SNAP CODE: **030322**

SOURCE ACTIVITY: **PROCESSES WITH CONTACT**
Alumina Production

NOSE CODE: **104.12.13**

NFR CODE: **1 A 2 b**

ISIC: **2420**

1 ACTIVITIES INCLUDED

This chapter covers emissions released from combustion processes within alumina production. Alumina production is an ore treatment step in the production of primary aluminium (SNAP code 040301, chapter B431).

2 CONTRIBUTION TO TOTAL EMISSIONS

The contribution of emissions related to fuel use, released from the alumina production to total emissions in countries of the CORINAIR90 inventory is minor, as indicated in Table 2.1.

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

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**										
Aluminia Production	030322	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP*	PM_{10}*	$PM_{2.5}$*
Typical contribution		0	0	-	-	-	-	-	-	0.316	0.599	0.440
Highest value										1.001	2.472	1.818
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

3 GENERAL

3.1 Description of activities

The base ore for primary aluminium production is bauxite. Alumina is produced by the Bayer process. In this process the ore is dried, ground in ball mills, and mixed with a leaching solution of sodium hydroxide at an elevated temperature and pressure, producing a sodium aluminate which is separated from the impurities and cooled, during which the alumina precipitates. After washing to remove impurities the alumina is dried and calcined to produce a crystalline form of alumina.

3.2 Definitions

Bauxite A hydrated oxide of aluminium consisting of 30-70 percent alumina and lesser amounts of iron, silicon and titanium.

3.3 Techniques

The calcination of the aluminium-hydroxide takes place in rotary kilns at about 1,300 °C or in fluidised bed furnaces at lower temperatures. The furnaces are fired with heavy oil and gas.

3.4 Emissions

The main emissions are dust emissions occurring during the grinding of the bauxite and the calcining of the aluminium hydroxide.

Pollutants related to fuel use are sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compunds (non-methane VOC and methane (CH_4)), carbon monoxide (CO), carbon dioxide (CO_2), and nitrous oxide (N_2O). Of these, according to CORINAIR90, the main relevant pollutants are SO_2 and NO_x (see also table 1).

3.5 Controls

Dust emissions can be abated by cyclones, spray towers, floating bed scrubbers, quench towers, or electrostatic precipitators (ESP). The dust trapped in the calcining process is usually reused.

No information is available about control of gaseous emissions.

4 SIMPLER METHODOLOGY

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

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

[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.

The Tier 1 default emission factors also assume an average or typical process description.

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

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

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

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

Consequently the simplified methodology is to combine an activity rate (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.

5 DETAILED METHODOLOGY

A detailed methodology is possible if sufficient measurements are available about the situation in an individual plant.

The detailed methodology (equivalent to Tier 3), to estimate emissions of gaseous pollutants from the primary aluminium production is based on measurements or estimations using plant specific emission factors - guidance on determining plant specific emission factors is given in Measurement Protocol Annex.

The detailed methodology to estimate emissions of trace elements from the primary aluminium production is similar to the simpler one. However, more information on the type of the process, as well as on the type of the industrial technology should be made available. This information shall be used to estimate specific emissions for at least a specific industrial technology.

Measurements of the emission rate and chemical composition of fine particles with < 1.0 µm diameter are often carried out at major aluminium plants world-wide. The results of these measurements are then used to estimate atmospheric emissions of several trace elements contained as impurities in the raw materials and fuel.

Reference emission factors for comparison with users own data are provided in Section 8.

6 RELEVANT ACTIVITY STATISTICS

Production and energy statistics, 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 of primary aluminium produced by various types of industrial technologies employed in 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

Aluminium production plants containing an alumina production department can be considered as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

For the situation in the Netherlands, the following can be proposed:
Controlled and uncontrolled emission factors for dust are available for both sectors of the Bayer process. These emission factors for dust are presented in Table 8.1. See also Table 8.3 for emission factors for dust (TSP, PM_{10} and $PM_{2.5}$).

Table 8.1: Emission factors for dust from alumina production in gram/kg aluminium produced

	Bauxite grinding	Calcining
Uncontrolled	3.0	100.0
Spray towers	0.5	30.0
Floating bed scrubber	0.85	28.0
Quench tower	0.5	17.0
Electrostatic precipitator	0.06	2.0

Source: EPA Compilation of air pollutant emission factors AP-42.

The following Table 8.2 contains fuel related emission factors for the alumina production based on CORINAIR90 data in [g/GJ]. In the 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 8.2: Emission factors for the alumina production[2)]

		Type of fuel	NAPFUE code	Emission factors						
				SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O
				[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[kg/GJ]	[g/GJ]
l	oil	residual	203	419[1)]	123[1)]	7.4[1)]	1[1)]	5[1)]	79[1)]	
g	gas	natural	301	8[1)]	60[1)]	10[1)]	2[1)]	30[1)]	55[1)]	

1) CORINAIR90 data, area sources

2) It is assumed, that emission factors cited within the table are related to combustion sources in alumina production; other process emissions are not covered.

Following Table 8.3 contains emission factors for the primary alumina production based on CEPMEIP data in [kg/ton aluminium].

Table 8.3: Emission factors for the alumina production in g/kg primary aluminium (CEPMEIP)

Technology and abatement	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Uncertainty-factor**
Cyclones or scrubbers only; limited abatement of fugitive emission	10	6	2.7	1.5
Effective capturing fugitive sources; extensive application of fabric filters	3	2.85	1.28	2
Conventional installation: moderate collection of fugitive dust; combined usage of cyclones, ESP and scrubbers	4	3.2	1.44	1,5

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 by 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 8.3): The uncertainty in the emission factor for $PM_{2.5}$ for a plant with only cyclones or scrubbers and limited abatement of fugitive emission (first row in table) is 1.5. The emission factor with uncertainty range will therefore be 2.7 kg per tonne primary aluminium with an uncertainty range of 1.8 (2.7 / 1.5) to 4 (2.7 x 1.5).

9 SPECIES PROFILES

The species profile of the dust is directly related to the bauxite composition which may differ from location to location.

10 UNCERTAINTY ESTIMATES

The uncertainty classification of the emission factors expressed per kg aluminium is estimated to be C.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspects discussed here are related to fuel use related emission factors.

The fuel specific emission factors provided in table 3 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

National emission estimates can be disaggregated on the basis of plant capacity, employment or population statistics.

13 TEMPORAL DISAGGREGATION CRITERIA

Alumina production is usually a continuous process.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

Environmental Protection Agency, Compilation of Air Pollutant Emission Factors. AP-42.

16 VERIFICATION PROCEDURES

Verification may be done by comparing the calculated emissions with measurements from individual plants.

17 REFERENCES

/1/ VDI (ed.): Auswurfbegrenzung - Aluminium-Monoxidgewinnung und Aluminium-schlmelzflußelektrolyse (Entwurf); 1974

/2/ Visschedijk, A.J.H., J. Pacyna, T. Pulles, P. Zandveld and H. Denier van der Gon, 2004, Cooordinated 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

Version: 2.1

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Source: J J M Berdowski, P F J van der Most
TNO
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20 POINT OF ENQUIRY

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