PCDDs/PCDFs Emissions from a Crematory

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ABSTRACT

PCDDs/PCDFs emissions as well as NOx, CO and HCl were measured at a crematorium in Japan. All concentrations were below the limit of the present emission standards for MSW incinerators.
Although the process is unsteady, the concentrations of PCDDs/PCDFs is low. OCDD, HCDD, OCDF and HCDF are the dominant components of the PCDDs/PCDFs.

KEY WORDS
PCDDs/PCDFs, NOx, HCl, CO, Dust, Crematory

INTRODUCTION

The propotion of cremation has been increasing in Japan and now is about 98 % of all funerals. There were 1,965 crematoria in 1993. In recent years the number of aged persons increased gradually so that the number of cremations is expected to increase steadily. Because it is very difficult to find out suitable sites for constructing new crematoria, many municipalities in Japan are compelled to re-construct new ones at the site of old crematoria. There are some-times many houses present in close proximity of such sites, and the municipalities will build new crematoria in densely populated areas. The emissions from crematories should be minimized to be accepted

by the residents.
Most large cities in Japan built and have plans to build large sized crematoria with 15-20 sets of cremation chambers and which can cremate 5,000-15,000 bodies annually.
Under these conditions the crematory should conform to exacting emission controls surpassing even strictest standards.
PCDDs/PCDFs emissions as well as NOx, CO and HCl were measured at a crematorium in Japan. The crematorium tested is located in a city of rural area whose population is 27,000, and it has 3 chambers and cremates about 700 bodies annually.
The crematorium was build 5 years ago and was surrounded by many private houses at about 100 meters distance.

METHOD

The cross section of the cremator tested is illustrated in Figure 1. The Japanese cremation's special feature is that bereaved families pick up the burned bone after the cremation. Therefore, the bottom of the furnace is movable and the cremator are operated in completely batch-wise fashion.

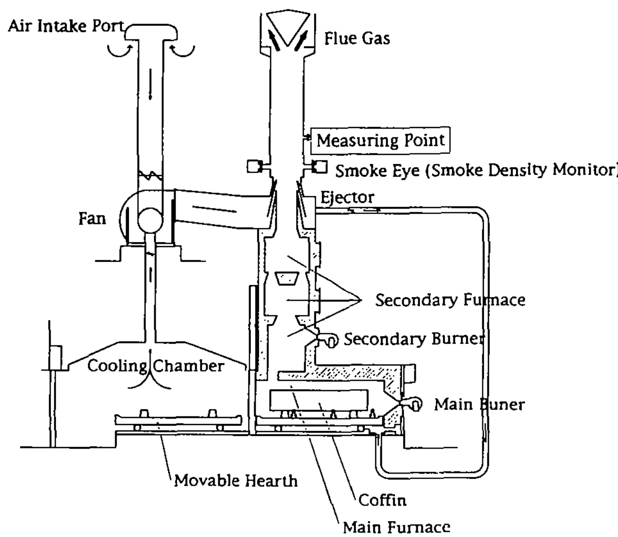


Figure 1. Cross Section of Tested Crematory

Table 1.
Specificaton of Cremator

1. Size (1)Main Furnace (The Internal Size) Width 650mm Height 725mm Length 2100mm (2)Secondry Furnace (The Internal Diameter) Width 700mm Height 2800mm
2. Fuel Kerosene
3. Residence Time of gas at Secondary Furnace Approx. 1 sec.
4. Time of Cremation Approx. 1 hour.

Tabal 2.
The Components of Combustion Materials

Composition		Dead body (60kg)		Coffin (20kg)		Sub funeral material (5kg)		Total 85kg	
		Proportion (%)	Weight (kg)	Proportion (%)	Weight (kg)	Proportion (%)	Weight (kg)	Proportion (%)	Weight (kg)
Component	M (Moisture)	70	42	12	2.4	20	1.0	53.41	45.4
	C (Carbon)	14.15	8.49	47.0	9.4	43.0	2.15	23.58	20.04
	H (Hydrogen)	2.1	1.26	4.5	0.9	4.0	0.2	2.78	2.36
	O (Oxygen)	8.35	5.01	34.0	6.8	27.5	1.375	15.51	13.185
	S (Sulfur)	0.2	0.12	-	-	-	-	0.14	0.12
	N (Nitrogen)	0.2	0.12	1.0	0.2	3.5	0.175	0.58	0.495
	Ah (Ash)	5.0	3.0	1.5	0.3	2.0	0.1	4.0	3.4
Total		100	60	100	20	100	5	100	85

Table 1 presents the specification of the crematory, and the contents of the combustion materials at the desiging basis are shown in Table 2. Because of the batch-wise operation the process of combustion proceeds inevitably unsteadily. Keeping high temperature and high oxygen concentration in the furnace is an important condition to guarantee complete combustion.

The secondary combustion chamber was designed to ensure that the residence time of the gas exceeds one second at all times.

The measurements were done for three cremations. The flue gas was sampled throughout the cremation (from start to end) for the first and the second cremation (Run 1 and Run 2). At the third cremation, the flue gas was sampled for every 20 minutes in the course of the cremation process (Run 3). One cremation takes approximately 60 minutes.

The sampling and analysis of PCDDs/PCDFs are carried out according to the instructions of the manual by The Waste Research Foundation, Japan. The other measurements are based on JIS (Japanese Industrial Standards). The sampling point of the flue gas is shown in Figure 1. The condensates of PCDDs/PCDFs sample were extracted with toluene or dichloromethane and the fly ashes collected in the thimble were Soxhlet extracted with toluene. The extract was concentrated and cleaned up. The final samples were analysed by HRGC/HRMS using 60 m SP-2331 and 30 m DB-1 columns.

RESULTS AND DISCUSSION

Figure 2 shows the changes in flue gas flow rates at Run 1 to 3, and Figure 3 illustrates the variation of pressure and temperatures at the main combustion chamber, at the secondary combustion chamber and of the flue gas (Run 3). The coffin, other funeral material and the dead body in turn catch fire in the cremation process. The temperatures change keenly at the beginning of the process, and they become comparatively stable after 10 to 15 minutes from the start of the cremation.

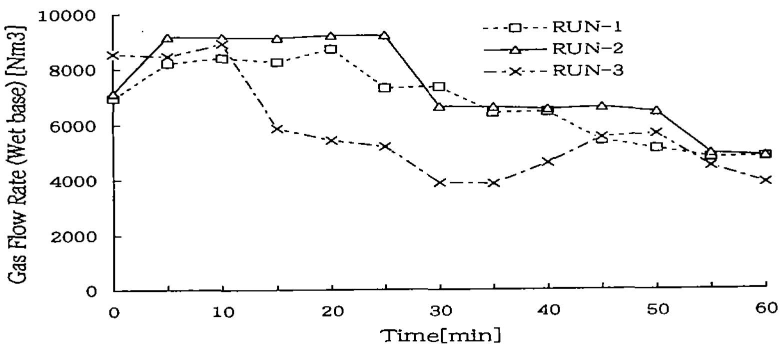


Figure 2. Flue Gas Flow Rate

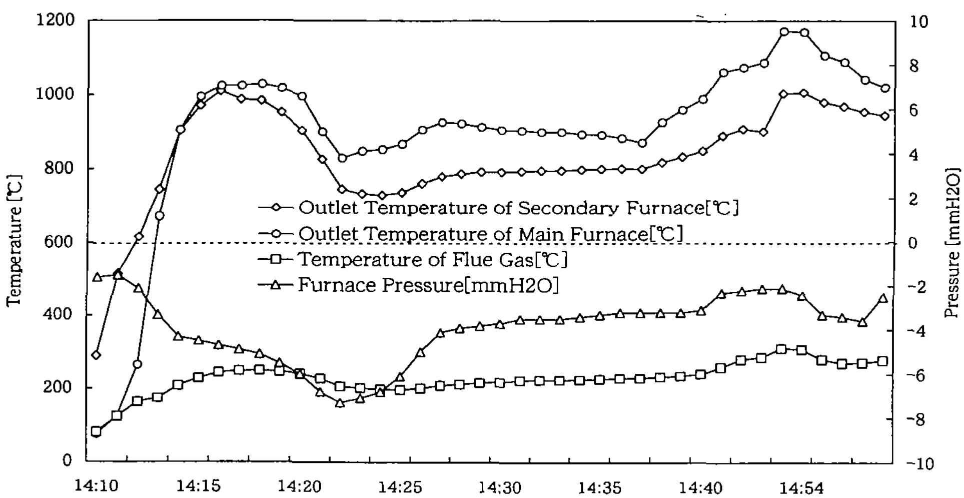


Figure 3. Variations of Pressure and Temperature(RUN-3)

Table 3 and Table 4 show the results of dust, HCl, NOx and CO concentrations. At the moment there are no emission standards for crematories in Japan. All of these concentrations are below the limit of the typical emission standards for MSW incinerators (dust=0.5g/Nm³, HCl=700 mg/Nm³, and NOx=250 ppm).

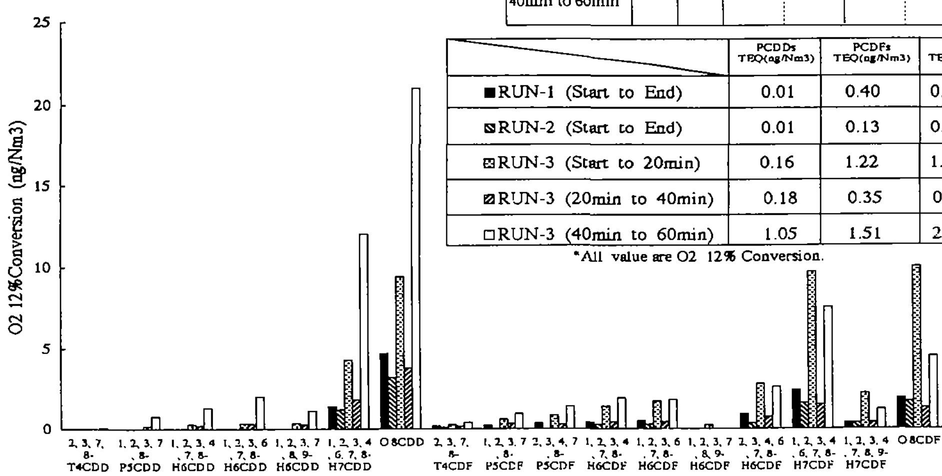
Figure 4 shows the isomer specific concentrations and TEQs of flue gases. Although the process is unsteady, the concentrations of PCDDs/PCDFs are relatively low. OCDD, HCDD, OCDF and HCDF are the dominant components of the PCDDs/PCDFs.

Table 3.
Dust and HCl Concentrations

	Dust (g/Nm³)		HCl (mg/Nm³)	
	Measured value	O2 12% Conversion	Measured value	O2 12% Conversion
Run 1 Start to End	0.016	0.069	15	64
Run 2 Start to End	0.028	0.11	7.2	29
Run 3 Start to 20 min	0.043	0.15	55	200
Rnu 3 20 min to 40 min	0.064	0.15	16	38
Run 3 40min to End	0.029	0.087	2.9	8.7

Table 4.
Average Concentrations of NOx and CO

	Temp (℃)	O2 (%)	NOx (ppm)		CO (ppm)	
			Measured value	O2 12% Conversion	Measured value	O2 12% Conversion
Run 1 Start to End	196	18.9	32	142	15	100
Run 2 Start to End	212	18.8	27	111	6	23
Run 3 Start to End	242	17.9	37	114	10	26
Run 3 Start to 20min	208	18.5	45	166	30	83
Run 3 20min to 40min	256	17.2	41	105	0	0
Run 3 40min to 60min	258	18.0	26	77	0	0



	PCDDs TEQ(ng/Nm3)	PCDFs TEQ(ng/Nm3)	TOTAL TEQ(ng/Nm3)
■RUN-1 (Start to End)	0.01	0.40	0.41
RUN-2 (Start to End)	0.01	0.13	0.14
RUN-3 (Start to 20min)	0.16	1.22	1.38
RUN-3 (20min to 40min)	0.18	0.35	0.53
□RUN-3 (40min to 60min)	1.05	1.51	2.56

*All value are O2 12% Conversion.

Figure 4. Isomer Specific Concentrations of PCDDs/PCDFs

At the end of the process (40~60 min.) in Run 3, the TEQ value is comparatively high. Some of the funeral materials might catch fire and generate chlorinated compounds. Books, flowers, fruits, jewelley etc. may be put in the coffin in Japanese funerals.
One of actual emission measurements from the crematoria was repoted as 8 ng TEQ/m³ but the exact calculation of annual release was not reported[1]. The working group of the subcommittee air/technology of German Federal Government reported, in September 1994, that reductions of the dioxin emissions could be achieved by measures relating to the materials utilized as well as by combustion technology and waste gas measures at crematoria[2].
Measures relating to the materials utilized are avoidance of the use of plastics containing halogens, no application of wood treatment agents such as ammonium chloride, no application of odor-blanketing agents which contain halogens such as 1,4-dichlorobenzene and a control of the decorations of the coffin.
These are the recommendations by the VDI Guideline 3891 "Emission Reductions - Crematorium Funerals" (8/92). According to the results of the measurements of this German working group, these measures were to be supported as well as combustion technology.
A particularly efficient method of particle collection was also recommended.
Most of the crematories in rural areas, have no equipment for flue gas treatment, but introduction of fabric filter could reduce the concentrations of PCDDs/PCDFs.

PEFERENCES

1) Hutzinger, O. and Fiedler, H. (1993), From Source to Exposure: Some Open Questions, Chemosphere, 27(1-3), 121-129.
2) The Working Group of Subcommittee Air/Technology of the Federal Govemment Federal States Pollution Control Committee, Germany (1994), Determination of Requirements to Limit Emissions of Dioxins and Furans.