# ELEVATED LEVEL OF PCDD/F-EMISSION FROM A WOOD-CHIPS-FIRED-BOILER AFTER A SMALL FAILURE OF OPERATION CONDITIONS

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## 1. Abstract

In this work we present data of the PCDD/F emissions from continuously wood-chips-fired boiler and their dependency on operation conditions. The measurement campaigns are characterized by partially incomplete combustion conditions and elevated CO level (~1000 mg/m$^3$). The measurements indicate that the poor incineration conditions during run 1 primarily lead to elevated lower chlorinated dioxins and furans which explains the relatively strong increase of the I-TEQ value. To realize low organic, inorganic and dust emission levels in the clean gas of old wood-chips-fired boiler plants further investigations are necessary to find out appropriate primary and secondary measures.

## 2. Introduction

Wood as fuel becomes very popular particularly as a benefit to reduce the $CO_2$ emission. Furthermore the advantages of the incineration of wood chips coming from the production of furniture is often used as a substitute of other fuel types for energy reduction. However, incineration of wood leads to the emission of inorganic and organic gases even of PCDD/F [1,2,3,4,5,6]. Primarily the combustion conditions and the furnace heat release has a main impact of the PCDD/F emisson level. The primary strategy to reduce the PCDD/F emissions should consist of the optimization of the total combustion process and a comprehensive substitution of halogenated materials to increase the combustion quality as well as the use of air pollution control measures, especially at large facilities [7,8,9].

In this work we present data of the PCDD/F emissions from continuously wood-chips-fired boiler and their dependency on operation conditions.

## 3. Plant description

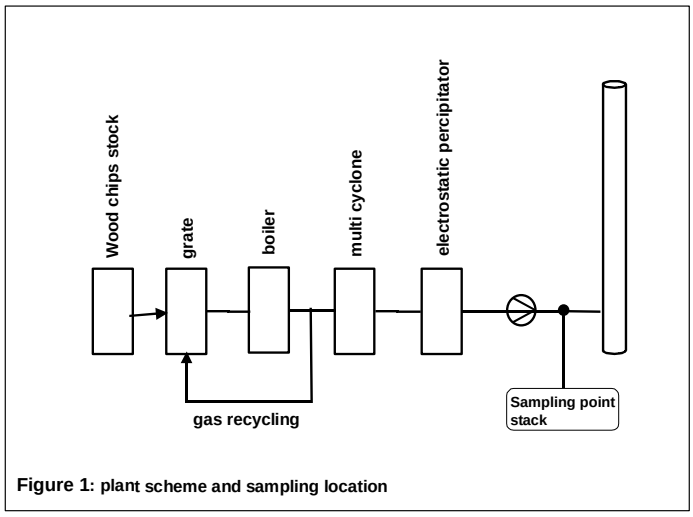


**Figure 1: plant scheme and sampling location**

A furniture producing facility uses the vapor and heat of the wood-chips-fired boiler for press machines and hot water supply. The combustion system consisted of the following. A "WEISS-HOLZ-HW-Waermeerzeueger" (established 1993) for the combustion of wood-chips equipped with a boiler (180 °C/18 bar) with a nominal output of 3.5 MW. The wood chips and the sawdust from chipboards coming out of the furniture production consists of pieces between 0,1 up to 10 mm and are stored in a container. The chipboards with ammonium sulfate hardener are covered with a paper coating which is fixed by wood glue. The combustion furnace has a 3 zone grate with a furnace heat release of 4.4 MW and a gas recycling of the flue gas. Supplies of primary and secondary air were regulated with the suction fan connected to the boiler thermostat. The air pollution control device consists of a multi cyclone in combination with a electrostatic precipitator for dust removal. The temperature of the post combustion zone is recorded with thermocouples (see fig. 1).

## 4. Methods and Materials

According to the regulations three PCDD/F measurements in the clean gas were carried out. The sampling and analysis was performed according to the EN 1948 method with the exception that the sampling time was shortened due to the low consumption of vapor and hot water[10]. Each of the 3 runs lasted 1 hour. The detection limit was 0.001 ng I-TEQ/Nm³ for all 2,3,7,8-substituted isomers. All data are standardized to 273 K and 1013 hPa at 11% $O_2$. In addition NO, $NO_2$, CO, $CO_2$, $O_2$ and TOC were continuous measured and 4 dust measurements were performed.

## 5. Results and Discussion

There were considerable differences in the emissions of the first, the second and third measurement. During measurement no. 2 and 3 the PCDD/F level was at the official emission limit whereas the PCDD/F result of measurement no. 1 (0,44 ng (I-TEQ)/$m^3$) exceeded significantly the regulated maximum value of 0,1 ng (I-TEQ)/$m^3$ (Table 1).

**Table 1:** PCDD/PCDF-values at sampling location stack

| measurement no. | **1** | **2** | **3** |
|---|---|---|---|
| sampling date | 31.03.2007 | 31.03.2007 | 31.03.2007 |
| sampling time | 04:10-05:10 | 05:30-06:30 | 06:40-07:40 |
| load | 69% | 40% | 40% |
| PCDD/F (11 % O2) | [ng/Nm3] | [ng/Nm3] | [ng/Nm3] |
| **I-TEQ (Nato-CCMS)** | **0,440** | **0,107** | **0,085** |
| sum TetraCDD | 2,678 | 1,055 | 0,843 |
| sum PentaCDD | 3,847 | 2,078 | 1,925 |
| sum HexaCDD | 2,614 | 1,171 | 1,061 |
| sum HeptaCDD | 2,838 | 0,751 | 0,739 |
| sum OctaCDD | 0,402 | 0,070 | 0,113 |
| sum PCDD | 12,379 | 5,125 | 4,681 |
| sum TetraCDF | 41,963 | 8,392 | 6,889 |
| sum PentaCDF | 10,957 | 3,061 | 2,409 |
| sum HexaCDF | 2,663 | 0,995 | 0,827 |
| sum HeptaCDF | 0,857 | 0,348 | 0,302 |
| sum OctaCDF | 0,049 | 0,021 | 0,018 |
| sum PCDF | 56,489 | 12,816 | 10,445 |
| total PCDD+PCDF | 68,868 | 17,941 | 15,126 |
| 2378-TetraCDD | 0,098 | 0,014 | 0,010 |
| 12378-PentaCDD | 0,107 | 0,028 | 0,023 |
| 123478-HexaCDD | 0,049 | 0,016 | 0,015 |
| 123678-HexaCDD | 0,118 | 0,038 | 0,035 |
| 123789-HexaCDD | 0,087 | 0,028 | 0,026 |
| 1234678-HeptaCDD | 0,306 | 0,080 | 0,080 |
| 2378-TetraCDF | 0,609 | 0,096 | 0,081 |
| 12378PentaCDF | 0,234 | 0,055 | 0,041 |
| 23478-PentaCDF | 0,297 | 0,086 | 0,064 |
| 123478HexaCDF | 0,123 | 0,043 | 0,032 |
| 123678-HexaCDF | 0,115 | 0,043 | 0,034 |
| 123789-HexaCDF | 0,011 | 0,004 | 0,003 |
| 234678-HexaCDF | 0,115 | 0,046 | 0,040 |
| 1234678-HeptaCDF | 0,168 | 0,061 | 0,056 |
| 1234789-HeptaCDF | 0,031 | 0,012 | 0,022 |

During the first measurement a massive disturbance of the incineration conditions could be observed indicated by a strong increase of the CO-level. In the last 10 minutes of the sampling period (equivalent to 15 % of the sampling time) CO-concentrations up to 1000 mg/$m^3$ were measured while under normal operation conditions the CO-level is around 60 mg/$m^3$. Also the TOC-concentration increased to 122 mg/$m^3$ (see Figure 2). It is a well known phenomena that failure in the operation process often leads to worsen combustion conditions with increased CO, TOC, dust and soot levels[11]. The dust level detected in the first measurement (no. 1) was about 3 times higher than in the other measurements (Table 2). Considering the flow stream (run #1: 5.100 $Nm^3$/h, run #2, #3: 3.200 $Nm^3$/h) the mass flow of dioxins and furans during the first measurement are 7 times higher, the mass flow of dust 8 times higher compare to run #2, #3.

The measurements indicate that the poor incineration conditions during run 1 primarily lead to elevated lower chlorinated dioxins and furans which explains the relatively strong increase of the I-TEQ value. In a German R&D-study about the PCDD/F-emissions from wood burning facilties similar results could be observed at a wood-chips fired boiler. In this R&D study 10 measurement campaigns under various conditions were carried out at a wood chips fired boiler with comparable input material and combustion conditions (plant #5: furnace heat release of 234 KW, primary and secondary air were regulated with the suction fan connected to the boiler thermostat, average particle size of wood chip 1 – 5 mm, 50 kg/h input mixture: sawdust from chipboard and solid wood, no air pollution control device)[7,8] which led to nearly the same increasing factors for PCDD/F for poor incineration conditions with elevated CO-levels as observed in run 1.

| measurement no. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| sampling date | 31.03.2007 | 31.03.2007 | 31.03.2007 | 31.03.2007 |
| sampling time | 04:26-05:56 | 05:13-05:43 | 05:55-06:25 | 06:27-06:57 |
| load | 69% | 40% | 40% | 40% |
| concentration | [mg/Nm3] | [mg/Nm3] | [mg/Nm3] | [mg/Nm3] |
| **dust** | **15** | **4,4** | **3,5** | **6,2** |

**Table 2:** Dust values at sampling location stack

The increasing factor for the PCDD/F was determined by dividing the concentrations of the measurement under disturbed incineration conditions by the values obtained from runs under normal operation conditions (run #9/run #2 from plant #5 in the R&D-study and run #2/run #1 and run #3/run #1 in this study). The increasing factors for the homologues as well as for the 2378-substituted congeners and the toxic equivalents in this study and in the R&D-study are very similar (see figure 3, figure 4).

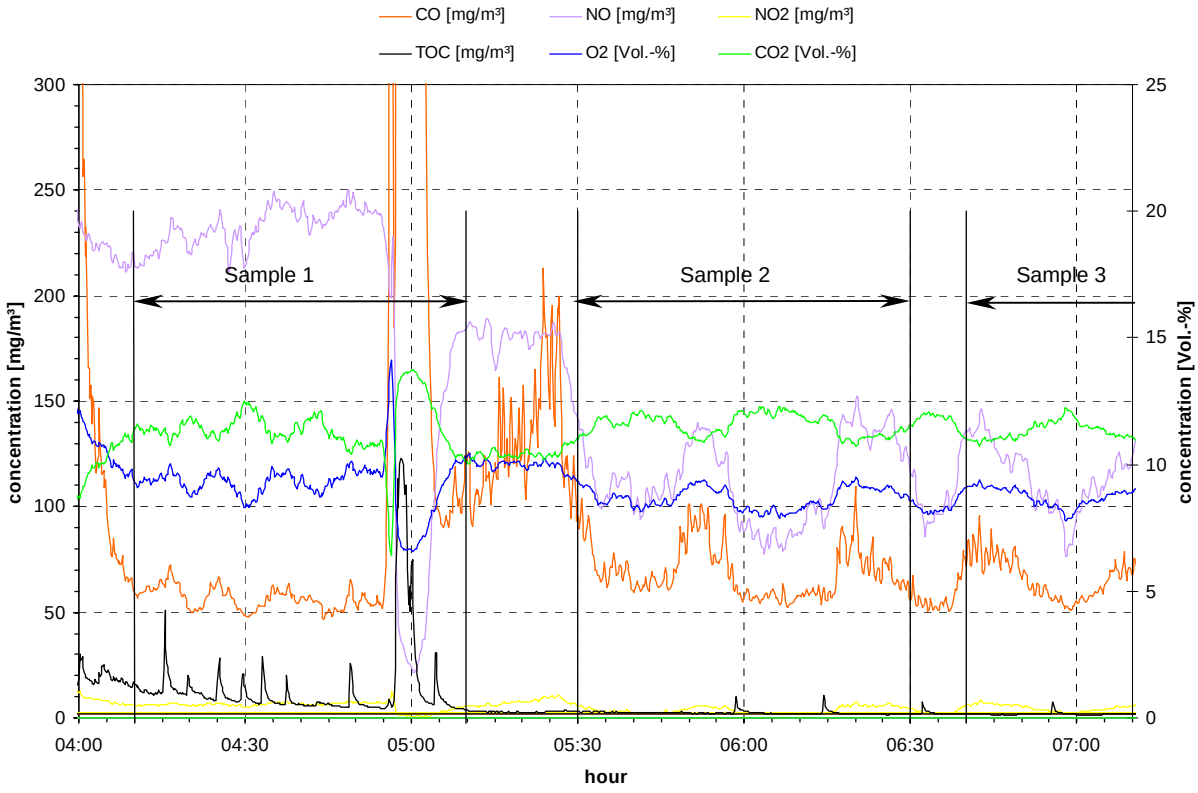


**Figure 2:** Normalized emissions (273 K, 101,3 kPa) of inorganic gases at sampling location stack

Both campaigns are characterized by incomplete combustion conditions and elevated CO level ( ~1000 mg/m$^3$). This indicates contaminations of the boiler surface with soot particles and formation processes of the PCDD/F[12]. Due to the absence of rubber and plastic material of the flue system this contaminations are less influenced by the well known memory effect[11].

As a result of this measurement campaign it is probable that the combustion of wood chips and saw glue in old boiler technology with insufficient process control system can lead to the exceedance of the German regulatory level in case of disturbed combustion conditions. To evaluate appropriate primary and secondary measures even for the optimization of the inorganic compounds and dust emission (PM 2,5 and PM10) at old wood-chips-fired boiler plants further investigations are necessary.

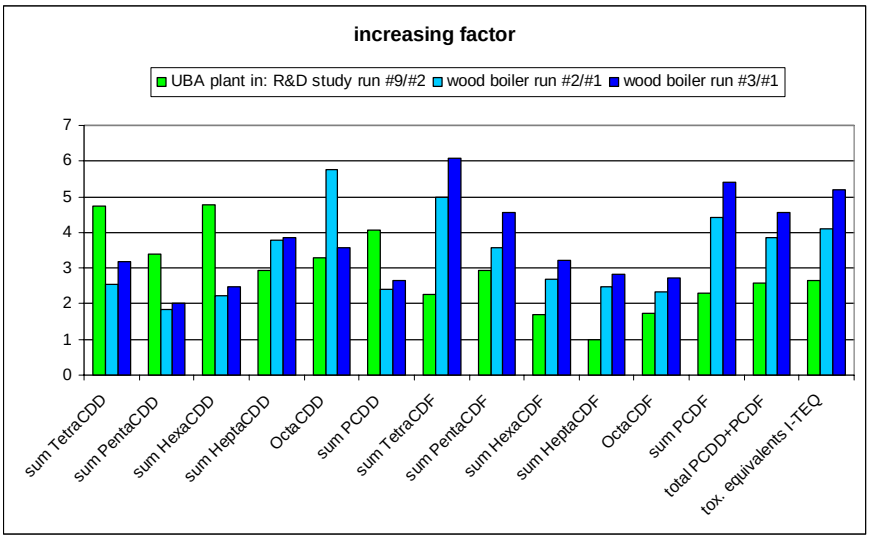


**Figure 3: Comparison of PCDD/F-**increasing factors for the homologues and I-TEQ [7,8]

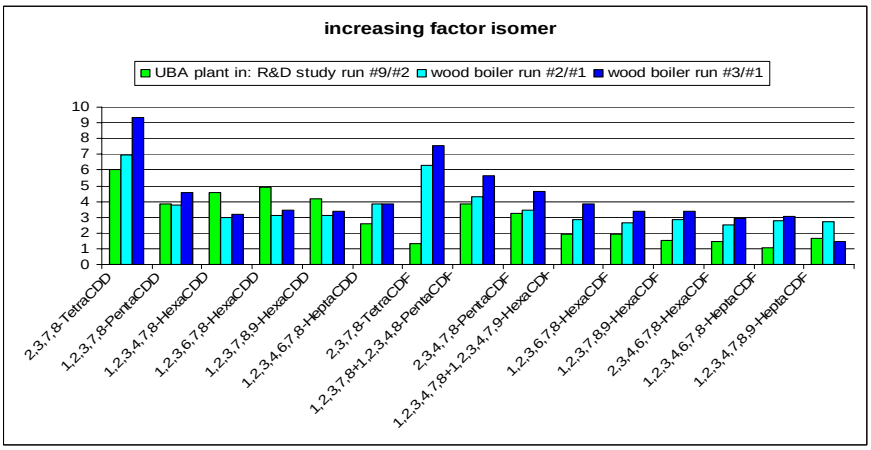


**Figure 4: Comparison of PCDD/F-**increasing factors for the 2378-substituted congeners[7,8]

**Acknowledgements**

The authors would like to thank the plant manager for providing the necessary data.

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