

090202**Incineration of industrial wastes (except flaring)***Process description*

Depending on the type of waste, its composition and physical/chemical characteristics different processes and facilities are used:

- *rotary kilns*

Rotary kilns are suited for (mixtures of) solid, pasty and liquid waste streams. The kiln consists of a cylindrical, slowly revolving drum that is lined inside with firebrick. The longitudinal axis is slightly sloping, so that the waste slowly descends through the kiln, as it rotates. This rotation results in the waste being mixed well, simultaneously providing a continuously renewed contact between the waste and the warm kiln walls. There is always a combustion chamber behind the rotary kiln to incinerate the combustion gases. Sometimes still combustible liquid waste is injected into this combustion chamber. Kiln temperatures range from 800 to 1300 °C, incineration temperatures from 900 to 1300 °C.

- *Liquid-injection furnaces*

Liquid waste is burnt via burners in liquid-injection furnaces in chambers lined inside with firebrick, at temperatures of usually 1000 °C and higher. In a number of cases, fuel is added to reach the desired temperature. In some industries, gaseous waste substances are also injected into the furnace, in which case the liquid-injection furnace also serves as a thermal after burner (see below).

- *Fluid bed furnaces*

- In fluid bed furnaces, inert granular particles are brought in suspension (fluidisation) by an upward flow of air. The (solid or liquid) waste substances to be incinerated are dosed into the hot bed material where they are incinerated. Low-temperature burning (no higher than about 900 °C) is essential, otherwise the bed material may sinter.

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Fluid bed furnaces can also be applied to burning coatings (e. g. paint) off materials at lower temperatures (400-600 °C).

- *Fixed grate furnaces*

Fixed grate furnaces consist of a chamber lined with firebrick; in this chamber, waste substances are usually incinerated on a grate in a batch process. Air is usually supplied in stages. A sub-stoichiometric amount of air is admitted through the grate. The waste deaerates and the remaining char is incinerated. The discharging gases are incinerated after the supply of secondary air. This process is also (incorrectly) indicated as pyrolysis combustion. Fixed grate furnaces are mostly used for the recovery of metals from waste (e. g. photographic film materials). The temperature in the combustion chamber is on average 600-1000 °C, the after-burning temperature is about 1000 °C.

Abatement technologies:

- After burners

Thermal after burners

Thermal after-burning is a waste gas purification technique in which the (in this case: chlorine containing) contaminants present are oxidised (burned) at high temperatures. these after burners usually consist of combustion chambers that are lined inside with firebrick, in which the gas stream to be incinerated is brought to a high temperature using burners that are fired with support fuel (or sometimes with liquid waste, see above). The incineration temperatures vary between 750 and 1200 °C. The incineration of gaseous wastes in existing (steam or hot-water) boilers is also reckoned under thermal after-burning.

Catalytic after burners

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Catalytic after burners for hazardous wastes are operating with a catalyst and at lower temperatures.

- Flue gas treatment

The methods used for flue gas treatment differ strongly. In a number of cases, the flue gases are emitted into the atmosphere, without being cleaned and cooled. Possible dioxin formation no longer takes place then behind the furnace (what subsequently happens in the plume is not known).

Another variant is cooling the flue gases in a boiler or using an evaporation cooler. In this case, the detention time of the gases at 200-400 °C is such that dioxin formation is in essence possible. After the flue gases are cooled, they are usually cleaned with an electrostatic precipitator, lime injection, fabric filter, wet scrubber, or combinations thereof.

A third variant to treat the flue gases is to quench them from high temperatures down to below 200 °C. The detention time of the gases between 400 and 200 °C is then minimal. This happens especially where the process is used to recover HCl from the flue gases; after this, the flue gases pass scrubbers before being emitted.

Plant data/European situation

Incineration of hazardous waste is either done on-site at the location where the waste materials are generated (e. g. chemical production plants) or at special plants where the waste has to be transported to. A complete survey on the existing plants in the countries under consideration could not be gathered. Some information mentioning plants in B (1), D (5) , DK (1), F (4), S (1), SF (1) and UK (3) must be considered as incomplete as the number of plants being in operation in Germany alone amounts to 28.

Concerning dioxin emissions this sector is the only one being regulated by a European Guideline which sets a limit of 0.1 ng I-TEQ/m³. It can be anticipated therefore that

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plants with higher emissions will be closed or retrofitted with abatement systems within the next future. Hence the relevance of hazardous waste incineration - having been only of medium importance before - is decreasing.

Activity data

The activity data (shown 090202—Table 4) were taken from the national inventories and from statistic data of the OECD; but neither national inventories nor the OECD data provided a complete record of activity data for all 17 countries considered. Therefore a combination of both was used for the estimation of annual dioxin emissions.

Emission factors

The Emission factors for incineration of industrial wastes as reported by the national dioxin inventories are shown in 090202—Table 3. A quite narrow range of dioxin concentrations in the flue gas was found by measurements at these plants. This results in a remarkably narrow emission factor range.

From these studies the following emission factors were selected for the estimation of the annual dioxin emission in each country (090202—Table 1):

typical	minimum	maximum
20.0	2.0	200.0

090202—Table 1 **Default emission factors for incineration of industrial wastes [$\mu\text{g I-TEQ/t}$]**

Emission estimation

With the selected emission factors and activity rates the standardised annual PCDD/F emissions were derived. Note: the re-calculated values represent the emission situation in Europe before the European Guideline on incineration of hazardous waste had been

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implemented. For all 17 countries considered the following results are obtained (090202—Table 2):

	TOTAL
national inventories	37
Re-evaluation, min	9
Re-evaluation, max	881
Re-evaluation, typical	88
Re-evaluation *)	4

*) after full implementation of the European Guideline

**090202—Table 2 Summary of re-evaluated typical PCDD/F air emissions
[g I-TEQ/a] from incineration of industrial wastes**

However, using the default emission factors apparently leads to overestimation of the emissions from German and French plants. On the contrary considerable emissions likely to occur in some countries (in particular Italy and Spain) could not be assessed since the data on activity rates are very incomplete. In view of these difficulties the values provided by the basic documents are adopted here having in mind that the total emission of 37 g I-TEQ/a most probably is underestimated.

Conclusions/recommendations

Due to the European guideline on hazardous waste incineration a decreasing relevance of industrial waste incinerators for the total PCDD/F emission in Europe may be expected. Therefore no extra measurements are considered to be necessary because it can be anticipated that during the implementation of the European guideline measurements will be carried out anyway to check whether these plants meet the required limit.

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	Flue gas conc. [ng I-TEQ/m ³]			Emission factors [µg/t]			Remarks
	typ	min	max	typ	min	max	
A	0.013			0.22			
B				48			concerns special combustion installations; co-combustion in cement production is not regarded
CH				89			not regarded: waste incineration in cement works! calculated from EFs for dust and HCl.
D		0.13	6.9	0.65	0.01	34.5	
E							
F	0.4			2			
NL	0.11	0.04	9.7	3.5	0.1	310	Emission factors reflect 1991 situation; largely improved by 1994
S				0.19			emission factor for 1990 reported to be about 5 times higher.
SF		0.1	0.2				
UK		0.5	3	12	5	30	measurements performed only at commercial plants; no data available for in-house combustion facilities
		0.5	3	20	2	200	Chosen value: rounded arithm. means of reported values

090202—Table 3 PCDD/F air emission factors for incineration of industrial wastes from national dioxin inventories

	Activity rates [kt/a]		
	from Inv.	from statistics*)	combined
A	76	123	76
B	436		436
CH		266	266
D	2000		2000
DK			nd
E			nd
F		1040	1040
GR			nd
I			nd
IRL			nd
L			nd
N		3	3
NL	154	160	160
P		10	10
S	31.4		31.4
SF		44	44
UK	290		290
Total			4356.4

*) OECD Environmental Compendium; nd: no data

090202—Table 4 Activity rates related to incineration of industrial wastes

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		Annual emission			with limit of 0.1 ng/m ³ #)
		from Inv.	from activity rates and default emission factors		
		typ	min	max	
A	0,017	2.46	0.246	24.6	0.123
B	20.9	8.72	0.872	87.2	0.436
CH	7	5.32	0.532	53.2	0.266
D	1.3	40	4	400	2
DK	0,23	nd	nd	nd	nd
E	nd	nd	nd	nd	nd
F	2	20.8	2.08	208	1.04
GR	nd	nd	nd	nd	nd
I	nd	nd	nd	nd	nd
IRL	nd	nd	nd	nd	nd
L	nd	nd	nd	nd	nd
N		0.06	0.006	0.6	0.003
NL	1*)	3.2	0.32	32	0.16
P		0.2	0.02	2	0.01
S	0.007	0.628	0.0628	6.28	0.0314
SF	**)	0.88	0.088	8.8	0.044
UK	3.6	5.8	0.58	58	0.29
Total	37	88	9	881	4

#): assuming a specific flue gas flow of 10.000 m³/t; *) emission estimate given for 1994 after upgrading/modification of some plants

***) emissions probably included in value for municipal solid waste

090202—Table 5 Annual PCDD/F air emissions [g I-TEQ/a] for incineration of hazardous wastes (reference period: 1993-1995)

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References to 090202

see national inventories for further information