

DIOXIN EMISSION OF AN OPTIMIZED FLUIDIZED BED SOLID WASTE INCINERATOR

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Introduction

The stringent limiting value for PCDD/PCDF emission of 0.1 ng TEQ/Nm³ for municipal and hazardous waste incinerators has been in effect in several European countries and in Japan for new municipal waste incinerators (MWIs)¹⁻³.

Additionally for Japan the "New Guideline For Controlling Dioxin"² include the aim to decrease the total PCDD/F release from all streams of MSWI - air, solids and water - into the environment³.

In this respect the importance of primary measures - i.e. minimizing the formation of PCDD/F by combustion technology and boiler technology - became a new actuality since pure adsorption technology "mainly diverts" the dioxin flux from stack emission to the release on solids (fly ash).

In this paper we want to compare two fluidized bed incinerators (FBI) combusting municipal solid waste (MSW) in respect to the actual Japanese regulations for stack emission and fly ash concentration and demonstrate the importance of good combustion practice.

Materials and Methods

Plant design

The flow sheet of the two facilities are shown in Figure 1. The fundamental design of the facilities are comparable. The feed rates of the sampled FBI A and B are 200 and 160 ton/day municipal solid waste, respectively. Recalculating to the amount of waste, the size of the combustion zones are equivalent. In the FBI the waste is decomposed and gasified in an air bubbled sand bed at around 650°C and the emitted volatile compounds are burned in the secondary combustion chamber for more than two seconds above 850 °C to complete combustion.

Both flue gas lines are equipped with boiler and economizer for heat recovery. Ca-spray (Ca(OH)₂) for semi dry removal of acidic gases and carbon spray for removal of Dioxins are applied. Bagfilters (BF) guarantee a high removal efficiency for particles. For destruction of NO_x both plants use SCR honey comb catalysts in a temperature range of 210-230°C. Facility A is additionally equipped with a wet scrubber after BF for high efficient removal of heavy metals.

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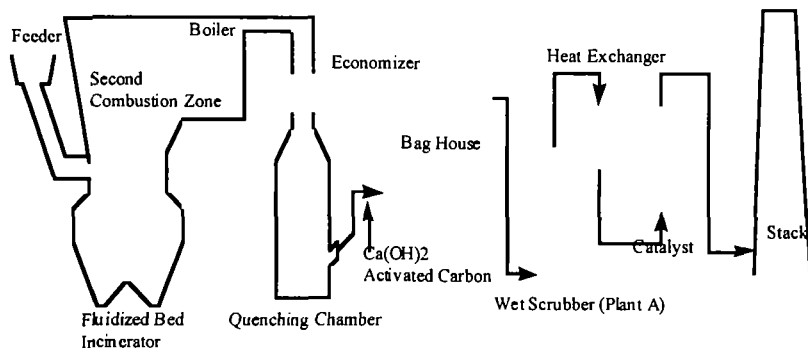


Figure 1: Flow sheet of the two fluidized bed incinerators.

Table 1: Emission data of fluidized bed incinerator A and B

Plant	Flue gas Volume Nm ³ /hr	O ₂ Vol-%	CO ppm	NO _x ppm	SO _x ppm	HCl ppm	Dust mg/Nm ³
A	53000	11	25	18	<1	<2	<2
B	37000	11	35	25	<1	5	<2

Sampling and analysis

Sampling and quantification for PCDD/F were carried out according to the procedure of the Japanese Waste Research Foundation⁴ and concentrations were normalized to 12% oxygen. The analysis was performed with a HP6890 gas chromatograph connected to a Micromas Autospec Ultima operating at a resolution of >10 000.

Results and Discussion

The use of carbon spray for the removal of Dioxin and the low BF temperatures of 150°C (facility A) and respectively 160°C (facility B) result for both facilities in BF-out values considerably below 0.1 ng TEQ/Nm³ (Table 2). The average value of facility B were 0.04 ng TEQ/Nm³. Using the standard manual for official measurements⁴ (3 Nm³ sampling volume and analysis by high resolution MS at a resolution of >10 000), in facility A from the 2378-substituted PCDD/F only OCDD/F, H₂CDD and H₆CDF could be detected. The other 2378 substituted PCDD/F were below the detection limit. Recalculation from the total amount of the detected non 2378-substituted isomers result in an estimated BF-out values for facility A of around 0.005 ng TEQ/Nm³.

Table 2: Detected PCDD, PCDF (ng/Nm³) and I-TEQ (pg/Nm³) values of FBI A and B at BF out and Stack and for FBI B additionally at catalyst-in

plant (sampling)	FBI A (I)	FBI A (II)	FBI A (III)	FBI A (I)	FBI A (II)	FBI B (I)	FBI B (II)	FBI B (III)	FBI B (I)	FBI B (I)	FBI B (II)
Location	BF out	BF out	BF out	Stack	Stack	BF out	BF out	BF out	Cat-in	Stack	Stack
PCDD (ng/Nm ³)	0.31	0.20	0.30	0.12	0.10	2.8	3.9	4.3	33.6	3.6	3.1
PCDF (ng/Nm ³)	0.13	0.11	0.18	0.03	0.03	1.7	2.3	1.2	14.0	1.6	4.0
I-TEQ (pg/Nm ³)	0.58	0.43	0.56	0.03	0.03	31	46	31	536	55	85

In MSWI using active carbon spray for Dioxin removal and semi dry system for removal of acid gases at low BF temperature - a common combination in Japanese incinerators - more than 99%

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of total Dioxin remain adsorbed on the fly ash. The fly ashes values of facility A lay in average at 0.45 (± 0.14) ng TEQ/g. While the fly ashes in facility B contain PCDD/F values of 4.31 (± 1.59) ng TEQ/g (Table 3). Therefore facility B generate around 10 times the Dioxin amount compared to facility A. In addition, the values in plant B exceed the Japanese regulation limit of 3 ng TEQ/g and according to the new guideline would require an additional treatment (for destruction of Dioxin or cementation).

	FBI A	FBI B	FBI B (optimized)
PCDDs (ng)	19.6 (± 8.1)	547.0 (± 276.6)	60.4 (± 18.0)
PCDFs (ng)	20.1 (± 5.7)	173.8 (± 89.5)	74.9 (± 23.5)
Total I-TEQ (ng)	0.45 (± 0.14)	4.31 (± 1.59)	1.46 (± 0.40)

Table 3: PCDD/F (ng/g) and TEQ (ng/g) values in fly ash sampled in FBI B with ordinary and optimized operation conditions and from FBI A (at least 5 fly ashes were analyzed for each facility/condition)

In a program for decreasing the PCDD/F output of facility B the operation conditions were optimized. This was mainly achieved by decreasing the combustion temperature in the first combustion zone and a change in supply of primary combustion air.

The fly ash values after optimization lay in average around 1.46 (± 0.40) ng TEQ/g (Table 3). These values are considerably below the 3 ng TEQ/g regulation limit. However, also with optimized operation conditions the total Dioxin output of Facility B is still three times higher compared to Facility A.

The main differences of the two facilities are the operation conditions of the first combustion zone. In facility B also after optimization the higher combustion rates resulted in a slightly unstable combustion with temporary CO peaks.

Facility A use a new developed fluidized bed combustion control.

This was mainly achieved by two improvements:

- the equipment maintaining a homogeneous sand fluidization and an optimized air supply at low space velocity of 0.4 – 0.45 m/s of the primary air and the use of fine sand
- a new soft ware using a neuronal combustion control

These developments guarantee soft burning conditions avoiding sudden gas expansion and result in an optimum stable fluidized bed combustion.

Reformation of PCDD/F in heat exchanger

Both facilities are equipped with SCR catalyst after BF for NO_x removal. In facility A the Dioxin values further decreased by the SCR catalyst (Table 4). The SCR catalysts are high effective here in the decomposition of PCDD/F and can therefore be used for the combined destruction of NO_x and PCDD/F⁵⁻⁷.

For facility B, however, the values increased from 0.04 ng TEQ/Nm³ at BF-out up to 0.085 ng TEQ/Nm³ at stack (Table 2). This was not in accordance with the expectation of the above mentioned effect of PCDD/F destruction by the SCR catalyst. Therefore an additional measurement was done at catalyst-in. The Dioxin value at this location was higher than 0.5 ng TEQ/Nm³ (Table 3). Therefore the Dioxin amount increased 10 times from BF-out to the position after heat exchanger. The heat exchanger is operated here at 220-240°C and therefore in the lower temperature window of PCDD/F *de novo* formation range. By the catalyst the reformed PCDD/F were then destroyed below the 0.1 ng TEQ/Nm³ limit (Table 2).

An increase of PCDD/F amount at the position of heat exchanger was also reported in another study⁸ and seems therefore not a unique phenomena. This possibility have therefore to be considered when the values at BF-out and catalyst-out show not the expected effectiveness of the catalyst.

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The reason for the contamination of the heat exchanger in facility B was a temporary defective single bag filter 6 month before the actual measurement. Some dust were attached to the heat exchanger and the duct causing *de novo* formation of PCDD/F. For facility B presently a cleaning of the heat exchanger is conducted.

The two FBI demonstrate that a facility with elevated PCDD/F fly ash values (BF-in values) may get difficulties to meet the stringent limiting value of 0.1 ng TEQ/Nm³ - despite of the proper use of carbon spray/catalyst - due to contamination resulting from temporary defective single bags as reported also in another study for contamination of a wet scrubber⁹. While a FBI fulfilling the policy of optimized combustion conditions, proper maintenance of the plant and usual measures for dioxin removal/destruction is not exposed to this risk and stack gas values considerably below 0.1 ng (even below 0.01 ng) TEQ/Nm³ and fly ash values below 0.5 ng TEQ/g can be achieved.

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