

Exposure to PCDD's and PCDF's during welding, cutting and burning of metals

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## Introduction

In Germany the exposure to PCDD's and PCDF's at the workplace was regulated in 1986 by the classification of 2,3,7,8 - TCDD as a group IIIA2 compound, a carcinogen for animals at conditions comparable to occupational human exposure. In 1993 the german ordinance TRGS 102 determined, for technical reasons, a permissive ceiling value of dioxins at the work - place ( Technische Richtkonzentration, TRK-Wert ) in the air as 50 pg/m<sup>3</sup> and at the same time introduced the Toxicity Equivalency Factor calculation for all chlorinated Dibenzodioxins and Dibenzofuranes ( I-TEQ according to NATO-CCMS ). In our first studies we investigated the occupational exposure to PCCD/PCDF during routine operation at all Hazardous Waste Incineration (HWI) plants in the federal state of Hessen. This exposure was shown to be low, since the highest concentration found was 3,8 pg/m<sup>3</sup> I-TEQ<sup>1,2</sup>. Of 31 employees, whose blood was tested for its PCDD/PCDF concentration, two showed somewhat elevated values for Hexa-, Hepta- and Total PCDF's; one of them was involved in burning of metals ( thermal oxygen cutting ) and welding operations during the annual renovation of the HWI - plant. This observation and the expectation of higher exposures during renovation of the plants as compared to routine operation, caused us to investigate these operations as well as the cutting, welding and burning of metals (thermal oxygen cutting) outside of HWI's.

## Methods

Seventeen airsamples were taken at 3,3 l/min by person - carried pumps with filters and plugs separating particular- and gasphase, which were analysed - except for two cases - together. Ten of these were taken during repair works in HWI's, two at a demolition site, four were taken at two different metal reclamation sites and one in a wood-chip-dryer within a card board factory. In the latter case (mechanical) cutting and welding operations were performed, while at the scrap metal and the demolition site only burning of metal was performed. PCDD/PCDF analysis in blood fat were done for five persons currently performing metal burning operations, for nine industrial welders and for sixteen white collar workers, serving as an intern reference group. About 60 ml blood was collected in precleaned, heparinized glassbottles, deepfrozen and analysed for PCDD/PCDF's<sup>2</sup> and the results compared with those of a larger reference group<sup>3</sup>.

## Results

As can be seen from table 1, milling and welding of boiler pipes in an HWI-plant results in PCDD/PCDF concentrations in excess of the TRK-Wert of 50 pg/m<sup>3</sup> I-TEQ. Fitting new pieces into the waste - chute of the plant, which includes (mechanical) cutting, burning and short term electric welding, leads to much higher PCDD/PCDF concentrations however, reaching almost 50fold TRK-Wert values (HWI No.1). At the next possible opportunity to monitor repair works on a hazardous waste chute, we air-sampled the three repair steps separately: burning of the damaged parts, fitting the new parts and welding of the new parts (HWI No.2). However, the two measurements differed very much from each other, since before the second repair, the waste chute was pre-cleaned extensively and the forced air exchange increased drastically, which is also reflected by the lower dust concentrations (Table 1). As can be seen, these actions resulted in a 20 to 50 fold reduction of the PCDD/PCDF concentration in the air at the workplace. The fitting of new parts still exceeds the TRK-Wert threefold and therefore requires personal protective measures. Since ten to thirty percent of PCDD/PCDF are not bound to particles (HWI 2, fifth row), protection against gaseous PCDD/PCDF should be taken into account as well.

Very low concentrations of PCDD/PCDF are found when (mechanically) cutting and electric welding is done in the wood chip dryer, a process quite similar to fitting of new parts into the chute, except that it is done outside a HWI - plant. In contrast to this are the results for the burning of metal in the open air at a demolition site of a coal power plant, where PCDD/PCDF concentrations exceeded the TRK - Wert seven- to ninefold. Obviously such high PCDD/PCDF exposures are not confined to HWI - plants, but appear to be associated with the burning process. The materials burned in this case were steel constructions, high pressure boilers and pipes, turbines and other machines. There was no „suspicious“ material, such as electric transformers or condensers. The parts were oil- and greasefree, but some were painted. The paint layers were analysed by a quicktest for organohalids, which was negative most of the time, although a more thorough analysis is requested. The gases used for burning were in all cases technical oxygen and technical propane, except for the HWI-plant, where Acetylen was used.

Similar high concentrations of PCDD/PCDF were found at two metal reclamation sites, where the burning also was done in the open air. The material burned was typical for those locations: big containers, machines, truck bodies and so on. In contrast to the demolition site - burning, these parts were not oil- and greasefree. Surprisingly high concentrations of PCDD/PCDF were detected by a stationary pump situated in the open air 5 to 8 m apart from two men burning metals: 39 pg/m<sup>3</sup> I-TEQ. This stresses the importance of PCDD/PCDF exposure especially in closed buildings and also reminds us of the necessity to consider exposure for bystanders.

Having found these rather substantial exposures to PCDD/PCDF at workplaces where metals are subject to heating, it is of interest to determine, whether the high concentrations in the air has consequences for the PCDD/PCDF body burden of those, who execute such work. As can be seen from figure 1, the PCDD/PCDF body burden of three groups of people with different current occupational activities, differ considerably. While our small reference group ( n=16 ) shows a median of 18.5 pg I-TEQ/g blood fat with a 95% percentil of 28,3 pg/g, the industrial welders are somewhat higher: 29,9 pg/g median and 37,8 pg/g 95% percentil. Much higher concentrations are found in those men, currently engaged in metal burning ( n=5 ) with a median of 46,7 pg/g. As also can be seen, there is virtually no difference between our small reference group and the bigger one ( n = 134 ) reported by Pöpke<sup>3</sup> with respect to the

# HUM II

PCDD/PCDF body burden (figure 1), which also applies to the median of the age of the two groups: 39 years<sup>3</sup> and 42 years for our smaller group. As can be seen from figure 2, the observed large „scatter“ in the body burden, indicated in figure 1 for those involved in metal burning, is not random but rather a consequence of the duration of exposure at the workplace.

## Discussion

In this paper we demonstrate, that burning ( thermal oxygen cutting ), fitting and welding of the waste chute in HWI's can lead to exceptionally high concentrations of PCDD/PCDF's in the air, which can be reduced drastically by intensive precleaning of the chute and by increase of the forced ventilation. However, the legal threshold in Germany, the TRK - Wert of 50 pg/m<sup>3</sup> I-TEQ still is surpassed and consequently requires personal protective measures. Such very high PCDD/PCDF concentrations in the air at workplaces are not restricted, however, to HWI's. They also occur - as we have shown here for the first time - at demolition sites where steel constructions and machines are burned as well as at metal reclamation sites, where scrap metal is being burned. It should be stressed, that at all six metal - burning workplaces outside HWI's we have monitored, the TRK -Wert threshold was surpassed 2 to 24fold.

Since this is the first report on the very high PCDD/PCDF exposures at workplaces where metals are burned, we can not compare these results with the literature. As much as welding is concerned, it is obvious that it differs very much from burning, as documented by us for electric welding in the wood-chip-dryer as well by others for MAG (metal activated gas) welding<sup>4</sup>, resulting in much lower exposures - provided the process is not HWI - associated.

## Consequences

1. The very high PCDD/PCDF exposure during burning ( thermal oxygen cutting ) of metals both inside and outside of Hazardous Waste Incinerators, which we report here for the first time, requires reconfirmation on a broad basis.
2. The mechanism of PCDD/PCDF formation in this process must be revealed in order to find means to inhibit it completely and thereby exclude exposure. This requires careful investigations, which must give due attention to the technical gases used.
3. Due to the extent of PCDD/PCDF exposure and the impossibility to predict them, burning of metals should be done at present only under appropriate protective measures.

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Table 1  
PCDD/PCDF Concentrations in air at different workplaces

Workplace	Activity	Sample Duration h' min"	Total Dust [mg/m <sup>3</sup> ]	Dioxinconcentration I - TEQ [pg/m <sup>3</sup> ]	Total - Dioxin (D) 2,3,7,8 Congenere [pg/m <sup>3</sup> ]	Total - Furan (F) 2,3,7,8 Congenere [pg/m <sup>3</sup> ]	Ratio F/D	Threshold	Specific acticity dust i -TEQ [ng/g]
								TRK Multiples	
HWI No.1	Bioler pipes: welding	3' 18"	4,9	56	541	833	1,5	1,1	11,4
	" " : milling	3' 36"	16,8	87	975	1451	1,5	1,7	5,2
	Waste chute: fitting	2' 06"	25,2	1830	21678	31549	1,5	36,6	72,6
	" " : fitting	1' 20"	20,8	2430	20038	37509	1,9	48,6	116,8
HWI No.2	Waste chute: burning	3' 41"	3,8	80 (28% gas.)	6911	8319	1,2	1,6	20,9
	" " : "	3' 56"	1,5	20	354	415	1,2	0,4	13,3
	" " : fitting	3' 32"	5,9	30 (10% gas.)	794	897	1,1	0,6	5,1
	" " : "	3' 15"	9,8	140	2680	2947	1,1	2,8	14,2
	" " : welding	2' 20"	4,3	44	1058	1142	1,1	0,9	10,3
	" " : "	2' 09"	2,6	11	204	238	1,2	0,2	4,1
Wood - Chip - Dryer	Cutting and welding	57"	n.d.	2	61	18	0,3	0,04	n.d.
Power - Plant - Demolition	Open air burning	6' 18"	10,5	459	20	2415	121,0	9,2	43,7
	" " "	5' 36"	16,7	358	39	1651	42,0	7,2	21,4
Metal - Reclamation 1.	Open air burning	4' 30"	12,3	858	1266	4804	3,8	17,1	69,8
	" " "	24"	20,9	98	227	773	3,4	2,0	4,7
Metal - Reclamation	Open air burning	2' 37"	12,7	348	95	2329	24,5	7,0	27,4
	" " "	3' 06"	22,1	1183	300	7825	26,0	23,7	53,5

n.d. = not done

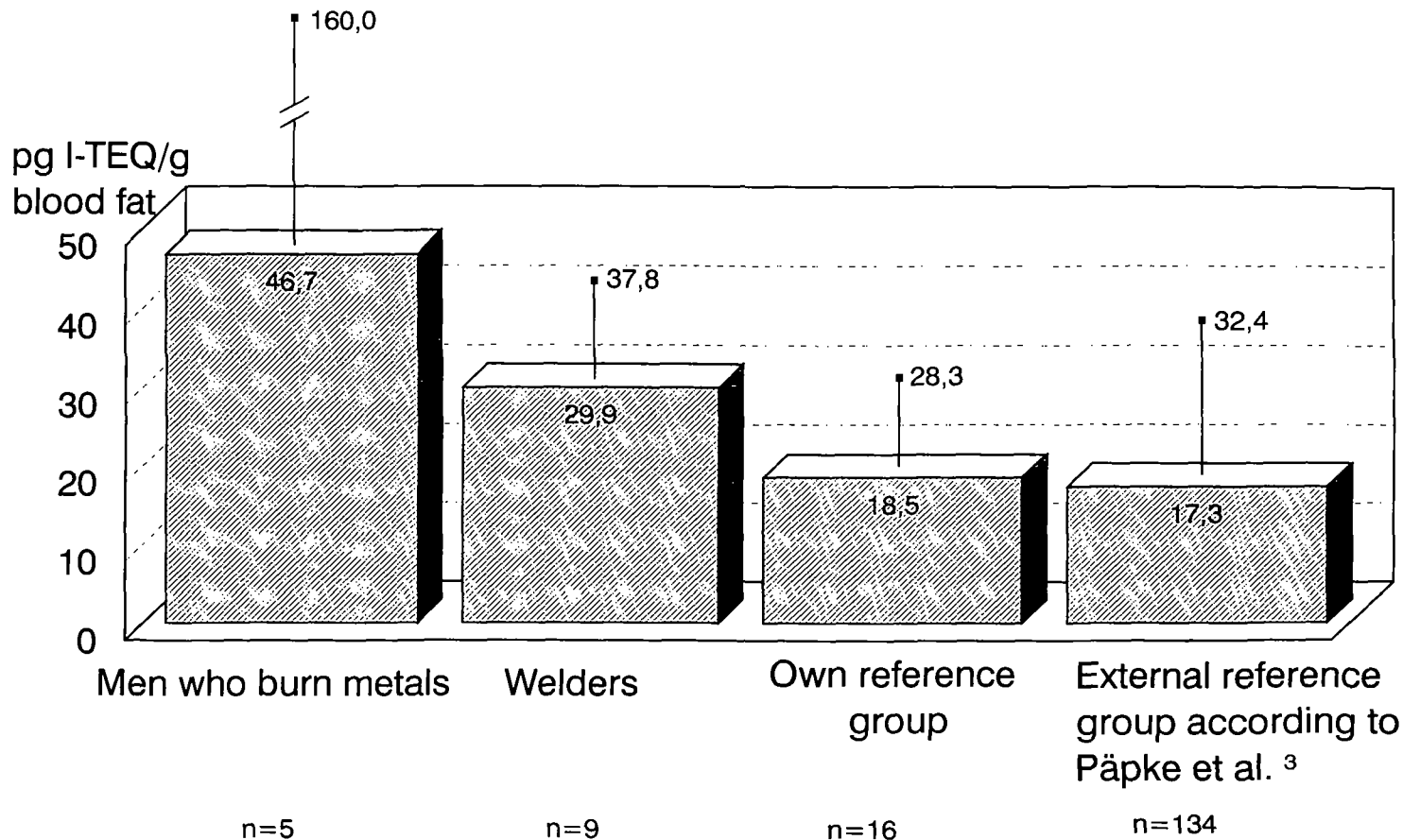


Fig. 1: PCDD/PCDF concentrations in the blood of men who currently weld or burn metals (median and 95% Percentils of I-TEQ in pg/g bloodfat).

Fig. 2: Dioxin body burden pg I-TEQ/g blood-fat as function of job years burning metals

