

**SNAP CODE:** 090207

**SOURCE ACTIVITY TITLE:** WASTE INCINERATION  
*Incineration of Hospital Wastes*

**NOSE CODE:** 109.03.04

**NFR CODE:** 6 C

## 1 ACTIVITIES INCLUDED

This section includes the volume reduction, by combustion, of hospital wastes. Principally this section covers the emissions from chimneys and ductwork because of the availability of measurement data.

In some cases hospital waste is combusted in municipal waste incinerators, or in 'hazardous waste incinerators' along with hazardous/ chemical wastes from industrial processes. Users of this chapter should be aware of the potential for double counting of activity data with this chapter and the chapters on SNAP 090201 and SNAP 090202.

## 2 CONTRIBUTION TO TOTAL EMISSIONS

The relative proportion of emissions contributed by hospital waste incineration varies between pollutants. The process is likely to be a source (0.1-1% of total European emissions) of some persistent organic pollutants (POPs), such as PCDD/Fs, HCBs, TRI, PER, TCE, PAHs and some heavy metals such as cadmium, mercury etc. (ETC/AEM-CITEPA-RISOE 1997).

Emissions of compounds such as volatile organic compounds (VOCs), sulphur dioxide and nitrogen oxides (NO<sub>x</sub>, N<sub>2</sub>O) and particulate matter (Table 2.1) from hospital waste incineration are unlikely to contribute significantly to total emissions (< 0.1%), while substances such as sulphurhexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs) are generally not relevant (ETC/AEM-CITEPA-RISOE 1997).

**Table 2.1: Contribution to total particulate matter emissions from 2004 EMEP database (WEBDAB)†**

NFR Sector*	Data	PM <sub>10</sub>	PM <sub>2.5</sub>	TSP
6 C - Waste Incineration	No. of countries reporting	13	11	14
	Lowest Value	0.0%	0.0%	0.0%
	Typical Contribution	1.2%	1.6%	0.8%
	Highest Value	5.8%	7.3%	5.9%

\*Includes contribution from Chapters 921, 921, 925, 970 and 991

†These activities are not believed to be a significant source of PM<sub>2.5</sub> for the majority of countries. Data reported for 2004, however, indicates that it may be significant for in some cases. See relevant chapter B111 supplementary chapter for PM emission factors.

### 3 GENERAL

#### 3.1 Description

Hospital waste may be identified as 'specific hospital waste' and 'other hospital waste'. Specific hospital waste includes human anatomic remains and organ parts, waste contaminated with bacteria, viruses and fungi, and larger quantities of blood.

Incineration of hospital wastes has been banned in some European countries. In countries where the process is allowed, for the most part incinerators are currently small facilities located on-site at hospitals. However, there is generally a move towards larger, centralised facilities.

#### 3.2 Definitions

BAT - best available technology.

HCB - hexachlorobenzene.

HWID - hazardous waste incineration directive.

I-TEQ - International Toxic Equivalent (of PCDD/Fs).

NMVOCS - non-methane volatile organic compounds.

PAHs - polycyclic aromatic hydrocarbons.

PCBs - polychlorinated biphenyls.

PCDD/Fs - polychlorinated dibenzo-para-dioxins and polychlorinated dibenzo furans - a series of chlorinated aromatic compounds, commonly known as 'dioxins'.

PER - tetrachloroethylene.

POPs - persistent organic pollutants.

TCE - trichloroethane.

TRI - trichloroethylene.

Adsorption using activated carbon / activated lignite coke - several different technologies have been developed for dioxin and mercury control. These systems can also be fairly effective at removing HCl and SO<sub>2</sub> and act as a useful polisher for these acid gases.

Controlled air incinerators - also known as modular starved air incinerators, are commonly used units, which consist of two stages. During the first stage (starved air section), the air-to-fuel ratio is kept low to promote drying and volatilisation at temperatures of ~ 800 - 900 °C. In the second stage (secondary combustion chamber) excess air is added and temperatures

elevated to  $> 1000$  °C by support burners to ensure complete gas phase combustion. The relatively low bed temperature and combustion air velocities mean that metal species tend to remain in the bed and, together with particulates, are less likely to be entrained in the flue gases than with other types of incinerator (e.g. excess air incinerators).

Dry sorbent injection systems - involve the injection of an alkaline reagent (e.g. calcium hydroxide or sodium bicarbonate) as a fine, dry powder to remove and neutralise acid gases. The neutralised product is normally collected in a fabric filter.

Electrostatic precipitators (ESP) - use the principle of electrostatic attraction to remove entrained particles from the flue gases. They consist of rows of discharge electrodes (wires or thin metal rods), through which a high voltage is applied, and which run between an array of parallel rows of metal plates which collect the charged particles (note - not very common in clinical waste incinerators).

Energy recovery - the removal of heat from the exhaust gases so as to provide heat and/or electricity for use in the plant or elsewhere.

Excess air incinerators - also referred to as batch incinerators, are typically small modular units consisting of a series of internal chambers and baffles. They are usually operated batchwise, but can be operated continuously. Excess air incinerators generally consist of two main chambers; a primary combustion chamber where drying and volatilisation occurs and a secondary chamber to ensure complete gas phase combustion. These plant are operated at lower temperatures than controlled air incinerators (secondary chamber temperature  $\sim 900$  °C), with complete combustion promoted by maintaining excess air levels of up to 300 % throughout (usually  $\sim 100$  % for burning pathological waste only).

Fabric filters - consist of semi-permeable material in the form of bags or sleeves, which trap particles and which, are mounted in an airtight housing (baghouse) which is divided into a number of compartments. Fabric filters are also used as a second stage in acid gas control systems.

Rotary kiln - waste is fed into a slightly inclined, rotating, refractory-lined drum which acts as a grate surface. The rotating action of the drum mixes it with air supplied through the walls.

Semi-dry scrubbers / spray absorber systems (spray drying) - make use of an alkaline reagent slurry (usually calcium hydroxide) which is introduced into the flue gases as a spray of fine droplets. The acid gases are absorbed into the aqueous phase on the surface of these droplets and neutralised to form a dry product, which is collected in an electrostatic precipitator or fabric filter. Spray absorbers tend to use a reaction tower; of the several different designs available, the gas suspension absorber is the most commonly employed in hospital waste incinerators. This involves a re-circulation of particulate matter and unreacted lime back into the reaction tower.

Wet scrubbers - remove acid gases (e.g. HCl, HF and SO<sub>2</sub>) by washing the flue gases in a reaction tower. Designed to provide a high gas-liquid contact. In the first stage, the gases are quenched by water sprays to remove HCl, HF, some particulates and some heavy metals. In

the second stage, calcium hydroxide or another suitable alkali is used to remove SO<sub>2</sub> and any remaining HCl.

### 3.3 Techniques

There are many different furnace designs and combustion techniques used in Europe for hospital waste incineration. Generally, incinerators consist of the following components:

- a lidded charge box or feed hopper where the batch is first deposited;
- a hydraulic ram/ feeder which pushes the charge into the furnace;
- a pyrolysis furnace where the waste is degassed, releasing moisture and volatile components (at temperatures 800 - 900 °C);
- an after-burning chamber or secondary combustion chamber where the volatile components and products of incomplete combustion are completely destroyed by thermal oxidation in the presence of excess air, at temperatures above 1000 °C and with a gas residence time of 2 seconds;
- burners to heat up the plant when started, initiate combustion and to regulate the temperature in all parts, especially the secondary combustion chamber;
- a residue handling system.

#### Incinerator Size

Small incinerators (< 1 tonne/hr) may be designed to be operated during the day only, and tend to be used to incinerate batches. At start-up, the furnace is heated using support burners and, if required, the burning of domestic hospital waste. Daily, after the last waste input, the furnaces are maintained at temperature for a further 2 - 4 hours using the burners. The furnace is then cooled by leading ambient air through it for a number of hours before manual de-ashing is carried out.

Larger incinerators (> 1 tonne/hr) normally employ continuous operation. Conditions are adapted to ensure that there is effective combustion throughout, e.g. by using multi-hearth plant or rotary kilns under appropriate conditions of temperature/ air.

The main influences on the total emission expected from these incinerators are the waste burning capacity of the incinerator, the type of plant, the way in which it is operated (e.g. whether it includes heat recovery), its gas phase combustion efficiency and the degree of abatement fitted to the plant.

### 3.4 Emissions

The most significant pollutants from this process are some heavy metals (e.g. Pb, Cu, Cd, Cr, Ni, Hg). A variety of organic compounds, including PCDD/Fs, chlorobenzenes, chloroethylenes and polycyclic aromatic hydrocarbons (PAHs), are present in hospital waste or can be formed during the combustion and post-combustion processes. Organics in the flue gas can exist in the vapour phase or can be condensed or absorbed on fine particulates.

Other pollutants released are HCl, sulphur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (non-methane VOCs and methane (CH<sub>4</sub>)), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O).

Carbon monoxide emissions result when carbon in the waste is not completely oxidised to carbon dioxide (CO<sub>2</sub>). High levels of CO normally indicate that the combustion gases were not held at a sufficiently high temperature in the presence of oxygen (O<sub>2</sub>) for a long enough time to convert CO to CO<sub>2</sub>, or that quenching has occurred. Because O<sub>2</sub> levels and air distributions vary among combustor types, CO levels also vary among combustor types. Carbon monoxide concentration is a good indicator of gas phase combustion efficiency, and is an important criterion for indicating instabilities and non-uniformities in the combustion process (US EPA 1995).

Nitrogen oxides are products of all fuel/air combustion processes. Nitric oxide (NO) is the primary component of NO<sub>x</sub>; however, nitrogen dioxide (NO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O) are also formed in smaller amounts. Nitrogen oxides are formed during combustion through oxidation of nitrogen in the waste, and oxidation of atmospheric nitrogen. Conversion of nitrogen in the waste occurs at relatively low temperatures (less than 1,090 °C), while oxidation of atmospheric nitrogen occurs at higher temperatures. NO<sub>x</sub> from hospital waste incineration is typically lower than from other waste incineration processes.

### 3.5 Controls

Emissions may be controlled by modification of process techniques and physical parameters to optimise combustion conditions, or by employment of abatement techniques. The level of abatement at an incinerator plant varies, depending on the size of the plant, age and emission regulations etc.

Generally, there are three types of plant (LUA, 1997):

- type 1 are small on-site plants without abatement technology;
- type 2 are larger on-site facilities equipped with de-dusting systems;
- type 3 are incinerators which comply with the hazardous waste directive.

There are also a large number of facilities, which are intermediate between types 2 and 3, with varying levels of abatement.

Mainly for economic reasons, in recent years there has been a move towards larger, modern plant. Such plant includes emission abatement equipment, which aim to ensure compliance with emission regulations, addressing the three main environmental impacts of waste incineration/ products of incomplete combustion: acid gas, heavy metal and dioxin emissions. Typical approaches used include:

- good combustion practice - optimal conditions of time/ temperature/ turbulence/ air to ensure complete oxidation of products of incomplete combustion;
- wet scrubbers (acid gas removal);
- fabric filters (particle control);
- electrostatic precipitators (particle control);
- semi-dry scrubbers / spray absorber systems (acid gas removal);

- dry sorbent injection systems (acid gas removal);
- adsorption using activated carbon / activated lignite coke (PCDD/F and mercury removal).

These control systems are described in section 3.2. These systems are usually needed in combination.

#### 4 SIMPLER METHODOLOGY

The simpler methodology relies on the use of a single emission factor for each pollutant species combined with a national hospital waste incineration statistic:

$$\text{Total emission} = \text{mass of hospital waste incinerated (tonnes)} \times \text{overall emission factor (emission per tonne of waste incinerated)} \quad (1)$$

A typical emission factor for hospital waste incinerators within a country can be estimated from the emission factors given in section 8 combined with knowledge of the typical level of abatement and its efficiency:

$$\text{Typical overall emission factor} = \text{baseline emission factor (uncontrolled)} \times (1 - \text{overall abatement efficiency}) \quad (2)$$

N.B There are no emission factors available for PM<sub>2.5</sub>. The source is <0.1% of the total PM emissions for most countries.

#### 5 DETAILED METHODOLOGY

The detailed methodology involves the use of plant specific emission factors calculated from regulatory emission measurement programmes and using plant specific throughput data normally obtained by each plant. The detailed method will therefore involve the use of a similar equation to the one in section 4, but the equation will be plant specific.

Should a key source analysis indicate this to be a major source of particulate matter (TSP, PM<sub>10</sub> or PM<sub>2.5</sub>) then installation level data should be collected using a measurement protocol such as that illustrated in Measurement Protocol Annex.

#### 6 RELEVANT ACTIVITY STATISTICS

##### 6.1 Simpler methodology

For the simpler methodology the national annual incineration of hospital waste is required. In addition, a more reliable estimate can be made if information is available on the typical levels of abatement technology used and on the associated overall abatement efficiency.

In determining the emissions from the incineration of hospital waste, one of the most difficult tasks for the user is to correctly derive the fraction of waste actually being incinerated from the overall clinical waste being produced in a country.

## 6.2 Detailed methodology

The more detailed method requires information on plant specific waste throughput and abatement technology, obtained from the operators.

If neither of these values is available the mass burn rate of each incinerator should be multiplied by an estimated operating time.

## 7 POINT SOURCE CRITERIA

The number of clinical waste incinerators is small so they may be treated as point sources if plant specific data are available.

## 8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

### 8.1 Simpler Methodology

Tables 8.1 to 8.20 give default emission factors for the most significant pollutants, where available, for:

- type 1 plant - small on-site facilities without abatement technology;
- type 2 plant - larger on-site facilities equipped with de-dusting systems;
- type 3 plant - facilities, which comply with the hazardous waste incineration directive (HWID) (94/67/EC).

Data for specific plant configurations (controlled air/ rotary kiln) are also included where available for a variety of abatement options. [\* denotes limited data available].

No emission factors are available for HCB, TRI, PER, TCE or PAHs.

Users of the Guidebook are advised to consider that from country to country the composition of the incinerated waste may vary due to differences in waste definitions and fractionation. This could lead to country-specific emission factors that are not comparable to those of other countries.

**Table 8.1 – Default Emission Factors for Aluminium (Al)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Al	Controlled air	5	E	uncontrolled	USA	US EPA 1998
Al	Controlled air	2*	E	controlled (various types of abatement)	USA	US EPA 1998
Al	Rotary kiln	306	E	uncontrolled	USA	US EPA 1998
Al	Rotary kiln	1 - 2	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.2 – Default Emission Factors for Antimony (Sb)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Sb	Controlled air	6	D	uncontrolled	USA	US EPA 1998
Sb	Controlled air	0.1 - 0.2	E	controlled (various types of abatement)	USA	US EPA 1998
Sb	Rotary kiln	10	E	uncontrolled	USA	US EPA 1998
Sb	Rotary kiln	0.1 - 0.2	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.3 – Default Emission Factors for Arsenic (As)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
As	Controlled air	0.1	B	uncontrolled	USA	US EPA 1998
As	Controlled air	0.00002 - 0.07	E	controlled (various types of abatement)	USA	US EPA 1998
As	Rotary kiln	0.2	E	uncontrolled	USA	US EPA 1998



**Table 8.4 – Default Emission Factors for Barium (Ba)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Ba	Controlled air	2	B	uncontrolled	USA	US EPA 1998
Ba	Controlled air	0.04 - 0.1	E	controlled (various types of abatement)	USA	US EPA 1998
Ba	Rotary kiln	45	E	uncontrolled	USA	US EPA 1998
Ba	Rotary kiln	0.06 - 0.1	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.5 – Default Emission Factors for Beryllium (Be)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Be	Controlled air	0.003	D	uncontrolled	USA	US EPA 1998
Be	Controlled air	0.002*	E	controlled (various types of abatement)	USA	US EPA 1998
Be	Rotary kiln	0.02	E	uncontrolled	USA	US EPA 1998
Be	Rotary kiln	0.003*	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.6 – Default Emission Factors for Cadmium (Cd)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Cd	type 1	7 – 17	D/ C	none	UK	Wenborn et al. 1998
Cd	type 2	6 – 9	C	particle abatement only (dedusting)	UK	Wenborn et al. 1998
Cd	type 3	1	D	BAT for compliance with HWID	UK	Wenborn et al. 1998
Cd	Controlled air	3	B	uncontrolled	USA	US EPA 1998
Cd	Controlled air	0.006 – 3	E	controlled (various types of abatement)	USA	US EPA 1998
Cd	Rotary kiln	8	E	Uncontrolled	USA	US EPA 1998
Cd	Rotary kiln	0.01 - 0.03	E	Controlled (various types of abatement)	USA	US EPA 1998

**Table 8.7 – Default Emission Factors for Chromium (Cr)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Cr	Controlled air	0.4	B	Uncontrolled	USA	US EPA 1998
Cr	Controlled air	0.001 - 0.5	E	Controlled (various types of abatement)	USA	US EPA 1998
Cr	Rotary kiln	2	E	Uncontrolled	USA	US EPA 1998
Cr	Rotary kiln	0.04 - 0.05	E	Controlled (various types of abatement)	USA	US EPA 1998

**Table 8.8 – Default Emission Factors for Copper (Cu)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Cu	Controlled air	0.6	E	uncontrolled	USA	US EPA 1998
Cu	Controlled air	0.1 - 0.6	E	controlled (various types of abatement)	USA	US EPA 1998
Cu	Rotary kiln	98	E	uncontrolled	USA	US EPA 1998
Cu	Rotary kiln	0.2 - 0.3	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.9 – Default Emission Factors for Iron (Fe)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Fe	Controlled air	0.7	C	uncontrolled	USA	US EPA 1998
Fe	Controlled air	0.5*	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.10 – Default Emission Factors for Lead (Pb)**

Substance	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country	Reference
Pb	type 1	75 - 150	D/ C	none	UK	Wenborn et al. 1998
Pb	type 2	54 - 74	C	particle abatement only (dedusting)	UK	Wenborn et al. 1998
Pb	type 3	5	D/ C	BAT for compliance with HWID	UK	Wenborn et al. 1998
Pb	Controlled air	364	B	uncontrolled	USA	US EPA 1998
Pb	Controlled air	0.03 - 40	E	controlled (various types of abatement)	USA	US EPA 1998
Pb	Rotary kiln	62	E	uncontrolled	USA	US EPA 1998
Pb	Rotary kiln	0.04 - 0.1	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.11 – Default Emission Factors for Manganese (Mn)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Mn	Controlled air	0.3	C	uncontrolled	USA	US EPA 1998
Mn	Controlled air	0.2 - 0.3	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.12 – Default Emission Factors for Mercury (Hg)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Hg	type 1	not available	N/A	none	UK	Wenborn et al. 1998
Hg	type 2	4 –5	C	particle abatement only (dedusting)	UK	Wenborn et al. 1998
Hg	type 3	1	C/ D	BAT for compliance with HWID	UK	Wenborn et al. 1998
Hg	Controlled air	54	C	uncontrolled	USA	US EPA 1998
Hg	Controlled air	0.2 – 15	E	controlled (various types of abatement)	USA	US EPA 1998
Hg	Rotary kiln	43	E	Uncontrolled	USA	US EPA 1998
Hg	Rotary kiln	4 – 33	E	Controlled (various types of abatement)	USA	US EPA 1998

**Table 8.13 – Default Emission Factors for Nickel (Ni)**

Compound	Plant type	Emission factor g/tonne waste	Data Quality	Abatement type	Country or region	Reference
Ni	Controlled air	0.3	B	uncontrolled	USA	US EPA 1998
Ni	Controlled air	0.1 – 16	E	controlled (various types of abatement)	USA	US EPA 1998
Ni	Rotary kiln	2	E	uncontrolled	USA	US EPA 1998
Ni	Rotary kiln	0.02 - 0.04	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.14 – Default Emission Factors for PCDD/Fs**

Compound	Plant type	Emission factor µg I-TEQ/tonne of waste	Data Quality	Abatement type	Country	Reference
PCDD/Fs	type 1	800 – 2500	E	none	W Europe	LUA 1997, Berdowski 1995
PCDD/Fs	type 2	80 – 250	D/E	particle abatement only (dedusting)	W Europe	LUA 1997, Berdowski 1995
PCDD/Fs	type 3	1	D/C	BAT for compliance with HWID	W Europe	LUA 1997, Berdowski 1995

**Table 8.15 – Default Emission Factors for Polychlorinated Biphenyls (PCBs)**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
PCBs (total)	Controlled air	0.02	E	uncontrolled	USA	US EPA 1998

**Table 8.16 – Default Emission Factors for HCl**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
HCl	Controlled air	16800	C	uncontrolled	USA	US EPA 1998
HCl	Controlled air	5- 6370	E	controlled (various types of abatement)	USA	US EPA 1998
HCl	Rotary kiln	22100	E	uncontrolled	USA	US EPA 1998
HCl	Rotary kiln	134 – 14700	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.17 – Default Emission Factors for Particulates (PM)**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
PM	Controlled air	2330	B	uncontrolled	USA	US EPA 1998
PM	Controlled air	36-1450	E	controlled (various types of abatement)	USA	US EPA 1998
PM	Rotary kiln	17300	E	uncontrolled	USA	US EPA 1998
PM	Rotary kiln	39 – 427	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.18 – Default Emission Factors for Carbon Monoxide (CO)**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
CO	Controlled air	1480	A	uncontrolled	USA	US EPA 1998
CO	Rotary kiln	191	E	uncontrolled	USA	US EPA 1998
CO	Rotary kiln	19 – 30	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.19 – Default Emission Factors for NO<sub>x</sub>**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
NO <sub>x</sub>	Controlled air	1780	A	uncontrolled	USA	US EPA 1998
NO <sub>x</sub>	Rotary kiln	2310	E	uncontrolled	USA	US EPA 1998
NO <sub>x</sub>	Rotary kiln	2040 – 2630	E	controlled (various types of abatement)	USA	US EPA 1998

**Table 8.20 – Default Emission Factors for SO<sub>2</sub>**

Compound	Plant type	Emission factor g/tonne of waste	Data Quality	Abatement type	Country or region	Reference
SO <sub>2</sub>	Controlled air	1090	B	uncontrolled	USA	US EPA 1998
SO <sub>2</sub>	Controlled air	8 – 1040	E	controlled (various types of abatement)	USA	US EPA 1998
SO <sub>2</sub>	Rotary kiln	540	E	uncontrolled	USA	US EPA 1998
SO <sub>2</sub>	Rotary kiln	150 – 324	E	controlled (various types of abatement)	USA	US EPA 1998

## 9 SPECIES PROFILES

The dioxin profile for the relative emissions of the individual isomers measured to make up the Toxic Equivalence does not vary in overall shape between most combustion samples. The profile is likely to be dominated by octa-chlorinated dioxins and furans.

## 10 UNCERTAINTY ESTIMATES

Emission factors are likely to vary considerably between different incinerators, depending on the operating conditions and on which of the many combinations of gas cleaning equipment is in use on the plant. The variability at just a single plant for PCDD/Fs, for example, can be an order of magnitude between different sampling periods. The ranges in emission factors and the data quality ratings (mainly C, D or E) demonstrate the high uncertainty.

## 11 WEAKEST ASPECTS / PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Further work should be invested to develop emission factors, both to reduce the uncertainty of the emission factors in section 8, and to include important pollutants for which no information is available (e.g. other POPs). Improvements to emission factors would be easier if the measurement information collected by national regulatory authorities was collated.

## 12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

All sources should be considered point source if possible.

## 13 TEMPORAL DISAGGREGATION CRITERIA

Unless information available suggests otherwise, the smaller plant operating at less than 1 tonne per hour should be treated as 8 hour 5 days a week processes. It is likely that larger incinerators may operate more continuously and should be treated as 24 hour 7 days a week processes.

## 14 ADDITIONAL COMMENTS

No additional comments

## 15 SUPPLEMENTARY DOCUMENTS

No supplementary documents are required.

## 16 VERIFICATION PROCEDURES

Verification is through comparison with emission estimates from different countries together with a measurement programme for selected sites.

## 17 REFERENCES

Berdowski J.J.M., Veldt C., Baas J., Bloos J.P.J., Klein A.E. (1995) Technical paper to the OSPARCOM-HELCOM-UNECE emission inventory of heavy metals and persistent organic pollutants. Report no TNO-MEP-R95/247.

ETC/AEM-CITEPA-RISOE (1997) Selected nomenclature for air pollution for CORINAIR94 inventory (SNAP 94), version 1.0.

LUA (1997) The Identification of Relevant Industrial Sources of Dioxins and Furans in Europe (The European Dioxin Inventory).

US EPA (1998): Compilation of Air Pollutant Emission Factors AP42, Fifth Edition & Supplements (internet).

Wenborn M.J., Coleman P.J., Passant N.R., Salway A.G., Lymberidi E. (1998) Future UK Emissions of Persistent Organic Pollutants, Cadmium, Lead and Mercury.

## 18 BIBLIOGRAPHY

APARG (1995) Report on the Abatement of Toxic Organic Micropollutants (TOMPs) from Stationary Sources. Air Pollution Abatement Review Group, DoE, UK. Available from National Environmental Technology Centre, Culham, Abingdon, Oxfordshire, OX14 3DB, UK.

Bremmer H.J., Troost L.M., Kuipers G., de Koning J. and Sein A.A. (1994) Emissions of Dioxins in The Netherlands. TNO / RIVM Report 770501018.

Cremer and Warner (1990) Pollution Control at Clinical Waste Incinerators, Department of the Environment: HMIP-commissioned research.

Environment Agency (1996) Processes Subject to Integrated Pollution Control S2 5.01: Waste Incineration.

Grochowalski A. (1998) PCDDs and PCDFs Concentration in Combustion Gases and Bottom Ash from Incineration of Hospital Wastes in Poland. *Chemosphere* Vol. 37 pp. 2279-2291.

Lee C.C., Huffmann G.L. (1996) Review: Medical Waste Management/ Incineration, *J. Hazardous Materials*, Vol 48, 1-30.

Scutter J., Tipping P., Storey R. (1995) An Assessment of Clinical Waste Combustion and Pollution Abatement Technology, ETSU report B/RR/00360/REP contracted to WS Atkins Consultants Ltd for the DTI.

Walker B.L., Cooper C.D. (1992) Air Pollution Emission Factors for Medical Waste Incinerators, *J. Air Waste Management Association* **42**, 784.

## **19 RELEASE VERSION, DATE AND SOURCE**

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Original author: Jessica Sully  
AEA Technology Environment  
UK

Updated with particulate matter details by:  
Mike Woodfield  
AEA Technology  
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## **20 POINT OF ENQUIRY**

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