Düsseldorf Airport Fire 1996: Results and Comparison with Accidental Fires

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INTRODUCTION

Controlled and well-managed combustion processes, such as municipal solid waste incineration, coal combustion in power plants, *etc.*, are characterized by a good burn-out which leads to the ultimate combustion products carbon monoxide (CO) and water (H_2O) and, in the presence of chlorine in the feed material to HCl. Accidental fires, however, very often with under-stoichiometric oxygen supply, typically generate larger amounts of products of incomplete combustion (PICs), which are visible as smoke and soot. Among the PICs, polycyclic aromatic hydrocarbons (PAH) and polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans are of special concern (Hutzinger and Fiedler 1991, Stieglitz *et al.* 1989, Wirts 1994).

On April 11, 1996, a fire occurred in the main building of the Düsseldorf Airport (Germany) which killed 17 people and injured more than 80 others. Due to the presence of flammable insulation material and several safety violations, the fire spread quite rapidly and heavy smoke was transported through the building. Consequently, large parts of the airport were closed immediately for rescue works and the same day samples were analysed to determine the severity of the damage and developing a plan for remediation (Expert Commission 1997). Here we report on the results of the analyses for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/PCDF) and evaluate the analytical results in the light of other accidental fires and limit or guideline levels set by German authorities.

EXPERIMENTAL

Seven soot samples were collected from the airport (see Samples A-F and Q in Table 1). Sample E was from the location where the fires occurred and Sample D from a nearby site. Sample Q is a composite sample of many individual pick-ups from throughout the departure hall.

For comparison, additional samples from accidental fires which occurred in North-rhine Westfalia during the last years were included into our evaluation as well as the results from a PVC burning experiment in the laboratory and finally a fly ash sample from the Düsseldorf municipal solid waste incinerator (for sample identification see Table 2).

A brief description of the accidental fires discussed is given below (Lindert and Fiedler 1998):
Düsseldorf Airport Fire: On April 11, 1996, a fire occurred in the major building of the Düsseldorf Airport. Polystyrene sheets and PVC-coated cables were involved in the fire together with PCB-containing condensers (bulbs).
Metro Station Heinrich-Heine-Allee, Düsseldorf: In October 1991, a cable fire occurred in a metro station which caused severe damages of corrosion due to the presence of hydrochloric acid. In addition, the PCDD/PCDF contamination was 5-fold above the guideline value for remedial action (= 10 ng TEQ/m²).
Arts Museum, Düsseldorf: In September 1993, a video system caught fire. The presence of halogenated flame retardants and PVC caused PCDD/PCDF contaminations in soot up to 180 ng TEQ/m² and PBDD/PBDF up to 50 mg/kg.
Hospital, Aachen: After a cable fire in April 1995, 358 ng I-TEQ/m² were detected in the soot.
School at Kikweg, Düsseldorf: After a fire in a working room up to 80 ng TEQ/m² were found.
Kindergarten, Maintal: On May 14, 1990, a fire in a Kindergarten caused by arson destroyed parts of the roof, windows and the furnishings. PCDD/PCDF concentrations up to 45,251 ng I-TEQ/kg, corresponding to ~15,000 ng I-TEQ/m² were found in the soot.

RESULTS

The results of the chemical analyses together with the concentrations in toxicity equivalents and the sum of 2,3,7,8-substituted PCDD/PCDF congeners which are regulated in the German Chemical's Law (ChemVerbotsV 1996) of all samples are summarized in Table 1 and Table 2.

For the Düsseldorf Airport fire, the surface contamination with PCDD/PCDF was up to 334 ng I-TEQ/m². In addition, due to the presence of the brominated flame retardant hexabromocyclododecane polybrominated and mixed halogenated dibenzo-*p*-dioxins and dibenzofurans were detected at concentrations up to 0.9 mg/kg soot. PAH contamination exceeded maximum guideline concentrations as well. The concentrations in soot ranged from 7 to 130 µg I-TEQ/kg soot; in all samples, the maximum concentration for the sum of all seventeen 2,3,7,8-substituted congeners of the Chemical's Law (limit value = 100 µg/kg) was succeeded (range: 64-1,091 µg/kg) in all samples except two (Samples D and E). Interestingly, Samples D and E were taken from or close to the center of the fire.

A comparison of the data obtained from the Düsseldorf Airport Fire with the data from Table 2 shows that the concentrations in the soot from accidental fires are in the same range. However, much lower contamination was found as well even when PVC or other potential dioxin precursors were involved. Based on the few data, it can be seen that the laboratory experiment, when burning PVC under worse case conditions, produced PCDD/PCDF in the range of maximum formation in real fires. The PCDD/PCDF in fly ash from a modern municipal waste incinerator produced under controlled combustion conditions gave much lower concentrations.

The dataset was analyzed by a hierarchical cluster analyses and showed that the PCDD/PCDF patterns of all fires were quite similar (not shown here) and very different from the pattern found in pentachlorophenol (PCP). However, PCP could be identified by cluster analysis as a constituent of a painted wall in the Kindergarten and was also present in a sample of burnt painted wall after the fire (Fiedler *et al.* 1993, Lindert and Fiedler 1998).

After two years of remediation, Terminal A of the Düsseldorf Airport was reopened in April 1998. Reconstruction of Terminal B is still in progress.

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Table 1: Concentrations of PCDD/PCDF in samples after the Düsseldorf Airport fire. All concentrations in µg/kg

PCDD/PCDF Sample ID	Depart. B/C A	Termin-als A/B B	Gallery C	Main Building D	Main Building E	Depart. A F	Compo-site Q
Σ Cl_4DD	178	130	188	23	12.7	57.7	56
Σ Cl_5DD	230	93	175	51	19.2	62.7	67
Σ Cl_6 DD	301	167	159	45	20.2	80.3	94
Σ Cl_7DD	312	201	137	28	16	81	84
Cl_8DD	263	184	93	25	10.9	74.9	73
Σ Cl_4DF	744	835	1173	62	114	428.4	485
Σ Cl_5DF	639	861	603	57	45.2	262.8	268
Σ Cl_6DF	331	312	314	38	22.4	87.6	167
Σ Cl_7DF	137	135	123	17	7.4	46.9	46
Cl_8DF	52	46	39	5	2.3	16.4	23
2,3,7,8-Cl_4DD	9.1	8	5.2	0.3	0.3	3.8	2.5
1,2,3,7,8-Cl_5DD	13.8	12.4	8.7	1	0.9	4.5	4.8
1,2,3,4,7,8-Cl_6DD	9	6.7	4.4	0.8	0.5	2.8	2.8
1,2,3,6,7,8-Cl_6DD	26.3	16.7	11	1.9	1.5	7.7	6
1,2,3,7,8,9-Cl_6DD	20.2	14.5	10.4	1.7	1.2	6.8	7.4
1,2,3,4,6,7,8-Cl_7DD	165.2	107.6	70.4	13.2	8.3	45	41.6
Cl_8DD	262.9	183.6	93.1	24.9	10.9	74.9	73
2,3,7,8-Cl_4DF	119.7	172.8	131.1	4.9	13.5	74.9	53.1
1,2,3,7,8(13469)-Cl_5DF	41.9	50.8	41	3.9	4.2	22.9	19.6
2,3,4,7,8-Cl_5DF	138.5	147.3	91.5	6.5	6.6	40.8	45.9
1,2,3,4,7,8-Cl_6DF	69.1	75.5	60.6	5.6	4.5	24.9	28
1,2,3,6,7,8-Cl_6DF	25.6	31.9	24.4	3.3	1.6	9.7	9.9
1,2,3,7,8,9-Cl_6DF	2	2.5	1.7	0.3	0.1	0.7	1.3
2,3,4,6,7,8-Cl_6DF	47.7	57.9	44	5	2.7	18.8	20
1,2,3,4,6,7,8-Cl_7DF	77.6	74.2	72.7	10.1	4.4	27.7	30.3
1,2,3,4,7,8,9-Cl_7DF	10.3	12.4	10.6	1.5	0.6	4.4	5.8
Cl_8DF	52.1	46.1	38.5	5	2.3	16.4	23
I-TEQ	122	130	88	6.9	7	43.1	42.6
ChemVerbotsV (17 c.)	1091	1021	719	90	64	387	376

Table 2: Concentrations of PCDD/PCDF in additional samples from accidental fires. All concentrations in µg/kg

PCDD/PCDF	Metro A	Metro B	Muse-um A	Muse-um B	Hospi-tal	Cable	Kinder-garten	PVC Lab.	Fly Ash MSWI
I-TEQ	9.8	0.5	99	129	0.022	51	45.3	43	1.5
ChemVerbotsV	100	5.6	1423	2013	0.354	1190	197	410	22