Parallels Between Danish and German Studies On Dioxin Emissions From Waste Incineration

Vladimir Boscak
Environmental Consultant, P.O. Box 113,
2970 Hørsholm, Denmark

ABSTRACT

Both Danish and German environmental authorities issued the reports on dioxin emissions from about 10 waste incinerators under the different operating conditions. Both studies indicated that the correlation between dioxin emissions and operating parameters was vague, even though in the former study a dioxin emission model was derived. The closer examination of the data in both studies by the author revealed that the major correlation is between the exit gas temperature and dioxin emission, the lower the temperature the lower the emissions. Another parallel is between the toxic equivalent and sum of dioxins (and furans), with the toxic equivalent being about 1.5 to 2% of the sum.

DANISH STUDY ON DIOXIN EMISSIONS

In November 1989 the Danish Ministry of Environment issued the report on the Dioxin Emissions from Waste Incineration[1]. This investigation dealt with the PCDD/F emissions measured in 160 situations at 10 municipal solid waste (MSW) incinerators and two furnaces for the destruction of hospital waste.

Several vague correlations between PCDD/F emissions and operating parameters were seen. Based on the PCDD/F emission data a model of general validity correlating emissions with the operating conditions was developed. Three operating parameters correlated with the emissions were incineration load, excess oxygen and HCl concentration. One of the disturbing findings was that PCDD/F emissions measured at the same plants at 2-3 occasions varied considerably.

CORRELATION BETWEEN PCDD/F EMISSION AND TEMPERATURE

In order to explain the variation of emissions at different testing periods the report's data were reanalysed by the author. It was found that the major parameter dictating PCDD/F emissions was the exit gas temperature.

The PCDD/F sampling (and exit gas temperature measurement) took place between the electrostatic precipitator and exhaust fan i.e. after the fly ash has been removed from the gas stream.

The time variation of PCDD/F emissions could be explained by the different exit gas temperatures at different testing periods. The exit gas temperature varied because of different boiler cleaning intervals, prior to the commencement of the testing.

31/ld080891.vb
ehk/1

The simple explanation for the correlation between PCDD/F emission and temperature is the vapor-solid phase partition of PCDD/Fs which depends on the temperature[2]. The PCDD/Fs condensed on the fly ash (or not desorbed upon de-novo synthesis) are removed in electrostatic precipitator and are therefore not present in the cleaned gas. The fugacity calculations of vapor-flyash partition of PCDD/F showed that the separation of fly ash at low temperature should decrease the total emission up to a factor of hundred[3]. Boscak proposed that PCDD/Fs are formed through an activated complex and that PCDD/F formation/emission is a complex function of copper catalytic activity (Deacon process), formation/destruction, and evaporation/condensation equilibria all governed by the temperature[4].

Figure 1 shows the correlation between PCDD/F emission and the exit gas temperature.

The major practical benefit of this correlation is that the exit gas temperature can in the first approximation be used as a surrogate for PCDD/F emissions.

GERMAN STUDY ON DIOXIN EMISSION

In April 1991 a report on testing programme realized within the frame of the German National MSW Incineration Testing Program for Dioxin from 1985 to 1990 was issued[5]. The testing was carried out at 11 waste incineration plants with the intention to measure the PCDD/F emissions under normal operation and to correlate the emissions with operating parameters. The PCDD/F emissions varied widely between 0.2 and 63 ng I-TE/m^3 (NATO-CCMS) and no simple correlation between operating parametes and emissions was seen.

Good combustion conditions in the furnace (3 T's of combustion), low O_2 and CO content, high SO_2 content, addition of lime, and use of active coke all resulted in lower PCDD/F emissions.

Poor combustion conditions, high CO and O_2 content, resulted in the increase of PCDD/F emissions while the variations in chlorine content in waste, secondary air addition, use of afterburners, ammonia injection, and flue gas quenching had no important impact on the emissions.

MVA ISERLOHN TESTING DATA

In seeking the parallels between Danish and German studies the Iserlohn data were the most interesting. This plant with three incineration lines had the widest range of flue gas temperatures (in electrostatic precipitator), and it had measurements for both filtered and clean gas. The temperatures' difference, 180°C for line 1 and 275°C for line 2 are the consequence of facility upgrading with measurements carried out in line 1 after, and in line 2 before the upgrading. The PCDD/F emissions from line 2 were the highest of all for both filtered and clean gas, while the EP temperatures were also the highest.

Figure 2 shows the comparison of Danish data with emission data from Iserlohn plant. It is clear that Iserlohn PCDD/F emissions have the same exponential increase as a function of the increased EP temperature. The values for clean gas i.e. after wet scrubbing are lower than for the filtered gas. This is probably due to the partial removal of fly ash and/or PCDD/F in a wet scrubbing system.

31/1d080891.vb
ehk/2

GERMAN DATA ON FILTERED GAS AND CLEAN GAS

The best comparison between German and Danish data on PCDD/F emissions is possible when one compares the German emissions data on filtered flue gas with Danish data, since the data were obtained under the same conditions i.e. after the fly ash was removed in EP, but in front of the wet scrubbing system.

Figure 3 shows the comparison between the Danish and the German data for the filtered flue gas. Except for a slight deviation for the Stapelfeld measurement the correlation is very good.

In the Danish study the correlation between PCDD/F emission and exit gas temperature was very clear for the plants where only EP was used for the fly ash removal but was blurred when semi-dry or dry scrubbing system was used.

Figure 4 shows the correlation between PCDD/F emission in clean gas and EP temperature for all German data. Eventhough the data are somewhat scattered one can see the exponential increase in PCDD/F emission with the increase in EP temperature.

CORRELATION BETWEEN SUM OF PCDD/F AND TE

Since some of the PCDD/F cogeners are more carcinogenic than the others more important from the health risk point of view is the toxic equivalent (TE) than their sum. The current regulations for MSW incinerators emissions in many countries call for 0.1 ng/m^3 TE. Fortunately, there appears to be a good correlation between the sum of PCDD/Fs and TE. The analysis of data in the Danish study showed that the Nordic toxicity equivalent is obtained when one multiplies the sum of PCDD/F with 0.015 i.e. TE is about 1.5% of the sum.

The correlation between the sum of PCDD/F and TE (NATO-CCMS) for German data on clean gas and fly ash was also examined. Again a good correlation between sum of PCDD/F and TE was obtained. For clean gas TE is about 2 per cent of the sum while in the fly ash TE is about 1.5 per cent. The standard deviations are 0.37 and 0.4, respectively.

Consequently one can predict (in the first approximation) the TE in the incinerators exit gas by using its exit gas temperature as a surrogate.

REFERENCES

1 Miljøstyrelsen. Dioxin Emissions from Waste Incineration, Miljøprojekt No. 117, November 1989, (In Danish)
2 Boscak, V., Kotynek, G. Techniques for Dioxin Emission Control, 2nd International Conference on Municipal Waste Combustion, Tampa, Florida, April 1991.
3 Schramm, K.W., et al. Fugacity Calculations of Vapor-Flyash Partition of Polyhalogenated Dioxins and Furans, Chemosphere, Vol. 20, No. 5, 563-568, 1990.
4 Boscak, V. Role of Temperature in Formation and Emission of PCDD/F, Dioxin '90, Vol. 3, 35-38, Bayreuth, Germany, September 1990.
5 Greiner, B., Stelzner, E. Final Report on: Coordination, Compilation and Evaluation of Dioxin Tests in MSW-Incinerators, ARGUS at T.U. Berlin, Reference No. 1460539/1, 1991, (In German).

31/1d080891.vb
ehk/3

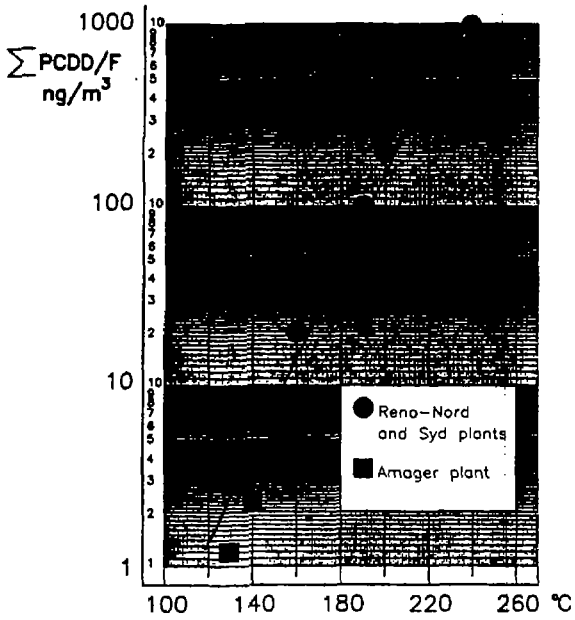

FIGURE 1. CORRELATION BETWEEN EXIT GAS TEMPERATURE AND PCDD/F EMISSIONS.

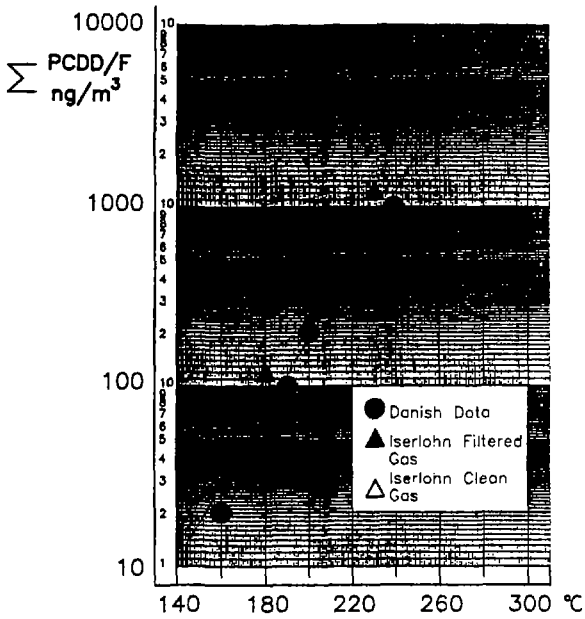

FIGURE 2. COMPARISON BETWEEN DANISH AND ISERLOHN CLEAN AND FILTERED GAS DATA

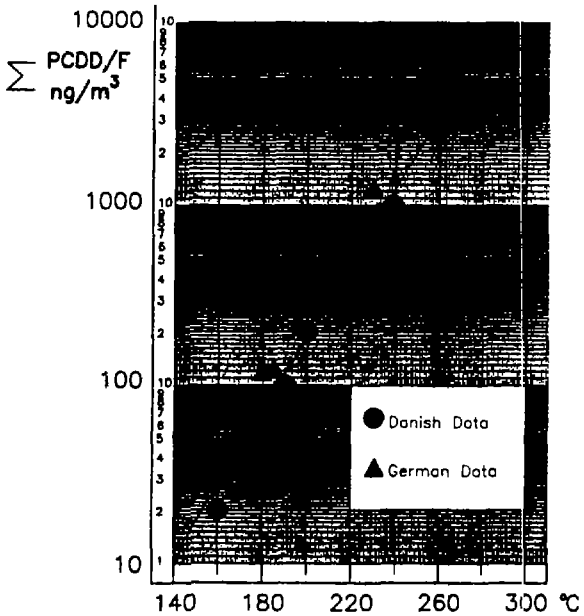

FIGURE 3. COMPARISON BETWEEN DANISH AND GERMAN DATA ON FILTERED GAS

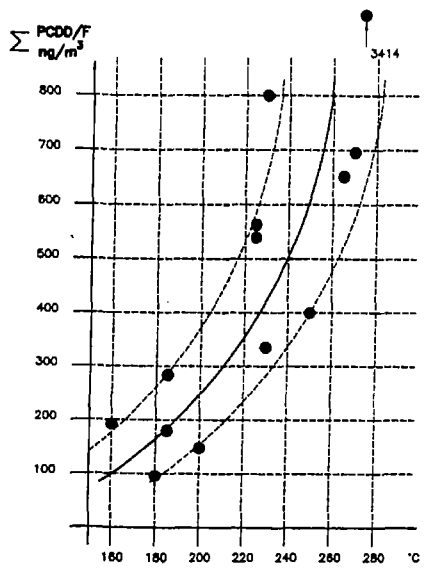

FIGURE 4. CORRELATION BETWEEN PCDD/F EMISSION IN CLEAN GAS AND EP TEMPERATURE.