Practical Concepts to Minimize the Emission of Halogenated Organic Compounds from Municipal Solid Waste Incinerators

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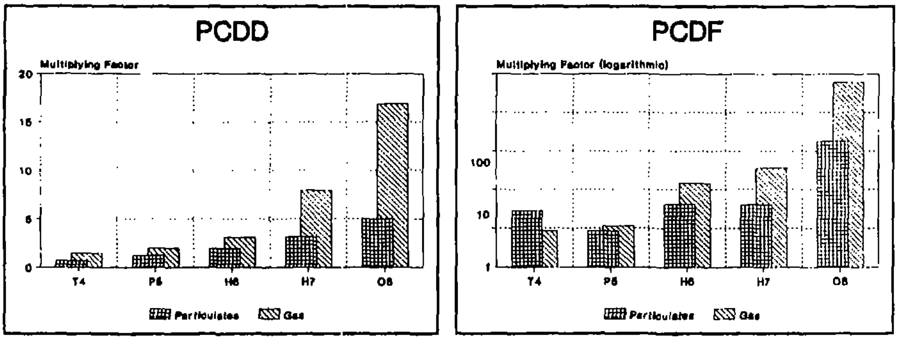
The emission of halogenated organic compounds is a major concern in siting and operating municipal solid waste incinerators. Several monitoring series conducted by ITU since 1989 have inquired into the formation processes of PCDD/PCDF and other organohalogen compounds, in state-of-the-art waste incinerators in Germany. The results of these studies and the consequences for minimizing the emission of organohalogen compounds are presented below.

In order to identify factors relevant to the shaping of PCDD/PCDF emission levels, ITU conducted a number of test series at various incinerators at among others MWI Berlin-Ruhleben[1] or MWI Bielefeld-Herford[2]. For the first series of experiments, sampling alone took several hours. For the second series, ITU developed an improved sampling equipment combined with a high performance GC/MS, permitting monitoring even at low concentration levels in scrubbed flue-gas within a collection period of five minutes.

In order to investigate the influence of operating conditions such as O_2 and CO levels in the combustion chamber, temperature regimes and composition of input material, ITU monitored emission levels of waste incinerators while varying these parameters. Results of input variation have already been published[3].

Within multiple tests with varying concentrations of carbon monoxide and oxygen, one of the most instructive set of results was gained through the "cold blowing" program. This program is performed with a minimum of hot steam and of combustion chamber temperature, and a maximum of CO and O_2 in flue gas. Parameter change resulted in an increase on PCDD/PCDF concentration in flue gas and, to a lower extent, in clean gas (see fig. 1). Our findings show that suppressing CO peaks and minimizing oscillating O_2 levels during the incineration process lead to considerable emission reduction. Measures to minimize CO levels can therefore be regarded as important in reducing PCDD/PCDF emissions.

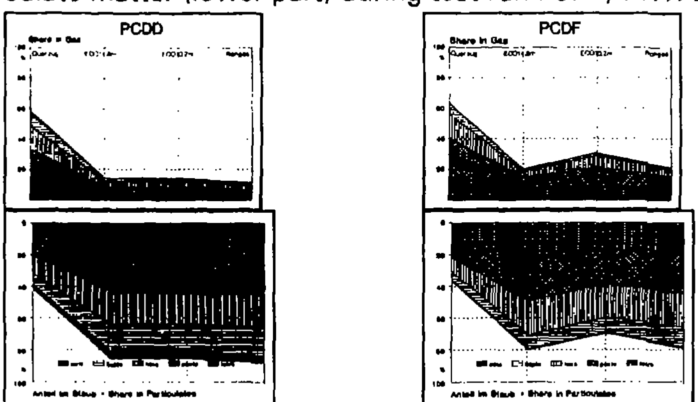
Fig. 1: Relation of PCDF (log scaling) and PCDD within "cold blowing" performance compared to routine performance, separate data for gas (light hatching) and particulate matter (dark hatching)



In order to detect changes in PCDD/PCDF concentration and distribution, ITU analyzed samples taken simultaneously at different temperature zones of the boiler area and from flue gas. The next figure shows the relative distribution of PCDD and PCDF in gas (upper part) and particulate matter (lower part) within test run no. 7. An additional test run showed similar distributions. The four sampling locations to which this figure relates were

- Querzug	level 22.6 m	approx. 470°C
- ECO (Economizer)	level 14.5 m	approx. 265°C
- ECO (Economizer)	level 10.2 m	approx. 210°C
- Rohgas (flue gas)		approx. 185°C.

Fig. 2: Relative distribution of PCDD and PCDF in gas (upper part) and particulate matter (lower part) during test run no. 7, MWI Berlin-Ruhleben



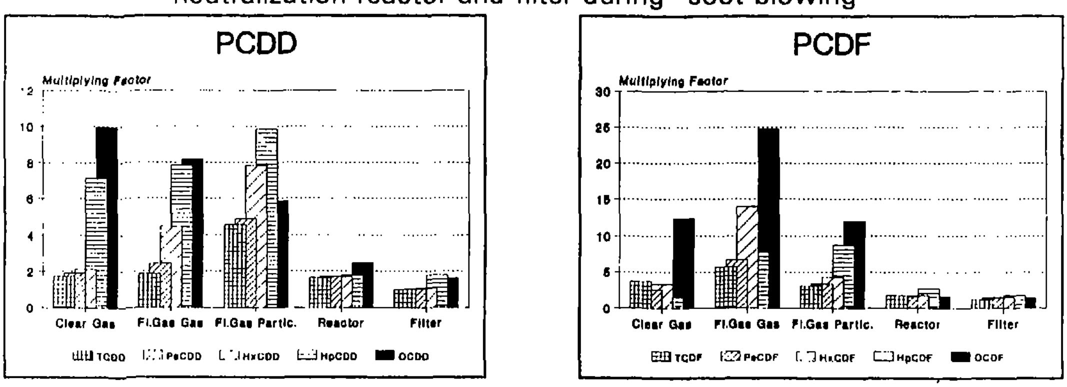
The graphs illustrate that cooling of the gas stream shift PCDD/PCDF distribution from the gaseous phase to the particulate matter. This shift primarily occurred in in the temperature zone between 470°C and 265°C. However it preferably affected dioxin and furan molecules with a lower chlorination degree, while octa-substituted dioxins and furans only showed minimal effect.

One cause for this result is suspected to be a change in adsorption characteristics of PCDD/PCDf molecules in relation to particulate matter with decreasing temperature. A similar effect occurred at the textile filter, where reduction rates of more than 99 % were achieved for tetrachlorinated dioxins and furans. This effect might not only be the result of particulate removal, but can also be attributed to an adsorptive transfer of low chlorinated PCDD/PCDF from the gaseous phase to particulate matter.

ITU analyzed emission of organic pollutants during maintenance procedures such as "soot blowing". This term describes the automatically performed cleaning program for heat exchange surfaces. All soot blowing units are activated subsequently, interrupted by breaks of a few minutes. The entire procedure lasts about 40 minutes. Within this procedure, flue gas containes approximately 10-fold higher amounts of particulate matter than during routine performance. Furthermore, considerably increased concentrations of PCDD and PCDF occurred in flue gas, which resulted in 30-fold higher concentration and load of PCDD and PCDF in flue gas compared to routine performance. This increase is more significant for higher chlorinated substances than for those with a lower chlorination degree. Though the efficiency of the flue gas purification system was much higher during "soot blowing" (up to 99.8 %) compared to routine performance, overall PCDD/PCDF emission had multiplied threefold (see fig. 3).

The extended residence time for particulate matter in the boiler system between the periods of "soot blowing" appears to be responsible for the increase in PCDD/-PCDF concentration and load. A reduction of particulate disposal on the boiler surfaces through more frequent cleaning could therefore lead to a reduced overall emission of these compounds. Taking into account that 40 minutes "soot blowing" takes place three times a day, and that this results in a three-fold increase of PCDD/PCDF loads, about 20 % of the normal daily emission can be calculated to stem from this maintenance procedure.

Fig. 3: Increase in concentration of tetra- to octa-chlorinated dioxins and furans in flue gas (gaseous phase and particulate matter), clear gas, neutralization reactor and filter during "soot blowing"



Between part I and II of ITU's research at the MWI Berlin-Ruhleben, a new dry scrubber system was installed. It reduced PCDD/PCDF concentration in flue gas by more than 98 % (average). In comparison to the former flue gas cleaning system, it proved to be 20-fold more effective. Test runs at a later stage with a further improved scrubber and addition of lime and activated carbon (Sorbalit^R) demonstrated that emission levels significantly below 0.1 ng TE/m^3 can be achieved.

Based on ITU's research findings, the following recommendations for reducing PCDD/PCDF emissions are considered to be of general importance.

Concerning the design of MWI:

* Avoid the risk of cold zones in the combustion chamber through providing
  - air flow regulation according to demand
  - means for equal distribution of waste material on the combustion grate
  - means for homogenization of input material (e.g. mill).
* Avoid "cold blowing" effects through extensive preheating of combustion air.
* Install continuously performing technologies (e.g. ultrasonic) for cleaning of the boiler surfaces.
* Provide for a cooling section for flue gas to enhance transformation processes of gaseous PCDD/PCDF into particulate bound form.
* Consider a high-performance flue-gas purification system with efficient particulate removal and acid neutralization features (scrubber, electrostatic precipitator, baghouse, injection of additives (limestone, activated carbon, etc.).
* *Consider nitrous oxide removal features (i.e. catalytic converter).*
* Reduce flue gas temperature after the boiler system below 250°C.
* Reduce flue gas temperature at the electrostatic precipitator considerably below 250°C.

Concerning operating conditions:

* Keep operation conditions constant.
* Avoid CO peaks and high O_2 surplus.
* Reduce particulate and soot deposition through more frequent cleaning
* Reduce halogen availability in combustion chamber through addition of halogen fixing additives such as limestone etc..
* Increase the transformation of gaseous PCDD/PCDF into particulate bound form by addition of adsorptive solids, like activated carbon.
* Improve flue gas purification through addition of a mixture of limestone and granulated activated carbon (e.g. Sorbalit^R).

1. Jager J, Wilken M, Beyer A: Praktische Konzepte zur Verminderung der Bildung von PCDD und PCDF bei kommunalen Muellverbrennungsanlagen. UBA-research report no. 14 30 378, April 1990

2. Lahl U, Wilken M, Zeschmar-Lahl, Jager J. PCDD/PCDF balance of different municipal waste management methods. Chemosphere, in press

3. Wilken M, Beyer A, Jager J. Generation of brominated dioxins and furans in a municipal waste incinerator (MWI) - results of a case study. Organohalogen Compounds 2, 377 - 380, 1990