A Study of Total PCDDs/Fs Release to Environment from MSWI

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Abstract

Total PCDDs/Fs release to environment from MSWI has been explored by sampling and analysing PCDDs/Fs in various points in a MSWI. Incinerating MSW by the full equiped system advocated in "A New Guideline of 1997, Japan", the total PCDDs/Fs release to environment was calculated about 0.97-2.59 μ g TEQ per ton of MSW. It is considerably lower than 5 μ g TEQ per ton of MSW specified in the new guideline. And by using ash melting process, total amount of PCDDs/Fs release of 0.52-0.90 μ g TEQ per ton of MSW is expected.

1. Introduction

It is generally known that municipal solid waste incinerator(MSWI) is one of the large sources of PCDDs/Fs release. In Japan, approximately 75 percent of MSW is incinerated [1] and the total number of MSWI is about 1,870. In order to reduce amount of PCDDs/Fs release from MSWI, "A New Guideline For Controlling Dioxin" was issued in January of 1997 by Ministry of Health & Welfare, instead of the old guideline promulgated in 1990.

Accoding to the new guideline, if the high advanced technologies are adopted, PCDDs/Fs release from MSWI will be largely reduced and after 10 years the full amount of PCDDs/Fs release from MSWI in all of Japan will be 100 g TEQ/year that is about 2% of 4,300 g TEQ/year at 1996. And in the near future, 5 μ g TEQ per ton MSW of PCDDs/Fs release from all streams of MSWI into environment will be

provided [2]. The main technologies advocated are 1) Achievement of 3-Ts(Retention Time, Temperature, Turbulence) in incinerator furnace; 2) Adoption of fabric filter(or other collector but low temperature operation) with high-advanced flue gas cleaning and 3) Adoption of thermal dechlorination process or melting process for MSWI residues.

In order to investigate total amount of PCDDs/Fs release to environment from MSW by incineration, sampling and analysing of PCDDs/Fs in various points (such as: flue gas, bottom ash, fly ash and wastewater) were made in a MSWI equiped with the full technologies advocated in the new guideline. This paper firstly describes the findings in comparing of these results, and secondly tries to calculate the amount of total PCDDs/Fs release to environment per ton of MSW by incineration.

2. Outline of the MSWI

The outline of the MSWI is given in Table 1, and the process flow is shown in Figure 1. Flue gas treatment system is equiped in each incinerator and the thermal dechlorination process and wastewater treatment system are common facilities of 3 incinerators in the MSWI.

MSW is fed into incinerator, where the volume of MSW would be reduced in good sanitary conditions and energy would be recovered by Waste Heat Boiler(WHB). The temperature of secondary furnace is about 850-900 ° C and the flue gas retention time is about 2 sec in the secondary furnace. Bottom ash is discharged and conveyed to landfill.

Flue gas from WHB is led to gas cooling chamber, mixed with sprayed water and cooled down to an appropriate temperature(170 ° C) and then flue gas is injected with a powdered hydrated lime. Fly ash, consisting of soot and dust, reaction products of HCl and SOx and surplus hydrated lime is collected effectively by fabric filter. Flue gas from fabric filter is led to wet scrubber for further removal of HCl and SOx. Then flue gas is heated to the temperature of 200 ° C and is led to DeNOx reactor by reacting with the injected ammonia in presence of the catalyst. The fabric filter is pulse type and its gas flow is 33,000 Nm^3/h(max.). The DeNOx reactor is SCR type(V_2O_5/TiO_2) and its volume is 6.2m^3.

Fly ash from fabric filter and gas cooling chamber is conveyed to a thermal dechlorination process of PCDDs/ Fs. The process specifications are given in Table 2. The process consists of a reactor and a cooler as main equipments. PCDDs/Fs would be dechlorinated when fly ash is heated up to 300-400 ° C with oxygen deficient condition by an electric heater arranged around the reactor, and then fly ash is rapidly cooled down in the cooler. The released vent gas and condensed drain from the thermal dechlorination process are also investigated to be suitably treated. The treatment efficiency of the thermal dechlorination process of PCDDs/Fs in detail was reported in Dioxin'96 [3]. Treated fly ash is led into cement solidification process for stabilizing heavy metals.

Wastewater from wet scrubber is led into wastewater treatment system where heavy metals, F, SS and COD are effectively removed.

Table 1 Outline of the MSWI

Site area	Approx. 24,600 m ^{2}
Capacity of MSW	300 ton/24h (100 ton/24h × 3 furnaces)
Completed in	October of 1995
Furnace type	Continuous combustion incinerator (stoker furnace)
Gas cooling facility	Waste Heat Boiler (WHB)
Flue gas treatment	Fabric filter + Wet Scrubber + DeNOx reactor
Fly ash treatment	Thermal dechlorination process
Bottom ash treatment	Landfill

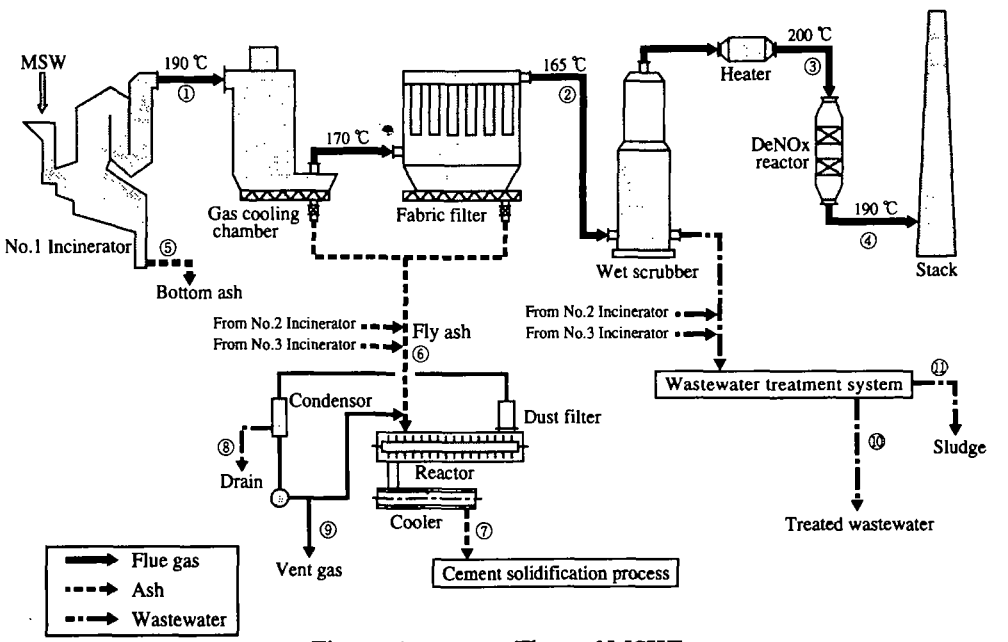

Figure 1 Process Flow of MSWI

Table 2 Specifications of thermal dechlorination process

Capacity		500 kg/h (max.)
Reaction temperature in reactor		300 ~ 400 ° C
Discharge temp. from cooler		60 ° C or below
Reactor	Type	Electrical Heated Cylindrical
	Size	1.2 m(ϕ) × 5.0 m(L)
Cooler	Type	Water Cooling Jacket Cylindrical
	Size	0.41 m(ϕ) × 3.44 m(L)

3. PCDDs/Fs samping and analysis

Samping and analysis of PCDDs/Fs in flue gas, bottom ash, fly ash and wastewater were carried out according to "Measuring Manual of Dioxins for Waste Treatment" by Japan Waste Research Foundation.

4. Results and Discussion

4.1 PCDDs/Fs concentration in flue gas and fly ash treatment

PCDDs/Fs in the flue gas, bottom ash, fly ash and wastewater were sampled at 11 points as shown in Figure 1. The samplings were made twice as sample 1 and sample 2 under same operation condition of MSWI. PCDDs/Fs concentration in these points are shown in Table 3.

In the flue gas, it is shown that PCDDs/Fs would be removed by both fabric filter and DeNOx(SCR) reactor. Finally, PCDDs/Fs in the stack are less than 0.1 ng TEQ/Nm ^{3} .

PCDDs/Fs concentration in the fly ash is higher than that in the bottom ash. Treating by thermal dechlorination process, PCDDs/Fs in fly ash is largely reduced from 0.29 and 0.19 ng TEQ/g to 0.0076 and 0.0099 ng TEQ/g thus less than 0.01 ng TEQ/g. PCDDs/Fs in the drain and the vent gas are also detected. Wastewater from wet scrubber is treated. Finally, it is discharged as treated wastewater and sludge from MSWI to environment. PCDDs/Fs are also detected in both of them.

Table 3 Concentration of PCDDs/Fs in the sampling points

Point	①*) WHB outlet	②*) Fabric filter outlet	③*) DeNox reactor inlet	④*) Stack inlet
Sample 1	0.58	0.056	0.18	0.096
Sample 2	2.3	0.12	0.073	0.0053

Point	⑤**) Bottom ash	⑥**) Untreated fly ash	⑦**) Treated fly ash	⑧***) Drain	⑨*) Vent gas
Sample 1	0.0020	0.29	0.0076	20	0.077
Sample 2	0.017	0.19	0.0099	7.0	0.075

Point	⑩***) Treated wastewater	⑪***) Sludge
Sample 1	0.094	2.0
Sample 2	0.0010	0.90

Unit: *: ng TEQ/Nm ^{3} @O $_2$ 12%; **: ng TEQ/g; ***: ng TEQ/ ℓ .

4.2 Total PCDDs/Fs release

Releasing points of PCDDs/Fs to environment from the MSWI are stack, bottom ash, treated fly ash, drain and vent gas of thermal dechlorination process, treated wastewater and sludge. 4,348 ng TEQ/h and 12,971 ng TEQ/h of total release rate of PCDDs/Fs in these points at samples 1 and sample 2 are given in Table 4, based on each measured flow rate and its PCDDs/Fs concentration.

Finally, using 4.5 and 5.0 ton/h that were average flow rate of MSW incinerated at the measurement, 0.97 - 2.59 μ g TEQ of PCDDs/Fs per ton of MSW is calculated to release to environment as follows.

At sample 1: 4,348 ng/h ÷ 4.5 ton/h = 0.97 μ g TEQ/ton(MSW)

At sample 2: 12,971 ng/h ÷ 5.0 ton/h = 2.59 μ g TEQ/ton(MSW)

It is understood that these figures are considerably lower than 5 μ g TEQ of PCDDs/Fs per ton of MSW, that was specified in "A New Guideline".

Table 4(1) Rate of PCDDs/Fs release at sample 1

Point	Flow rate	PCDDs/Fs conc.	PCDDs/Fs rate
④ flue gas	19,200 Nm^3 /h, dry	0.096 ng/Nm^3	1,843 ng/h
⑤ bottom ash	0.677 ton/h	0.0020 ng/g	1,354 ng/h
⑦ treated fly ash	0.40 ton/h ÷ 3furnaces	0.0076 ng/g	1,013 ng/h
⑧ drain	4.0 ℓ /h ÷ 3furnaces	20 ng/ ℓ	27 ng/h
⑨ vent gas	2 Nm^3 /h, dry ÷ 3furnaces	0.077 ng/Nm^3	0.05 ng/h
⑩ wastewater	1,400 ℓ /h ÷ 3furnaces	0.094 ng/ ℓ	44 ng/h
⑪ sludge	100 ℓ /h ÷ 3furnaces	2.0 ng/ ℓ	67 ng/h
Total rate of PCDDs/Fs(I-TEQ) release at sample 1			4,348 ng/h

Table 4(2) Rate of PCDDs/Fs release at sample 2

Point	Flow rate	PCDDs/Fs conc.	PCDDs/Fs rate
④ flue gas	19,200Nm^3 /h, dry	0.0053 ng/Nm^3	102 ng/h
⑤ bottom ash	0.677 ton/h	0.017 ng/g	11,509 ng/h
⑦ treated fly ash	0.40 ton/h ÷ 3furnaces	0.0099 ng/g	1,320 ng/h
⑧ drain	4.0 ℓ /h ÷ 3furnaces	7.0 ng/ ℓ	9.3 ng/h
⑨ vent gas	2 Nm^3 /h, dry ÷ 3furnaces	0.075 ng/Nm^3	0.05 ng/h
⑩ wastewater	1,400 ℓ /h ÷ 3furnaces	0.0010 ng/ ℓ	0.5 ng/h
⑪ sludge	100 ℓ /h ÷ 3furnaces	0.90 ng/ ℓ	30 ng/h
Total rate of PCDDs/Fs(I-TEQ) release at sample 2			12,971 ng/h

4.3 Study of PCDDs/Fs release in case of ash melting process

Another measure to reduce PCDDs/Fs in ash is the melting process. Though the MSWI does not have the plasma melting process, we are designing an actual ash melting process of plasma arc type for a new MSWI. Process flow of ash melting process in the MSWI is shown in Figure 2. Both bottom ash and fly ash from incinerator are fed into the plasma melting furnace, where the ash is to be melted at the operating temperature of 1400 - 1500 ° C. The off gas from the furnace is finally to be merged in incinerating flue gas at inlet of the flue gas treatment system for the MSWI. PCDDs/Fs in the flue gas is to be removed by both fabric filter and DeNOx reactor(SCR). On the other hand, PCDDs/Fs in both slag and secondary fly ash from the plasma melting furnace are to be as shown in Table 5 according to our pilot test. Assuming substituting the slag and secondary fly ash for the bottom ash and the fly ash in Figure 1, using the average PCDDs/Fs concentration in Table 5, and being the same for the remainder, the total PCDDs/Fs release can be calculated to get 0.52-0.90 μ g TEQ per ton of MSW for the case of ash melting process. It is known that the total PCDDs/Fs release can be further reduced by choosing ash melting process.

Table 5 PCDDs/Fs concentration in both slag and secondary fly ash from melting furnace (ng TEQ/g)

Sample No.	Sample 1	Sample 2	Sample 3	Average
Slag	0.000	0.000	0.000	0.000
Secondary fly ash	0.0013	0.040	0.034	0.0251
Flow ratio	Slag ratio *) = 0.80 kg/kg; Secondary fly ash ratio *) = 0.13 kg/kg			

*) Ratio = Slag(or secondary fly ash)/(Bottom ash + Fly ash)

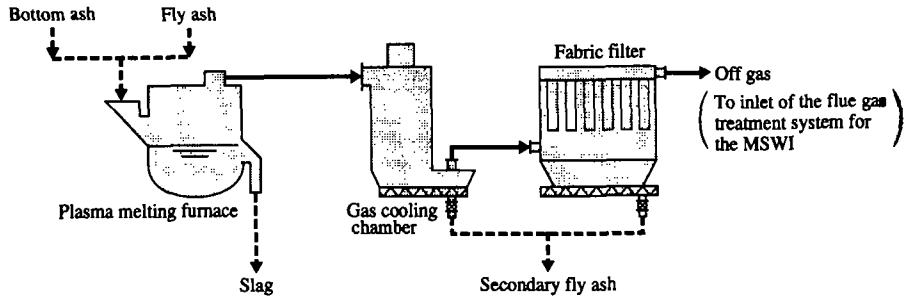

Figure 2 Process Flow of Ash Melting Process

5.Conclusion

PCDDs/Fs in various points of a MSWI were measured, and total PCDDs/Fs release per ton of MSW was also tried to calculate. The conclusions are as follows:

(1)PCDDs/Fs in flue gas would be removed by both fabric filter and DeNOx reactor(SCR) to be less than 0.1 ng TEQ/Nm^3.

(2)PCDDs/Fs in fly ash would be effectively dechlorinated by thermal dechlorination process to be less than 0.01 ng TEQ/g. Amount of them in both drain and vent gas release are very little.

(3)Incinerating MSW by the full equiped system advocated in new guideline (Japan, 1997), the total PCDDs/Fs release to environment was calculated about 0.97-2.59 μ g TEQ per ton of MSW. It is considerably lower than 5 μ g TEQ per ton of MSW, that was specified in "A New Guideline of 1997, Japan".

(4)By using ash melting process, total amount of PCDDs/Fs release of 0.52-0.90 μ g TEQ per ton of MSW is expected.

Finally, we would like to express our appreciation to the people in the MSWI concerned for the detailed information provided for the purposes to this study.

6. References

(1)Ministry of Environment, Government of Japan: An Environment White Paper(1995).

(2)Ministry of Health & Welfare, Government of Japan: A Guideline For Controlling Dioxin(1997).

(3)P.Nie, M.Ishida, R.Shiji, N.Nakamura and S.Sakai: Full-scale Plant Study on Low Temperature Thermal Dechlorination of PCDDs/PCDFs in Fly Ash, 16th Symposium on Chlorinated Dioxins and Related Compounds, Vol.27, p.147(1996).