COMPARISON OF PCDD/F, PCB AND PAK IN FLUE GAS: CLEAN GAS AND STACK EMISSION IN DEPENDENCE OF POST COMBUSTION TEMPERATURE AT A MUNICIPAL WASTE INCINERATOR

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Introduction

In 1998 we reported PCDD/F-emissions in dependence of the variation of the post combustion oxygen content of a municipal waste incinerator (MWI) [1]. Actual measurement results (campaign 2005) regarding PCDD/F, PCB and PAH in the flue, clean and stack gas (sampling points "after boiler", "after bag house 1" and "stack" (Fig.1) under the variation of the post combustion temperature will be discussed in this paper.

Plant Description

The MWI (Fig.1) has 2 identical combustion lines equipped with a forward feed grate designed for incinerating 21.5 Mg of waste per hour. The flue gas cleaning system for each combustion unit consists of a selective non-catalytic reduction of NOx (SNCR) by injection of steam-dispersed ammonia into the post-combustion chamber, a 4 stage boiler with the super heater section and the economizer, a first fabric filter (bag house1), a two step scrubber, an alkaline scrubber and a second fabric filter (bag house 2) with the injection of carbon and the reinjection of the filter dust into bag house 1. The plant scheme and the sampling points are described in Fig. 1.

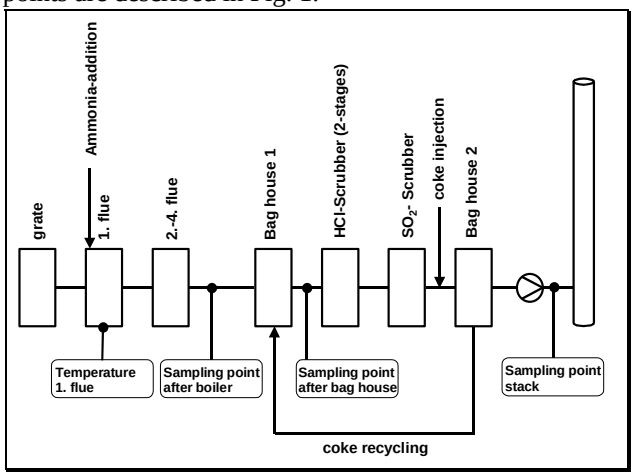


Fig.1: plant scheme and sampling locations

Methods and Materials

Parallel to POP emission measurement GfA carried out temperature grid-measurements parallel in two levels of the post combustion chamber at each incinerator line in accordance to the German guideline [2].

All POP sampling and sample-extractions were performed according to European guideline EN 1948 except sampling time was shortened and adjusted to the different phases of the post combustion temperature ranges. After clean-up, PCDD/F and WHO-PCB have been analysed in accordance to EN 1948 [3] with HRGC/HRMS using ^{13}C-labeled PCDD/F and PCB-standards, added before extraction. For PAH analysis in accordance to

ISO 11338 [4] an aliquot of the sample extract has been spiked with D-labeled PAH-standards. After clean-up, samples were analysed using GC/MS.
Limits of quantification were ~ 0,001 – 0,05 ng/Nm^3 (TCDD/F-OCDD/F), 0,035 – 1,3 ng/Nm^3 (WHO-PCB) and 0,01 – 0,6 µg/Nm^3 (EPA-PAH).

Results and Discussion
Concentrations in the raw gas (after boiler) were in the range of ~ 1 – 4 ng ITEQ/Nm^3 for PCDD/F, 0,6 – 4,5 ng ∑ WHO-PCB/Nm^3 (0,01 – 0,08 ng WHO-TEQ/Nm^3) for PCB and 0,1 – 1,1 µg/Nm^3 for sum of EPA-PAH. The results in the gas after bag house 1 and in the stack were clearly lower, resulting in PCDD/F-values significantly below the limit value 0,1 ng $_{ITEQ}$/Nm^3.
The PAH were dominated by the low boiling components (Naphthalene, Fluorene, Phenanthrene, Anthracene and Fluoranthene) at similar levels for all sampling points. This may be explained by the working temperature of 160-170°C of the bag houses leading to volatilisation of these compounds.

Table 1: combustion line 1 - results of PCDD/PCDF, WHO-PCB and EPA-PAH

measur	post comb temp. °C	after boiler			after bag house 1			stack		
		PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3	PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3	PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3
1	847	5,30	0,111	5,51	0,0523	ND	1,92	0,0029	ND	0,93
2	812	3,81	0,078	0,50	0,0212	ND	1,01	0,0015	0,00001	0,25
3	825	3,71	0,066	0,63	0,0154	ND	0,81	0,0013	ND	0,38
4	897	1,79	0,028	1,13	0,0079	0,00002	1,24	0,0000	ND	0,05
5	838	2,11	0,030	1,06	0,0049	0,00002	1,79	0,0001	ND	0,46
6	914	1,23	0,014	0,78	0,0039	ND	2,16	ND	ND	ND

ND = not detected, all isomers below limit of quantification

Table 2: combustion line 2 - results of PCDD/PCDF, WHO-PCB and EPA-PAH

measur	Post comb temp. °C	after boiler			after bag house 1			stack		
		PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3	PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3	PCDD/F ng ITEQ/Nm^3	WHO-PCB ng TEQ/Nm^3	∑ EPA-PAH µg/Nm^3
1	883	1,63	0,041	0,119	0,0074	0,00001	0,210	0,00386	ND	0,131
2	878	3,35	0,061	0,172	0,0084	0,00002	0,217	0,00133	ND	0,134
3	839	3,49	0,054	0,104	0,0104	0,00002	0,192	0,00072	ND	0,122
4	890	1,59	0,023	0,364	0,0022	ND	0,328	ND	ND	0,109
5	834	2,03	0,026	0,266	0,0139	ND	0,305	ND	ND	0,106
6	900	2,38	0,029	0,228	0,0016	0,00001	0,270	ND	ND	0,149
7	911	1,05	0,016	0,380	0,0011	0,00002	1,319	0,00028	0,0004	0,758

ND = not detected, all isomers below limit of quantification

In Table 1 and 2 the results of PCDD/F, WHO-PCB and EPA-PAK from six respectively seven measurement campaigns at each line are summarized. All data are standardized to 273 K and 1013 hPa at 11 % O_2 .

Correlation between PCDD/PCDF- and WHO-PCB-emissions has been evaluated choosing linear regression, where correlation is expressed by the correlation coefficient (R^2). A clear correlation can be shown for line 1, whilst it is not as good for line 2:

PCDD/F **:** WHO-PCB Line 1, after boiler: R^2 = 0,99
PCDD/F **:** WHO-PCB Line 2, after boiler: R^2 = 0,79

In a former work the authors reported similar correlations between PCCD/F and Chlorophenols [5].
No correlation could be observed for the PAH with PCDD/F or PCB.
Due to the very low concentration levels in the clean gas after bag house 1 and in the stack correlations have not be evaluated here.

During the measurement campaign, post combustion temperature could be adjusted at different levels. Figures 2 and 3 show the correlation between the post combustion temperatures and the concentrations of PCDD/F and WHO-PCB respectively at sampling point after boiler. At line 1, R^2 is 0,82 for PCDD/F **:** temperature and 0,75 for WHO-PCB **:** temperature. At line 2, the influence of the combustion temperature is not significant (PCDD/F **:** temperature R^2=0,29, WHO-PCB **:** temperature R^2=0,24). The consideration of the flue gas mass flow does not lead to different results.

Figure 2: line 1 - correlation of PCDD/PCDF and WHO-PCB with post combustion temperature

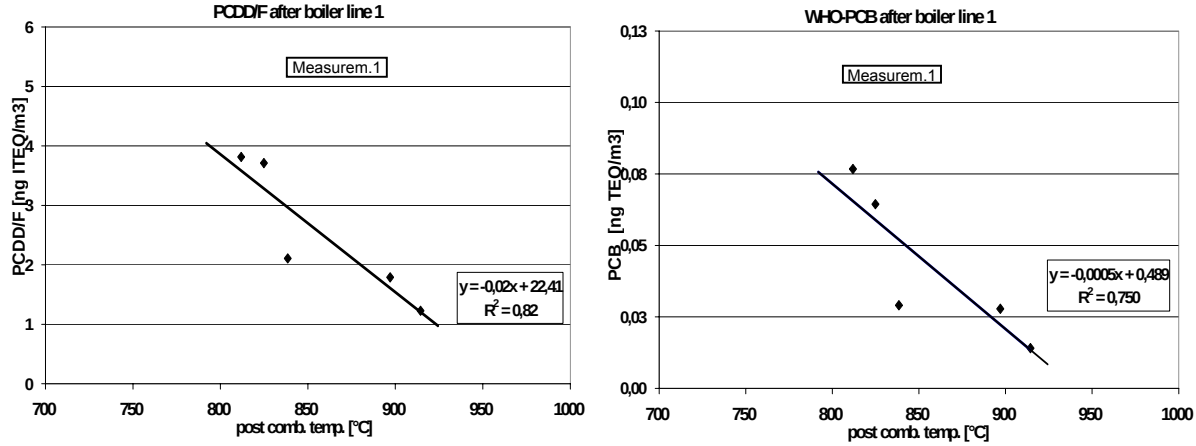
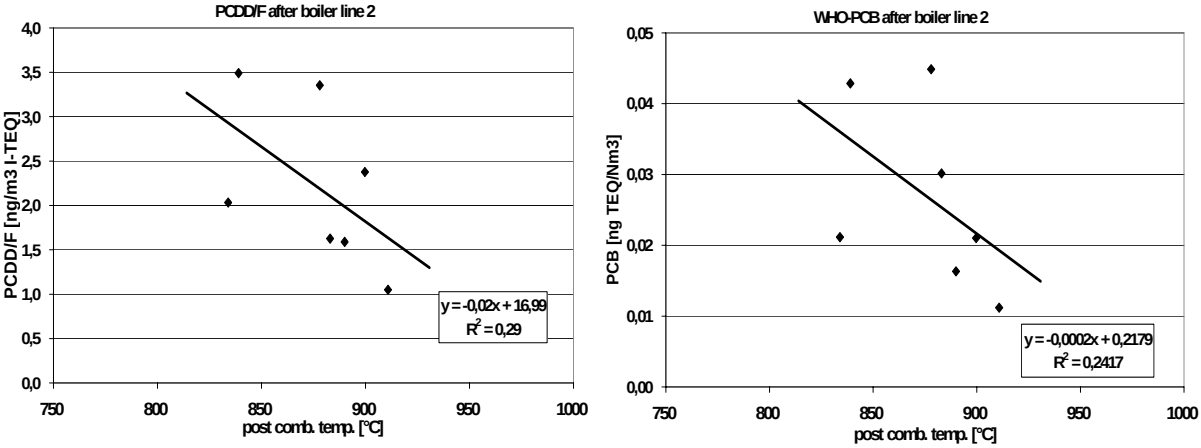


Figure 3: line 2 - correlation of PCDD/PCDF and WHO-PCB with post combustion temperature



It was assumed, that the outstanding values of measurement campaign 1 for all compounds at all sampling points at line 1 were influenced not only by the combustion temperature, but mainly by events that took place before the measurements started. This measurement was therefore not considered for the regressions of the temperature influence on the POP-levels.

Conclusions

A slight influence of the post combustion temperature on POP emissions could be observed after the 4th flue of the boiler especially for line 1 of the municipal waste incinerator, but the POP emission levels at post combustion temperatures below 850 °C are still in the same magnitude as the levels at temperatures above 850 °C (up to 914°C). On the other hand the POP emissions after the gas cleaning system are always on a very low level. Even with the lowest combustion temperatures (812°C, line 1) PCDD/PCDF concentrations were significantly below the limit value of 0,1 ng ITEQ/Nm^3 and WHO-PCBs were hardly detectable.

Due to the cost intensive consumption of primary energy and the CO_2-climate problems connected, the authors suggest to optimize the post combustion temperature for each individual combustion line. Thus an individual lower limit for that temperature may be defined, where all limit values for PCDD/F and B(a)P are surely met and no increase of the POP mass flow after boiler would be observed.

Acknowledgement

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References

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