IMPACT OF COPLANAR-PCB ON TEQ EMISSION IN FLUIDIZED BED INCINERATION

Takeshi Sakurai[1], Roland Weber[1], Shunichiro Ueno[1], Junya Nishino[1], Masaru Tanaka[2]

[1]Environmental Process Development Department, Ishikawajima-Harima Heavy Industries Co., Ltd., 1, Shin-Nakahara-cho, Isogo-ku, Yokohama 235-8501, Japan
[2]Okayama University, Tsushima-Naka, Okayama 700-8530 , Japan

Introduction

Stringent limits for PCDD/F emission of 0.1 ng TEQ/Nm^3 for municipal and hazardous waste incinerators have been imposed in several European countries, and in Japan for new municipal waste incinerators[1-3]. In addition, in Japan a "Law Concerning Special Measures against Dioxins"[4] was recently endorsed. This regulation includes coplanar PCB for TEQ calculation. The guidelines followed the assignment of toxicity equivalent factors for non-ortho and mono-ortho substituted PCBs by the WHO[5].
The PCB emission (TEQ) from grate fired incinerators are generally less than 10% of the total TEQ[6-8]. However, there is no literature available considering the impact of PCB on the emission from fluidized bed incinerators (FBI). The contribution of PCDD and PCDF to the total TEQ value differs slightly between fluidized bed incinerators compared to grate fired incinerators[9]. Therefore the aim of this study was to investigate the impact of coplanar PCB on total TEQ emission from fluidized bed waste incinerators.

Materials and Methods

Fluidized bed incinerators. Five fluidized bed incinerators combusting municipal solid waste were analysed for PCDD, PCDF and PCB concentration in the flue gas. All plants were full scale incinerators with a capacity of 60-200 t/day. The incinerators were equipped with bagfilters for effective removal of particles operated below 200°C. Some of the plants used activated carbon spray (Table 1).
Sampling and analysis. Sampling and analysis for PCDD/F gas samples were carried out according to the procedure of the Japanese Waste Research Foundation[10]. Concentrations were normalised to 12% oxygen. The GC/MS analysis were performed on a Micromass Autospec coupled to a HP 6980 gas chromatograph. For the isomer specific analysis of $T_4CDD/F-H_6CDF$ a SP-2331 column (60 m, 0.25 mm i.d., 0.2 µm film thickness, Supelco, Bellefonte/USA) was used. For analysis of H_7CDD/F, OCDD/F and isomer specific analysis of PCB a DB-5 a fused silica column (30 m, 0.32 mm i.d., 0.25 µm film thickness, J&W Scientific, Folsom/USA) was used.

Results and Discussion

The distribution of TEQ in the five fluidized bed incinerators is shown in Table 1. The coplanar PCB contributed between 1.6% to 5.3% to the total TEQ value. This is comparable with the distribution in grate fired incinerators[6-8].

No correlation was found between the total TEQ emission in an incinerator and the %-contribution of PCB to total TEQ. Nor did the use/not use of active carbon (AC) spray show a significant effect on the contribution of PCDD, PCDF and PCB to total TEQ (Table 1).

Table 1: TEQ stack concentration of PCB and total TEQ in different fluidized bed incinerators

Plant (measurements)	Plant A (4)	Plant B (5)	Plant C (3)	Plant D (3)	Plant E (2)
Flue gas cleaning	BF/AC; Cat	BF/AC	BF/AC	BF	BF
Co-PCB (ng TEQ/Nm^3)	0.0006	0.002	0.004	0.04	0.09
PCDD/F+PCB (ng TEQ/Nm^3)	0.012	0.071	0.26	1.41	4.05
% Co-PCB to total TEQ	5.3%	2.5%	1.6%	2.8%	2.3%

Four of the fluidized bed incinerators sampled showed similar contributions of coplanar PCB to total TEQ. The only "outliner" was Plant A which was found to emit coplanar PCB concentrations at the lower end of all five incinerators, yet their contribution to total TEQ was found to be the highest with 5.3% (Table 1). Therefore we analysed the measurements in plant A in more detail. The flue gas was sampled at three positions: bagfilter-in (BF-in), bagfilter-out (BF-out) and stack. Figure 1 shows the contribution of PCB on total TEQ along the flue gas line. At BF-in, the coplanar PCB amount in all runs to less than 1.7% of total TEQ (average 1.4%). Their contribution increased to more than 2.5% (in average 3.3%) at the bagfilter outlet (which is only slightly higher compared to the other plants (Table 1)). A further increase of PCB contribution to TEQ was found between the BF-out position and the stack with an impact of PCB up to 7.5% of total TEQ (average 5.3%).

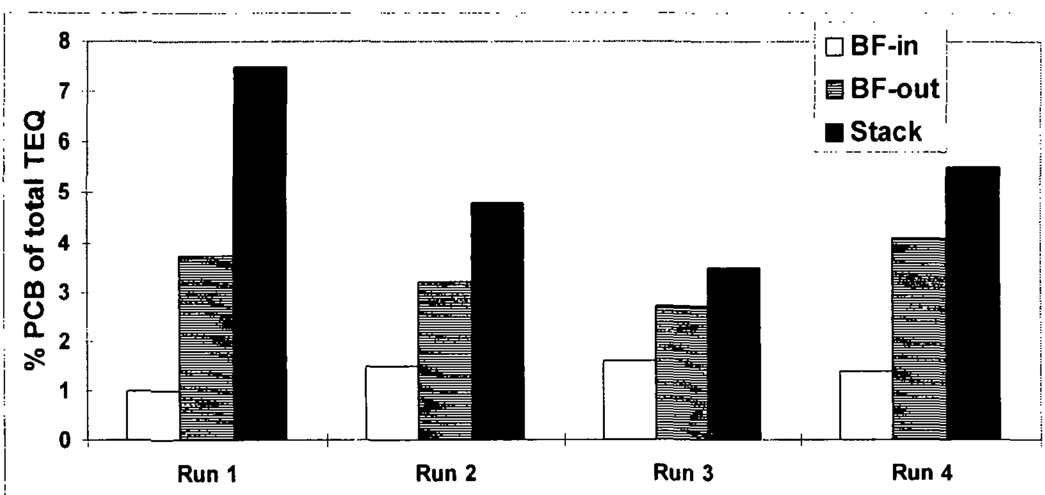

Figure 1: Contribution of coplanar PCBs to total TEQ at BF-in, BF-out and stack in plant A.

To understand these shifts, a closer analysis on the impact of individual PCB and PCDD/F isomers on TEQ is necessary. PCB#126 (3,3',4,4',5-P_5CB) amounted to more than 90% of TEQ within the coplanar PCBs and together with PCB#169 (3,3',4,4',5,5'-H_6CB), these two non-ortho-substituted coplanar PCB amounted to more than 98% of PCB-TEQ (Figure 2). This distribution did not change at the different sampling positions (nor for different incinerators*) (Figure 2). Among PCDD/F, the main contribution to total TEQ was found to derive from P_5CDF and H_6CDF. The shift in the TEQ distribution between BF-in and BF-out position is caused by the respective removal efficiency. The removal efficiency of the bagfilter (in average about 99%) is mainly caused by adsorption effects. Therefore less volatile compounds are removed with higher efficiency which for example results in. an increasing removal efficiency of PCB with increasing chlorination degree (Figure 3). Hence, the higher volatility of P_5CB#126 compared to 2,3,7,8-substituted P_5CDF and H_6CDF, results in an increased contribution of PCB to TEQ between BF-in and BF-out.

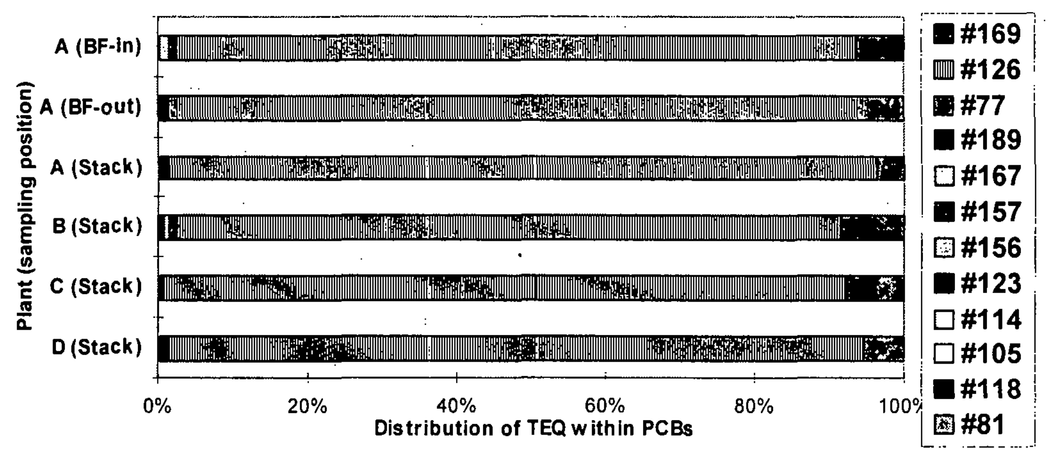

Figure 2: Distribution of TEQ within the coplanar PCBs in BF-in, BF out and stack gas of plant A and of stack gas of plant B, C and D.

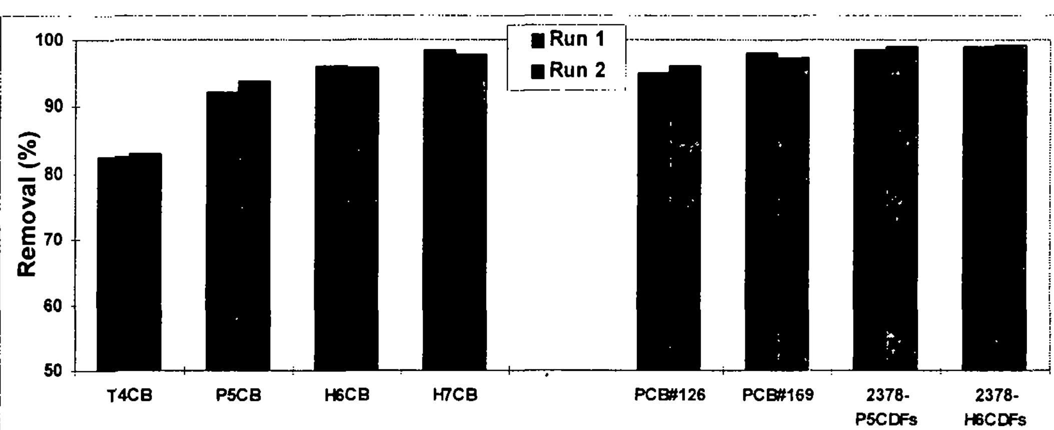

Figure 3: Removal efficiency of T_4CB-H_7CB by the bagfilter/AC-spray and comparison of removal efficiency for PCB#126, PCB#169 and 2,3,7,8-substituted P_5CDF and H_6CDF

* A similar destribution of TEQ within the coplanar PCB was reported for off gas and fly ash of waste incinerators[11].

The second increase of the PCB contribution to total TEQ between BF-out and stack (Figure 1) was caused by the SCR catalyst. Plant A was equipped with a SCR-catalyst (Table 1) for NO_x removal operated at 230°C. It has been shown that these catalysts are also very effective in the decomposition of PCDD/F[12,13]. The removal efficiency of the SCR catalyst for PCB was slightly smaller than for the PCDD/F which caused the further shift to a higher impact of PCB on TEQ.

Conclusions

In fluidized bed incinerators combusting municipal waste, coplanar PCB contribute an average of about 3% to total TEQ. This is comparable with results from stoker incinerators.
Bagfilters (with or without carbon spray) or SCR catalysts capable for reduction of PCDD/F, also decrease the PCB emission. However, the PCB are removed slightly less efficiently compared to PCDD/F. This results in a relative increase of coplanar PCB to total TEQ along the flue gas cleaning line. Depending on the off-gas cleaning technologies, PCB may amount up to 10% of total TEQ. Consequently the PCDD/F still contributed more than 90% to total TEQ in the stack gas suggesting a minor impact of PCB from combustion sources on total environmental TEQ burden.

References

1. Directive 2000/76/EC of the European parliament and the council of 4 December 2000 on incineration of waste, Official Journal of the European Community, L332/91, Volume 43, 28 December 2000.
2. The Advisory Committee for Controlling PCDDs/DFs in MSW Management (1997); Ministry of Health and Welfare of Japan. Guideline for Controlling PCDDs/DFs in MSW Management.
3. Hiraoka M., Sakai S., Sakagawa T. and Hata Y. (1997) Organohalogen Compounds 31, 446.
4. Environmental Agency of Japan (1999). Law Concerning Special Meausures against Dioxins.
5. M. Van den Berg et al. (1998) Environ Health Perspect. 106, 775.
6. Sakai S., Hiraoka M., Takeda N. and Shiozaki K. (1993) Chemosphere 27, 233.
7. Sakai S., Hiraoka M., Takeda N. and Shiozaki K. (1994) Chemosphere, 29, 1979.
8. Alcock R. E., Behnisch P., Jones K. C. and Hagenmaier H. (1998) 37, 1457.
9. Weber R. and Sakurai S. (2001) Chemosphere, accepted for publication.
10. Japanese Ministry of Health and Welfare (1997). A standard manual for analysis of polychlorinated dibenzo-p-dioxins and dibenzofurans in MSW control.
11. Shibayama M, Yasuda N., Inoue T. and Takasuga T. (2000) 9th Symposium on Environmental Chemistry, Sapporo (Japanese), 170.
12. Hagenmaier H. and Mittelbach G. (1990) VGB Kraftwerkstechnik 6, 70.
13. Fahlenkamp H., Mittelbach G., Hagenmaier H., Brunner H. and Tichaczek K.-H. (1991) VGB Kraftwerkstechnik 7, 71.