Category		Title
NFR	2.C.2	Ferroalloys production
SNAP	040302	Ferroalloys
ISIC		
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Contents

1 Overview

Ferroalloys are master alloys containing iron and one or more non-ferrous metals as alloying elements. The ferroalloys are usually classified in two groups: bulk ferroalloys (produced in large quantities in electric arc furnaces), and special ferroalloys (produced in smaller quantities, but with growing importance). Bulk ferroalloys are used in steel making and steel or iron foundries exclusively, while the use of special ferroalloys is far more varied. In total, 86.7 % of the ferroalloys produced are used in the steel industry (European Commission, 2001).

Emissions from the production of ferroalloys are not considered significant, since the contribution to the total national emissions is thought to be insignificant, i.e. less than 1 % of the national emissions of any pollutant. However, this version of the Guidebook does provide default emission factors for this source category.

The present chapter provides a very simple process description and a Tier 1 approach to estimate emissions from this source category.

2 Description of sources

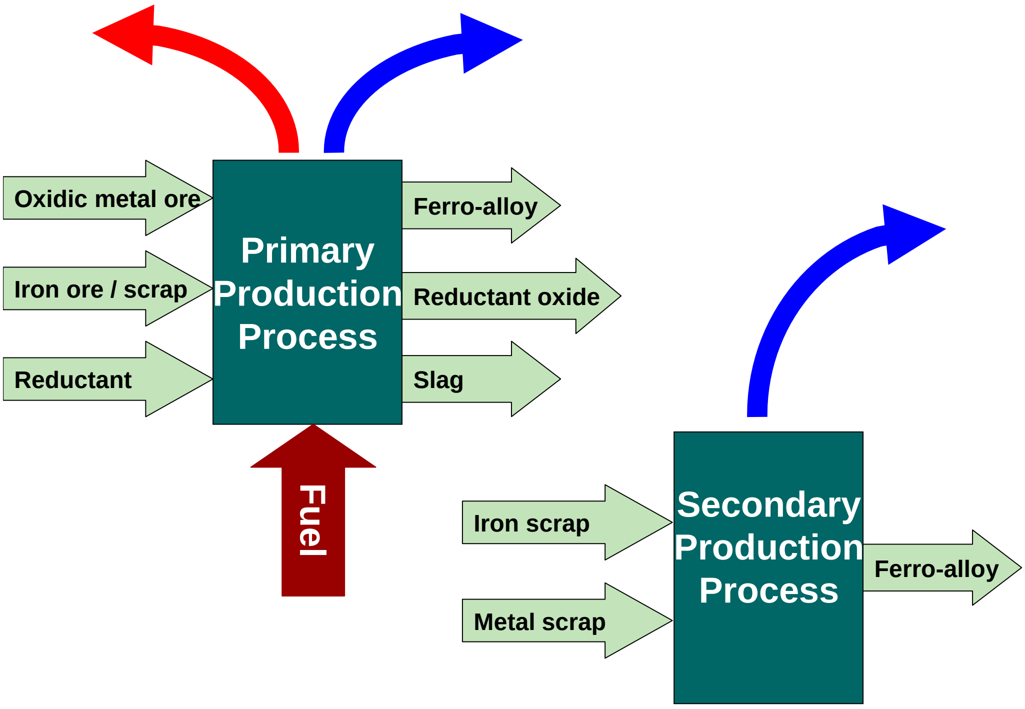
2.1 Process description

Production of ferroalloys generally involves the use of electric arc furnaces and reaction crucibles into which natural products (e.g. quartz, lime, various ores, wood etc.) with relatively fluctuating physical compositions are loaded. Due to this, the main environmental impact of producing ferroalloys is the emission of dust and fumes from the smelting processes.

2.2 Techniques

Depending on the raw material that is used (primary or secondary raw material) the production of ferroalloys can be carried out as a primary or secondary process. The principal chemistry of both processes is shown in Figure 2.1.

Figure 2.1 Simplified process scheme for primary (top left) and secondary (bottom right) production of ferroalloys



The primary process can be either carbo-thermic of metallo-thermic reduction of oxidic ores or concentrates. In the carbo-thermic reduction (the most important process), carbon in the form of coke (metallurgical coke), coal or charcoal is used as the reducing agent. When a blast furnace is used, coke is also needed as an energy source. To account for this, the process scheme also contains a fuel input and combustion emissions output.

Metallo-thermic reduction is mainly carried out with either silicon or aluminium as the reducing agent.

2.3 Emissions and controls

Dust emissions also occur from storage, handling (chapter 2.C.5.e) and the pre-treatment of raw materials where fugitive dust emissions play an important role. Depending on the raw material and the process used, other emissions to air are sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and volatile metals. The formation of dioxins in the combustion zone and in the cooling part of the off-gas treatment system may be possible.

Heavy metals are carried into the process as trace elements in the raw material. Part of the heavy metals will escape as metal vapour. This process depends heavily on the type of ferroalloy produced and the temperature of the smelting process.

A lot of information on the processes and techniques used in the production of ferroalloys can be found in the Best Available Techniques Reference (BREF) document on non-ferrous metal industries

(European Commission, 2001) as well as the draft BREF (European Commission, 2009) with expected adaptation in 2013.

This chapter only covers the process emissions from ferroalloys production. The combustion-related emissions are addressed in chapter 1.A.2.b. Note that no specific ferroalloys combustion-related emission factors (EFs) are provided in 1.A.2.b. It is assumed that combustion is similar for all metal production.

Measurements of emissions of particulate matter from ferroalloys production above may use techniques which give filterable, condensible or total PM. A number of factors influence the measurement and determination of primary PM emissions from activities such as ferroalloys production. The quantity of PM determined in an emission measurement depends to a large extent on the measurement conditions. This is particularly true of activities involving high temperature and semi-volatile emission components – in such instances the PM emission may be partitioned between a solid/aerosol phase and material which is gaseous at the sampling point but which can condense in the atmosphere. The proportion of filterable and condensable material will vary depending on the temperature of the flue gases and in sampling equipment.

A range of filterable PM measurement methods are applied around the world typically with filter temperatures of 70-160°C (the temperature is set by the test method). Condensable fractions can be determined directly by recovering condensed material from chilled impinger systems downstream of a filter – note that this is condensation without dilution and can require additional processing to remove sampling artefacts. A common approach for total PM includes dilution where sampled flue or exhaust gases are mixed with ambient air (either using a dilution tunnel or dilution sampling systems) which collect the filterable and condensable components on a filter at lower temperatures (but depending on the method this can be 15-52°C).

Tier 1 PM emission factors have been reviewed to identify if the data represent filterable or total (filterable and condensable) PM. This identifies whether the PM emission factors (for TSP, PM_{10} and $PM_{2.5}$) represent total PM, filterable PM or whether the basis of the emission factor cannot be determined.

Note that PM emission factors in the Guidebook represent primary emissions from the activities and not formation of secondary aerosol from chemical reaction in the atmosphere after release.

3 Methods

This section provides default emission factors for this source category. Since it is only a minor source of emissions, only Tier 1 default emission factors are provided.

3.1 Choice of method

Not applicable, since only Tier 1 factors are presented. However, if facility level data are available and these are good enough they can also be used.

3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \quad (1)$$

The Tier 1 emission factors assume an 'averaged' or typical technology and abatement implementation in the country and integrate all the different sub-processes.

3.2.2 Default emission factors

Default emission factors are provided in Table 3.1. The emission factor for dust (total suspended particulate matter – TSP) is based on the Air Pollution Engineering Manual (Air & Waste Management Association, 1992).The distribution between TSP, PM_{10} and $PM_{2.5}$ is based on expert judgement, combined with US EPA (2011a; 12.4). PM_{10} and $PM_{2.5}$ are assumed to constitute 85 % and 60 % of TSP respectively. For more detailed information on the dust emissions from different types of ferroalloys and/or the various process steps, please refer to the BREF document for non-ferrous metal industries (European Commission, 2001). This document also gives more information on the emissions originating from combustion activities (NO_x, SO_x, VOC and PAH). The emission factor for BC[1] from ferroalloys production (ferro-manganese) is obtained from US EPA, SPECIATE database version 4.3 (US EPA, 2011b). The EF for BC relates to the emission of $PM_{2.5}$.

The emission factor for TSP proposed in the table below is in the same order of magnitude as the summation of all available emission factors for subprocesses in the BREF document.

[1] For the purposes of this guidance, BC emission factors are assumed to equal those for elemental carbon (EC). For further information please refer to Chapter 1.A.1 Energy Industries.

Table 3.1 Tier 1 emission factors for source category 2.C.2 Ferroalloys production.

Tier 1 default emission factors					
	Code	Name			
NFR source category	2.C.2	Ferroalloys production			
Fuel	NA				
Not applicable	HCH, PCBs, HCB				
Not estimated	NOx, CO, NMVOC, SOx, NH3, Pb Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	1 000	g/Mg alloy produced	100	10 000	Air & Waste (1992)
PM_{10}	*850*	*g/Mg alloy produced*	*85*	*8 500*	*Expert judgement based on US EPA (2011a).*
$PM_{2.5}$	*600*	*g/Mg alloy produced*	*60*	*6 000*	*Expert judgement based on US EPA (2011a).*
BC	10	% of $PM_{2.5}$	5	20	US EPA (2011b, file no.: 91151)

Note:

These PM factors represent filterable PM emissions only (excluding any condensable fraction).

3.2.3 Activity data

A lot of information on production statistics (for various source categories) is available from United Nations statistical yearbooks or national statistics.

Further guidance might also be provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

3.3 Tier 2 technology-specific approach

The BREF document for the non-ferrous metal industry (European Commission, 2001) distinguishes a number of ferroalloy types that may be produced. These are:

- ferro-chrome:
  - High-carbon ferro-chrome (HC FeCr), containing 4–10 % carbon;
  - Medium-carbon ferro-chrome (MC FeCr), containing 0.5–4 % carbon;
  - Low-carbon ferro-chrome (LC FeCr), containing 0.01–0.5 % carbon;
- ferro-silicon and silicon alloys:
  - Ferro-silicon (FeSi), with a silicon content less than 96 %;
  - Si-metal (Si-metal), with a silicon content above 96 %;
  - Silico-calcium (Calcium-silicon), with a silicon content of about 60–65 % and calcium content of 30–35 %;
- ferro-manganese and manganese alloys:
  - High-carbon ferro-manganese (HC FeMn), with maximum 7.5 % carbon;
  - Medium-carbon ferro-manganese (MC FeMn), with maximum 1.5 % carbon;

  - Low-carbon ferro-manganese (LC FeMn), with maximum 0.5 % carbon;
  - Silicomanganese (SiMn), with maximum 2 % carbon;
  - Low-carbon silico-manganese (LC SiMn), with maximum 0.05 % carbon;
- ferro-nickel (FeNi);
- ferro-vanadium (FeV);
- ferro molybdenum;
- ferro-tungsten;
- ferro-titanium;
- ferro-boron;
- ferro-niobium.

The BREF document only provides emission factors for certain sub-processes for a number of these ferroalloy types. Since most of this information is incomplete, no generic Tier 2 emission factors could be extracted from this information.

3.4 Tier 3 emission modelling and use of facility data

A lot of specific information is available in the BREF document for the non-ferrous metal industries (European Commission, 2001), in the chapter on ferroalloys. This document extensively discusses various types of ferroalloys and process steps.

4 Data quality

There are no specific issues for this source category.

5 References

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US EPA 2011a. AP-42, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition (with revisions till January 2011), (https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors), accessed 19 July 2019.

US EPA, 2011b. SPECIATE database version 4.3, U.S. Environmental Protection Agency's (EPA). (http://cfpub.epa.gov/si/speciate/), accessed 19 July 2019.

6 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection's expert panel on Combustion and Industry. Please refer to the TFEIP website (www.tfeip-secretariat.org) for the contact details of the current expert panel leaders.