
VOLUME 1, PART B:
Evaluation of Emission Estimates

RESULTS

AIR EMISSIONS

Data available from national inventories

Volume 2 comprises a brief evaluation of information on dioxin emissions contained in national dioxin inventories and related documents. Below, an overview is given on the available estimates of the total PCDD/F air emissions and the distribution of air emissions to the Corinair main subgroups 01-12 (Table 1; subgroup 12 „fires“ was newly defined for this study and includes fires of buildings, vehicles and landfill fires).

Because updated information was used in connection with the basic documents listed in Table 1 the total air emissions shown in Table 8 may differ from those originally reported in the surveyed national documents.

Besides the „typical“ emission estimates also minimum and maximum values are presented. They were derived using indices of uncertainty which were selected to represent the order of magnitude of the emission estimates (see Volume 2). Thus, a large potential maximum emissions means that the data basis — activity rates and/or emission factors — is considered to be very uncertain. Usually the quality of the emission factors needs to be improved, e.g. by additional measurements; because with a few exceptions the activity rates are rather precise in most cases.

It should be noted again that the minimum/maximum values have to be considered only as indicative values for the quality of the basic data rather than being actually possible values. However, as shown in the next section they are useful in order to get an idea which emission sources should be considered as „relevant“.

Results

CORINAIR SNAP	01 Comb. in energy prod. and transform.	02 Non-ind. combustion plants	03 Comb. in manufac- turing industry	04 Produc- tion pro- cesses	05 Extract. and dis- trib. of foss. fuel	06 Solvent and other product use	07 Road transport	08 Other mobile sources, machin.	09 Waste treat- ment and disposal	10 Agricul- ture and forestry. land use .	11 Nature	12 Fires	ALL		
													typical	min.	max.
A	0.1	15.1	11.8						0.2		0.02		27	0	0
B	2.3	122.2	221.8	8.0		25.0	1.7		343.9	0.1		1.9	727	268	9540
CH	0.8	0.7	2.7	10.6		2.7	0.8	0.1	154.0			9.1	182	0	0
D	3.6	14.5	215.0	121.5			3.8		160.7			81.0	600	165	4605
DK	2.0	1.1	1.5	7.5			0.2		30.3				43	0	8
E	3.9	43.9	67.5	18.0					0.6				134	0	0
F			457.5						163.4				621	270	2700
L			26.8	2.4					0.1				29	0	0
N			37.3	4.8					2.8				45	0	0
NL	3.0	11.3	33.7	3.3		25.1	2.1	0.6	8.8	0.3			88	14	400
S	0.6	5.1	14.3	3.6			0.6	0.8	3.5			7.9	36	13	157
SF	0.5	1.1	0.5	15.7			3.6		3.2				25	15	41
UK	10.7	32.0	82.7	12.8		0.3	6.1		568.4		2.2		715	564	2596
Sum	27.5	247.0	1173.1	208.2	nd	53.1	19.0	1.5	1440.0	0.4	2.2	99.9	3272	1310	20047

Table 8: Survey on PCDD/F AIR EMISSIONS [g I-TEQ/a] as revealed by the (partly updated) national inventories; open areas: no data available

Identification of relevant air emission sources for PCDD/F

The term „relevant source“ can be defined in different ways depending on the used context:

- On the European level a source or group of sources may be termed „relevant“ if they contribute to a large extent to the total annual PCDD/F emissions.
- The same applies in principle on the national scale; however, sources being almost insignificant for Europe may be highly relevant for a particular country, if the total emission level of this country is low but dominated by the source under consideration (e.g. Austria, domestic combustion)
- On the local scale flue gas concentrations can become at least as important as the annual emission freight. Thus, sources with low annual emissions and minor importance for the national or European balance may be relevant if high concentrations of the flue gas directly influence the immission situation (low stack heights).

Following these definitions the identification of relevant sources can be done in principle by ranking the sources according to their emissions on the different levels of consideration. However, this would require a complete database or at least a database with a comparable degree of completion for all countries. Obviously, this is not the case regarding emission estimates of dioxin and furans into the air (and the situation is even worse with respect to other media).

The data gaps can be closed partly by additional statements about the probability that a source may be relevant. This probability can be assessed by estimating the uncertainty of the basic data followed by calculation of the possible emission range. Of course, no statements can be made about sources that have not been investigated at all.

With respect to these considerations an attempt was made in the following to set up a list of emission sources being the most important in view of the 90% emission reduction goal as it was set by European politics:

Results

- At first, emission sources with high absolute emissions contributing by a large fraction to the „typical“ total annual emission in Europe were extracted. In the following this approach is termed as “TypEm” approach.
- To identify sources with still small but highly uncertain absolute emission estimates the maximum emission approach was used („MaxEm“ approach“).
- As mentioned above flue gas concentrations should be considered as an index of relevance with respect to a possible local environmental impact where annual emission freights are not sufficient enough. In order to assure the generation of a complete list the maximum concentrations even when observed in single cases only - serve as search parameter („MaxConc“-approach).
- Finally, an additional check was made for per-capita emission values in order to find out those source types which had been investigated only in a small number of countries but which might become relevant if they were considered for all countries („PerCap“-approach).

A description of the procedures for setting up the listings according to the four approaches is shown in Table 9.

Results

	TypEM	MaxEm	MaxConc	PerCap
Basic data	typical national PCDD/F emission data	maximum national PCDD/F emission data	maximum PCDD/F concentrations (flue gas) reported in national documents	typical national PCDD/F emission data
Transformation	-	-	-	division of national emission by capita
Aggregation	Sum for all countries	Sum for all countries	-	average of per-capita values for those countries reporting any data
Stop condition	cumulative percentage of all-country total > 90 %	cumulative percentage of all-country total > 90 %	maximum concentration < 10 ng I-TEQ/m ³ *)	cumulative percentage of typical emissions (all-country total) > 90 %

Table 9 Procedures for the different approaches applied to identify relevant air emission sources

*) this stop condition is assumed to correspond to „typical“ concentrations being considerably lower (< 1 ng I-TEQ/m³)

Results

In Table 10 - Table 13 the emission sources fulfilling the conditions of the different approaches are listed. In any case the evaluation was made separately for the three levels of source diversification of the Corinair system; furthermore, a fourth level describing the specific processes and materials was introduced for this evaluation. Those source categories being additionally included to the previous list are indicated by shaded fields. Table 14 shows the list of relevant sources resulting from the combination of the different approaches.

The most remarkable observations are:

1. Despite considerable effort having been spent during the last years to decrease the emissions from municipal waste incinerators this source type still dominates the input of PCDD/F into the atmosphere. Some countries (e.g. Austria, Germany) have set an emission limit of 0.1 ng I-TEQ/m³ for these plants which are expected to be complied with at the end of the century. Other countries with considerable amounts of waste being burned set up emission guide values (like UK, 1 ng I-TEQ/m³); there remain a number of states without any regulation concerning PCDD/F emissions from waste incinerators (France, Spain, Italy). Moreover, it must be assumed that high amounts of dioxins and furans are emitted in countries without waste incineration plants just through illegal domestic or open burning of waste or from landfill fires.
2. Put together, the total emissions from certain processes in the metal industries are not much less than from MSW incineration. This estimation is connected with a high uncertainty since a large variety of processes is applied mostly having neither been investigated nor optimised with regard to PCDD/F emissions.
3. Non-industrial sources like domestic burning and various types of (accidental) fires also play an important role. A high uncertainty exists not only because emission factors are difficult to evaluate but also because the statistics are largely insufficient.
4. Some groups of industries or source categories, which have been in the focus of research or of the public were not indicated as relevant; this mainly applies to the chemical industries and for road transport, but for different reasons:

In the case of chemical industry only few processes have been investigated so far and were indeed shown to be of minor importance. Furthermore, chemical production processes generally or at least in large chemical plants might be considered as well-controlled with respect to air emissions; problems of PCDD/F emissions are more likely to occur with residue and waste flows and with the products.

Regarding SNAP 07 („road transport“), the majority of emission estimates are available from countries with decreasing or already stopped consumption of leaded fuel. Hence, in this case the typical and even the maximum emission estimate may considerably underestimate the real situation. Therefore, emissions from road transport will be added to the following part of the report.

The actual list of sources is somewhat shorter than Table 14 might pretend since different levels of aggregation used in the CORINAIR system are not regarded. The SNAPs 0202 (residential combustion) and 0203 (combustion in agriculture, forestry and aquaculture) can be seen together because in both cases mainly „domestic“ heating systems are considered. Hence the same emission factors can be applied as done in the Austrian inventory which is the only inventory reporting separately emission data for these groups.

Results

CORINAIR '94 SNAP	Source Category	material/ process	Typical annual Emissions [g I-TEQ/a]				% of total	Cumulative % of total
	TOTAL OF ALL SOURCE CATEGORIES:		LEVEL 1 3250	LEVEL 2 3201	LEVEL 3 3112	LEVEL 4 2454		
LEVEL 1								
09	Waste Treatment and Disposal		1417.8				43.6	43.6
03	Combustion in Industry		1173.1				36.1	79.7
02	Combustion in Commercial, Residential,...		247.0				7.6	87.3
04	Production Processes		208.2				6.4	93.7
LEVEL 2								
0902	Waste Incineration			1402.9			43.8	43.8
0303	Processes with contact			1123.3			35.1	78.9
0202	Residential combustion			238.3			7.4	86.4
0403	Non ferrous metal industry			136.4			4.3	90.6
LEVEL 3								
090201	Inc. of Dom. or municipal wastes				1215.1		39.0	39.0
030301	Sinter plants				812.5		26.1	65.2
0202	Res. combustion: Boilers, stoves, fireplaces				238.3		7.7	72.8
090207	Inc. of hospital wastes				150.9		4.8	77.7
040309	Other: sintering of special materials				115.6		3.7	81.4
030309	Secondary copper production				103.0		3.3	84.7
060406	Preservation of wood				53.0		1.7	86.4
030310	Secondary aluminium production				64.2		2.1	88.5
040207	Electric furnace steel plant				51.9		1.7	90.1

Table 10 Evaluation of relevant air emission sources;

sorting parameter: total of typical potential emission

stop condition: cumulative fraction of total emission > 90 % (continued on next page)

Results

CORINAIR '94 SNAP	Source Category	material/ process	Typical annual Emissions [g I-TEQ/a]				% of total	Cumulative % of total
			LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4		
LEVEL 4								
030301	Sinter plants	stack emission				790.1	32.2	32.2
090201	Inc. of Dom. or municipal wastes	medium quality APCS				603.2	24.6	56.8
090201	Inc. of Dom. or municipal wastes	none or low quality APCS				540.5	22.0	78.8
0202	Res. combustion: Boilers, stoves, fireplaces	wood				143.9	5.9	84.7
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite				73.7	3.0	87.7
040207	Electric furnace steel plant	controlled emission				47.1	1.9	89.6
090201	Inc. of Dom. or municipal wastes	illegal domestic burning				31.5	1.3	90.9

Table 10 (cont.) Evaluation of relevant air emission sources;

sorting parameter: total of typical potential emission

stop condition: cumulative fraction of total emission > 90 %

APCS: air pollution control system

Results

CORINAIR '94 SNAP	Source Category	material/ process	Maximal annual Emissions [g I-TEQ/a]				% of total	Cumulative % of total
	TOTAL OF ALL SOURCE CATEGORIES:		LEVEL 1 20047	LEVEL 2 19927	LEVEL 3 13698	LEVEL 4 10144		
LEVEL 1								
03	Combustion in Industry		7877.9				39.3	39.3
09	Waste Treatment and Disposal		3746.0				18.7	58.0
02	Combustion in Commercial, Residential,...		3370.9				16.8	74.8
12	Fires		2700.7				13.5	88.3
04	Production Processes		1946.2				9.7	98.0
LEVEL 2								
0303	Processes with contact			7447.3			37.4	37.4
0902	Waste Incineration			3557.7			17.9	55.2
02 02	Residential combustion			3370.9			16.9	72.1
0301	Industrial Combustion (boilers etc.): Non-fossil fuels			338.6			1.7	73.8
1202	fires: buildings/vehicles			2621.6			13.2	87.0
0403	Non ferrous metal industry			1694.5			8.5	95.5
LEVEL 3								
030301	Sinter plants				3488.0		25.5	25.5
030309	Secondary copper production				2705.6		19.8	19.8
090201	Inc. of Dom. or municipal wastes				2105.9		15.4	15.4
040309	Other: Non ferrous metal foundries				1341.4		9.8	9.8

Table 11 Evaluation of relevant air emission sources;

sorting parameter: total of maximum potential emission as revealed by uncertainty estimates (cf. Volume 2);

stop condition: cumulative fraction of total emission > 90 % (continued on next page)

Results

	Source Category	material/ process	Maximal annual Emissions [g I-TEQ/a]				% of total	Cumulative % of total
			LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4		
090207	Inc. of hospital wastes				1012.2		7.4	7.4
030310	Secondary aluminium production				703.6		5.1	5.1
090202	Inc. of Industrial wastes				421.3		3.1	3.1
040309	Other: sintering of special materials				333.9		2.4	2.4
LEVEL 4								
030301	sinter plants	stack emission				3264.0	32.2	32.2
0202	Res. combustion: Boilers, stoves, fireplaces	wood				2926.0	28.8	28.8
090201	Inc. of Dom. or municipal wastes	medium quality APCS				1178.6	11.6	11.6
090201	Inc. of Dom. or municipal wastes	none or low quality APCS				577.5	5.7	5.7
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite				354.6	3.5	3.5
090201	Inc. of Dom. or municipal wastes	Open burning of MSW				300.0	3.0	3.0
090202	Inc. of Industrial wastes	hazardous waste				261.3	2.6	2.6
030301	sinter plants	diffuse emission				224.0	2.2	2.2
040207	Electric furnace steel plant	controlled emission				208.9	2.1	2.1

Table 11 (cont.) Evaluation of relevant air emission sources;

sorting parameter: total of maximum potential emission as revealed by uncertainty estimates (cf. Volume 2);

stop condition: cumulative fraction of total emission > 90 %

APCS: air pollution control system

Results

CORINAIR '94 SNAP	Source Category	material/ process	Annual Emissions [g I-TEQ/a]				Flue gas concentrations [ng I-TEQ/m ³]
			LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	maximum
1201	TOTAL OF ALL SOURCES		3250	3201	3112	2454	
090207	fires: landfill			17.0			518
090201	Inc. of hospital wastes				150.9		460
090201	Inc. of Dom. or municipal wastes	none or low quality APCS				540.5	306
030326	Other	metal reclamation from cables			1.7		254
030308	Secondary zinc production				32.6		120
040309	Other: dressing facilities				0.0		83.6
090901	Cremation: Inc. of Corpses				9.8		71.3
040309	Other: sintering of special materials				115.6		70
030301	sinter plants	stack emission				790.1	43.2
030309	Secondary copper production	refined from scrap			103.0		29.5
030311	cement				27.6		19.5
090201	Inc. of Dom. or municipal wastes	illegal domestic burning				31.5	16.6
090201	Inc. of Dom. or municipal wastes	medium quality APCS				603.2	14.8
030310	Secondary aluminium production				64.2		11.6

Table 12 Evaluation of relevant air emission sources;

sorting parameter: maximum flue gas concentrations found in any country,

stop condition: maximum flue gas concentration < 10 ng/m³

APCS: air pollution control system

Results

CORINAIR '94 SNAP	Source Category	material/ process	Typ. annual Emissions [g I-TEQ/a]				Cumulative % of total	Average Emission per Capita [µg/a]
	TOTAL OF ALL SOURCES:		LEVEL 1 3250	LEVEL 2 3201	LEVEL 3 3112	LEVEL 4 2454		
LEVEL 1								
03	Combustion in Industry		1173.1				36.1	9.0
09	Waste Treatment and Disposal		1417.8				79.7	5.9
02	Combustion in Commercial, Residential...		247.0				87.3	1.8
04	Production Processes		208.2				93.7	1.5
LEVEL 2								
0303	Processes with contact			1123.3			35.1	9.6
0902	Waste Incineration			1402.9			78.9	5.8
02 02	Residential combustion			238.3			86.4	1.7
0402	Iron and Steel Industry			71.6			88.6	1.1
1201	Fires: landfill			17.0			89.1	1.1
0203	Agriculture, Forestry, Fishing			7.7			89.4	1.0
0403	Non ferrous metal industry			136.4			93.6	0.7

Table 13 Evaluation of relevant air emission sources;

sorting parameter: average of the per-capita-emission for those countries reporting an estimate,

stop condition: cumulative fraction of total typical emission > 90 % (continued on next page)

Results

CORINAIR '94 SNAP	Source Category	material/process	Typ. annual Emissions [g I-TEQ/a]				Cumulative % of total	Average Emission per Capita [µg/a]
			LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4		
LEVEL 3								
030301	Sinter plants				812.5		26.1	8.8
090201	Inc. of Dom. or municipal wastes				1215.1		65.2	4.6
090207	Inc. of hospital wastes				150.9		70.0	1.8
0202	Res. combustion: Boilers, stoves, fireplaces				238.3		77.7	1.7
040309	Other: sintering of special materials				115.6		81.4	1.4
030309	Secondary copper production				103.0		84.7	1.4
060406	Preservation of wood				53.0		86.4	1.1
040207	Electric furnace steel plant				51.9		88.1	1.1
030310	Secondary aluminium production				64.2		90.1	1.0

Table 13 (cont.) Evaluation of relevant air emission sources;

sorting parameter: average of the per-capita-emission for those countries reporting an estimate,

stop condition: cumulative fraction of total typical emission > 90 % (continued on next page)

Results

CORINAIR '94 SNAP	Source Category	material/ process	Typ. annual Emissions [g I-TEQ/a]				Cumulative % of total	Average Emission per Capita [$\mu\text{g/a}$]
			LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4		
LEVEL 4								
030301	sinter plants	stack emission				790.1	32.5	8.7
090201	Inc. of Dom. or municipal wastes	medium quality APCS				603.2	57.1	5.4
090201	Inc. of Dom. or municipal wastes	none or low quality APCS				540.5	79.7	4.6
090201	Inc. of Dom. or municipal wastes	Open burning of MSW				30.0	80.3	3.0
090201	Inc. of Dom. or municipal wastes	illegal domestic burning				31.5	81.6	1.9
0202	Res. combustion: Boilers, stoves, fireplaces	wood				143.9	87.4	1.3
040207	Electric furnace steel plant	controlled emission				47.1	89.4	1.1
0203	Agriculture, Forestry, Fishing: Boilers, stoves, fireplaces	wood				7.6	89.7	1.0
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite				73.7	92.7	0.6

Table 13 (cont.) Evaluation of relevant air emission sources;

sorting parameter: average of the per-capita-emission for those countries reporting an estimate,

stop condition: cumulative fraction of total typical emission > 90 %

APCS: air pollution control system

Results

CORINAIR '94 SNAP	Source Category	material/ process
02	Combustion in Commercial, Residential...	
0202	Residential combustion	
0202	Res. combustion: Boilers, stoves, fireplaces	wood
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite
0203	Agriculture, Forestry, Fishing	
0203	Agriculture, Forestry, Fishing: Boilers, stoves, fireplaces	wood
03	Combustion in Industry	
0301	Industrial Combustion (boilers etc.): Non-fossil fuels	
0303	Processes with contact	
030301	Sinter plants	
030301	Sinter plants	stack emission
030301	Sinter plants	diffuse emission
030308	Secondary zinc production	
030309	Secondary copper production	
030310	Secondary aluminium production	
030311	Cement	
030312	Lime (incl. Iron/steel and paper pulp industries)	
030326	Other	metal reclamation from cables

Table 14 Evaluation of relevant air emission sources: Combined list of sources indicated as relevant in Table 10 - Table 13
(continued on next page)

Results

CORINAIR '94 SNAP	Source Category	material/ process
04	Production Processes	
0402	Iron and Steel Industry	
040207	Electric furnace steel plant	controlled emission
0403	Non ferrous metal industry	
040309	Other: dressing facilities	
040309	Other: sintering of special materials	
040309	Other: Non ferrous metal foundries	
06	Use of Solvents	
060406	Preservation of wood	
09	Waste Treatment and Disposal	
0902	Waste Incineration	
090201	Inc. of Dom. or municipal wastes	
090201	Inc. of Dom. or municipal wastes	none or low quality APCS
090201	Inc. of Dom. or municipal wastes	illegal domestic burning
090201	Inc. of Dom. or municipal wastes	medium quality APCS
090201	Inc. of Dom. or municipal wastes	Open burning of MSW
090201	Inc. of Dom. or municipal wastes	illegal domestic burning
090202	Inc. of Industrial wastes	
090202	Inc. of Industrial wastes	hazardous waste
090207	Inc. of hospital wastes	
090901	Cremation: Inc. of Corpses	
12	Fires	
1201	Fires: landfill	
1202	Fires: buildings/vehicles	

Table 14 (cont.): Evaluation of relevant air emission sources: Combined list of sources indicated as relevant Table 10 - Table 13

Re-estimation of air emissions for all countries

Approach

In order to obtain a more complete picture of the emission situation and of the relative importance of the most relevant sources as being identified before, a brief re-evaluation of the likely air emission levels in the considered countries is made. This re-evaluation procedure mainly involves 3 steps:

1. Comparison of the emission factors used in the national inventories in order to obtain a default emission factor.
2. Collection of plant and activity data needed for the estimation of PCDD/F emissions
3. Calculation and comparison of the likely annual emission (and its range if feasible).

This procedure is applied to all countries having no national inventory yet, and wherever no data are given for a considered source type in an existing inventory. Furthermore, data from national inventories solely being based on estimations will be compared with the emission values obtained by re-calculations using standard emission factors.

Evaluation

The data about sources to be re-evaluated are presented according to the following structure which comprises a number of additional information:

- *Process description:* A short overview is presented on the principles of operation and on processes relevant for dioxin emissions.
- *Abatement technologies:* The flue gas cleaning system usually applied and those specifically developed for PCDD/F are described.
- *Plant data/European situation:* Information is provided on the situation and activities of the respective industry including plant data (location, capacities etc.) if available.
- *Emission factors:* A comparison is made of the emission factors used within the national inventories (basic documents of this study). From these emission factors a

default emission factor is derived to be used for the re-evaluation of the annual PCDD/F air emissions in Europe. If possible, the emission factors are related to different abatement technologies/qualities.

- *Activity data:* Relevant activity data are tabled taken from the basic documents or from official statistics.
- *Emission estimation:* Using the default emission factors and the acquired activity rates the annual PCDD/F air emission is recalculated. The results are compared with the data of the basic documents.
- *Conclusions/recommendations:* Comments are given on the reliability of the new emission estimate. Recent and possible future changes are taken into account to assess the requirements for additional information to be gained by measurements and experimental or non-experimental studies.