SNAP CODE: **040207**

SOURCE ACTIVITY TITLE: **PROCESSES IN IRON & STEEL INDUSTRIES & COLLIERIES**
Electric Furnace Steel Plant

NOSE CODE: **105.12.07**

NFR CODE: **2 C 1**

1 ACTIVITIES INCLUDED

The electric steel furnace is a part of the production process for primary iron and steel. Figure 1.1 in the Introduction of the Guidebook shows a flow sheet of an integrated iron and steel plant. The block where scrap is added is where the electric furnace is situated. The figures 5.3 and 5.4 in the Guidebook Introduction show a more detailed picture of an electric furnace.

2 CONTRIBUTION TO TOTAL EMISSIONS

Electric furnaces contribute substantially to the total emission of particulates (PM), cadmium, chromium, zinc, hexachlorobenzene and dioxins and furans (see Tables 2.1-2.3).

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory (*28 countries*)

Source-activity	SNAP-code	Contribution to total emissions [%]								
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	PM*
Electric Furnace Steel Plant	040207	0	0.1	0	-	0.6	-	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported
* = PM (inclusive of TSP, PM_{10} and $PM_{2.5}$) is <0.1% of total PM emissions

Table 2.2: Contribution to total heavy metal (HM) emissions of the OSPARCOM-HELCOM-UNECE Emission Inventory (*38 countries*; Berdowski et al; ref. 17)

Source-activity	SNAP-code	Contribution to total emissions [%]								
		dust[1]	Cd	Hg	Pb	As	Cr	Cu	Ni	Zn
Electric Furnace Steel Plant	040207	9	7	2	2	1	28	1	1	16

1) contribution of total iron and steel industry to total European (excluding the former U.S.S.R.) PM_{10} emission (ref. 18)
0 = emissions are reported, but the exact value is below the rounding limit (0.5 per cent)

- = no emissions are reported

Table 2.3: Contribution to total POP emissions of the OSPARCOM-HELCOM-UNECE Emission Inventory (*38 countries*; Berdowski et al.; ref. 17)

Source-activity	SNAP-code	Contribution to total emissions [%]	
		Hexachlorobenzene	Dioxins/Furans
Electric Furnace Steel Plant	040207	3	3

0 = emissions are reported, but the exact value is below the rounding limit (0.5 per cent)

Electric furnace steel plant are unlikely to be a significant source of sulphurhexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), (ETC/AEM-CITEPA-RISOE 1997; ref. 19).

3 GENERAL

3.1 Description

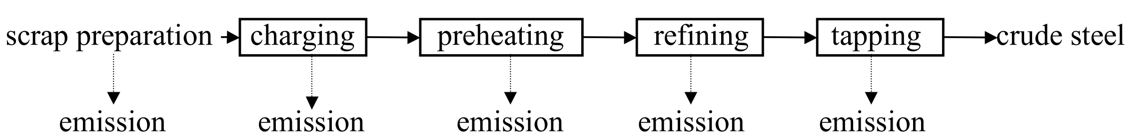
In an electric arc furnace non-alloyed, and low-alloyed steel is produced from polluted scrap. The scrap is mainly produced by shredding cars and does not have a constant quality.

Through carbon electrodes electricity is added to the scrap in the furnace, thus raising the temperature to 1700 ^{o}C. Lime, anthracite and pig-iron are then added. Depending on the desired quality of the steel, chromium, manganese, molybdenum or vanadium compounds can be added. The process is a batch process. Each cycle consists of the same steps: charging of scrap, preheating, refining with addition of other material and tapping (see figure 3.1).

Emissions are produced during each step of a cycle. Several abatement techniques are used to reduce the dust emissions (see Section 3.5).

The interior of the furnace is covered with fire-resistant coating.

Figure 3.1. The steps in a production cycle of an electric arc furnace.



3.2 Definitions

Electric arc furnace: A furnace equipped with carbon electrodes between which a high voltage is applied. The resulting electric arc melts the scrap.

Coating material: Fire-resistant material covering the interior of the furnace. The coating is repaired from time to time and removed after a limited number of cycles. The coating material used can contain tar, but tar-free material is available.

3.3 Techniques

The techniques used are extensively described in literature.

3.4 Emissions

Besides carbon monoxide and carbon dioxide, dust is the main emission. Sixty percent of the dust particles are smaller than ten micron. Because polluted scrap is used, the dust contains heavy metals such as lead and zinc. Also copper, chromium, nickel, arsenic, cadmium, and mercury are present.

Small amounts of hexachlorobenzene and dioxins and furans are also emitted. Emissions of PAH depend on the coating material used, e.g. in the Netherlands PAH are not emitted, because tar-free materials are used for the coating.

3.5 Controls

Reduction of the emissions can be achieved by technological process changes as well as by abatement equipment. Varying the operating conditions or the design of the furnace may lead to a reduction in the amount of dust produced. Use of an 'after burner' reduces the amount of CO emitted. Use of equipment to capture the emitted particles, e.g. fabric filter or electrostatic precipitators (ESP), reduces the amount of dust emitted.

Fugitive emissions can be reduced by placing the furnace in a doghouse (a 'hall') and using abatement equipment to clean the effluent from the doghouse. Table 3.1 lists the overall efficiency of several abatement technologies.

Table 3.1. Abatement technologies and their efficiencies for complete electric furnace steel plants (assuming good housekeeping).

Abatement technology	efficiency (%)
fabric filter	95%[1]
electrostatic precipitators (ESP)	>95%[1]
doghouse, suction hood and fabric filter	>99.5%[1]
fibrous filter and post-combustion	>95%[1]

[1)] abatement for PM (and for most HM, but not for As and Hg)

4 SIMPLER METHODOLOGY

Emissions can be estimated at different levels of complexity; it is useful to think in terms of three tiers[1]:

Tier 1: a method using readily available statistical data on the intensity of processes ("activity rates") and default emission factors. These emission factors assume a linear relation between the intensity of the process and the resulting emissions. The Tier 1 default emission factors also assume an average or typical process description.

Tier 2: is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed.

Tier 3: is any method that goes beyond the above methods. These might include the use of more detailed activity information, specific abatement strategies or other relevant technical information.

By moving from a lower to a higher Tier it is expected that the resulting emission estimate will be more precise and will have a lower uncertainty. Higher Tier methods will need more input data and therefore will require more effort to implement.

For the simpler methodology (equivalent to Tiers 1 and 2), where limited information is available, a default emission factor can be used together with production capacity information for the country or region of interest without further specification on the type of industrial technology or the type and efficiency of control equipment.

Consequently the simplified methodology is to combine an activity rate (A) with a comparable, representative, value of the emissions per unit activity, the emission factors (EF). The annual emission is determined according to Equation (1) by an activity and an emission factor:

$$E_i = EF_i \cdot A \qquad (1)$$

E_i annual emission of pollutant i

EF_i emission factor of pollutant i

A activity

The activity A and the emission factor EF_i have to be determined on the same level of aggregation by using available data.

5 DETAILED METHODOLOGY

Extensive measurements in a local situation will provide better information. Another way of estimating the emissions is using a mass balance. A third way is by estimating the emissions for each step of a production cycle.

1 The term "Tier" is used in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and adopted here for easy reference and to promote methodological harmonization.

Should a key source analysis indicate this to be a major source of particulate matter (TSP, PM_{10} or $PM_{2.5}$) then installation level data should be collected using a measurement protocol such as that illustrated in the Measurement Protocol Annex.

6 RELEVANT ACTIVITY STATISTICS

The electric energy comes from an external power plant. For preheating of the scrap natural gas (heat content 31.65 MJ/m^3) is used. The amount used is about 3 - 7 m^3 per ton scrap.

Simpler methodology
The production statistics needed is the total secondary steel production of the country and a way to distribute this production over the plants (e.g. capacity per plant).

Detailed methodologies
Needed for: method 1 - Per plant measurements
method 2 - All flows going in and out of each plant
method 3 - The amount of product in each step of the production cycle
For the third methodology some information is presented in the tables.

7 POINT SOURCE CRITERIA

All electric (arc) furnace plants should be considered as point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

From the smelters in the Netherlands about 2,800 ton dust a year is captured. The dust production can be calculated to be about 11.6 kg/ton steel. The abated dust emission is about 0.64 kg/ton steel produced (abatement efficiency 95%). From this figure emission factors for heavy metals have been calculated. The BAT Reference document for production of iron and steel gives a dust range of 0.001-0.780 kg/tonne and USEPA gives a filterable PM range of 0.009-0.05 kg/tonne.

Table 8.1. Emission factors for (in)direct greenhouse gases plus SO_x from electric arc furnaces.

Plant type	Compound	Emission factor g/Mg	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
us[7]	SO_x	350	D	*unknown*	*unknown*	*unknown*	USA	15
stack, cs[6]	SO_x	350	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	SO_2	28-350[1]	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	SO_2	130	D	*unknown*	*unknown*	*unknown*	Switzerland	5
us[7]	SO_2	130	D	*unknown*	*unknown*	*unknown*	Netherlands	3
us[7]	NO_x	200	D	*unknown*	*unknown*	*unknown*	*unknown*	15
stack, cs[6]	NO_x	50	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	NO_x	80-820[2]	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	NO_x	220	D	*unknown*	*unknown*	*unknown*	Switzerland	5
us[7]	NO_x	470	D	*unknown*	*unknown*	*unknown*	Netherlands	3
us[7]	NMVOC	90	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	NMVOC	170	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	NMVOC	33-180[3]	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	NMVOC	80	D	*unknown*	*unknown*	*unknown*	Switzerland	5
charging, us[7]	VOC	0.5	D	*unknown*	*unknown*	*unknown*	*unknown*	15
tapping, us[7]	VOC	1	D	*unknown*	*unknown*	*unknown*	*unknown*	15
stack, cs[6]	VOC	175	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	VOC	58	D	*unknown*	*unknown*	*unknown*	Netherlands	3
us[7]	CH_4	10	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	CH_4	10	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	CO	10000	D	*unknown*	*unknown*	*unknown*	*unknown*	15
carbon steel	CO	9000	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	CO	1000-11500[4]	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	CO	1000	D	*unknown*	*unknown*	*unknown*	Switzerland	5
us[7]	CO	1500	D	*unknown*	*unknown*	*unknown*	Netherlands	3
us[7]	CO_2	150000-220000	D	*unknown*	*unknown*	*unknown*	Denmark	6
us[7]	CO_2	2000-100000[5]	D	*unknown*	*unknown*	*unknown*	*unknown*	15
us[7]	CO_2	100000	D	*unknown*	*unknown*	*unknown*	Switzerland	5
us[7]	CO_2	1400000	D	*unknown*	*unknown*	*unknown*	Netherlands	3
us[7]	N_2O	5	D	*unknown*	*unknown*	*unknown*	*unknown*	15

1) suggested value: 130 g/Mg
2) suggested value: 200 g/Mg
3) suggested value: 90 g/Mg
4) suggested value: 10000 g/Mg
5) suggested value: 50000 g/Mg
6) cs is carbon steel
7) us is unknown type of steel

Table 8.2. Emission factors for heavy metals from electric arc furnaces.

Plant type	Compound	Emission factor g/Mg	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
ccs[1]	As	0.1	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Cd	0.25	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Cr	1	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Cu	0.8	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Hg	0.15[1]	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Ni	0.25	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Pb	14	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Se	0.05	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ccs[1]	Zn	50	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	As	0.015	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Cd	0.07	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Cr	15	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Cu	0.5	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Hg	0.15[1]	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Ni	5	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Pb	2.5	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Se	0.05[1]	E	*unknown*	*unknown*	*unknown*	Netherlands	1
ss[2]	Zn	6	E	*unknown*	*unknown*	*unknown*	Netherlands	1
us[3]	As	0.048	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	As	0.002	E	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Cd	0.086	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Cd	0.004	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Cd	0.39	E	*unknown*	*unknown*	*unknown*	} United	12
us[3]	Cd	0.22	E	*unknown*	*unknown*	*unknown*	} Kingdom	12
us[3]	Cd	0.23	D	*unknown*	91%	*unknown*	Switzerland	5
us[3]	Cr	0.61	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Cr	0.03	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Cr	0.12 - 7.9	E	*unknown*	*unknown*	*unknown*	Poland	4
us[3]	Cu	0.55	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Cu	0.03	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Cu	0.05 - 3.1	E	unknown	*unknown*	*unknown*	Poland	4
us[3]	Hg	0.0048	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Hg	0.0002	E	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Hg	1	E	*unknown*	*unknown*	*unknown*	Switzerland	5
us[3]	Ni	0.086	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Ni	0.004	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Pb	18	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Pb	1	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Pb	0.08 - 5.5	E	unknown	*unknown*	*unknown*	Poland	4
us[3]	Pb	21	E	*unknown*	*unknown*	*unknown*	} United	12
us[3]	Pb	12	E	*unknown*	*unknown*	*unknown*	} Kingdom	12
us[3]	Pb	31	D	*unknown*	91%	*unknown*	Switzerland	5
us[3]	Zn	190	E	uncontrolled	0%	*unknown*	Netherlands	3
us[3]	Zn	11	D	fabric filter	95%	*unknown*	Netherlands	3
us[3]	Zn	0.37 - 24	E	*unknown*	*unknown*	*unknown*	Poland	4
us[3]	Zn	94	D	*unknown*	91%	*unknown*	Switzerland	5

1) ccs is carbon & construction steel
2) ss is stainless steel
3) us is unknown type of steel

Table 8.3. Emission factors for dust from electric arc furnaces.

Plant type	Compound	Emission factor g/Mg	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
charging, us[4]	dust	100 - 300	E	*unknown*	*unknown*	*unknown*	France	11
tapping, us[4]	dust	60 - 130	E	*unknown*	*unknown*	*unknown*	France	11
ccs[1]	dust	60 - 200	E	*unknown*	*unknown*	*unknown*	Sweden	2
stack, cs[2]	dust	25000	E	*unknown*	*unknown*	*unknown*	*unknown*	15
ss[3]	dust	30 - 900	E	*unknown*	*unknown*	*unknown*	Sweden	2
us[4]	dust	120 - 150	D	filter	*unknown*	*unknown*	Denmark	6
us[4]	dust	6000 - 20000	E	*unknown*	*unknown*	*unknown*	France	11
us[4]	dust	11000 - 23000	E	uncontrolled	*unknown*	*unknown*	Germany	9
us[4]	dust	610	E	uncontrolled	0%	*unknown*	Netherlands	3
us[4]	dust	30	D	fabric filter	95%	*unknown*	Netherlands	3
us[4]	dust	1300	D	*unknown*	91%	*unknown*	Switzerland	5

1) ccs is carbon & construction steel
2) cs is carbon steel
3) ss is stainless steel
4) us is unknown type of steel

Table 8.4. USEPA Particulate matter emission factors* for electric arc furnaces (g/Mg) (ref. 20)

Process	Control	Emission factor, g/Mg				
		PM	Rating	PM_{10}	$PM_{2.5}$	Rating
Electric arc furnace(steel minimills AP-42 Chapter 12.5.1 (2004)						
Charging, melting, slagging, tapping	Shell evacuation and roof canopy to fabric filter	0.050	D	*0.038*	*0.038*	*E*
Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition, ladle furnace melting	Shell evacuation and roof canopy to fabric filter	0.030	E	*0.023*	*0.023*	*E*
Charging, melting, slagging, tapping, continuous caster	Shell evacuation and roof canopy to fabric filter	0.009	E	*0.007*	*0.007*	*E*
Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition, ladle furnace melting , continuous caster	Shell evacuation and roof canopy to fabric filter	0.034	E	*0.026*	*0.026*	*E*
Electric arc furnace steel production AP-42 Chapter 12.5 (1986)						
Melting and refining	Uncontrolled carbon steel	19000	C	11020	8170	D
Charging, tapping, and slagging steel	Uncontrolled emissions escaping monitor	700	C	*400*	*300*	*E*
Melting, refining, charging, tapping, and slagging	Uncontrolled – alloy steel	5650	A	*3280*	*2430*	*E*
	Uncontrolled – carbon steel	25000	C	*15000*	*11000*	*E*
	Building evacuation to baghouse for alloy steel	150	A	*110*	*110*	*E*
	Direct shell evacuation (plus charging hood) vented to common baghouse for carbon steel	21.5	E	16	16	E

* = In the absence of more appropriate data use the AP 42 emission factors, figures in italics for PM_{10} and $PM_{2.5}$ derived from USEPA particle size profiles for uncontrolled and fabric filter.

Table 8.5. Emission factors for dioxins and furans and benzo(a)pyrene from electric arc furnaces.

Plant type	Compound	Emission factor µg I-TEQ/Mg	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
us[1]	dioxins/fur.	5[4]	E	*unknown*	*unknown*	*unknown*	Belgium	13
us[1]	dioxins/fur.	6	E	*unknown*	*unknown*	*unknown*	France	7
us[1]	dioxins/fur.	0.15 - 1.8	C	fabric filter	*unknown*	*unknown*	Germany	13
us[1]	dioxins/fur.	0.068 - 0.23	C	ESP	*unknown*	*unknown*	Germany	13
us[1]	dioxins/fur.	2	E	semi-abated	*unknown*	*unknown*	Netherlands	16
us[1]	dioxins/fur.	20	E	semi-abated	*unknown*	PVC cont.	Netherlands	16
us[1]	dioxins/fur.	0.7	E	*unknown*	*unknown*	no Cl_2	} United	13
us[1]	dioxins/fur.	10	E	*unknown*	*unknown*	high Cl_2	} Kingdom	13
us[1]	dioxins/fur.	0.2 - 8.6[2]	E	*unknown*	*unknown*	*unknown*	Sweden	13
us[1]	dioxins/fur.	11	E	*unknown*	*unknown*	*unknown*	Switzerland	5,13
us[1]	B(a)p[3]	17[3]	E	*unknown*	*unknown*	*unknown*	Czech Rep.	8

[1)] unknown type of steel
[2)] ng NTEQ/Mg
[3)] B(a)p (benzo(a)pyrene) in mg/Mg
[4)] value based on data from Sweden and the Netherlands; the range is 0.1 - 50 µg I-TEQ/Mg

9 SPECIES PROFILES

Comparison of species profiles with local information about ore and scrap compositions might be useful for verification purposes. However, no generalised information is available. See Table A.2 in Annex A for an example of dust composition.

10 UNCERTAINTY ESTIMATES

The uncertainty differs per compound. It varies between a factor of 1.5 and 3.5.

Since most material is on Western European countries, it can only be applied to Southern and Central and Eastern European countries when no better information is available.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect of the methodology is the lack of measurements in relation to the type of steel produced, the composition of the scrap/ore used in the furnace and the abatement.

For the simpler methodology a formula to calculate an emission factor based on ore/scrap composition used, steel type produced and abatement used would be very useful. Ideally the formula would be in this form:

$E.F. = å \bullet [x]_{in} \bullet f_x \bullet PM \bullet ç_x$ with å is an enrichment factor, $[x]_{in}$ is concentration of metal x in ore/scrap, f_x is a factor depending on concentration of metal x in steel produced, PM is the amount of particulates emitted and $ç_x$ is the abatement efficiency for compound x.

Not enough information is available to breakdown the emission factors for the total production cycle to emission factors for each step of a production cycle.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

The basic steel plants are to be regarded as point sources.

13 TEMPORAL DISAGGREGATION CRITERIA

Although the electric arc furnace is a discontinuous process, the smelter operation as such is a continuous process. The plant is operating 24 hours a day and 7 days a week.

14 ADDITIONAL COMMENTS

No additional comments

15 SUPPLEMENTARY DOCUMENTS

US Environmental Protection Agency, Compilation of air pollutant emission factors AP-42

16 VERIFICATION PROCEDURE

Verification of heavy metal emissions by comparing the profile of the emissions with ore and scrap compositions could be used as a verification method. A mass balance over the complete plant (one of the detailed methods) can be used as verification method.

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No additions to the general literature about iron and steel production.

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20 POINT OF ENQUIRY

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ANNEX A: CONCENTRATION DATA FOR COMPOUNDS IN FLUE GASES AND DUST

Table A.1. Compound concentration in the flue gas of electric arc furnaces.

Plant type	Compound	Concentration mg/m3	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
us[3]	SO_2	5 - 50	D	*unknown*	*unknown*	*unknown*	France	11
us[3]	NO_x	50	D	*unknown*	*unknown*	*unknown*	France	11
us[3]	dust	0.08	D	filter	*unknown*	*unknown*	Denmark	6
us[3]	dust	500 - 15000	E	uncontrolled	*unknown*	*unknown*	Germany	
us[3]	dust	0.7 - 13.5	D	}	97.4%	*unknown*	Germany	9
us[3]	As	-	-	}	-	*unknown*	Germany	9
us[3]	Cd	<0.001 - 0.015	C	} doghouse &	>92.5%	*unknown*	Germany	9
us[3]	Cr	<0.001 - 0.008	C	} spark arrester	>98.4%	*unknown*	Germany	9
us[3]	Ni	<0.001 - 0.003	C	} & bag &	>90%	*unknown*	Germany	9
us[3]	Pb	0.04 - 0.7	C	} pocket filters	>93.6%	*unknown*	Germany	9
us[3]	Zn	0.23 - 0.7	C	}	>98.5%	*unknown*	Germany	9
us[3]	dust	2	C	)	99.9	*unknown*	Germany	9
us[3]	As	<0.001	C	)	>95	*unknown*	Germany	9
us[3]	Cd	<0.002	C	) doghouse &	>99.8	*unknown*	Germany	9
us[3]	Cr	<0.002	C	) suction hood &	>99.9	*unknown*	Germany	9
us[3]	Ni	<0.001	C	) fabric filter	>99.6	*unknown*	Germany	9
us[3]	Pb	0.08	C	)	99.9	*unknown*	Germany	9
us[3]	Zn	0.8	C	)	99.9	*unknown*	Germany	9
us[3]	dioxins/fur.	0.016 - 0.26[1]	C	fabric filter	*unknown*	*unknown*	Germany	13,14
us[3]	dioxins/fur.	0.010 - 0.040[1]	C	ESP	*unknown*	*unknown*	Germany	13,14
us[3]	dioxins/fur.	2.3[1]	D	fibrous filter	*unknown*	*unknown*	Luxembourg	13
us[3]	dioxins/fur.	0.77[1]	D	fibrous filter & post-combustion	*unknown*	*unknown*	Luxembourg	13
us[3]	dioxins/fur.	0.04[1]	E	*unknown*	*unknown*	*unknown*	Netherlands	13
us[3]	dioxins/fur.	0.1 - 1[2]	E	*unknown*	*unknown*	*unknown*	Sweden	13

1) ng I-TEq/m³
2) ng NTEQ/m³
3) unknown type of steel

Table A.2. Concentration of heavy metals in dust (in wt.%).

	Cd	Cr	Cu	Ni	Pb	Zn	Country	Ref.
Low alloy steel	0.1	0.14 - 0.6	0.4	0.1	6.1-7.0	17 - 31	France	11
Stainless steel	0.03	13.7	0.3	3.8	1.9	1.9	France	11
Steel	0.017	*unknown*	*unknown*	*unknown*	2.3	7.0	Switzerland	5
Steel	0.02 - 0.1	*unknown*	*unknown*	*unknown*	1.3-3.7	*unknown*	UK	10

Table A.3. Concentration of dioxins/furans in filter dust.

Plant type	Compound	Emis. Factor µg I-TEq/Mg filter dust	Data Quality	Abatement type	Abatement efficiency	Fuel type	country or region	Ref.
us[2]	dioxins/fur.	1000[1]	E	*unknown*	*unknown*	*unknown*	Sweden	13
us[2]	dioxins/fur.	150	E	*unknown*	*unknown*	*unknown*	Netherlands	13
us[2]	dioxins/fur.	74 - 1500	D	*unknown*	*unknown*	*unknown*	Germany	13

1) ng NTEQ/Mg filter dust
2) unknown type of steel.