Category		Title
NFR	2.C.5	Lead production
SNAP	040309b	Lead production
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1 Overview

This chapter presents information on atmospheric emissions during primary and secondary lead production.

The main air pollutants emitted during the production of lead are sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO) and carbon dioxide (CO_2). Since NO_x, CO and CO_2 are assumed to originate mainly from combustion activities, emissions of these pollutants are addressed in chapter 1.A.2.b. The most important process emissions are SO_x, heavy metals (particularly lead) and dust.

2 Description of sources

2.1 Process description

2.1.1 Primary lead production

There are two pyrometallurgical processes available for the production of lead from lead sulphide or mixed lead and zinc sulphide concentrates:

- sintering/smelting in a blast furnace or Imperial Smelting Furnace (ISF);
- direct smelting.

The last primary sinter and shaft furnace operating in the EU-28 switched over to the direct smelting process in October 2013. All smelting processes may also be used for concentrates mixed with secondary raw materials.

In the sintering process fine particles of metal ores are agglomerated into nodules, briquettes, sinter, or pellets. The sintering process is more extensively discussed in chapter 2.C.1 (Iron and Steel Production). Also a roasting process is involved in which lead sulphide is converted into lead oxide. This is performed either in a blast furnace or ISF. Dust emissions result from handling and stockpiling of raw materials or intermediate products. Abatement methods are the use of bag filters, wet scrubbers or electrofilters.

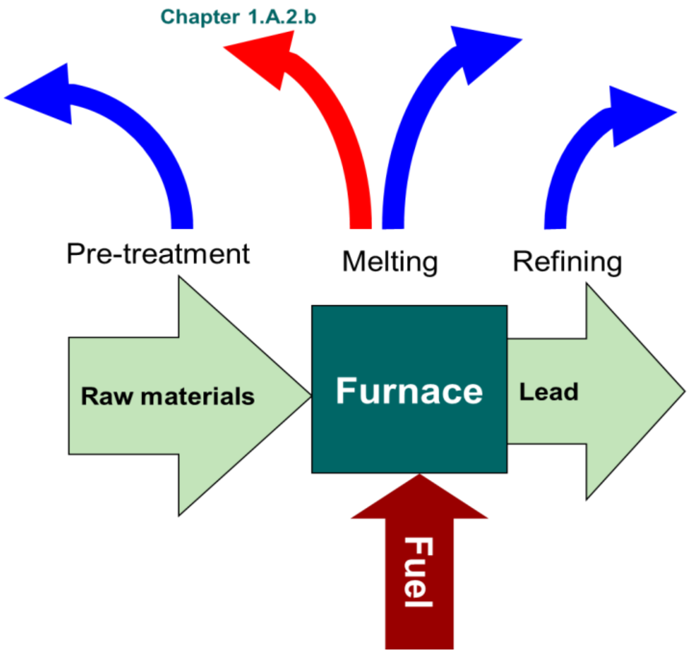
Direct smelting can be carried out in the following furnaces: Ausmelt/ISA Smelt (bath furnace, top-submerged lancing furnace) -sometimes in combination with blast furnaces, Kaldo (TBRC) and the QSL (bath furnace) integrated processes, and Electric fiurnace. The Kivcet integrated process is also used and is a flash smelting process. In all direct smelting processes, concentrates alone or together with secondary material are mixed with other smelting additives and fluxes to produce a fairly constant feed. In all furnaces, the lead sulphide concentrates and secondary materials mix is charged directly to a furnace, then melted and oxidised. SO_x is formed and is collected, cleaned and converted to sulphuric acid. Carbon (coke or gas) and fluxing agents are added to the molten charge. Lead oxide is reduced to lead and a slag is formed. Dust abatement can be provided by bag filters or electrofilters. Improved abatement is encapsulation or evacuation of the process.

The refining process is mainly directed at the removal of copper, silver, bismuth, antimony, arsenic, tin, and other impurities. There are two methods of refining crude lead: electrolytic refining and pyrometallurgical refining. Electrolytic refining uses anodes of decopperised lead bullion and starter cathodes of pure lead. This is an expensive process and is not currently used by plants in the EU-28, although it is used in a number of other countries worldwide.

Pyrometallurgical refinery consists of a series of kettles, which are indirectly heated by oil or gas. Dust emissions mainly occur at the treatment of the different by-product streams. After refining, the lead may be alloyed and cast to market qualities.

Several improved processes are either in the pilot stage or being used at a single plant. However, no general applicable information is available yet.

Figure 2.1 Process scheme for lead production (primary process only).



2.1.2 *Secondary lead production*

A secondary lead smelter is defined as any plant or factory, in which lead-bearing scrap or lead-bearing materials, other than lead-bearing concentrates (ores) derived from a mining operation, are processed by metallurgical or chemical methods into refined lead, lead alloys or lead oxide. The high proportion of scrap acid batteries that is reprocessed provides feed for the alloy lead market (Barbour *et al*., 1978; European Commission, 2014).

Secondary lead can be produced using pyrometallurgical or hydrometallurgical processes. Until now, hydrometallurgical processes have only been used at a preliminary stage. The pyrometallurgical processes are subdivided as follows (Rentz *et al*., 1996a):

- battery breaking and processing (scrap preparation);
- smelting of battery scrap materials;
- refining.

After refining, the lead may be alloyed and cast to market qualities. In contrast to secondary zinc and copper production, which use a great variety of secondary materials, the recycling of secondary lead materials is concentrated on the processing of scrap batteries, which accounts for about 80 % of secondary lead recycling globally. Metal sheets, pipe scraps, sludge, dross and dusts play only a minor role as secondary raw materials. The reason for this is that most of the lead is used for manufacturing batteries.

Secondary lead is sometimes combined with primary material for refining. Various pyrometallurgical refining technologies can be applied, depending on the feed material and product specification.

2.2 Techniques

2.2.1 Primary lead production

Primary lead smelting can be performed in a number of different furnaces, as described in section 2.1.1. Direct smelting can be undertaken using the following furnaces: Ausmelt/ISA, Kaldo (TBRC), QSL (bath furnace) integrated processes, the electric furnace, and the Kivcet integrated process. Sintering/smelting can also be performed in the blast furnace and the ISF. For refining, the main techniques are pyrometallurgical refining and hydrometallurgical refining. Several direct smelting technologies have been under development or are being developed. Information about the emissions of these techniques is not yet available.

2.2.2 Secondary lead production

In general, for the production of secondary lead from battery scrap *two basic process routes* are possible. One route is based on breaking up and dismantling old batteries, and separating the paste, metals and organic substances. Melting and reduction is carried out afterwards in different types of furnaces with an additional refining step. The other route is characterised by the direct treatment of complete and non-dismantled batteries with or without sulphuric acid inside in various smelting furnaces, also with an additional refining step. In detail, in the various stages of pyrometallurgical processing the following technologies are used worldwide (Rentz et al., 1996a):

- **Battery scrap preparation**. For battery scrap preparation various processes are possible, which can be differentiated by the degree of separation of single battery components. On an industrial scale, the MA and CX processes are most common. Generally heavy metal emissions from battery scrap preparation play a minor role compared to the smelting operation. The Varta and the Bergsoe processes are smelting processes carried out without an initial separation, so that the batteries are directly smelted in a furnace.
- **Smelting.** For the industrial production of secondary lead, various kinds of smelting furnaces are employed. The following furnaces are used in secondary lead production:
  - blast furnaces;
  - rotary furnaces;
  - reverberatory furnaces;
  - electric furnaces.
- **Refining**. The lead bullion from secondary lead production contains various impurities, such as copper, silver, bismuth, antimony, arsenic, tin, and other impurities. However, in the majority of cases, antimony dominates. As with primary lead, refining can be carried out either electrolytically or pyrometallurgically.

2.3 Emissions

2.3.1 Primary lead production

The main emissions to air from lead and tin production are:

- sulphur dioxide (SO_2), other sulphur compounds and acid mists;
- oxides of nitrogen (NO_X) and other nitrogen compounds;
- metals and their compounds;
- dust;
- sometimes NMVOC and PCDD/F.

Other pollutants are considered to be of negligible importance for the industry, partly because they are not present in the production process and partly because they are immediately neutralised (e.g. chlorine or HCl) or occur in very low concentrations (e.g. CO). Emissions are to a large extent bound to dust (except cadmium, arsenic and mercury that can be present in the vapour phase).

The major sources of SO_x emissions are diffuse emissions from the oxidation stages, direct emissions from the sulphuric acid plant and the emissions of residual sulphur in the furnace charge. Good extraction and sealing of the furnaces prevents diffuse emissions, with the collected gases from the oxidation stages passed to a gas-cleaning plant and then to the sulphuric acid plant or gypsum plant.

The smelting stages are potential sources of nitrogen oxides (NO_x). NO_x may be formed from nitrogen components that are present in the concentrates or as thermal NO_x. The sulphuric acid produced can absorb a large part of the NO_x, and this can affect the sulphuric acid quality. Other furnaces that use oxy-fuel burners can also exhibit a reduction in NO_X. The range for all the processes is 20 mg/Nm^3 to 300 mg/Nm^3.

Dust carry-over from the smelting processes is a potential source of direct and diffuse emissions of dust and metals. The gases are collected and treated in the gas-cleaning processes and for SO_x rich gases in the sulphuric acid plant. Dust is removed, leached to bring out Cd or Cl_2 if necessary, and returned to the process. Slag treatment and quenching also give rise to dust. The range of dust emissions from these captured sources is <1 mg/Nm^3 to 20 mg/Nm^3.

Emissions of aerosols also take place in the cell room and battery breakers and may contain metals. The range of mist and dust emissions from these sources is 0.1 mg/Nm^3 to 4 mg/Nm^3. While controlled emissions have known sources and can be captured and treated, diffuse emissions can evolve almost anywhere on a plant site. The main sources of diffuse emissions are material storage and handling, dust sticking to vehicles or streets, and open working areas or areas where no abatement is performed.

Organic carbon compounds and CO can be emitted from the drying stage depending on the raw materials and the fuel used for drying. But, in lead production, the most significant source of organic carbon compounds and CO is the reduction step of the smelting process, especially when plastic/plastic residues are present in the furnace charge. An afterburner is the most common technique used to abate this pollutant.

In the production of lead, the emissions of PCDD/F are, on average, below 0.1 ng I-TEQ/Nm^3, and the maximum values are usually below 0.4 ng I-TEQ/Nm^3. The values are independent of the feed material due to the use of abatement techniques

The energy requirement for the different lead processes varies to a large extent. It depends on the quality of the feed and the products, the use of latent or waste heat and the production of by-products. Refer to the Best Available Techniques Reference (BREF) document for additional information on energy use and emissions from lead production (European Commission, 2014) with expected adoptation in 2016 ([1]).

2.3.2 Secondary lead production

In the secondary lead production process various direct and fugitive heavy metal emission sources are present (Rentz *et al*., 1996a):

From *battery scrap preparation* only small amounts of particulate heavy metals are emitted as direct emissions if single preparation devices are equipped with a special waste gas cleaning facility.

For the *smelting process*, depending on the type of furnace various kinds of fuels are used. Generally short rotary furnaces and long rotary kilns are equipped with natural gas/air burners or sometimes with oxy-fuel burners, while shaft furnaces use coke as fuel. With the generated waste gas, irrespective of which kind of furnace is used, considerable amounts of heavy metals contained in the dust are released, as well as certain amounts of gaseous heavy metals, depending on the melting temperature and the vapour pressure.

For *refining and alloying*, several kettles are installed depending on the required lead quality. Because of the reactions in the waste gas from the refining and alloying kettles, various amounts of heavy metals in particulate and gaseous form may be emitted.

Fugitive emissions from secondary lead smelting are released with almost all *stockpiling, transferring, charging,* and *discharging processes* The amount and composition greatly depends on the process configuration and operation mode. Values concerning the magnitude of unabated and abated emissions have not been revealed. The smelting furnaces are connected with fugitive emissions during the *charging* of raw materials and the *discharging* of slag and lead bullion. Also the *furnace openings* may be an emission source. Fugitive emissions from refining operations arise mainly during *charging, discharging* and *metal transfer* operations. Refining vessels not covered with primary hoods may be a further emission source.

As in many plants, direct emission sources are preferably equipped with emission reduction measures and fugitive emissions released into ambient air in secondary lead production are generally much higher than direct emissions.

By far the most important SO_x and NO_x emission source during secondary lead production is smelting furnaces. The amount of SO_x formed is mainly determined by the amount of sulphur contained in the raw materials and in the fuel used. Although a major part of the sulphur remains in the slag formed during the smelting process, some can be converted to SO_x.

SO_x concentrations in the off-gas from reverberatory furnaces and blast furnaces are only available on a volume percentage basis. During tests carried out at a reverberatory furnace using natural gas as a fuel, the concentration of SO_x in the off-gas was measured at about 0.1% v/v. At a blast furnace

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([1]) The BREF document for non-ferrous metals industries is presently in the final draft stage. A finalised version is expected to be adopted in 2016. Information concerning the status of BREF documents is available at http://eippcb.jrc.es/reference/. The previous version of the BREF was published in 2001 (European Commission, 2001).

using coke as fuel an even smaller off-gas concentration in the range of about 0.03% v/v was measured (Rentz et al., 1996b).

The formation of polychlorinated dioxins and furans depends on a number of factors such as scrap composition, process type and temperature.

2.3.3 Particulate matter (PM)

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.

A number of factors influence the measurement and determination of primary PM emissions from activities and, 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).

The review identifies whether the PM emission factors (for TSP, PM10 and PM2.5) represent total PM, filterable PM or whether the basis of the emission factor cannot be determined (see individual emission factor tables).

2.4 Controls

2.4.1 Primary lead production

Dust emissions can be abated using fabric filters, wet scrubbers or electro-filters. Improvement can be achieved by using encapsulation or evacuation. New approaches are under development.

Emissions containing SO_x are often used as input for sulphuric acid plants. Here, emissions from combustion and from other process steps are reconciled. Single stage sulphuric acid plants can attain sulphur oxide levels of 5.7 g/m^3, and dual stage plants can attain levels of 1.6 g/m^3. Some wet sulphuric acid plants are designed to capture and convert incoming SO_x in the smelting stage with an efficiency of at least 99.8 %, resulting in an SO_x emission level from the tail gas scrubber of no more than 400 mg/Nm3 (European Commission, 2014). Other technically feasible SO_x control methods are elemental sulphur recovery plants and dimethylamine and ammonia absorption processes (US EPA, 1990).

Primary measures for the control of SO_x aim to reduce the sulphur content in the fuel and in the raw materials used. Accordingly, lower SO_x emissions occur when using natural gas instead of heavy fuel oil for short rotary, long rotary and reverberatory furnace firing. Within blast furnace operation, the use of coke with low sulphur content reduces emissions.

For more information, consult the revised Best Available Techniques Reference (BREF) document for additional information (European Commission, 2014).

2.4.2 Secondary lead production

Most secondary lead smelters are equipped with dust removing installations, such as cyclones in combination with baghouses for the control of direct emissions. The control efficiency of these installations is often very high and can reach 99.9%. In secondary lead production for most processes it is possible to carry out final dust removal with fabric filters. In this way clean gas dust loads in general below 5 mg/m3 (STP) are achieved. For covering direct emissions from the refining and alloying kettles, primary suction hoods are arranged above the refining and melting kettles. These hoods are also linked to fabric filters. Waste gases from the furnace and the refining kettles may be de-dusted together in one filter. Electrostatic precipitators or wet scrubbers may be in use for special raw gas conditions. Wet scrubbers are sometimes in place for the control of SOx. Fugitive particulate emissions can be collected by local systems like hoods and other suction facilities or by partial or complete enclosures (Rentz et al., 1996a).

Oxy-fuel burners have been used in short rotary furnaces resulting in a significant reduction of the fuel input. Accordingly, a smaller pollutant mass flow is observed, although the concentration in the off-gas may be higher than in conventional firing technologies.

SO_x emissions from secondary smelters can be reduced by the addition of iron and/or soda. Iron added to the furnace reacts with sulphur contained in the feed material to form a matte (for example, iron sulphide), thus capturing the sulphur and preventing SO_x emissions. The capture rate by producing matte is approximately 90 % under optimal conditions. SO_x. For more information, consult the revised Best Available Techniques Reference (BREF) document for additional information (European Commission, 2014).

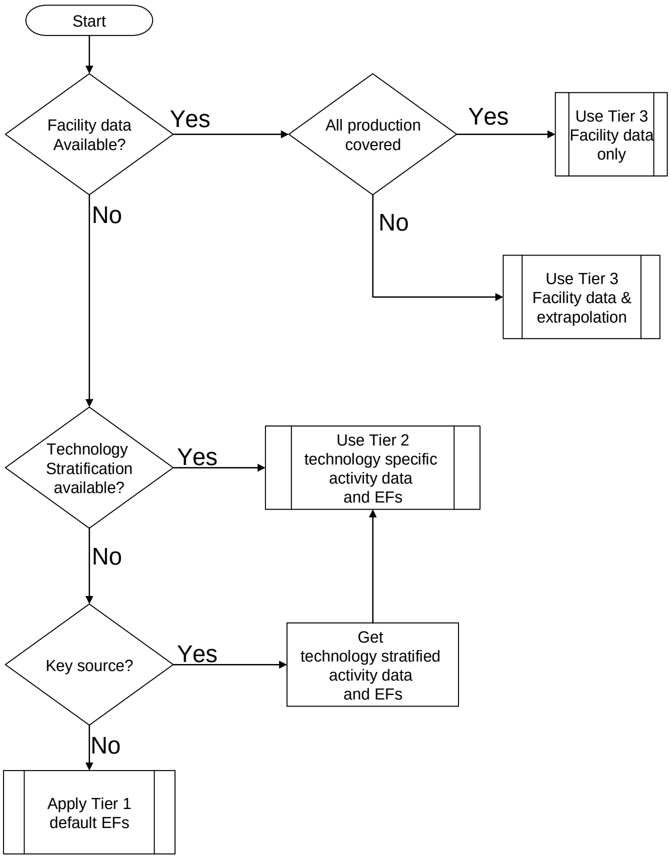
3 Methods

3.1 Choice of method

Figure 3.1 presents the procedure to select the methods for estimating process emissions from the lead production industry. The basic idea is as follows.

- If detailed information is available: use it.
- If the source category is a key category, a Tier 2 or better method must be applied and detailed input data must be collected. The decision tree in Figure 3.1 directs the user in such cases to the Tier 2 method, since it is expected that it is more easy to obtain the necessary input data for this approach than to collect facility level data needed for a Tier 3 estimate.
- The alternative of applying a Tier 3 method, using detailed process modelling is not explicitly included in this decision tree. However, detailed modelling will always be done at the facility level and results of such modelling could be seen as 'facility data' in the decision tree.

Figure 3.1 Decision tree for source category 2.C.5 Lead production



3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach for process emissions from lead production uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \tag{1}$$

Where:

$E_{pollutant}$ = the emission of the specified pollutant

$AR_{production}$ = the activity rate for the lead production

$EF_{pollutant}$ = the emission factor for this pollutant

This equation is applied at the national level, using annual national total lead production. Information on the production of lead, suitable for estimating emissions using the simpler estimation methodology (Tier 1 and 2), is widely available from United Nations statistical yearbooks or national statistics.

Tier 1 emission factors assume an 'averaged' or typical technology and abatement implementation in the country and integrate all sub-processes in lead production from inputting the raw material to the final shipment off the facilities.

In cases where specific abatement options are to be taken into account, a Tier 1 method is not applicable and a Tier 2 or Tier 3 approach must be used.

3.2.2 Default emission factors

The Tier 1 approach needs emission factors for all relevant pollutants, which integrate all sub-processes within the industry from inputting raw materials to the final shipment of the products off site. The default emission factors for primary and secondary lead production are given in Table 3.1. The emission factors for dust and heavy metals are primarily obtained from the revised BREF (European Commission, 2014). The share of PM_{10} and $PM_{2.5}$ is estimated by applying the distribution given in Visschedijk et al. (2004) to TSP.

Emission factors in BREF documents are mostly given in ranges. Where these emission factors are used in the tables below, the range is interpreted at the 95 % confidence interval, while the geometric mean of this range is chosen as the value for the emission factor.

Emissions of NO_x and CO are assumed to originate mainly from combustion and are discussed in chapter 1.A.2.b. SO_x emissions originate from both the combustion of fuels and the melting of lead sulphide concentrates and are therefore discussed in the present chapter and chapter 1.A.2.b. All other emissions are assumed to originate primarily from the process and are therefore discussed in the present chapter.

Table 3.1 Tier 1 emission factors for source category 2.C.5 Lead production

Tier 1 default emission factors					
	Code	Name			
NFR source category	2.C.5	Lead production			
Fuel	NA				
Not applicable	HCH				
Not estimated	NO$_x$, CO, NMVOC, NH$_3$, Cr, Cu, Ni, Se, BC, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	6	g/Mg lead	1	35	European Commission (2014)
PM$_{10}$	5	g/Mg lead	0.8	29	Visschedijk et al. (2004) applied on TSP
PM$_{2.5}$	2.5	g/Mg lead	0.4	14	Visschedijk et al. (2004) applied on TSP
SO$_x$	2050	g/Mg lead	700	6000	European Commission (2014)
Pb	1.8	g/Mg lead	0.5	6.8	European Commission (2014)
Cd	0.1	g/Mg lead	0	0.12	European Commission (2014)
Hg	0.1	g/Mg lead	0.04	0.44	Theloke et al. (2008) applied on Pb
As	0.1	g/Mg lead	0.04	0.5	European Commission (2014)
Zn	0.6	g/Mg lead	0	1.2	European Commission (2014)
PCB	2	µg/Mg lead	0.7	5.8	Note 1
PCDD/F	4.5	µg I-TEQ/Mg lead	0.4	50	UNEP (2005)

Notes: The EF for PCB may be revised in the future based on new information from UNEP: Toolkit for Identification and Quantification of Releases of Dioxins and Furans and Other Unintentional POPs: http://chm.pops.int/Implementation/UnintentionalPOPs/ToolkitforUPOPs/Overview/tabid/372/Default.aspx

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

3.2.3 Activity data

Information on the production of lead, suitable for estimating emissions using the simpler estimation methodology (Tier 1 and 2), is widely available from United Nations statistical yearbooks or national statistics.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 4.6.2.3 ‘Choice of activity data’ (IPCC, 2006).

3.3 Tier 2 technology-specific approach

3.3.1 Algorithm

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different techniques that may occur in the country.

The Tier 2 approach is as follows:

Stratify the lead production in the country to model the different product and process types occurring in the national lead industry into the inventory by:

- defining the production using each of the separate product and/or process types (together called ‘technologies’ in the formulae below) separately; and
- applying technology specific emission factors for each process type:

$$E_{pollutant} = \sum_{technologies} AR_{production,technology} \times EF_{technology,pollutant} \tag{2}$$

where:

$AR_{production,technology}$ = the production rate within the source category, using this specific technology

$EF_{technology,pollutant}$ = the emission factor for this technology and this pollutant

A country where only one technology is implemented will result in a penetration factor of 100 % and the algorithm reduces to:

$$E_{pollutant} = AR_{production} \times EF_{technology,pollutant} \tag{3}$$

where:

$E_{pollutant}$ = the emission of the specified pollutant

$AR_{production}$ = the activity rate for the lead production

$EF_{pollutant}$ = the emission factor for this pollutant

The emission factors in this approach will include all sub-processes within the industry from inputting raw materials until the produced lead is shipped to the customers.

3.3.2 Technology-specific emission factors

This subsection provides technology-specific emission factors for primary and secondary lead production. Typical technologies represent typical emission factors for both primary and secondary lead production, while specific technology tables include abatement and regional aspects. Information on abatement of heavy metals is available from Theloke *et al*. (2008). However, no data are available on the abatement of particulates in those particular situations and the typical emission factors for PM are presented in these tables. Since in reality PM and heavy metal emissions will be correlated, inconsistencies between the tables do exist and these emission factors should be handled with care.

Additionally, it must be mentioned that emission factors from various sources have been combined to derive the set of emission factors for each technology and control technology. These data are not always consistent with each other, for instance when the BAT emission factor is higher than an emission factor which is not BAT. This is another reason why the selection of appropriate emission factors from the present subsection must be undertaken with care.

As for the Tier 1 approach, emissions of NO_x and CO are assumed to originate mainly from combustion and are discussed in chapter 1.A.2.b. SO_x emissions originate from both the combustion of fuels and the melting of lead sulphide concentrates and are therefore discussed both in the present chapter and chapter 1.A.2.b. All other emissions are assumed to originate primarily from the process and are therefore discussed in the present chapter.

Primary lead production

Table 3.2 presents emission factors that can be used for primary lead production; unabated. For Table 3.2, the PM_{10} emission has been estimated from the composition of particulate matter emitted from lead smelters given in the SPECIATE database (US EPA, 2011) and the emission of heavy metals given by Theloke et al. (2008). The unabated emission factors can be combined with abatement efficiencies as presented in section 3.3.3 to calculate pollutant emissions to air. Table 3.3 presents emission factors for primary lead production using currently installed technology in the EU-28, taken mainly from the revised BREF (European Commission, 2014).

Table 3.2 Tier 2 emission factors for source category 2.C.5 Lead production, primary lead production, unabated.

Tier 2 default emission factors					
	Code	Name			
NFR source category	2.C.5	Lead production, primary			
Fuel	NA				
SNAP (if applicable)	030304 Primary lead production				
Technologies/Practices	Primary lead production				
Region or regional conditions					
Abatement technologies	Unabated				
Not applicable	HCH				
Not estimated	NO_x, CO, NMVOC, SO_x, NH_3, BC, As, Cr, Cu, Ni, Se, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	560	g/Mg lead	280	1 120	Visschedijk et al. (2004) applied on PM_{10}
PM_{10}	450	g/Mg lead	225	900	US EPA (2011, file no. 9000510)
$PM_{2.5}$	225	g/Mg lead	110	450	Visschedijk et al. (2004) applied on PM_{10}
Pb	150	g/Mg lead	100	200	Theloke et al. (2008)
Cd	0.80	g/Mg lead	0.60	1.2	Theloke et al. (2008)
Hg	1.0	g/Mg lead	0.80	1.2	Theloke et al. (2008)
As	0.18	g/Mg lead	0.12	0.24	Theloke et al. (2008)
Zn	75	g/Mg lead	37	150	US EPA, no. 9000510 applied on Theloke et al. (2008)
PCB	1.9	μg/Mg lead	0.66	5.8	Note 1
PCDD/F	5	μg I-TEQ/Mg lead	0.38	49	UNEP (2005)

Notes: The EF for PCB may be revised in the future based on new information from UNEP: Toolkit for Identification and Quantification of Releases of Dioxins and Furans and Other Unintentional POPs: http://chm.pops.int/Implementation/UnintentionalPOPs/ToolkitforUPOPs/Overview/tabid/372/Default.aspx

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

Table 3.3 Tier 2 emission factors for source category 2.C.5 Lead production, primary lead production assuming average technology in the EU-28.

Tier 2 default emission factors					
	Code	Name			
NFR source category	2.C.5	Lead production, primary			
Fuel	NA				
SNAP (if applicable)	030304 Primary lead production				
Technologies/Practices	Primary lead production				
Region or regional conditions	EU-28				
Abatement technologies	Current (2015) technology level				
Not applicable	HCH				
Not estimated	NOx, CO, NMVOC, NH3, BC, As, Cr, Cu, Ni, Se, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	4.5	g/Mg lead	1	20	European Commission (2014)
PM_{10}	3.5	g/Mg lead	0.8	15	Visschedijk et al. (2004) applied on TSP
$PM_{2.5}$	1.7	g/Mg lead	0.4	7.6	Visschedijk et al. (2004) applied on TSP
SO_x	1450	g/Mg lead	700	3000	European Commission (2014)
Pb	4.1	g/Mg lead	2.5	6.8	European Commission (2014)
Cd	0.1	g/Mg lead	0.05	0.12	European Commission (2014)
Hg	0.3	g/Mg lead	0.2	0.4	Theloke et al. (2008) applied on Pb
As	0.1	g/Mg lead	0.04	0.1	European Commission (2014)
Zn	0.6	g/Mg lead	0	1.2	European Commission (2014)
PCB	1.9	µg/Mg lead	0.66	5.8	Note 1
PCDD/F	5	µg I-TEQ/Mg lead	0.38	49	UNEP (2005)

Note:

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

Secondary lead production

Table 3.4 presents a set of emission factors that can be used for secondary lead production; unabated. However, data were not available for all pollutants (only for the values referenced in Theloke *et al*., 2008). For Table 3.4, the PM_{10} emission has been estimated from the composition of particulate matter emitted from lead smelters given in the SPECIATE database (US EPA, 2011) and the emission of heavy metals given by Theloke et al. (2008). The unabated emission factors can be combined with abatement efficiencies as presented in section 3.3.3 to calculate pollutant emission to air. Table 3.5 presents emission factors for secondary lead production in the EU-28 using currently installed technology, taken mainly from the revised BREF (European Commission, 2014).

Table 3.4 Tier 2 emission factors for source category 2.C.5 Lead production, secondary lead production; unabated.

Tier 2 default emission factors					
	Code	Name			
NFR source category	2.C.5	Lead production, secondary			
Fuel	NA				
SNAP (if applicable)	030307 Secondary lead production				
Technologies/Practices	Secondary lead production				
Region or regional conditions					
Abatement technologies	Unabated				
Not applicable	HCH				
Not estimated	NO_x, CO, NMVOC, SO_x, NH_3, BC, Hg, As, Cr, Cu, Ni, Se, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	14 800	g/Mg lead	7 400	29 600	Visschedijk et al. (2004) applied on PM_{10}
PM_{10}	11 800	g/Mg lead	5 900	23 600	US EPA (2011, file no. 2040110)
$PM_{2.5}$	8 800	g/Mg lead	4 400	17 600	Visschedijk et al. (2004) applied on PM_{10}
Pb	5 800	g/Mg lead	2 000	8 000	Theloke et al. (2008)
Cd	15	g/Mg lead	20	40	Theloke et al. (2008)
As	47	g/Mg lead	30	70	Theloke et al. (2008)
Zn	35	g/Mg lead	17	70	US EPA (2011, file no. 2040110) applied on Theloke et al. (2008)
PCB	3.2	µg/Mg lead	1.1	9.6	Note 1
PCDD/F	8	µg I-TEQ/Mg lead	0.5	80	UNEP (2005)

Notes: The EF for PCB may be revised in the future based on new information from UNEP: Toolkit for Identification and Quantification of Releases of Dioxins and Furans and Other Unintentional POPs: http://chm.pops.int/Implementation/UnintentionalPOPs/ToolkitforUPOPs/Overview/tabid/372/Default.aspx

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

Table 3.5 Tier 2 emission factors for source category 2.C.5 Lead production, secondary lead production assuming average technology in the EU-28.

Tier 2 default emission factors					
	Code	Name			
NFR source category	2.C.5	Lead production, secondary			
Fuel	NA				
SNAP (if applicable)	030307 Secondary lead production				
Technologies/Practices	Secondary lead production				
Region or regional conditions	EU-28				
Abatement technologies	Current technology level				
Not applicable	HCH				
Not estimated	NO_x, CO, NMVOC, NH_3, BC, Hg, As, Cr, Cu, Ni, Se, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	20	g/Mg lead	11	35	European Commission (2014)
PM_{10}	16	g/Mg lead	9	29	Visschedijk et al. (2004) applied on TSP
$PM_{2.5}$	8	g/Mg lead	4.5	14	Visschedijk et al. (2004) applied on TSP
SO_x	5000	g/Mg lead	4000	6000	European Commission (2014)
Pb	1.1	g/Mg lead	0.5	2.5	European Commission (2014)
Cd	0.05	g/Mg lead	0	0.1	European Commission (2014)
As	0.3	g/Mg lead	0.15	0.5	European Commission (2014)
Zn	0.05	g/Mg lead	0	0.1	European Commission (2014)
PCB	2.6	µg/Mg lead	1.3	5.2	Note 1
PCDD/F	3.2	µg I-TEQ/Mg lead	1.1	9.6	UNEP (2005)

Note:

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

3.3.3 Abatement

A number of add-on technologies exist that are aimed at reducing the emissions of specific pollutants. The resulting emission can be calculated by replacing the technology specific emission factor with an abated emission factor as given in the formula:

$$EF_{technology,abated} = \eta_{abatement} \times EF_{technology,unabated} \qquad (4)$$

where:

$EF_{technology,\ abated}$ = the emission factor after implementation of the abatement

$\eta_{abatement}$ = the abatement efficiency

$EF_{technology,\ unabated}$ = the emission factor before implementation of the abatement

This subsection presents default abatement efficiencies for particulates, heavy metals and SO_x. Abatement efficiencies for particulates are presented in Table 3.6. The particulate matter (PM) efficiencies for older abatement equipment are based on AP 42 (US EPA, 1998), while efficiencies for modern equipment are based on the draft BREF document for the large combustion plants sector (European Commission, 2013). It should be noted that the efficiencies from the LCP BREF are primarily based on observations made for fly ash from coal-fired power plants. For other types of dust efficiencies may be lower. Table 3.7 presents the SO_x abatement efficiency of sulphuric acid plants, while Table 3.8 presents the abatement efficiency for heavy metals, PCB and PCDD/F using different abatement techniques. These abatement efficiencies are used to estimate abated emission factors in the Tier 2 tables with unabated emission factors above.

Table 3.6 Abatement efficiencies ($\eta_{abatement}$) for source category 2.C.5 Lead production for particulate matter.

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.C.5	Lead production			
Fuel	NA	not applicable			
SNAP (if applicable)	040309b	Lead production			
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Multicyclone	particle > 10 µm	78.7%	36.2%	92.9%	US EPA (1998)
	10 µm > particle > 2.5 µm	75.8%	27.5%	91.9%	
	2.5 µm > particle	75.0%	25.0%	91.7%	
Spray tower	particle > 10 µm	77.6%	32.7%	92.5%	US EPA (1998)
	10 µm > particle > 2.5 µm	74.4%	23.2%	91.5%	
	2.5 µm > particle	72.5%	17.5%	90.8%	
ESP + spray tower	particle > 10 µm	95.1%	85.3%	98.4%	US EPA (1998)
	10 µm > particle > 2.5 µm	94.6%	83.8%	98.2%	
	2.5 µm > particle	96.3%	88.8%	98.8%	
Wet ESP	particle > 10 µm	98.2%	94.5%	99.4%	US EPA (1998)
	10 µm > particle > 2.5 µm	96.4%	89.2%	98.8%	
	2.5 µm > particle	94.4%	83.1%	98.1%	
Modern ESP	particle > 10 µm	>99.95%			European Commission (2013)
	10 µm > particle > 2.5 µm	>99.95%			
	2.5 µm > particle	97.4%	>96.5%	>98.3%	
Crossflow packed bed scrubber	particle > 10 µm	71.9%	15.7%	90.6%	US EPA (1998)
	10 µm > particle > 2.5 µm	67.9%	3.8%	89.3%	
	2.5 µm > particle	76.9%	30.6%	92.3%	
Floating bed scrubber	particle > 10 µm	79.6%	38.8%	93.2%	US EPA (1998)
	10 µm > particle > 2.5 µm	76.8%	30.4%	92.3%	
	2.5 µm > particle	75.0%	25.0%	91.7%	
Venturi Scrubber	particle > 10 µm	96.7%	90.0%	98.9%	US EPA (1998)
	10 µm > particle > 2.5 µm	96.2%	88.6%	98.7%	
	2.5 µm > particle	92.3%	77.0%	97.4%	
Modern Venturi scrubber	particle > 10 µm	>99.9%			European Commission (2013)
	10 µm > particle > 2.5 µm	99.9%			

	2.5 µm > particle	99.0%	98.5%	99.5%	
Dry + secondary scrubber	particle > 10 µm	99.1%	97.4%	99.7%	US EPA (1998)
	10 µm > particle > 2.5 µm	98.3%	95.0%	99.4%	
	2.5 µm > particle	97.5%	92.5%	99.2%	
Coated fabric filter	particle > 10 µm	98.1%	94.3%	99.4%	US EPA (1998)
	10 µm > particle > 2.5 µm	96.3%	88.8%	98.8%	
	2.5 µm > particle	94.4%	83.1%	98.1%	
Modern fabric filter	particle > 10 µm	>99.95%			European Commission (2013)
	10 µm > particle > 2.5 µm	>99.9%			
	2.5 µm > particle	>99.6%			

Table 3.7 Abatement efficiencies ($\eta_{abatement}$) for source category 2.C.5 Lead production for SO_x

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.C.5	Lead production			
Fuel	NA	not applicable			
SNAP (if applicable)	040309b	Lead production			
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Single contact sulphuric acid plants	SOx	97.6%	96%	99.10%	European Commission (2014)
Double contact sulphuric acid plants	SOx	99.6%	99.20%	99.97%	European Commission (2014)

Table 3.8 Abatement efficiencies ($\eta_{abatement}$) for source category 2.C.5 Lead production for heavy metals, PCB and PCDD/F

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.C.5	Lead production			
Fuel	NA	not applicable			
SNAP (if applicable)	040309b	Lead production			
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Dry ESP	Hg	5%	0%	68%	Theloke et al. (2008)
	Cd	84.7%	54%	95%	Theloke et al. (2008)
	Ni	84.7%	54%	95%	Theloke et al. (2008)
	As	84.7%	54%	95%	Theloke et al. (2008)
	Pb	84.7%	54%	95%	Theloke et al. (2008)
State of the art fabric filter	Hg	10%	0%	70%	Theloke et al. (2008)
	Cd	99.99%	99.97%	99.997%	Theloke et al. (2008)
	Ni	99.99%	99.97%	99.997%	Theloke et al. (2008)
	As	99.99%	99.97%	99.997%	Theloke et al. (2008)
	Pb	99.99%	99.97%	99.997%	Theloke et al. (2008)
	PCDD/F	10%	0%	70%	Theloke et al. (2008)
Virgin activated carbon injection (SIC)+FF+FGD	Hg	90%	70%	97%	Theloke et al. (2008)
	Cd	99.99%	99.97%	99.997%	Theloke et al. (2008)

	Ni	99.99%	99.97%	99.997%	Theloke et al. (2008)
	As	99.99%	99.97%	99.997%	Theloke et al. (2008)
	Pb	99.99%	99.97%	99.997%	Theloke et al. (2008)
	PCB	12%	0%	71%	Theloke et al. (2008)
	PCDD/F	90%	70%	97%	Theloke et al. (2008)

3.3.4 Activity data

Information on the production of lead, suitable for estimating emissions using the simpler estimation methodology (Tier 1 and 2), is widely available from United Nations statistical yearbooks or national statistics. This information is satisfactory to estimate emissions with the use of the simpler estimation methodology.

For a Tier 2 approach these data need to be stratified according to technologies applied. Typical sources for this data might be industrial branch organisations within the country or specific questionnaires submitted to the individual lead works.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 4.6.2.3 'Choice of activity statistics' (IPCC, 2006).

3.4 Tier 3 emission modelling and use of facility data

3.4.1 Algorithm

There are two different emission estimation methods that go beyond the technology-specific approach described above:

- detailed modelling of the lead production process;
- facility-level emission reports.

Detailed process modelling

A Tier 3 emission estimate, using process details will make separate estimates for the consecutive steps in the production process of lead.

Facility-level data

Where facility-level emission data of sufficient quality (see the guidance chapter on QA/QC in Part A of the Guidebook) are available, it is good practice to use these data. There are two possibilities:

- facility reports cover all lead production in the country;
- facility-level emission reports are not available for all lead plants in the country.

If facility level data are covering all lead production in the country, it is good practice to compare the implied emission factors (reported emissions divided by national lead production) with the default emission factor values or technology-specific emission factors. If the implied emission factors are outside the 95 % confidence intervals for the values given below, it is good practice to explain the reasons for this in the inventory report

If the total annual lead production in the country is not included in the total of the facility reports, it is good practice to estimate the missing part of the national total emissions from the source category, using extrapolation by applying:

$$E_{Total,pollutant} = \sum_{Facilities} E_{Facility,pollutant} + \left(National\ \ Production - \sum_{Facilities} Production_{Facility} \right) \times EF \tag{5}$$

where:

$E_{total,pollutant}$	=	the total emission of a pollutant for all facilities within the source category
$E_{facility,pollutant}$	=	the emission of the pollutant as reported by a facility
$Production_{total}$	=	the production rate in the source category
$Production_{facility}$	=	the production rate in a facility
$EF_{pollutant}$	=	the emission factor for the pollutant

Depending on the specific national circumstances and the coverage of the facility-level reports as compared to the total national lead production, it is good practice to choose the emission factor *(EF)* in this equation from the following possibilities, in decreasing order of preference:

- technology-specific emission factors, based on knowledge of the types of technologies implemented at the facilities where facility level emission reports are not available;
- the implied emission factor derived from the available emission reports:

$$EF = \sum_{Facilities} E_{Facility,pollutant} \Big/ \sum_{Facilities} Production_{Facility} \tag{6}$$

- the default Tier 1 emission factor. This option should only be chosen if the facility-level emission reports cover more than 90 % of the total national production.

3.4.2 Tier 3 emission modelling and use of facility data

Lead production plants are major industrial facilities and emissions data for individual plants might be available through a pollutant release and transfer registry (PRTR) or another emission reporting scheme. When the quality of such data is assured by a well-developed QA/QC system and the emission reports have been verified by an independent auditing scheme, it is good practice to use such data. If extrapolation is needed to cover all lead production in the country, either the implied emission factors for the facilities that did report or the emission factors as provided above could be used.

No generally accepted emission models are available for the lead production industry. Such models could be developed, however, and used in national inventories. If this happens, it is good practice to compare the results of the model with a Tier 1 or Tier 2 estimate to assess the credibility of the model. If the model provides implied emission factors that lie outside the 95% confidence intervals indicated in the tables above, it is good practice to include an explanation for this in the documentation with the inventory and preferably reflected in the Informative Inventory Report.

3.4.3 Activity data

Since PRTRs generally do not report activity data, such data in relation to the reported facility-level emissions are sometimes difficult to find. A possible source of facility level activity might be the registries of emission trading systems.

In many countries national statistics offices collect production data at the facility level but these are in many cases confidential. However, in several countries national statistics offices are part of the national emission inventory systems and the extrapolation, if needed, could be performed at the statistics office, ensuring that confidentiality of production data is maintained.

4 Data quality

4.1 Completeness

Care must be taken to include all emissions, from combustion as well as from processes. It is good practice to check whether the emissions reported as 'included elsewhere' (IE) under source category 2.C.5 are indeed included in the emission reported under combustion in source category 1.A.2.b.

4.2 Avoiding double counting with other sectors

Care must be taken that the emissions are not double counted in processes and combustion. It is good practice to check that the emissions reported under source category 2.C.5 are not included in the emission reported under combustion in source category 1.A.2.b.

4.3 Verification

4.3.1 Best Available Technique emission factors

BAT emission limit values are available from the revised BREF document for the non-ferrous metal industry (European Commission, 2014).

The BREF document describes the technologies necessary to achieve BAT emission levels. For lead production, no generic emission concentrations are given that may be compared against the Tier 1 estimate. However, some numbers for different techniques and processes are available from the revised BREF document (European Commission, 2014) and may be used for verification purposes.

4.4 Developing a consistent time series and recalculation

No specific issues.

4.5 Uncertainty assessment

No specific issues.

4.5.1 Emission factor uncertainties

No specific issues. The quality of the emission factors presented is rated as 'B'. The guidance chapter on uncertainties in Part A of the Guidebook gives information on how to interpret this quality rating.

4.5.2 Activity data uncertainties

No specific issues.

4.6 Inventory quality assurance/quality control (QA/QC)

No specific issues.

4.7 Gridding

No specific issues.

4.8 Reporting and documentation

No specific issues.

5 Glossary

$AR_{production,\ technology}$	The production rate within the source category, using a specific technology
$AR_{production,\ technology}$	The production rate within the source category, using a specific technology
$AR_{production}$	The activity rate for the lead production
Combustion process with contact	A process in which the hot flue gases from a combustion process are directly injected into the reactor where the chemistry and physics take place converting the raw materials into the product. Examples are: • Primary iron and steel • Cement • …
$E_{facility,\ pollutant}$	The emission of the pollutant as reported by a facility
$E_{pollutant}$	The emission of the specified pollutant
$E_{total,\ pollutant}$	The total emission of a pollutant for all facilities within the source category
$EF_{country,\ pollutant}$	A country-specific emission factor
$EF_{pollutant}$	The emission factor for the pollutant
$EF_{technology,\ abated}$	The emission factor after implementation of the abatement
$EF_{technology,\ pollutant}$	The emission factor for this technology and this pollutant
$EF_{technology,\ unabated}$	The emission factor before implementation of the abatement
ESP	Electrostatic precipitator: dust emissions abatement equipment
FF	Fabric filters: dust emissions abatement equipment
$Penetration_{technology}$	The fraction of production using a specific technology
$Production_{facility}$	The production rate in a facility

$Production_{total}$	The production rate in the source category
$\eta_{abatement}$	The abatement efficiency

6 References

Barbour, A.K., Castle, J.F. and Woods, S.E., 1978. ‘Production of non-ferrous metals’. In: *Industrial Air Pollution Handbook*, A. Parker (ed.). Mc Graw-Hill Book Comp. Ltd., London.

European Commission, 2001. *Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques in the Non-Ferrous Metal Industries*, December 2001, (https://eippcb.jrc.ec.europa.eu/reference/) accessed 23 July 2019.

European Commission, 2013. *Integrated Pollution Prevention and Control (IPPC). Final Draft Reference Document on Best Available Techniques for the Large Combustion Plants*. Draft 1, June 2013, (https://eippcb.jrc.ec.europa.eu/reference/) accessed 23 July 2019.

European Commission, 2014. *Integrated Pollution Prevention and Control (IPPC). Final Draft Reference Document on Best Available Techniques for the Non-Ferrous Metals Industries*. Draft October 2014, (https://eippcb.jrc.ec.europa.eu/reference/) accessed 23 July 2019.

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). IGES, Japan.

Rentz, O., Sasse, H., Karl, U., Schleef, H.-J. and Dorn, R., 1996a. *Emission Control at Stationary Sources in the Federal Republic of Germany, Volume II, Heavy Metal Emission Control*. Umweltforschungsplan des Bundesministers für Umwelt, Naturschutz und Reaktorsicherheit, Luftreinhaltung, 204 02 360.

Rentz, O., Schleef, H.-J., Dorn, R., Sasse, H. and Karl, U., 1996b. *Emission Control at Stationary Sources in the Federal Republic of Germany, Volume I, Sulphur Oxide and Nitrogen Oxide Emission Control*. Umweltforschungsplan des Bundesministers für Umwelt, Naturschutz und Reaktorsicherheit, Luftreinhaltung, 204 02 360.

Theloke, J., Kummer, U., Nitter, S., Geftler, T. and Friedrich, R., 2008. *Überarbeitung der Schwermetallkapitel im CORINAIR Guidebook zur Verbesserung der Emissionsinventare und der Berichterstattung im Rahmen der Genfer Luftreinhaltekonvention*. Report for Umweltbundesamt, April 2008.

UNEP, 2005. *PCDD/PCDF Toolkit 2005*. United Nations Environmental Programme, Nairobi.

US EPA, 1990. *AIR Facility Subsystem*. United States Environment Protection Agency Doc. 450/4-90-003. Research Triangle Park, NC, USA.

US EPA, 1998. *AP 42 (5th edition), October 1998, Chapter 12*. US Environmental Protection Agency. (https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors), Accessed 9 July 2019.

US EPA, 2011. SPECIATE database version 4.3, U.S. Environmental Protection Agency’s (EPA), http://cfpub.epa.gov/si/speciate/. (accessed 5 June 2013).

Visschedijk, A.J.H., Pacyna, J., Pulles, T., Zandveld, P. and Denier van der Gon, H., 2004. 'Cooordinated European Particulate Matter Emission Inventory Program (CEPMEIP)'. In: Dilara, P. *et. al* (eds), *Proceedings of the PM emission inventories scientific workshop, Lago Maggiore, Italy, 18 October 2004*. EUR 21302 EN, JRC, pp 163–174.

7 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.