INDUSTRIAL SOURCES

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MINISTRY OF HOUSING, PHYSICAL PLANNING AND ENVIRONMENT

18.1 Gray iron foundry

18.1.1 Process description

The processes in a gray iron foundry that lead to the production of a complete casting are given in Fig. 7.

18.1.1.1 Pattern shop

A pattern is used for making the mould. This pattern has the outward shape and dimensions of the castings to be made. If internal recesses in the castings are required, then cores are used. These are sand cores made in core boxes that have a cavity, the shape and dimensions of which correspond with those of the core to be made. For the mechanical mould production pattern plates are applied on which the two mould halves are made separately. For larger series of castings the pattern plates and core boxes are made of metal or hard plastic, for smaller series they are usually made of wood. The foundries have the patterns and core boxes made and repaired by specialized pattern-making shops more and more frequently. Sometimes, pattern and core boxes are also supplied to the foundry by the buyers of the castings.

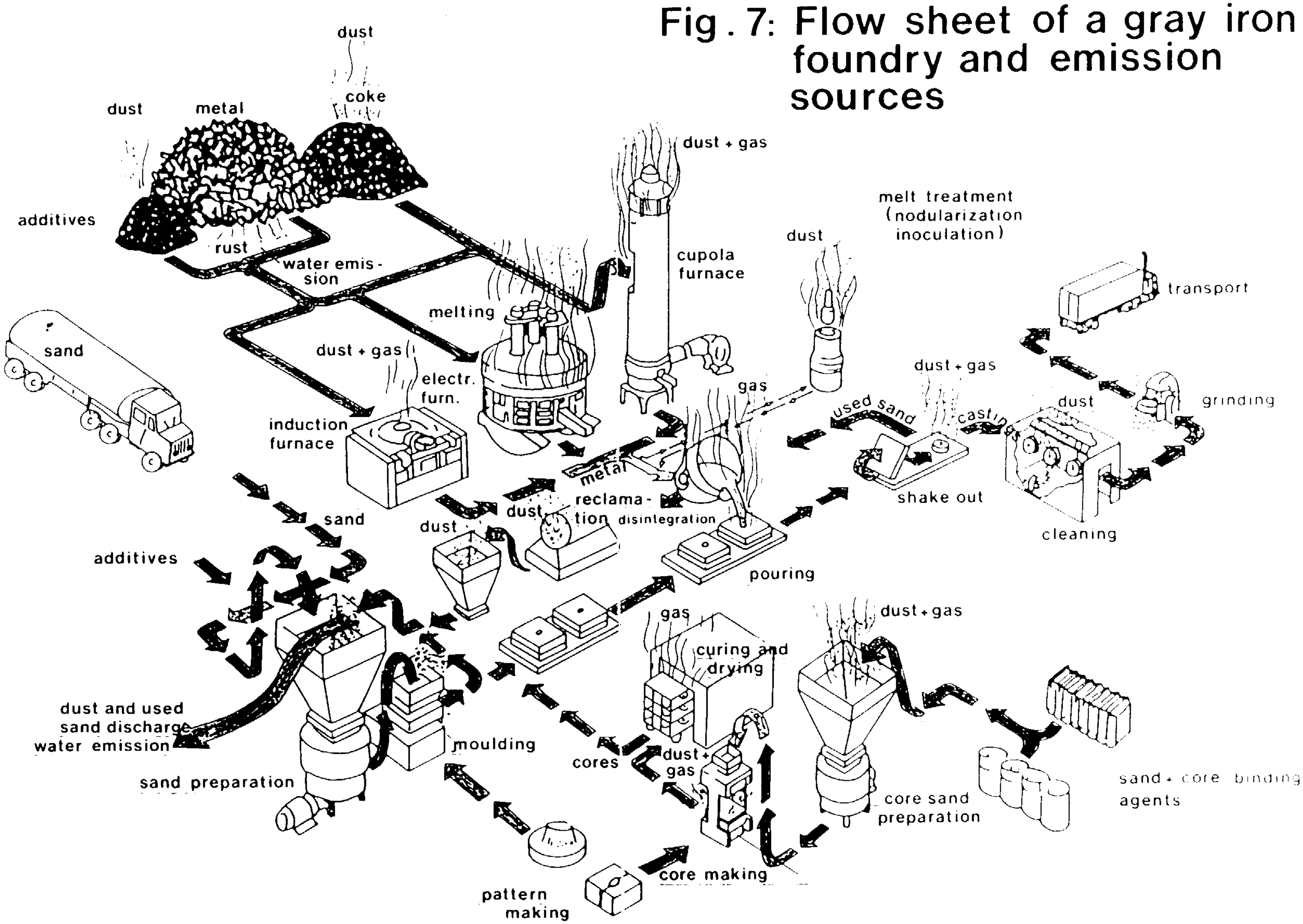
18.1.1.2 Sand preparation and sand moulding

A mould is made, in which the liquid iron can be poured to manufacture the casting. When moulding sand is rammed around the pattern. The complete mould consists of two or more parts, so that after moulding the pattern can be taken out of it.
A distinction can be made between:

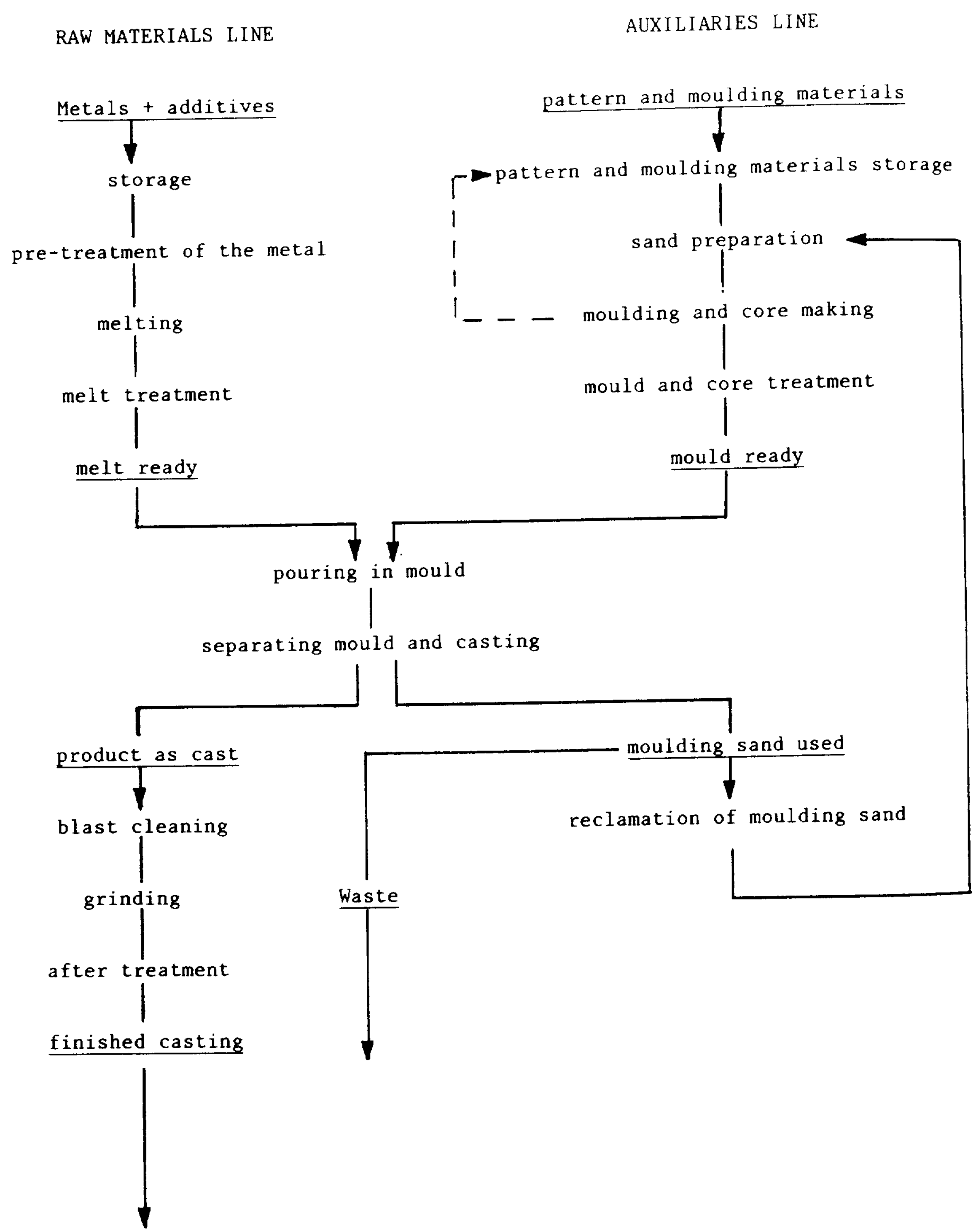
- moulding in clay-bonded sand for the lighter serial castings
- moulding in self-curing sand, for the heavier hand moulding work.

Clay-bonded moulding sand consists of sand, bentonite and water as a binding agent, and coal dust or a substitute to obtain a smooth surface on the casting.

Fig. 7: Flow sheet of a gray iron foundry and emission sources



PROCESS FLOW IN A GRAY IRON FOUNDRY



When moulding in self-setting sand, a chemical binding agent is added. This binding agent cures by polymerisation by means of a hardening agent or a catalyst. The reaction starts immediately the components are mixed.
When more than a certain amount of sand is used, it may be worthwhile reclaiming the sand and using it again.

18.1.1.3 Core making

Warm-curing and cold-curing systems can be used in core manufacturing. In a warm-curing system heat is needed to cure the core formed in the core box (Croning and hot-box processes).
In a cold-curing system curing takes place by passing through a gaseous catalyst (cold box and CO_2 processes) or by means of a catalyst mixed with the sand (the self-curing process with furane resin, cement or waterglass sand).
Hollow or shell cores are made by using the Croning process.
The sand mixture consists of sand with 3-5% phenol resin (novolac) and a curing agent, usually hexamethylene tetramine, often with small amounts of additives such as calcium stearate.
The resins qualifying for the hot-box process are phenol (urea) resins, furane resins, and combinations of them. The binding agent content amounts to approx. 2-2.5%; the sand also contains 0.3 to 0.5% curing catalyst, e.g. a chloride or a nitrate.
In a cold-box process curing takes place very quickly by passing a gaseous or a vapour catalyst through the core in the core box.
The binding agent here consists of a two-component synthetic resin system, one part being formed by a phenol resin (benzyl ether resin) and the other part by a polyiso-cyanate (M.D.I.). Both components are usually diluted with 5-25% organic solvent. Curing is obtained by a mixture of air or CO_2 with an amine, generally triethyl amine (TEA) or dimethyl ethylamine (DMEA).
When equal parts of resin and isocyanate are used the sand will contain 1.5 to 2% binding agent and 0.1 to 0.3% catalyst.
In the CO_2 process the curing of the sand is based on the curing of the water glass mixed with it by passing through CO_2.

The water glass content in the sand generally amounts to 2.5 to 4%, and the CO_2 consumption is 0.1 to 1%. Usually an amount of organic compound (0.5 to 5%), based on glucose, phenolate or pitch is added to the sand in order to improve the shake-out properties of the sand.

18.1.1.4 Melting process

The cupola furnace as well as the oil-fired, reverberatory furnaces and electric furnaces is commonly used. The basic raw materials needed for melting are pig iron, steel scrap, return material (recycled material from the foundry), coke and limestone, silicon briquettes, carburizing graphite and melt treatment agents such as ferro-silicon. A cupola furnace is first filled with a layer of coke which is then ignited. As soon as this layer is burning well, the furnace is filled with alternate layers of additives, metal and coke. Steel scrap is usually brought in from outside contaminated by paint residues, galvanic coats, non-ferrous metals etc.

Unlike the cupola furnace a reverberatory furnace does not work continuously and is mainly used in small foundries. Oil burners are used, because the flame must be highly radiant to ensure an adequate heat transfer.

The electrical furnaces are generally induction furnaces and are often used in conjunction with a cupola furnace for keeping the iron hot. In electric melting furnaces melting is not done continuously.

18.1.1.5 Casting process and shake out

In the foundry the liquid cast iron is poured into moulds and allowed to cool, after which the casting is shaken out of the mould. There are three ways to shake-out:

- on the floor; in this case the boxes are usually shaken when cold;
- hot shaking out which produces more dust;
- Mechanized or automated shake out which involves using all kinds of shaking and vibrating grids. This is generally a form of hot shake-out.

18.1.1.6 Cleaning process

After the casting is shaken out of the mould adhering mould material must be removed. This is done by steel-grit blasting. The blasting agent is of abrasion-resistant steel grit, which is blasted against the casting with a jet of air.

18.1.1.7 Deburring and grinding

The superfluous material is then removed from the casting. This entails the removal of the necessary gates and/or risers. The material that is removed forms the return scrap.

18.1.2 Emissions

18.1.2.1 Pattern shop

When processing wood and plastic, dust is produced. When glueing and lacquering, organic solvents are released in the form of vapour. Little is known about the emissions. They are slight in comparison with emissions from other processes, because only one pattern is required for a series of castings.

18.1.2.2 Sand preparation and sand moulding

The amount of dust formed when reconditioning clay-bonded sand is mainly determined by the iron/sand ratio. Dust extraction is generally carried out at over-loading points.
When the resin-bonded sand is manufactured the vapour/gas production already starts at the mixing and continues during the processing and curing of the sand. Dust generation may occur when mixing cement sand.
When the mixing and curing sand with synthetic resin, emissions occur of furfuryl alcohol, organic solvents, formaldehyde, and incidentally of phenol, depending on the type and the composition of the resins. The moulds and cores are usually provided with a refractory coating layer: a mixture of fine, refractory constituents in water or in an organic solvent, generally isopropyl alcohol. This solvent is emitted when the coating is drying.

18.1.2.3 Core making

The emissions produced when manufacturing cores are slight in comparison with the total emission from a foundry. The emissions depend greatly on the operating conditions, core baking temperature, binding agent etc.
Using the cold box process the amine emission can be considerably decreased by after-burning, or by washing.

18.1.2.4 Melting process

During the melting process dust is produced. This originates from:

Coke
Coke grit and dust are produced when the furnace is loaded.
During the combustion of coke ash is formed which is slagged for approx.75%. The remainder is taken up in the combustion gases.

Limestone
During loading, some grit and dust is produced. In the furnace limestone ($CaCO_3$) decomposes into lime (CaO) and CO_2. This lime forms one of the main constituents of the cupola furnace slag. A small amount of it is discharged by the gases as dust.

Refractory lining
A small part of the refractory lining is abraded as a result of the erosive action of the loading of the furnace, and is discharged with the flue gases. The greater part is, however, slagged.

Metals to be melted
During heating of the iron, oxides are formed on the surface which are attached to the metal and are not emitted. The impurities that are carried along with the scrap, such as rust, oil etc. are more important. There are also coatings on the scrap, such as paint, tar, zinc and chromium.
The coke contains sulphur. On combustion, SO_2 is produced, and then partially reduced to sulphur. Part of the CO_2 produced on combustion of coke is reduced to CO higher up in the furnace.

18.1.2.5 Casting and shake-out

During pouring, volatile products are generated from the moulding and core sands. The generation of these products continues during cooling and shaking-out of the castings. Mainly combustion products i.e. carbon monoxide and dust are formed during shaking-out. Clay-bonded moulding sand, which contains coal dust or a substitute for it, may emit carbon monoxide, hydrogen, aliphatic hydrocarbons, benzene, toluene, xylene, styrene, dibuthylphthalate, etc. Chemically bonded moulding sand may also emit carbon monoxide, and, in addition heterocyclic and cyclic hydrocarbons, amines, ammonia and cyanides.

18.1.2.6 Cleaning process

Dust generation during the blast cleaning of the castings is unavoidable because of the nature of the operation. All blasting installations have dust extraction with a dust collector.

18.1.2.7 Deburring and grinding

The grinding dust generated consists of approx. 95% burnt metal particles (iron and alloy elements, if any), and of approx. 5% grinding-stone material and silica, from the adhering sand remaining.

18.1.3 Emission factors

18.1.3.1 No data are known about the emissions from the pattern shop. They are very slight.

18.1.3.2 Table 149 gives the emission factors for the preparation of clay-bonded moulding sand, including the emission factors for shake-out.

TABLE 149 (kg/ton of melt)

dust:	bentonite, coal dust (or substitute),	
	silica uncontrolled	8-64
	with cyclone and wet scrubber	0-2.3

Table 150 gives the emission factors for the preparation of self-curing moulding sand

TABLE 150 (kg/ton of melt)

cement	0.5-1
for the gases see moulding process	

Table 151 gives the emission factors for the preparation of and the moulding in self-curing moulding sand

TABLE 151 (kg/ton of melt)

	furan resin sand	phenol resin sand	coating
furfuryl alcohol	0.5-2.5		
formaldehyde	0.05-0.1	0.1-0.2	
organic solvents	0.8-2.0	0.5-2	
phenol	0-0.04	0.05-0.3	
isopropyl alcohol			6-8

18.1.3.3 Table 152 gives the emission factors for the core manufacturing.

TABLE 152 (kg/ton of melt)[1)]

	Croning process	hot-box process	cold-box process
phenol	0-0.03	0-0.04	
formaldehyde	0-0.006	0-0.02	
cyanide	0-0.012		
ammonia	0-0.13		
dust (silica+fume)	0-0.006	0-0.006	
furfuryl alcohol		0-0.2	
solvent		0-0.05	
aromatic solvent			0-0.24
TEA[2)] or DMEA[3)]			0-0.25

1) without gas purification such as cyclones, wet scrubbers etc.

2) tri-ethylamine (catalyst)

3) dimethyl ethyl amine (catalyst)

18.1.3.4 Table 153 gives the emission factors for loading, melting and the melt treatment in the cupola furnace.

TABLE 153 (kg/ton of melt)

Measures	uncon-trolled	con-trolled I	con-trolled II	con-trolled III
Dust	<18			
I Fabric filter		<0.1		
II Disintegrator			<0.3	
III Multicyclone				<1.5

TABLE 153: (contd.)

Measures	uncon-trolled	con-trolled I	con-trolled II	con-trolled III
CO	<100			
I After burner		<1.5		
II After burning in furnace shaft			<1.4	
SO_2	<0.6			
I wet scrubber		<0.1		
II lime injection at fabric filter			<0.3	

N.B.: During melting in a cupola furnace, no NO_x-emission was found.

Table 154 gives the emission factors for loading, melting and the melt treatment in the reverberatory furnace.

TABLE 154 (kg/ton of melt)

Measures	uncon-trolled	con-trolled I	con-trolled II	con-trolled III
Dust	<1			
I fabric filter		<0.1		
II high pressure washer			<0.3	
III multicyclone				<0.1
SO_2	<3			
I high pressure washer		<0.2		
II lime injection with fabric filter			<1.5	
CO	<1.5			

N.B.: During melting in the reverberatory furnace no NO_x-emission was found.

Table 155 gives the emission factors for loading, melting and the melt treatment in the electrical furnace.

TABLE 155 (kg/ton of melt)

	Measure	
Dust	none	<0.3
	fabric filter	<0.1
CO	none	<7
SO_2		not detected
NO_x		not detected

18.1.3.5 Table 156 gives the emission factors for pouring iron into the self-curing moulds.

TABLE 156 (kg/ton of melt)

carbon monoxide	0.9-1.3
furfuryl alcohol	0.015-0.035
formaldehyde	0.015-0.035
aliphatic and heterocyclic hydrocarbons	0.09-0.35
aromatic hydrocarbons	0.04-0.06
ammonia	0-0.15
hydrogen cyanide	0-0.06
other gases	1.5-2.5
catalyst PTS:	
paratoluene sulphonic acid	
carbonyl sulphide	
carbon disulphide	0.35-0.45
hydrogen sulphide	
sulphur dioxide	
other gases	
catalyst:	
phosphoric acid	
volatile organic phosphorus compounds	
(bonded to phosphorus oxides)	0.07-0.15

Table 157 gives the emission factors for shaking-out and decoring of castings from moulds of self-curing sand with a coating.

TABLE 157 (kg/ton of melt)

Dust, uncontrolled	4-7
Dust, with exhaustion, cyclone and fabric filter	0.15-0.7

N.B.: The gases and vapours are included in the emission factors of the casting process.

Table 158 gives the emission factors for the reclamation of self-curing moulding sand.

TABLE 158 (kg/ton of melt)

Dust, uncontrolled	55-65
Dust, with cyclone and fabric filter	0.06-0.7

18.1.3.6 Table 159 gives the emission factors for cleaning the castings (blasting).

TABLE 159 (kg/ton of melt)

Dust, uncontrolled	5-50, depending on production method and type of casting
Dust, with exhaustion and fabric filter	0.1-2

N.B.: This dust is: 25-30% coating dust
30-35% dust of resin, catalyst, and silica dust
35-40% blasting agent dust.

18.1.3.7 Table 160 gives the emission factors for deburring and grinding.

TABLE 160 (kg/ton of melt)

Dust, uncontrolled	approx. 10
Dust, with exhaustion and fabric filter	0.1-1.8

N.B. : the dust consists of 95% metal-oxide dust and
5% grinder dust and silicon-dioxide dust

18.1.4 Source

The emission factors are mainly based on data stated in the references below.

18.1.5 References

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