SNAP CODE: **030301**
040209

SOURCE ACTIVITY TITLE: **PROCESSES WITH CONTACT**
Sinter and Pelletizing Plants
Sinter and Pelletizing Plants (Except Combustion 030301)

NOSE CODE: **104.12.02**
105.12.09

NFR CODE: **1 A 2 a**
2 C 1

1 ACTIVITIES INCLUDED

The sinter process is an ore pre-treatment step in the production of iron, non-ferrous metals and other special materials.

This chapter does not address sinter plants in the non-ferrous metal industry; these plants should be covered by the chapters in SNAP 040300.

With respect to the iron and steel industry, this chapter only addresses travelling grate sintering which is by far the most important technique for iron ore sintering. The discontinuous pan sintering process as well as the rotary kiln process are now used at very few plant and are not discussed here. In addition, other agglomeration processes like pelletisation, briquetting and nodulisation are not considered here.

2 CONTRIBUTION TO TOTAL EMISSION

Table 2.1 Contribution to total emissions of the CORINAIR 90 inventory (*up to 28 countries*)

Source-activity	**SNAP-code**	**Contribution to total emissions [%] (including emissions from nature)**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Sinter Plants	030301	1.3	1.0	0.1	0.1	4.9	0.4	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

Emissions of dust, heavy metals and POPs from sinter plants are also relevant but limited information is available. Europe-wide data on dust emissions is not readily available, but the PM10 contribution of sinter production to the UK's National Atmospheric Emissions Inventory for 1998 is given in Table 2.2.

Table 2.2 Contribution of cement production to the total emission of PM10 in the UK

Compound	Contribution (%)
PM10	1.5

Table 2.3 gives the contribution of sinter plant to total emissions of heavy metals and POPs from the OSPARCOM-HELCOM-UNECE emission inventory. For many heavy metals and POPs, but particularly in the case of PCDD/Fs, contribution to total emission may vary significantly from country to country and could be large (up to 50%).

Sinter plant are unlikely to be a significant source of sulphurhexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), (ETC/AEM-CITEPA-RISOE 1997, ref. 30).

Table 2.3 Contribution to total POP and heavy metal emissions of the OSPARCOM-HELCOM-UNECE emission inventory (up to 39 countries)

Source-activity	SNAP-code	Contribution to total emissions (including emissions from nature) [%]										
		As	Cr	Cu	Pb	Cd	Hg	Ni	Zn	PCBs	PCDD/Fs	PAH
Sinter plant	030301 / 040209	1.0	2.9	2.3	2.8	3.2	1.6	1.2	0.8	0.5	15	0

3 GENERAL

3.1 Description of activities

The sintering process is a pretreatment step in the production of iron where fine particles of metal ores are agglomerated by combustion. Agglomeration of the fine particles is necessary to increase the passageway for the gases during the blast furnace process. The strength of the particles is also increased by agglomeration.

The activities in the sinter plants include:

- treatment of the ores by crushing and sieving;
- mixing of treated ores, coke and flux compounds;
- combustion and agglomeration of a mixture of crushed ores, coke, small sintered agglomerates and flux compounds;
- sieving of the sintered agglomerates;
- cleaning of the combustion off-gases;
- transport and handling operations occurring between the above mentioned activities.

3.2 Definitions

Mixing of the ores	The ores are mixed with residual material, fuel (coke, breeze), and flux compounds. This is necessary for preparing the ore for the sintering process.
Crushing process	The ores are crushed to increase the contact area for the sintering. The sinter cake is crushed to improve the transportation to the furnace blasting process.
Sieving process	The crushed ores are sieved to prevent the ores which require further crushing from entering the sinter process. The crushed sinter cakes are sieved to prevent small sintered particles entering the furnace process.
Sintering process	During sintering ore particles, flux compounds and other material are agglomerated by the combustion of the coke / breeze. The temperature must stay below the melting temperature of the metals in the ores.
Air cleaning process	The air of the combustion and cooling process is cleaned by removing dust and sometimes other pollutants.
Basicity of sinter mixture	Basicity of the mixture may be an important parameter influencing the emissions of SO_2. It is defined by relation of the following compounds (fractions expressed as weight %): basicity = $(CaO + MgO)/(SiO_2 + Al_2O_3)$
POM	Polycyclic organic matter

3.3 Techniques used during the sintering process

The sintering process is used for several primary metal production processes, each having different designs. During sintering, fine-grained, smeltable ores, in particular iron ore, are agglomerated into compact lumps **by heating nearly to the melting or softening point**. Melting tends to occur at the grain boundaries leading to a caking of the material.

Before the sintering, the various substances are first mixed and, if desired, granulated. The iron ores are agglomerated on conveyor sinter installations, the conveyor belts consist of a large number of wagons. These wagons that have been linked up as an endless conveyor belt which can be as big as 4 m in width and 100 m in length. The fine ore to be sintered is moistened and fed on to the circulating grid together with coke breeze and additives such as limestone, quick lime, olivine or dolomite. Burners above a heat-resistant grate belt heat the material to the required temperature (1100-1200 °C). This causes the fuel in the mixture to be ignited. The combustion then is self supporting and provides sufficient heat, 1300 to 1480 °C, to cause surface melting and agglomeration of the mix. The carbon burns with the aid of the air sucked through the grid into the mixture, resulting in the flame front being moved through the sintering bed. On the underside of the sinter strand a series of windboxes is situated that draw combusted air down through the material bed into a common duct, leading to gas cleaning devices (ref. 1). The sintering processes are completed once the flame front has passed through the entire mixed layer and all fuel has been burnt.

The fused sinter is discarded at the end of the sinter strand, where it is crushed and screened. Undersize sinter is recycled to the mixing mill and goes back to the strand. The remaining sinter product is cooled in open air or in a circular cooler with water sprays or mechanical fans. The cooled sinter is crushed and screened for a final time, then the fines are recycled, and the product is sent to the blast furnaces to be charged (ref. 1).

The most common types of sinter coolers used include circular or straight line moving beds, quiescent beds, or shafts. Air or water is used as the cooling medium in these coolers, with air being prevalent in newer plants and water being dominant in older plants (refs. 2, 3).

Technical data which are typical for the plants operating in W-Europe are listed in Table 3.1:

Table 3.1 Range of technical parameters of European sinter plants

Parameter	Range	Ref.
width [m]	2,5-4,5	(ref. 4)
area [m²]	50-400 (1)	(ref. 4)
specific flue gas flows [m³/t sinter]	1800-2000	(ref. 5)
flue gas flows [million m³/h]	up to 1.5	(ref. 4)
height of sinter layer	ca. 250 -650 mm	(ref. 6)
coke input [kg/ton sinter]	38-55	

(1) some small installations are reported to be in operation in Poland, another one in Germany (sintering of iron containing return and filter materials)

The sinter plant plays a central role in an integrated iron and steel works for making use of production residues which would have to be disposed otherwise. Slags from steel production, filter dusts of diverse flue gas cleaning systems (including those applied to the sinter plant itself) and various iron-containing materials from residue treatment are recycled in the sinter plant. Recycling may lead to an enrichment of relevant compounds, particularly heavy metals. Some residue materials like roll mill scale may be contaminated with organic compounds (oils), being precursors for PAH and PCDD/F formation. An example of input material composition is shown in the Table 3.2 below.

Table 3.2 Example of input material composition to sinter plant

Material	% [1]
hematite	81.3
magnetite	2.7
returns	7.9
pellet abrasions	2.2
blast furnace dust	0.3
steel work dust	0.6
roll scale	1.3
limestone	9.4
olivine	3.5
coke breeze	5

[1] related to dry mixture

Chlorine compounds can enter into the sinter installation by means of the additive coke slack as well by the ore from its natural chloride contents. Furthermore, returned materials such as certain filter particles, scale and sludges from waste water treatment, which are added to the materials to be sintered, can also increase the chlorine content of the substances used. This is reflected in the waste gases from sinter installations which contain inorganic gaseous chlorine compounds.

An alternative process is pelletisation, where no combustion is necessary.

By 2010 a new technology called "converted blast furnace" or "melting-reduction technology" is expected to be operational. For this process sintering, pelletisation, and coke input will no longer be necessary (ref. 7).

3.4 Emissions

3.4.1 Emitted compounds

Of the 8 CORINAIR standard gaseous compounds, all except ammonia are known to be emitted by sinter plants.

- SO_2 emissions mostly originate from sulphur contained by the coke used as fuel. Actual emissions may be further dependent on the basicity of the mixture. With CaO dominated mixtures SO_2 production is decreased by increasing basicity. From MgO dominated mixtures about 97% of the sulphur content is converted to SO_2. The major fraction of the total SO_2 emission is generated in the hot part of the sinter belt (near the end), (ref. 5).
- Nitrogen oxides are mainly emitted as NO due to rapid downcooling of the flue gases. NO_X emissions originate from nitrogen contained in coke (ca. 80%) and iron ore (ca. 20%), (ref. 5).
- Raw materials contain heavy metals (HM). Dust emissions are generally associated with HM emission. During the sintering process some of the HM may be volatilised or converted into volatile compounds (e.g. chlorides) and can therefore be found in the flue

gas. This mainly concerns Zn, Pb, and Cd. Arsenic is emitted in gaseous form as As_2O_3, passing the dry gas cleaning facilities which are usually operated at 120 °C. Since these volatile compounds form or adsorb to fine particles which are removed by the gas cleaning facilities, they may be accumulated during the sinter return cycle. Moreover, fine particles passing the filters may have a much higher content of these metals than the raw gas dust or the sinter mixture (ref. 5).

- Polycyclic organic material (POM), eg. PAH and PCDD/F, may be formed from chlorine and precursor compounds like oily additives. Potentially, POM emissions may be released from the sinter machine windbox, from the sinter machine discharge point, and from sinter product processing operations (i.e. crushing, screening, and cooling). Because of the high temperatures used in sintering operations, it is probable that sinter plant POM emissions are in both gaseous and particulate matter forms (refs. 2, 8).
- Emissions of fluorides (sintering of ores recovered in Sweden) and hydrochloric acid (use of seawater moistening or coke treatment) have been observed (ref. 4)

3.4.2 Emission points

At a sinter plant, emissions may occur as (‘direct’) stack emissions and - to a minor degree - as fugitive (‘indirect’) emissions during all process steps mentioned above.

- Ambient air is sucked by several windboxes through the mixture to support the combustion process on the sinter belt. After passage of the belt the flue gases are collected, dedusted and released through the main stack.
- The main process steps (like coke crushing, raw material handling, belt charging and discharging, sintering) are usually done within encapsulated or semi-encapsulated housings. The housings may be equipped with suction hoods connected via flue gas cleaning devices to the main stack or to separate stacks. Thus, there may be more than one stack emission point at a given sinter plant.
- Fugitive dust emissions may arise during handling and transportation of the raw materials and of the cooled sinter as well as during maintenance and accidental interrupts of the cyclones or filters. More important, due to the strong thermal convection in the sinter hall’ fugitive emissions through leakages in the roof are likely to occur particularly at the end of the sinter belt.

3.4.3 Abatement measures

Gaseous compounds
Limited information is available about specific control measures for gaseous emissions. A desulphurisation facility is operated at a German plant (ref. 9). Measures for SO_2 and NOx reduction are known from plants operated in Japan (ref. 4).

Dust
Abatement measures are directed to dust emissions. In principle, reduction of dust emission also leads to reduction of emissions for those compounds being bound to particulates. Sinter strand windbox emissions commonly are controlled by cyclone cleaners followed by a dry or wet electrostatic precipitator (ESP), high pressure drop wet scrubber, or baghouse. Crusher and hot screen emissions are usually controlled by hooding and a baghouse or scrubber.

Usually horizontal dry electrostatic precipitators are used; however, less efficient mechanical dedusting devices (e.g cyclone batteries) might be installed in old sinter plants if only protection of the blower wheel rather than environmental protection is intended. Some sinter plants located in CIS countries are reported to have only this low standard abatement technology, others are equipped with wet venturi washers (ref. 10).

POM
Since being identified as a relevant source of dioxins and furans some sinter plants have been equipped with special abatement technologies (e.g. ‘Airfine-system’, Austria; injection of activated charcoal or open hearth coke in connection with fabric filter) or optimised dedusting facilities (‘MEEP’ = ESP with rotating electrode), (ref. 6).

4 SIMPLER METHODOLOGY

4.1 Calculation of emission

The simpler methodology involves the combination of emission factors (EF) (eg. mass of emitted compound per tonne of sinter produced) with activity statistics (A) (eg. mass of sinter material produced). Default emission factors are provided in Section 8.1.

5 DETAILED METHODOLOGY

An extensive measuring programme involving off-gas measurements at all relevant emission points is essential to get a clear picture of the actual emissions. Emission measurements should be performed at least at the main stacks connected to the windboxes of the sinter strand and to the hot crushing / sieving facility. This is particularly important concerning emissions of dioxins and furans since there is no way to date to estimate the emissions from different operating conditions.

Reference emissionfactors for comaprison with users own data are provided in section 8.2.

6 ACTIVITY STATISTICS

Standard international compilations of production statistics are available from

- EUROSTAT , Brussels (Iron and Steel, Yearly statistics, Theme 4, Series C);
- the International Iron and Steel Institute , Brussels;
- Wirtschaftsvereinigung Stahl, PO Box 10 54 64, 40045 Düsseldorf, Germany (Statistical Yearbook Iron and Steel Industry);
- National Statistical Yearbooks.

More details of these example data sources for activity statistics are given in Section 17 (References).

7 POINT SOURCE CRITERIA

Sinter plants usually are part of large integrated iron and steel plants connected to high chimneys (> 100 m), and should be regarded as point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Default emission factors for iron ore sinter plants - simple methodology

Pollutant	Emission factor	Units
Particulate matter		
Total suspended particulate	2	kg/t sinter
PM10	0.8	kg/t sinter
PM2.5	0.5	kg/t sinter
Arsenic	0.05	g/t sinter
Cadmium	0.08	g/t sinter
Chromium	0.5	g/t sinter
Copper	0.7	g/t sinter
Mercury	0.05	g/t sinter
Nickel	0.24	g/t sinter
Lead	4	g/t sinter
Selenium	0.02	g/t sinter
Zinc	0.9	g/t sinter
Dioxins and furans	15	µgTEQ/t sinter
Hexachlorobenzene	32	µg/t sinter
Polychlorinated biphenyls	200	µg/t sinter
Polyaromatic hydrocarbons	200	mg/t sinter

8.2 Detailed Methodology

This section provides reference emission factors for comparison with users own data.

The following emission factors are given in ref. 28 as recommended values for emission estimation concerning the compounds covered by the Corinair ‘90 inventory; they are based on the results reported by different sources in Western Europe and the U.S.A. (Annex 1); Emission factors reported for other sinter processes, other countries and additional compounds are given in Annex 1.

Since no assessment of uncertainty is given, data quality rating is generally assumed to be C.

N.B. It is assumed that the emission factors given in the following table were derived originally by relating the entire emission of a pollutant within a time period to the typical input of the mentioned fuels within the same time period, regardless of whether combustion of the fuel really causes any emission of the pollutant. While this procedure leads to chemically inconsistent emission factors it still enables the rough calculation of the entire emission of a plant when just knowing the input amount of one of the fuels used.

Table 8.2a Emission factors for gaseous compounds

Compound	**Emission factor**	**Abatement type**	**Abatement efficiency**	**Fuel type (NAPFUE code)**
	[mg/GJ]		[%]	
Sox	499	Uncontrolled	N/A	Coke breeze (107)
	658	Uncontrolled	N/A	Heating oil heavy (203)
	1410	Uncontrolled	N/A	heating oil light (204)
	4680	Uncontrolled	N/A	natural gas (301)
	5490	Uncontrolled	N/A	coke oven gas (304)
	8600	Uncontrolled	N/A	blast furnace gas (305)
		plus scrubber	90	all fuels
NOx	500	Uncontrolled	N/A	Coke breeze (107)
	134	Uncontrolled	N/A	Heating oil heavy (203)
	100	Uncontrolled	N/A	heating oil light (204)
	530	Uncontrolled	N/A	natural gas (301)
	2350	Uncontrolled	N/A	coke oven gas (304)
	8050	Uncontrolled	N/A	blast furnace gas (305)
		low NOx technology	30	all fuels
		secondary measures (SCR)	70	all fuels
MMVOC	50	uncontrolled or with controls for SOx and/or NOx only	N/A	Coke breeze (107)
	5	uncontrolled or with controls for SOx and/or NOx only	N/A	Heating oil heavy (203)
	1.5	uncontrolled or with controls for SOx and/or NOx only	N/A	heating oil light (204)
	14	uncontrolled or with controls for SOx and/or NOx only	N/A	natural gas (301)
	26	uncontrolled or with controls for SOx and/or NOx only	N/A	coke oven gas (304)
	0.25	uncontrolled or with controls for SOx and/or NOx only	N/A	blast furnace gas (305)
CH_4	50	uncontrolled or with controls for SOx and/or NOx only	N/A	Coke breeze (107)
	4	uncontrolled or with controls for SOx and/or NOx only	N/A	Heating oil heavy (203)
	1.5	uncontrolled or with controls for SOx and/or NOx only	N/A	heating oil light (204)
	14	uncontrolled or with controls for SOx and/or NOx only	N/A	natural gas (301)
	257	uncontrolled or with controls for SOx and/or NOx only	N/A	coke oven gas (304)
	257	uncontrolled or with controls for SOx and/or NOx only	N/A	blast furnace gas (305)

N/A = not applicable, Data Quality = C

Table 8.2a (continued) Emission factors for gaseous compounds

Compound	**Emission factor**	**Abatement type**	**Abatement efficiency**	**Fuel type (NAPFUE code)**
	[mg/GJ]		[%]	
CO	10500	uncontrolled or with controls for SOx and/or NOx only	N/A	Coke breeze (107)
	14	uncontrolled or with controls for SOx and/or NOx only	N/A	Heating oil heavy (203)
	13	uncontrolled or with controls for SOx and/or NOx only	N/A	heating oil light (204)
	2160	uncontrolled or with controls for SOx and/or NOx only	N/A	natural gas (301)
	35000	uncontrolled or with controls for SOx and/or NOx only	N/A	coke oven gas (304)
	84000	uncontrolled or with controls for SOx and/or NOx only	N/A	blast furnace gas (305)
	109000	uncontrolled or with controls for SOx and/or NOx only	N/A	Coke breeze (107)
	78000	uncontrolled or with controls for SOx and/or NOx only	N/A	Heating oil heavy (203)
	74000	uncontrolled or with controls for SOx and/or NOx only	N/A	heating oil light (204)
	55500	uncontrolled or with controls for SOx and/or NOx only	N/A	natural gas (301)
	46000	uncontrolled or with controls for SOx and/or NOx only	N/A	coke oven gas (304)
	200000	uncontrolled or with controls for SOx and/or NOx only	N/A	blast furnace gas (305)
	4	uncontrolled or with controls for SOx and/or NOx only	N/A	Coke breeze (107)
	10	uncontrolled or with controls for SOx and/or NOx only	N/A	Heating oil heavy (203)
	12	uncontrolled or with controls for SOx and/or NOx only	N/A	heating oil light (204)
	3	uncontrolled or with controls for SOx and/or NOx only	N/A	natural gas (301)
	2.3	uncontrolled or with controls for SOx and/or NOx only	N/A	coke oven gas (304)
	3	uncontrolled or with controls for SOx and/or NOx only	N/A	blast furnace gas (305)

N/A = not applicable

Data Quality = C

Table 8.2b Emission factors for dust

Process	Emission factor [kg dust/ Mg sinter]	Data quality	Abatement type	Abatement efficiency	Country	Ref
Sintering	4	C	Unabated	0	D	ref. 5
Cooling	3.5	C	Unabated	0	D	ref. 5
Sintering	14	E	Cyclones	60-70 %	CIS	ref. 29
Cooling	3	E	Cyclones	60-70 %	CIS	ref. 29
Sintering	0.3	C	ESP	>90 %	EU	ref. 16
Cooling	0.05	C	multi cyclone,	>90 %	EU	ref. 16
Handling	0.1	D	ESP, bag filters	> 90 %	EU	ref. 16
crushing, blending, sintering	0.25	D	“after abatement”	N/A	EU	ref. 31
Cooling	0.2	D	Cyclones	N/A	EU	ref. 31
Cooling	0.06	D	bag filters	N/A	EU	ref. 31
Windbox	5.56	B	Uncontrolled	N/A	US	ref. 1
Windbox	4.35	A	Uncontrolled (after coarse particles removal)	N/A	US	ref. 1
Windbox	0.8	B	ESP (dry)	N/A	US	ref. 1
Windbox	0.085	B	ESP (wet)	N/A	US	ref. 1
Windbox	0.235	B	Venturi scrubber	N/A	US	ref. 1
Windbox	0.5	B	Cyclone	N/A	US	ref. 1
Sinter discharge	3.4	B	Uncontrolled	N/A	US	ref. 1
Sinter discharge	0.05	B	Baghouse	N/A	US	ref. 1
Sinter discharge	0.295	A	Venturi scrubber	N/A	US	ref. 1
windbox and discharge	0.15	A	Baghouse	N/A	US	ref. 1

8.2c Heavy metal emission

The following factors are based on the emission factors shown in Annex 1. They may be applied to estimate emissions from sinter plants in the western European countries that are commonly equipped with dedusting facilities. For calculation of the possible emission range refer to the values tabled in Annex 1. In view of the higher dust emission reported for sinter plants located in the CIS, higher emissions (about factor 2-3) of heavy metals are likely there.

Table 8.2c Emission factors for heavy metals

Process	**Compound**	**Emission factor [g/ GJ sinter]**	**Data quality**
stack emission	As	0.05	C
	Cd	0.2	C
	Cr	0.2	C
	Cu	0.4	C
	Hg	0.05	C
	Ni	0.2	C
	Pb	8	C
	Se	0.02	C
	Zn	1	C

8.2d POP emissions

Since data on other POP were not available, only emissions of PCDD/Fs are included. Refer to Annex 1 to calculate potential emission range. It should be noticed that extremely high emissions from single plants may dominate the national emission. Therefore the simpler methodology should be applied cautiously.

Table 8.2d Emission factors for PCDD/Fs

Compound	**Process**	**Emission factor (1) [µg I-TEQ/ Mg sinter]**	**Data quality**	**Abatement type**	**Abatement efficiency**	**Country /region**
PCDD/F	sintering	6	C	dedusting, ESP	0% (2)	WEu
PCDD/F	cooling	1	C	dedusting, ESP or cyclones	0% (2)	WEu
PCDD/F	sintering	1.5	D	‘MEEP’ (Moving ESP)	30-70%	D
PCDD/F	sintering	0.5	D	injection of adsorbents/fabric filters	up to 90%	D
PCDD/F	sintering	0.3	C	high performance washer (Airfine)	90%	A

[1] = Note that measurements have shown that there is a significant temporal variation in PCDD/F emissions from sinter plant (about a factor of 2). Also, at one German plant very high PCDD/F emissions were measured (nearly 100 µg I-TEQ/ Mg sinter), showing that variation between plant is likely.

[2] = no significant differences in PCDD/F content measured in raw and clean gas (ref. 6).

9 SPECIES PROFILES

As mentioned in section 3.4 the heavy metal profile of the dust emitted from the hot sintering and crushing/sieving processes are not necessarily related to the profile of the raw materials due to volatilisation and accumulation of some compounds. The following enrichment factors have been observed (ref. 5) :

Table 9.1 Enrichment factors for heavy metals at sinter plant

	Zn	**Pb**	**Cd**
$C_{filter\ dust}/C_{Sinter\ mixture}$	5	450	30
$C_{clean\ gas\ dust}/C_{Sinter\ mixture}$	20	1,300	90

PCDD/F profile information is available from a recent German study (ref. 6). Table 9.2 gives average mass fractions for PCDD/F homologues as revealed by measurement results obtained from 3 plants (5 measurements).

Table 9.2 Species data for PCDD/F from sinter plant

Homologue	**Range [%]**	**mean [%]**
TetraCDF	37-46	40
PentaCDF	26-32	28.5
HexaCDF	10-13	12
HeptaCDF	3.5-5	4
OctaCDF		0.5
TetraCDD	1-5	2
PentaCDD	4-6	4.5
HexaCDD	3-8	5
HeptaCDD	2-4	3
OctaCDD	0-2	1.5

The European IPPC Bureau (ref. 31) includes a graph showing the grain size and weight distribution of dust, based on samples from a number of sinter strands. There are two distinct maxima, one in the range 0.1 – 3 µm, one close to 100 µm. Particles smaller than 0.1 µm and between 3 µm and 80 µm make up a much smaller fraction of the total. The coarse dust can be separated in ESPs with high efficiency. However, the composition of the fine dust, alkali chlorides, reduces the efficiency of ESPs.

The EPA's AP-42 document (ref. 1) gives size distributions for particulate matter emitted from the various stages of sinter production. These are reproduced in Table 9.3.

Table 9.3 Particle size distributions and size-specific emission factors (ref. 1)

Process	**Abatement technology**	**Particle size (μm)**	**Cumulative mass % < stated size**	**Cumulative mass emission factor (kg/t)**	**Quality rating**
Windbox	uncontrolled (leaving gate)	0.5	4	0.22	D
		1	4	0.22	
		2.5	6.5	0.28	
		5	9	0.5	
		10	15	0.83	
		15	20	1.11	
			100	5.56	
Windbox	ESP (wet)	0.5	18	0.015	C
		1	25	0.021	
		2.5	33	0.028	
		5	48	0.041	
		10	59	0.05	
		15	69	0.059	
			100	0.085	
Windbox	Venturi scrubber	0.5	55	0.129	C
		1	75	0.176	
		2.5	89	0.209	
		5	93	0.219	
		10	96	0.226	
		15	98	0.23	
			100	0.235	
Windbox	cyclone	0.5	25	0.13	C
		1	37	0.19	
		2.5	52	0.26	
		5	64	0.32	
		10	74	0.37	
		15	80	0.4	
			100	0.5	
Windbox	baghouse	0.5	3	0.005	C
		1	9	0.014	
		2.5	27	0.041	
		5	47	0.071	
		10	69	0.104	
		15	79	0.119	
			100	0.15	
Discharge breaker and hot screens	baghouse	0.5	2	0.001	C
		1	4	0.002	
		2.5	11	0.006	
		5	20	0.01	
		10	32	0.016	
		15	42	0.021	
			100	0.05	

10 UNCERTAINTY ESTIMATES

The main uncertainty relates to the emission factors. The data quality for all emission factors given in this chapter is from C to E. Emissions are likely to vary greatly between different plant and some emission factors are likely to vary by a factor of at least 10. More information is required on the variation of emissions with different types and sizes of process, different abatement etc.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Knowledge on abatement techniques, dust removal efficiencies and operating techniques is limited. Emission of PCDD/F may depend strongly on operation conditions and raw material composition; hence, estimation may be very uncertain and measurements are required so that a realistic understanding of the emissions can be developed. Data for other POP remain to be collected.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

This section is not relevant because sinter plant are part of large integrated iron and steel works and therefore should be considered as point sources.

13 TEMPORAL DISAGGREGATION CRITERIA

Sintering can be considered as a continuous process. However, emissions may vary with time (e.g. due to changes in raw material composition)

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

- Environmental Protection Agency: Compilation of Air Pollutant Emission Factors (AP 42);
- PARCOM-ATMOS Emission Factors Manual;
- Holtmann T., Rentz O., Samaras Z. Zachariadis T., Kulcke K, K.-H. Zierock: Development of a Methodology and a Computer Model for Forecasting Emissions from Relevant Mobile and Stationary Sources, Final Report 1995 (study on behalf of EC, DG XI,, Brussels).

16 VERIFICATION PROCEDURES

Verification of the emissions can be done roughly for metal emissions by calculating the emissions using the factors from section 8 and comparing the results with a mean profile of the ore used. A mass balance over the entire plant may also be a useful check. In case of PCDD/Fs verification can only be done by measurements.

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ANNEX 1 - BACKGROUND EMISSION MEASUREMENT INFORMATION

Emissions of gaseous compounds

Process type	**Iron ore sinter plants**								**Sintering of special materials**	
References	(ref. 11)	(ref. 7)		(ref. 12)		(ref. 13)	(ref. 14)	(ref. 15)	(ref. 7)	
Country or region	Int.	NL		USA		EU	Cz	P	NL	
Abatement	unknown	unabated	with abatement (abatement details unknown)	unknown		unknown	unknown	unknown	unabated	abated
Dimension	g/Mg product	g/Mg crude steel		g/Mg product		g/GJ (NAPFUE 107) (6)	g/GJ	g/Mg	g/Mg crude steel	
SO_x	2,000	857	86	1,250 (2)	70 (3)				1,181	118 (7)
SO_2						233-632		1200		
NO_x	1,500	388	66			300-702	137.9		450	90 (8)
NMVOC	108 (1)					8.5.	14.2	100	347	
VOC		254		700 (2)	25 (4)					
CH_4	292 (1)					15	38.4			
CO	20,000-40,000	15,367		22,000 (2)		272		12000	23,000	
CO_2		163,265				106			221,000	
N_2O						4				
Fluoride (5)		11.6	2					5 6)		
HCl (5)		47	9							

[1] = general, 73 % CH_4 for VOC as 400 g/Mg; [2] = windbox; [3] = cooler; [4] = general for sinter process; [5] = dim: g/Mg sinter; [6] = in the document referred to also emission factors for other fuels are given (NAPFUE 203,204,301,304,305); [7] = with lime scrubber; [8] = with SCR

Dust emissions

[kg dust/Mg sinter produced]

Process type	**Iron ore sinter plants**														
References	(ref. 5)				(ref.10)	(ref. 7)		(ref.16) (6)			(ref. 31)				
Country or region	D				CIS	NL		D;I,B			EU				
Abatement (dust)	unabated		Two field ESP	ESP + fabric filter (3)	unknown (4)	unabated	abated	Dry ESP (3-4 fields)	multi cyclones	dry ESP (2-3 fields) or bag filters	“after abatement”	“after abatement”	“after abatement”	cyclones	bag filters
Dust	2-6 (1)	3-4 (2)	0.135-0.6	<0.006	10-24 (5)	0.675	0.165	0.12-0.34 (7)	0.03-0.12 (8)	0.05-0.2 (9)	< 0.0045	0.09-0.44	0.009-0.25	0.09-0.41	0.037-0.1

[1] = windbox emissions; [2] = crushing and screening; [3] = with injection of lignite activated charcoal and lime; [4] = see description given in 3.4.3; [5] = without sinter cooler 10-18 kg/t; [6] = values calculated from given concentrations with spec flue gas flow; [7] = sintering process, Q_S assumed to be 2000 m³/Mg; [8] = Sinter cooling air (on strand) , Q_S assumed to be 700 m³/Mg; [9] = Sinter handling, Q_S assumed to be 1000 m³/Mg

Heavy metal emissions

[g/Mg sinter produced]

Process type	**Iron ore sinter plants**										
References	ref. 17	ref.18 (1)	ref.18 (2)	ref.19	ref. 20	ref. 21	ref. 7		ref. 5	ref. 6	ref. 22
Country or region	D	D		F	Int.	Int.			D (4)	D (3)	UK (4)
Abatement (dust)	electro-filters	electro-filters		electro-filters	electro-filters	cyclones	unabated	abated	electro-filters	electro-filters	unknown
Compound											
Arsenic (As)	-	0.025	0.009	-	-		0.05	0.01	0.026	0-0.038	
Cadmium (Cd)	-	$3*10^{-4}$	0.09	-	0.02-0.12	0.08	0.13	0.03	0.058	0.024-0.228	0.022
Chromium (Cr)	-	0.13	0.09	0.56	-	-	0.05	0.01	0.161	0.016-0.514	
Copper (Cu)	1	0.25	0.36	0.23	-	-	0.13	0.03	0.437	0.176-0.656	

n.r.a.= No range available

[1] = Diffuse sources, cold; [2] = Abated process emissions; [3]= calculated from given concentrations and spec. flue gas flow, [4]= calculated from reported annual emission with sinter production data

Heavy metal emissions (continued)

[g/Mg sinter produced]

Process type	**Iron ore sinter plants**										
References	ref.17	ref.18 (1)	ref.18 (2)	ref.19	ref. 20	ref. 21	ref. 7		ref. 5	ref. 6	ref. 22
Country or region	D	D		F	Int.	Int.			D (4)	D (3)	UK (4)
Abatement (dust)	electro-filters	electro-filters		electro-filters	electro-filters	cyclones	unabated	abated	electro-filters	electro-filters	unknown
Compound											
Mercury (Hg)	-	$6*10^{-5}$	0.01	-	-	-	0.04	0.01	0.012	0.010-0.106	
Nickel (Ni)	-	0.19	0.14	1.0	-	-			0.240	0.008-0.378	
Lead (Pb)	9	0.13	4.5	2.1	-	15.3	9.92	2.48	2.990	0.360-4.106	0.73
Selenium (Se)	0.02	$1*10^{-4}$	0.019	-	-	-			0.022		
Zinc (Zn)	-	0.13	0.9	2.1	-	-	0.37	0.09	0.678		
Manganese (Mn)									0.966	0.128-1.754	

n.r.a.= No range available

[1] = Diffuse sources, cold; [2] = Abated process emissions; [3]= calculated from given concentrations and spec. flue gas flow, [4]= calculated from reported annual emission with sinter production data

POP emissions

Data are available only for PCDD/Fs

µg I-TEQ/tonne of sinter produced (1)

Process type	**Iron ore sinter plants**									**Sintering of special materials**		
References	ref. 23		ref. 24	ref. 6			ref.25	ref. 26 (2)	ref. 27	ref.24 (8)	ref.25(9)	ref.25(10)
Country or region	A		D	D			NL	S	UK	D	NL	NL
Abatement (dust)	electro-filters	high performance wet scrubbing (‘Airfine’)	electro-filters	Moving electrofilters (‘MEEP’)	fabric filter, activated charcoal	fabric filter, hearth oven coke	electro-filters	electro-filters	electro-filters	electro-filter	fabric filter	washer
PCDD/Fs	4-5 (7)	0.4-1.0	1.3-27.7 (3) 5.9 (4) 0.88 (6)	1.4 (7)	0.24-4.95 (7)	0.04-4.2 (7)	0.3-17	1-2.8	1.2-9	338	0.3	4.5

[1] = I-TEQ: International toxicity equivalents according to NATO/CCMS; [2] = value given in N-TEQ (Toxicity equivalents, nordic model); [3] = windboxes, range except one-case maximum: 94.8 µg I-TEQ/t; [4] = typical value; [6] = sinter cooler; [7] = calculated from reported concentrations and estimate of specific flue gas volume (2000 m^3/t); [8] = sintering of iron containing residue materials; [9] = prod. of artificial gravel; [10] = prod. of phosphates