burning No. 6 fuel oil heated to 200°F.

The available measurements include air/fuel ratio, oil pressure, windbox pressure, furnace draft, fuel oil temperature, air preheater temperature and pressure, and oxygen in the stack gases. Fuel oil is not presently metered, although an orifice exists in the fuel oil line.

The fuel oil is supplied from large storage tanks to two smaller service tanks, each having a working capacity of 800 bbls. The tanks are run alternately, on about a 5-hour cycle, while 3600 to 3900 bbl per day of fuel oil are consumed. The tanks have open hatches at the top which could be used for pumping in other fuels to get a mixed fuel. The fuel is kept at 150°F in the service tanks. The fuel oil is pumped out of the service tanks by three 80 gpm pumps, and distributed through heat exchangers to raise the fuel temperature to 200°F. The fuel is then injected into each of the burners in the three boilers. The viscosity of No. 6 oil is sufficiently lowered by the 200°F preheat to get good burner and combustion performance.

The operations of the Shuffleton power plant are not expected to be hindered by the proposed PCB waste incineration, as indicated by the following discussion on feasibility. Three-shift operations coverage of the boiler and fuel handling system will provide the necessary surveillance of combustion performance that is needed for PCB incineration. There is reason to believe that close surveillance is mandatory for maintaining good combustion at Shuffleton. The plant has received frequent citations for opacity violations, despite a test of the No. 1 boiler which showed particulate emissions within compliance. A combustion consultant's report submitted to Puget Power identified possible causes of poor combustion to include inadequate fuel atomization (due to low fuel oil temperature) and dirty burner.

Recommendations on the Feasibility of Using the Shuffleton Boilers for PCB Waste Incineration

Suitability of Yellow Grease as a Boiler Fuel

The first consideration for suitability is the determination of miscibility, or degree of mixing, of grease and No. 6 fuel oil, since using a blended fuel is technically the simplest method for waste incineration in a large boiler. Yellow grease and No. 6 fuel oil mixing tests were conducted by Northwest Laboratories at two blend ratios (10% and 30% grease, by volume) and two temperatures (180°F and 200°F). The results of these four tests were consistent; the blends were miscible, with no stratification, at all conditions.

The inspection of a grease sample from one of the contaminated batches by Northwest Laboratories produced the results reported in Table 1; two grades of fuel oil are shown by comparison.

The previous inspection results provide further confidence that the grease will combust well with No. 6 fuel oil, since:

- The viscosity is between that of No. 5 and No. 6 fuel oil, so burner atomization with the blended fuel should be good.
- The fuel value of the grease is 93% of a No. 6 oil value.
- The ash content is low.

Estimated Destruction Efficiency

The residence time of the PCB's in the boiler combustion zone is a consideration in the evaluation of destruction efficiency. At a typical fuel feedrate of 38 gpm, and 4-5% excess oxygen, the calculated rate of combustion gas flow is 1111std cu ft/sec. The estimated residence time in the lower half of the boiler is 2.5 seconds, with another 2.5 seconds dwell in the upper zone. The temperature in the combustion zone, in the vicinity of the burners, has been measured at 2800°F.

The estimated destruction efficiencies under these conditions depend on a number of factors, including:

- Comparison of residence time and temperature to those specified in 40 CFR, Part 761, Subpart E: 1200°C (2192°F) @ 2 seconds, or 1600°C (2912°F) @ 1.5 seconds dwell: (these conditions are for waste incinerators, burning PCB wastes of any concentration).
- Efficiency of the burners and the ease of atomization of the grease and No. 6 fuel oil blend.
- The likelihood of achieving high destruction efficiencies with blended PCB concentrations of less than 100 ppm, vs. percentage range concentrations found in some other wastes (it's always easier to remove high percentages of high concentrations). A 99.9% destruction efficiency is often obtained with high efficiency incinerators and high PCB concentrations.

The likelihood of achieving 99.9% PCB destruction is estimated to be good, given the similarity of the boiler conditions to good incinerator practice, and the compatibility of the grease and No. 6 fuel oil.

It is recommended that the PCB incineration be conducted with a grease-to-fuel oil ratio of 30/70 instead of the standard prerequisite ratio of 10/90. There are good arguments for using a 30% blend, since the length of time needed to complete the effort will be shortened by a proportionate amount, and the grease is not expected to cause any combustion problems or available heat reductions. The environmental consequences of burning a 30% blend, and the logistical limitations of support-

Table 1. Laboratory Inspections

	Grease	No. 5 Fuel Oil	No. 6 Fuel Oil
Viscosity			
SUS @ 122°F	*143.7*	*40*	*300*
SUS @ 200°F	*59.8*	—	—
Density, lb/gal			
@ 122°F	*7.459*	*@ 60°, 8.0*	*@ 60°, 8.33*
@ 180°F	*7.266*	—	—
Btu/lb	*16,779*	*18,250*	*18,000*
Moisture %	*0.41*	*0.05*	*0.05*
Water & Sediment %	*2.8*	*1*	*2*
Carbon %	*76.6*	*87.5*	*88.3*
Hydrogen %	*11.9*	*10.2*	*9.5*
Oxygen %	*10.5*	—	—
Sulfur %	*0.01*	*1.1*	*1.2*
Ash %	*0.12*	—	*0.1*

ing a higher grease percentage, are discussed below.

Environmental Impact

The anticipated impact of PCB waste burning at Shuffleton power plant was modeled with the EPA "Valley" model, which takes into account a certain amount of terrain variation. The computer program was run by the PSPL quality control staff, using terrain and stack dimension parameters already set up for the Shuffleton plant and vicinity.

The model was run with a low wind speed of 2.5 m/sec and a prevailing southwest wind, over a range of atmospheric stability conditions. The most stable conditions ("F" stability) usually yield the highest ground concentrations of a pollutant, since dispersion by air mixing is minimal. The following normalized data factors were computed for stability Classes A through F (A being the most unstable). The data factors are multiplied by an estimated emission rate to get a maximum 1-hour concentration at the indicated downwind distance.

	Stability Class		
	F	*E*	*D*
Data Factor →	*3.95*	*2.11*	*0.027*
Location of max. 1 hr PCB concentration at groundlevel	*2 km NE*	*2 km NE*	*12 km NE*

	Stability Class		
	C	*B*	*A*
Data Factor →	*0.129*	*0.245*	*0.20*
Location of max. 1 hr PCB concentration at groundlevel	*4 km NE*	*2 km NE*	*near plant*

The maximum 1-hour PCB concentration can then be estimated using "F" stability conditions, from the emission rates determined as follows:

a. 10% blend, 3200 gal of 400 ppm (worst-case) grease burned over a 5-hour period yield 0.24 g/sec (no control), or 0.24 mg/sec (99.9% controlled) emission rate.

   Worst-case model prediction for downwind PCB concentration = 3.95 x 0.24 = 0.9 $\mu g/m^3$ (no control), or 0.9 ng/m^3 (99.9% control) at 2 km NE of plant.

b. 30% blend yields three times the emission rate above—0.71 g/sec (no control), or 0.71 mg/sec (99.9% control).

   Estimated downwind PCB concentration at 2 km NE then will be: 2.7 $\mu g/m^3$ (no control), or 2.7 ng/m^3 (99.9% control).

These estimates can be compared to the OSHA exposure limit for PCB's. The OSHA allowable concentration for worker exposure on an 8-hour day, 40-hour week basis is 1 mg/m^3 with 42% chlorine content in the PCB's.

Techniques for ambient monitoring of these extremely low PCB concentrations are still being developed, but it is recommended that an attempt be made to make such a measurement at the most likely downwind position, in support of the verification test.

J. E. Cotter and R. J. Johnson are with TRW, Inc., Redondo Beach, CA 90278.
***David C. Sanchez** is the EPA Project Officer (see below).*
The complete report, entitled "Facilities Evaluation of High Efficiency Boiler Destruction PCB Waste," (Order No. PB 81-178 287; Cost: $6.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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