

Co-Combustion of Alternative Fuel in a Coal-Fired Power Plant

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Abstract

Three series of measurements were taken during the normal operation (A) of a coal-fired power plant and during co-combustion (B) with alternative fuels. All feedstocks, residues, raw gas after the electrostatic precipitator (ESP) and clean gas after the wet scrubber were examined for organic and inorganic substances. The results for polychlorinated dibenzofurans and dibenzo-p-dioxins (PCDF/Ds) presented here show no effects produced by co-combustion. Polychlorinated biphenyls (PCBs) and polychlorinated benzenes (PCBzs) were not detected in the residues and flue gas. An increased input of heavy metals (HMs), demonstrated in this case by Sn and Zn, yielded an increased output in the residues and in the raw gas after the ESP. This effect does not appear in the clean gas after the scrubber.

Introduction

During the past 10 years, GfA has carried out measurements on more than 100 co-combustion trials, at which special substances as alternative fuels were used. Up until then, these were not permitted for use as feedstocks in thermal facilities. These trials were carried out mainly within the scope of approval procedures.

The inputs and the outputs of chlorinated aromatic hydrocarbons and heavy metals in a coal-fired power plant are presented in the following, both during normal operation while using alternative fuels from the chemical industry.

Experimental Methods

The coal-dust fired boiler plant is a 1 ½ pass radiation boiler with natural water circulation. The boiler has a furnace-thermal-output of 100 MW and is designed to supply a continuous power output of 120 tonnes of steam per hour.

Between 10 and 12 tonnes of coal per hour is used as the main fuel. Other fuels are heavy fuel oil and natural gas. The boiler plant has an ESP with a mechanical cleaner to remove the dust and a wet scrubber between the ESP and the smokestack.

Description of sampling and analyses

The sampling and analysis of the raw gas after the ESP and clean gas after the wet scrubber took place during normal operation and again while special substances from the chemical industry were being added to the feedstock. The samples were taken (in parallel in each case) over a period of 6 hours on three consecutive days in each plant operating conditions (A and B).

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Concurrent with the 6 hour period during which samples of PCDF/Ds were taken from the flue gas, all feedstocks and residues were sampled, mainly at hourly intervals, and combined with the 6 hour mixed samples. Table 1 shows the sample matrices, sampling conditions and the substances analysed.

The PCDF/D, PCB and PCBz concentrations were measured using an adsorption method in accordance with the German VDI guideline 3499, sheet 3. The analyses was carried out using HRGC/HRMS and ^{13}C labelled standards. The taking of HM samples and analyses for particle-bound substances and substances passed the filter was carried out according the German VDI guidelines 2066 and 3868.

Results and Discussion

The concentrations of PCDF/Ds of around $0.001\text{ }\mu\text{g ITE/kg}$ (see Figure 1) and PCBs from 12 to $80\text{ }\mu\text{g/kg}$ found in the coal samples lie well within the ranges usual for this matrix. As far as the PCDF/D concentrations are concerned, the alternative fuel used here is comparable to coal. No PCBs and PCBzs were found in the alternative fuel.

While the PCDF/D grate ash concentrations are comparable with those in the feedstock with regard to ITE values, those in the ESP dust are much lower. No PCB or PCBz congeners were found in any of the residues.

Because of the very low concentration of PCDF/Ds in the raw gas after the ESP, not many congeners could be found under operating conditions A and B. For a better interpretation therefore, concentrations in ng ITE/m^3 were used by including the detection limits for the congeners which were not found (worst case) or by not including (according to the stipulations of the 17th Federal Air Pollution Control Regulation BImSchV).

The PCDF/D concentrations were found to be around 0.001 ng ITE/m^3 in all cases. The differences are not significant when the accuracy of measurement for this concentration range is taken into account. As was already observed with the residues, neither PCBs nor PCBzs could be detected here either.

Unlike the situation with PCDF/Ds, changing the HM input produced a corresponding effect in the residues and, to some extent, in the flue gases of the power plant as well. As is made clear in Figure 2, an increased input of Sn and Zn from alternative fuels increased the concentration in the grate ash, ESP dust and raw gas. This effect could not disappear until the heavy metals have been precipitated in the wet scrubber.

Conclusions

The levels of concentration which were determined lie within the range which is typical for the corresponding matrices of a coal-fired power plant.

Changing the input of organic substances by using alternative fuels has no effect on the output of these substances in the residues and flue gases. Generally, however, this statement only applies to alternative fuels which - as in the present case - do not have a significant positive or negative effect on the combustion conditions in the furnace.

Changing the input of elements such as heavy metals by using alternative fuels results in a corresponding change in the output of these substances from the furnace. This can be seen to some extent in the grate ash, the ESP dust and in the raw gas after the ESP. However, as a rule this effect, as in the present case, is not to be found in the clean gas after the wet scrubber.

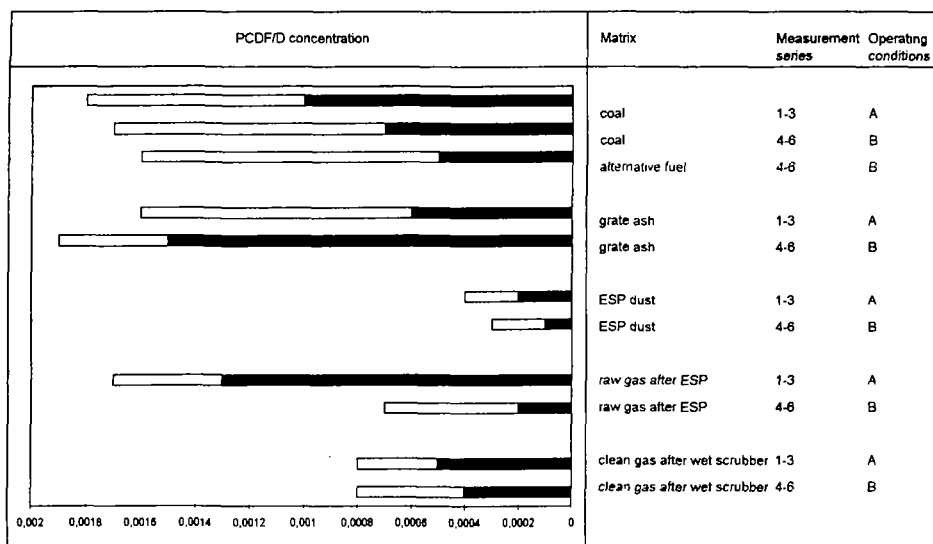
Table 1: Summary of samples and analyses referred to in this report

Measurement series	Operating conditions ^a	Matrix	Sampling time period	Analyses of			
				PCDF/Ds	PCBs	PCBzs	HMs
1-3	A	coal	b	x	x	x	x
4-6	B	coal	b	x	x	x	x
4-6	B	alternative fuel	c	x	x	x	x
1-3	A	grate ash	c	x	x	x	x
4-6	B	grate ash	c	x	x	x	x
1-3	A	ESP dust	c	x	x	x	x
4-6	B	ESP dust	c	x	x	x	x
1-3	A	raw gas after ESP	d	x	x	x	x
4-6	B	raw gas after ESP	d	x	x	x	x
1-3	A	clean gas after wet scrubber	d	x	x	x	x
4-6	B	clean gas after wet scrubber	d	x	x	x	x

- a A: normal operating conditions; B: co-combustion of alternative fuels from the chemical industry.
b half-hourly sampling over 2 hours at the hopper, afterwards making a mixed sample.
c hourly sampling over 6 hours, parallel to the flue gas measurements, afterwards making a mixed sample.
d each measurement series taking samples over a period of 6 hours for PCDF/s, PCBs, PCBzs and over a period of 2 hours for HMs.

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Figure 1: Average PCDF/D concentrations in the feedstocks and residues ($\mu\text{g ITE/kg}$), raw gas and clean gas (ng ITE/m^3) of a coal-fired power plant, (A) during normal operation and (B) during co-combustion of alternative fuels.

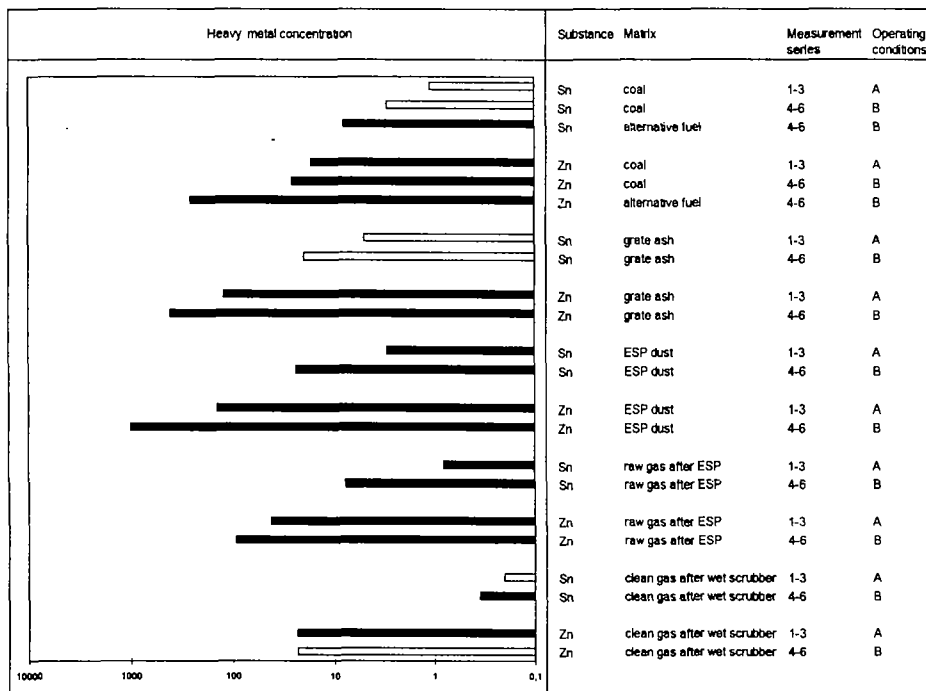


The rows which have not been filled correspond to the part-concentrations of congeners which were not found when the detection limits are taken into account.

Detection limit for 2378-tetraCDDs; approx. 0.0001 - 0.0004 $\mu\text{g/kg}$ or 0.0001 - 0.0002 ng/m^3 .

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Figure 2: Average concentrations of selected HMs in the feedstocks, residues, raw gas and clean gas, (A) during normal operation and (B) during co-combustion of alternative fuels.



The rows which have not been filled correspond to the detection limits of substances which were not found.