

SNAP CODE: 030304

SOURCE ACTIVITY TITLE: PROCESSES WITH CONTACT
Primary Lead Production

NOSE CODE: 104.12.05

NFR CODE: 2 C 5 / 1 A 2 b

ISIC: 2420

1 ACTIVITIES INCLUDED

The primary lead production process is defined as the production of lead from lead concentrates. A description of the process together with a brief description of the associated process steps (e.g. sintering) is provided in Section 3. Detailed descriptions of the associated process steps can be found in chapter B331.

2 CONTRIBUTION TO TOTAL EMISSIONS

The contribution of gaseous emissions released from primary lead production to total emissions in countries of the CORINAIR90 inventory is given as follows:

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	NM VOC	CH ₄	CO	CO ₂	N ₂ O	NH ₃	TSP*	PM ₁₀ *	PM _{2.5} *
Primary Lead Production (average)	030304	0.2	0	-	-	0	0	-	-	0.011	0.020	0.016
Highest value										0.045	0.075	0.061
Lowest value										-	-	-

* EU PM_{2.5} Inventory project for EU25 for the year 2000 (TNO, 2006), contribution to total national emissions, excluding agricultural soils

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)

- = no emissions are reported

The contribution of heavy metal emissions from primary lead production to the total heavy metal emissions, according to IWAD [7], is given in Table 2.2.

Table 2.2: The contribution of heavy metal emissions from primary lead production to the total emissions of the IWAD study [7]

Contribution to total emissions (%)					
Cd	Cr	Cu	Ni	Pb	Zn
1.1	0	0.2	0	1.5	0.3

0 = emissions are reported, but the exact value is below the rounding limit

3 GENERAL

3.1 Description of activities

This process contains the classical steps of ore pretreatment and concentration, sintering, smelting, and product refining. Most primary lead smelters also produce other metals to a certain extent. The process route is based on sintering, reduction of sinter in a shaft furnace, and refining of bullion, either pyrometallurgically or hydrometallurgically.

In the sintering process fine particles of metal ores are agglomerated into nodules, briquettes, sinter, or pellets. Also a roasting process is involved in which lead sulphide is converted into lead oxide. 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.

In the smelting process ore, coke, and flux compounds are heated either in a shaft furnace or an electric furnace. 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, zinc, and bismuth. Dust emissions mainly occur at the treatment of the different by-product streams.

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

3.2 Definitions

Sintering process	Agglomeration of ore particles, flux compounds and other material by the combustion of coke.
Roasting process	Oxidation of lead concentrate converting the lead sulphide to lead oxide.

3.3 Techniques

The main techniques for the smelting process are the shaft furnace and the electric furnace process. For refining the main techniques are pyrometallurgical refining and hydrometallurgical refining. Several direct smelting technologies have been under development or are being developed yet. Information about the emissions of these techniques is not yet available.

3.4 Emissions

The main emissions during the primary lead production are dust emissions.

Pollutants released are sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (non-methane VOC and methane (CH₄)), carbon monoxide (CO), carbon dioxide (CO₂), and nitrous oxide (N₂O). According to CORINAIR90 the main relevant pollutant is SO₂ (see also table 2.1).

The most relevant step with regard to SO₂ emissions is the sintering process (for details see B331). However, only about 7 % of the total sulphur in the ore is emitted as SO₂. The

remainder is captured by the slag. The concentration of this SO₂ stream can vary from 1.4 to 7.2 g/m³, depending on the amount of dilution air injected to oxidise the carbon monoxide and to cool the stream before baghouse particulate removal [1].

Nearly 85 % of the sulphur present in the lead ore concentrate is eliminated in the sintering operation (see chapter B331). In handling process offgases, either a single weak stream is taken from the machine hood at less than 2 % SO₂, or two streams are taken, a strong stream (5 to 7 % SO₂) from the feed end of the machine and a weak stream (less than 0.5 % SO₂) from the discharge end. Single stream operation has been used if there is little or no market for recovered sulphur, so that the uncontrolled, weak SO₂ stream is emitted to the atmosphere.

When sulphur removal is required, however, dual stream operation is preferred. The strong stream is sent to a sulphuric acid plant, and the weak stream is vented to the atmosphere after removal of particulate [1].

Sulphur oxides are also generated in blast furnaces during the smelting process from small quantities of residual lead sulphide and lead sulphates in the sinter feed. The quantity of these emissions is a function not only of the sinter's residual sulphur content, but also of the sulphur captured by copper and other impurities in the slag [1].

3.5 Controls

The dust emissions can be abated by using fabric filters, wet scrubbers or electrofilters. Improvement can be achieved by using encapsulation or evacuation. New approaches are under development.

The SO₂ containing emissions 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/m³, and dual stage plants can attain levels of 1.6 g/m³. Typical efficiencies of dual stage plants in removing sulphur oxides can exceed 99 %. Other technically feasible SO₂ control methods are elemental sulphur recovery plants and dimethylamine and ammonia absorption processes [1].

4 SIMPLER METHODOLOGY

Emissions can be estimated at different levels of complexity; it is useful to think in terms of three tiers¹:

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.

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.

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 (AR) with a comparable, representative, value of the emissions per unit activity, the emission factors (EF). The basic equation is:

$$\text{Emission} = \text{AR} \times \text{EF}$$

In the energy sector, for example, fuel consumption would be activity data and mass of material emitted per unit of fuel consumed would be a compatible emission factor.

NOTE: The basic equation may be modified, in some circumstances, to include emission reduction efficiency (abatement factors).

Default emission factors for this purpose are provided in Section 8.1.

5 DETAILED METHODOLOGY

Information about the newer processes mentioned above is not yet available to allow a more detailed methodology to be followed. However, reference emission factors for comparison with users own data are provided in Section 8.2.

6 RELEVANT ACTIVITY STATISTICS

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

The detailed methodology (Tier 3) requires more detailed information. For example, the quantities produced by various types of industrial technologies employed in the industry at plant level. This data is however not always easily available.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 2.2.1.3 "Choice of activity statistics".

7 POINT SOURCE CRITERIA

The primary lead production should be treated as a point source if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Default Emission Factors for use with simpler methodology

Table 8.1: Emission factors for primary lead production

Pollutant	Emission Factor		Units
	<i>Limited control</i>	<i>Abatement</i>	
Arsenic	3	0.5	g/tonne lead
Cadmium	10	1	g/tonne lead
Copper	10	5	g/tonne lead
Mercury	3	1	g/tonne lead
Lead	800	200	g/tonne lead
Vanadium	80	20	g/tonne lead
Particles ¹⁾			
TSP		0.5	g/tonne lead
PM ₁₀		0.4	g/tonne lead
PM _{2.5}		0.2	g/tonne lead

Source: Pacyna et al (2002)

1) CEPMEIP emission factors for conventional plant using ESP, settlers, scrubbers; moderate control of fugitive sources

8.2 Reference Emission Factors for Use With Detailed Methodology

The following tables provide emission factors for comparison with users own data. Emissions can vary widely depending on the ore used and the abatement measures applied as demonstrated by the reported emission factors given in Table 8.2a. The emission factors

given in Table 8.2b were prepared for the PARCOM-ATMOS Emission Factors Manual 1992.

Table 8.2c contains fuel related emission factors. Technique related emission factors, mostly given in other units (e.g. g/m³) are listed in footnotes. In case of using production statistics the specific energy consumption (e.g. GJ/Mg product) has to be taken into account, which is process and country specific. At this stage no data for the definition of appropriate conversion factors are available.

Table 8.2d contains emission factors for particles, total suspended particles (TSP), PM₁₀ and PM_{2.5}. The emission factors are derived from the CEPMEIP database.

Table 8.2a: Emission factors for primary lead production (g/Mg product) as reported by several countries/authors

Compound	Sweden [2]		Poland [3]			Germany [4]	Pacyna [5,6]
	limited	improved	limited	improved	unabated	unknown	unknown
Arsenic	3	0.2	16-43	-	-	3	300
Cadmium	3	0.6	10-22	-	-	6	10
Copper	10	4	10	7	-	-	-
Lead	400	200	560-1200	-	-	400	3000
Mercury	-	-	-	-	-	-	3
Zinc	50	20	110	-	680	-	110

Table 8.2b: Proposed emission factors for primary lead production (g/tonne Lead)

Substance	Emission factor		
	limited abatement	improved abatement	unknown level of abatement
Arsenic	3	0.5	10
Cadmium	10	1	15
Copper	10	5	10
Lead	800	200	2000
Mercury	3	3	3
Zinc	80	20	100

Table 8.2c: Emission factors for primary lead production⁶⁾

Type of fuel	NAPFU E code	Emission factors						
		SO ₂ ³⁾ [g/GJ]	NO _x ⁴⁾ [g/GJ]	NMVOC ⁵⁾ [g/GJ]	CH ₄ [g/GJ]	CO [g/GJ]	CO ₂ [kg/GJ]	N ₂ O [g/GJ]
s coal hc steam	102	149-520 ¹⁾	160 ¹⁾	15 ¹⁾	15 ¹⁾	100 ¹⁾	94 ¹⁾ , 99 ²⁾	4 ¹⁾
s coal hc sub-bituminous	103	838 ²⁾	39 ²⁾					
s coal bc briquettes	106	149-176 ¹⁾	140 ¹⁾	15 ¹⁾	15 ¹⁾	100 ¹⁾	97 ¹⁾	3.5 ¹⁾
s coke hc coke oven	107	149-520 ¹⁾ , 462-501 ²⁾	140 ¹⁾ , 35 ²⁾	0.5 ¹⁾	0.5 ¹⁾	100 ¹⁾	100- 105 ¹⁾ , 105 ²⁾	4 ¹⁾
s coke bc coke oven	108	660 ¹⁾	200 ¹⁾	05 ¹⁾	0.5 ¹⁾	100 ¹⁾	100 ¹⁾	4 ¹⁾
l oil residual	203	149- 1,470 ¹⁾	150- 175 ¹⁾	4 ¹⁾	4 ¹⁾	10-15 ¹⁾	76-78 ¹⁾	2 ¹⁾
l oil gas	204	68-1,410 ¹⁾	70-100 ¹⁾	2.5 ¹⁾	2.5 ¹⁾	10-12 ¹⁾	73-74 ¹⁾	2 ¹⁾
g gas natural	301	0.4-149 ¹⁾ , 371 ²⁾	50 ¹⁾ , 45 ²⁾	2.5 ¹⁾	2.5 ¹⁾	10 ¹⁾	55-56 ¹⁾ , 55 ²⁾	1.5 ¹⁾

¹⁾ CORINAIR90 data, area sources (preliminary data)

²⁾ CORINAIR90 data, point sources (preliminary data)

³⁾ SO_x: /1/ 17,209 · g/m³ fuel: primary metal production, process heaters, NAPFUE 204, S = sulphur content of fuel

19,006 · g/m³ fuel: primary metal production, process heaters, NAPFUE 203, S = sulphur content of fuel

Emission factors of SO₂ given here may contain emissions from combustion of fuel as far as emissions from sintering of ore.

⁴⁾ NO_x: /1/ 2,397 g/m³ fuel: primary metal production, process heaters, NAPFUE 204

6,591 g/m³ fuel: primary metal production, process heaters, NAPFUE 203

⁵⁾ VOC: 24 g/m³ fuel: primary metal production, process heaters, NAPFUE 204

/1/ 34 g/m³ fuel: primary metal production, process heaters, NAPFUE 203

⁶⁾ It is assumed, that emission factors cited within the table are only related to combustion sources in primary lead production (except of SO₂); other process emissions are not covered.

Table 8.2d: Emission factors for particles for primary lead production (kg/ton) (CEPMEIP)

Technologies	Abatement type	Unit	TSP	PM ₁₀	PM _{2.5}	Uncertainty	Country or region
Conventional plant	ESP, settlers, scrubbers; moderate control of fugitive sources	kg/ton	0.5	0.4	0.2	4	EU (CEPMEIP)
Modern plant	fabric filters for most emission sources, BAT	kg/ton	0.12	0.114	0.06	3	EU (CEPMEIP)
Older plant	limited control of fugitive sources	kg/ton	10	3	0.6	4	EU (CEPMEIP)

NOTE: The uncertainty range (95% confidence) in the emission factor is expressed as a factor. The lower limit of the uncertainty range can be found by dividing the emission factor with the uncertainty factor, whereas the upper limit of the uncertainty range can be found by multiplying the range with the uncertainty factor. Example (first row in table 8.2d): The uncertainty in the emission factor for PM_{2.5} from a conventional plant with an ESP settlers, scrubbers and moderate control of fugitive sources is 4. The emission factor for PM_{2.5} with uncertainty range will therefore be 0.2 kg per tonne with an uncertainty range of 0.05 (0.2/4) to 0.8 (0.2 x 4).

9 SPECIES PROFILES

Not applicable.

10 UNCERTAINTY ESTIMATES

The quality class of the emission factors is estimated to be about B.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspects in the current methodology are the emission factors.

The fuel specific emission factors provided in Table 8.2c are related to point sources and area sources without specification. CORINAIR90 data can only be used in order to give a range of emission factors with respect to point and area sources. Further work should be invested to develop emission factors, which include technical or fuel dependent explanations concerning emission factor ranges.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Not applicable if actively treated on a point source basis.

13 TEMPORAL DISAGGREGATION CRITERIA

The primary lead production as such is a continuous process.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

- Richtlinien zur emissionsminderung in nicht-eisen-metall-industrien. Umweltbundesamt 1980.
- US-EPA (ed.): AP 42 CD-Rom; 1994

16 VERIFICATION PROCEDURES

A comparison between the profile of the calculated emissions and the composition of the ore could be used as a verification method.

17 REFERENCES

- 1 EPA (ed.): AIR Facility Subsystem, EPA-Doc. 450/4-90-003, Research Triangle Park, 1990.
- 2 Preliminary note on guidelines on measures and methods for heavy metals emissions control for the primary non-ferrous metal industry in the framework of the ECE task force "Heavy metal emissions" Presented by Sweden on meeting Berlin 21-24 January 1992.
- 3 Heavy metals emission to air in Poland for years 1980-1992, Hlawiczka, S., Zeglin, M., Koterska, A., Inst. Ecol. Ind. Areas, Report 0-2.081, Katowice, 1995 (in Polish).
- 4 Datenerhebung über die Emissionen Umweltgefährdenden Schwermetalle; Jockel, W., Hartje, J.; Forschungsbericht 91-104 02 588, TÜV Rheinland e.V. Köln; 1991.
- 5 Emission factors of atmospheric Cd, Pb and Zn for major source categories in Europe in 1950-1985; Pacyna, J.M.; NILU Report OR 30/91 (ATMOS 9/Info 7); 1990.
- 6 Survey on heavy metal sources and their emission factors for the ECE countries; Pacyna, J.M.; Proc. 2nd Mtg Task Force Heavy Metals Emissions, ECE Convention on Long-range Transboundary Air Pollution Working Group on Technology, Prague, 15-17 October 1991; page 27-55; 1990.
- 7 Calculation of atmospheric deposition of contaminants on the North Sea, Baart, A.C., Berdowski, J.J.M., Jaarsveld, J.A. van, Wulffraat, K.J., TNO-report TNO-MW-R 95/138, 1995.
- 8 Pacyna et al (2002): Combustion and Industry Expert Panel Workshop, European Joint Research Centre (JRC) ISPRA 2002. Data compiled by: Pacyna J, van der Most P, Hobson M, Wieser, M, Müller B, Duval L, Spezzano P, Lotz T, Kakareka S.
- 9 Visschedijk, A.J.H., J. Pacyna, T. Pulles, P. Zandveld and H. Denier van der Gon, 2004, Coordinated European Particulate Matter Emission Inventory Program (CEPMEIP), In: P. Dilara et. Al (eds), Proceedings of the PM emission inventories scientific workshop, Lago Maggiore, Italy, 18 October 2004, EUR 21302 EN, JRC, pp 163 – 174

18 BIBLIOGRAPHY

No additional documents.

19 RELEASE VERSION, DATE, AND SOURCE

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20 POINT OF ENQUIRY

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