Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP42 Section 2.3

Reference: 18

Title: Report On A Stack Sampling Program To Measure The Emissions Of Selected Trace Organic Compounds, Particulates, Heavy Metals, And HCl From The Royal Jubilee Hospital Incinerator, Victoria, British Columbia,

M. J. Bumbaco,

Environmental Protection Programs Directorate, April 1983.

REPORT ON A STACK SAMPLING PROGRAM TO MEASURE THE EMISSIONS OF SELECTED TRACE ORGANIC COMPOUNDS, PARTICULATES, HEAVY METALS AND HCl FROM THE ROYAL JUBILEE HOSPITAL INCINERATOR, VICTORIA, B.C.

by

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2 PROCESS DESCRIPTION

The Royal Jubilee Hospital uses a Consumat Model C-760 pathological incinerator to dispose of its solid wastes. A schematic representation of this plant is given in Figure 1. The incinerator operates on the controlled air principle with combustion occurring in two stages. In addition, the plant is equipped with a system to extract heat from the stack gas before exhausting it to the atmosphere. The main components of the incinerator consist of the feed system, the primary combustion chamber, the secondary combustion chamber and the heat recovery unit.

2.1 Waste Feed System

The waste feed system consists of a 61 cu. ft. rectangular feed box, a fire door to isolate the loading chamber from the combustion chamber and a hydraulically operated ram to force the load into the combustion zone. With the ram fully retracted and the fire door closed, the wastes are loaded into the feed box. After the feed box door is closed, the loading of the charge into the incinerator is automatically controlled in order to minimize the amount of air entering the primary chamber and to prevent combustion in the feed box. The fire door opens, the ram pushes the load into the primary chamber and then withdraws to just clear the fire door. The fire door then closes and the ram fully retracts to allow the loading cycle to be repeated. During normal operation a batch of waste is fed into the incinerator about every 5 minutes.

2.2 Primary (Lower) Combustion Chamber

The primary combustion chamber is a 9' x 12' horizontal refractory-lined cylinder. After an initial charge of about 800 lbs has been loaded into the chamber, oil burners on each side ignite the wastes. The rate of combustion is then modulated by blowing controlled amounts of air into the chamber through ports, located near the bottom, along each side wall and in the end wall of the chamber. The primary chamber combustion temperature is normally set for 1400 °F. When this temperature is exceeded, water sprays located in the roof of the chamber, are turned on. The water sprays are turned off if the temperature falls below the 1400 °F set point.

The air supply to the primary chamber is controlled to below the stoichiometric requirements for combustion. In this way, the combustion rate is reduced, production of off-gases is limited and pyrolysis of the waste is encouraged. This results in

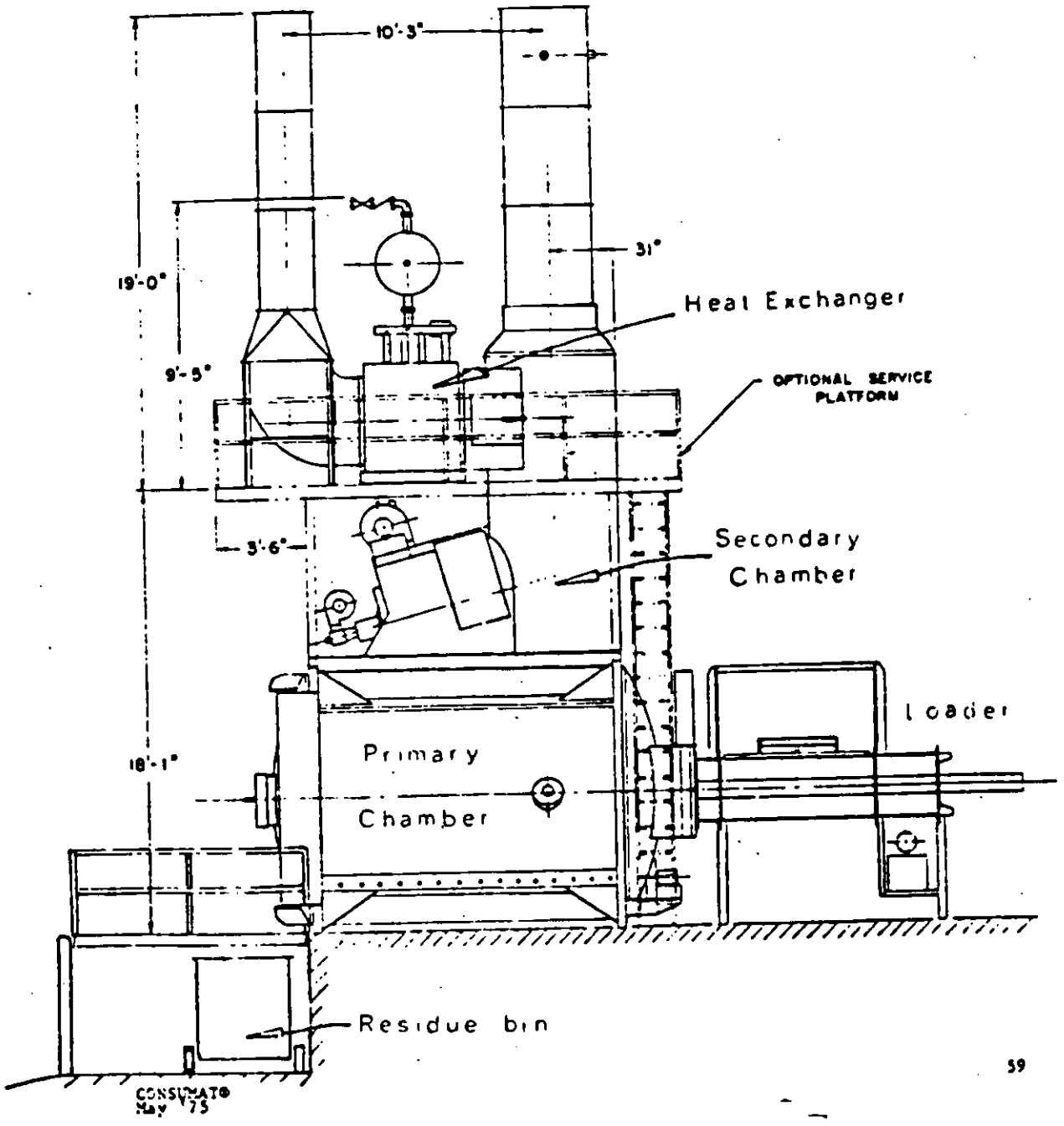

FIGURE 1 SCHEMATIC OF ROYAL JUBILEE HOSPITAL INCINERATOR

low gas velocity (increased residence time) in the primary chamber and reduced gas flowrates or carryover of unburned solids to the secondary chamber.

The incinerator is equipped with an adjustable 5-hour burndown timer that operates continuously after start-up. The timer is reset each time the fire door or manual charging door is opened. This allows the incinerator to burn down automatically and shut down after the last load of waste each day. The lower chamber air blower continues to run during this period to ensure complete combustion and to help cool the chamber. The ash is manually removed from the incinerator the next morning.

2.3 Secondary (Upper) Combustion Chamber

The secondary chamber is designed to burn the volatile gases and fine combustible particulates generated in the primary chamber. A thermocouple, located in the end of the secondary chamber, controls the modulating motor which opens the upper blower dampers and controls the firing rate of the burner in the secondary chamber. If the temperature rises rapidly or gets to within 50 °F of set point, the modulating motor will open the upper blower dampers and put the upper burner on the low fire position. At the same time, the lower chamber blowers will be turned off and, as the temperature drops, the system will modulate to maintain optimum temperature in the chamber. If the temperature falls 50 °F below the set point, the lower chamber blower is turned on again.

2.4 Heat Recovery Unit

The heat recovery system is a prepackaged unit which contains a water-tube heat exchanger, a steam separator drum and a soot blower. Gases from the secondary combustion chamber flow to the bottom of the dump (high temperature) stack. This stack has a 37" inside diameter, is refractory-lined and fitted with an annular orifice at its base to provide dilution air. This high temperature stack is used to vent the combustion gases when heat recovery is not required or during start-up when the flue gas temperatures are not hot enough. When heat is to be recovered, the hot gases are diverted from the dump stack by means of an aspiration unit. The aspirator section mates with the downstream end of the heat exchanger. An air jet pump creates a vacuum which draws the hot gases through the heat exchanger. Steam produced in the heat exchanger is stored in a reservoir, then transferred to the hospital boiler plant. The cooled gases flow out of the unit, mix with the aspirator jet, and are exhausted to atmosphere from the secondary stack. The secondary stack is a 29" i.d. mild steel unit which was fitted with a four-foot extension and appropriate ports to allow for sampling of the stack emissions.

2.5 Waste Composition

The hospital normally segregates bulk plastics from the feed and dispose of these to a landfill site. The majority of these larger plastic items come from the operating rooms and amount to about 150 lbs/day. During this study these bulk wastes were added to the feed for all runs except Run no. 4 on February 28. Originally, the intention was to quantify the effect of bulk plastics on the concentration of the organics in the exhaust gases. However, as the garbage already contained significant quantities of plastics it was decided that the bulk plastics would only have a marginal effect, if any, on the organic emissions.

3 SAMPLING PROCEDURES

Stack samples were obtained from two ports on the secondary stack which were about 9' below the stack exit and about 12' above the heat exchanger unit. A detailed description of the standard sampling techniques used is available in reference method EPS 1-AP-74-1, "Standard Reference Methods for Source Testing: Measurement of Emissions of Particulates from Stationary Sources".

For all seven test runs, multi-point isokinetic sampling was carried out along each of the two stack traverses. For the first test (Run 1), six points along each traverse were sampled. For each traverse, the six points were sampled twice - 10 min. on the way in and 10 min. on the way out. In this fashion, a total sample of 4 hours duration was obtained. After this first run, the number of points along each traverse was increased from six to twelve to account for the excessively skewed velocity profiles which were encountered. To maintain the four-hour total sample duration, each point on the traverse was sampled only once for 10 min. Tests 2-6 were all sampled in this fashion. For the last test (Run 7), the total sampling time was reduced to two hours by reducing the time per traverse point from 10 to 5 minutes.

3.1 Particulates/Metals/HCl

Two tests (1,7) were carried out for particulates, metals and HCl. The sampling train used in these tests is shown in Figure 2. The particulate matter in the exhaust gas sampled is collected on the filter and in the probe. Particulate loadings are determined gravimetrically and then analyzed for selected heavy metals. Gaseous HCl in the sample is collected in the first two impingers which contain distilled water as the trapping medium. The sample partitioning and recovery procedures used for this train are presented in Table 1.

3.2 Organics

A total of five organic runs were carried out - four for dioxin/furan analyses and one for PCB/PAH analyses. The same sampling train configuration was used for all the organic tests. A schematic of this train is shown in Figure 3.

Any particulate organics in the gas sampled are collected in the probe and on the filter. Gaseous organics passing through the filter are adsorbed on Amberlite XAD-2 resin contained in special glass cartridges. The first Amberlite cartridge contains a water condenser which cools the hot stack gases and condenses the moisture from the

TABLE 5 - SUMMARY OF PARTICULATE AND HCl TEST RESULTS

ROYAL JUBILEE HOSPITAL INCINERATOR		
DATE (1983)	Feb. 23	March 3
SAMPLING DATA		
RUN NUMBER	1	7
SAMPLING PERIOD	1053-1508	1007-1212
TEST DURATION (min)	240	120
SAMPLE VOLUME (m^3)*	3.39	1.70
ISOKINETICITY (%)	95.8	98.1
STACK GAS DATA		
VELOCITY (m/s)	11.7	12.1
FLOWRATE (m^3/min)*	200	202
TEMPERATURE (°C)	153	161
MOISTURE (%)	6.3	6.2
EXCESS AIR (%)	402.2	407.3
PROCESS DATA		
AMOUNT WASTE FED (kg)	3036	1827
WASTE FEED RATE (kg/hr)	714	876
(lb/hr)	1574	1931
PARTICULATE RESULTS		
AMOUNT COLLECTED (mg)	169.5	112.0
CONCENTRATION		
- MEASURED (mg/m^3)*	49.9	65.9
- CORR. 50% E.A. (mg/m^3)	167.1	222.9
EMISSION RATE (kg/hr)	0.60	0.80
EMISSION FACTOR (g/kg waste)	0.84	0.91
HCl RESULTS		
AMOUNT COLLECTED (mg)	1490	1140
CONCENTRATION		
- MEASURED (mg/m^3)*	438.2	670.6
- CORR. 50% E.A. (mg/m^3)	1467	2268
(ppm)	983	1520
EMISSION RATE (kg/hr)	5.3	8.0
EMISSION FACTOR (g/kg waste)	7.4	9.1

ppm 273.5

ppm 418.5

*Values reported are on a dry basis corrected to standard conditions of 25°C and 760 mm Hg.

$$ppm\ HCl = \frac{mg\ HCl}{m^3_{air}} \cdot \frac{1\ mole\ HCl}{36.5 \times 10^3\ mg\ HCl} \cdot \frac{.02278\ m^3_{air}}{mole\ air} \times 10^6$$

$$= 1624 \times \frac{mg\ HCl}{m^3\ air}$$

TABLE 6 HEAVY METAL TEST RESULTS - STACK SAMPLES

	Amount Collected		Concentration*		Emission Rate	
	Run 1	Run 7	Run 1 g/dscf	Run 7	Run 1	Run 7
	(mg)		(mg/m3) @68°F		(g/hr)	
Ca	25.62	27.31	7.56	16.06	90.7	194.6
Na	20.74	19.28	6.12	11.34	73.4	137.4
Al	19.84	23.28	5.85	13.69	70.2	165.9
K	13.85	16.01	4.09	9.42	49.1	114.2
Zn	10.26	7.55	~~3.03~~ 1.35 x10^-3	4.44 1.97x10^-3	36.4	53.8
Mg	7.57	8.34	2.23	4.91	26.8	59.5
Pb	4.94	2.67	1.46 6.48x10^-4	1.57 6.97x10^-4	17.5	19.0
Fe	2.28	1.11	0.67	0.65	8.0	7.9
	(µg)		(µg/m3)		(mg/hr)	
Bi	904	554	266.7	325.9	3200.4	3949.9
Cu	372	454	109.7 4.87x10^-5	267.1 1.19x10^-4	1316.4	3237.3
Cd	192	204	56.6 2.51x10^-5	120.0 5.33x10^-5	679.1 1.9	1454.4 3.32
Sn	142	151	41.9 1.86x10^-5	88.8 3.94x10^-6	502.8	1076.3
Mn	141	48	41.6 1.85x10^-5	28.2 1.25x10^-5	499.2	341.8
Cr	126	120	37.2 1.65x10^-5	70.6 3.14x10^-6	446.4	855.7
Ba	83	12	24.5 1.09x10^-6	7.1 3.15x10^-6	294.0	86.1
Sb	46	40	13.6 6.04x10^-6	23.5 1.04x10^-6	163.2	284.8
Ni	45	31	13.3 5.91x10^-6	18.2 8.08x10^-6	159.6	220.6
Ag	36	16	10.6 4.71x10^-6	9.4 4.17x10^-6	127.2	113.9
Li	17	10	5.0	5.9	60.0	71.5
Mo	10	11	3.0	6.5	36.0	78.8
Sr	9	57	2.7	33.5	32.4	406.0
Rb	6	4	1.8	2.4	21.6	29.1
Ta	6	ND	1.8		21.6	
Se	5	5	1.5	2.9	18.0	35.1
Nb	3.0	4.5	0.9	2.6	10.8	31.5
Hg	2.8	1.6	0.8	0.9	9.6 2.69x10^-2	10.9 2.49x10^-2
Co	2.3	2.3	0.7	1.4	8.4	17.0
V	0.3	0.2	0.1	0.1	1.2	1.2
Be	ND	ND				
W	ND	ND				
U	ND	ND				
As	ND	ND				
Te	ND	ND				

ND = not detected

*Concentrations are reported at dry and standard conditions (25°C and 760 mm Hg) but have not been corrected for excess air.

$$\frac{g}{dscf} = \frac{mg}{m^3} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1\,lb}{454 \times 10^3\,mg} \cdot \frac{7000\,gr}{lb} \times \frac{298}{293}$$

$$= 4.441 \times 10^{-4}$$

change from 25°C to 20°C