SNAP CODE: **030310**

SOURCE ACTIVITY TITLE: **PROCESSES WITHOUT CONTACT**
Secondary Aluminium Production

NOSE CODE: **104.12.11**
104.12.12

NFR CODE: **1 A 2 b**

1 ACTIVITIES INCLUDED

This chapter includes information on atmospheric emissions during the production of Aluminium in secondary Aluminium smelters. Secondary Aluminium smelters produce about 50 % of the total Aluminium production in the United States (e.g. UN, 1994). Similar Aluminium production proportion is found in the Netherlands, France, Austria, and Italy. The secondary Aluminium industry is characterised by a large number of relatively small plants treating mostly so-called new scrap. This chapter describes the methods to estimate emissions of atmospheric pollutants during the secondary Aluminium operations (e.g. Parker, 1978).

2 CONTRIBUTIONS TO TOTAL EMISSIONS

There are various pollutants which can be emitted during the secondary Aluminium production, including smoke, acids, and particles. Major problems may arise due to emissions of Aluminium chloride and its hydrolysis product, hydrochloric acid. These emissions are not very significant on a global scale. However, a secondary Aluminium smelter can be an important emission source of pollution on a local scale.

The contribution of emissions released from secondary Aluminium 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	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Secondary Aluminium Production	030310	0	0	0	-	-	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

Secondary Aluminium production plant have the potential to emit cadmium, hexachlorobenzene, dioxins and furans, PAHs and sulphurhexafluoride (ETC/AEM-CITEPA-RISOE 1997).

3 GENERAL

3.1 Description

A secondary Aluminium smelter is defined as any plant or factory in which Aluminium-bearing scrap or Aluminium-bearing materials, other than Aluminium-bearing concentrates (ores) derived from a mining operation, is processed into Aluminium Alloys for industrial castings and ingots. Energy for secondary refining consumes only about 5% of that required for primary Aluminium production.

In most cases, the first step in the secondary Aluminium production is removal of magnesium from the scrap charge in order to prevent off-grade castings when the refined Aluminium is cast. As much as 1% of magnesium can be found in the scrap charge and its reduction to 0.1% is necessary. This reduction can be achieved by lancing the molten charge with chlorine gas during and after the melting cycle (Barbour et al., 1978).

After pre-treatment the scrap charge is subjected to melting and demagging (chlorination). Small crucible furnaces are used to produce Aluminium Alloys for casting. Larger melting operations use reverberatory furnaces.

The final step in the production process is chlorination to obtain a high quality Aluminium product.

3.2 Definitions

Secondary Aluminium production: - production of Aluminium from materials other than ores.

3.3 Controls

Secondary Aluminium processing faces the difficult problem of suppressing emissions of corrosive Aluminium chloride associated with hydrogen chloride. Two approaches have been employed for some time to deal with the problem (Barbour et al., 1978). The Derham process uses proprietary fluxes. It claims more than 97% magnesium-chlorine efficiency for the chlorination stage at magnesium levels of less than 0.1%.

The Alcoa fumeless process depends on effecting a stoichiometric chlorination of magnesium in a multi-stage enclosed settler-reactor tank after melting and prior to casting (Barbour et al., 1978). Efficient gas-liquid contact gives a selective magnesium chlorination reaction (99% efficiency).

Afterburners are used generally to convert unburned VOC to CO_2 and H_2O. Wet scrubbers are sometimes used.

Controls in secondary Aluminium production should also include effective dust collecting arrangements for dust from both primary exhaust gases and fugitive dust emissions. Fabric filters can be used reducing the dust emissions to below 10 mg/ m^3.

4 SIMPLER METHODOLOGY

Application of general emission factors with appropriate activity statistics can be regarded as a simpler methodology for estimation of emissions from secondary Aluminium production. However, it should be admitted that the chemical composition of input scrap is one of the most important factors affecting the amount of emissions. The chemical composition of input scrap can vary considerably from one plant to another and so do emission factors.

5 DETAILED METHODOLOGY

In this case, different emission factors for various production technologies should be used. An account of the effect of emission controls should be considered. The different emission factors will have to be evaluated through measurements at representative sites.

6 RELEVANT ACTIVITY STATISTICS

Information on the production of Aluminium in secondary smelters is available from the UN statistical yearbooks (e.g. UN, 1994). This information is satisfactory to estimate emissions with the use of the simpler estimation methodology. However, in most cases, no information is available from the statistical yearbooks on the quantities of the metal produced by various types of industrial technologies employed in the secondary Aluminium industry. Therefore, the application of detailed estimation methodology may be complicated unless the statistical data are available directly from a given smelter.

7 POINT SOURCE CRITERIA

Secondary Aluminium smelters should be regarded as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

Emissions from secondary Aluminium operations include fine particles, gaseous chlorine, and selected persistent organic pollutants.

Table 8.1 contains fuel related emission factors for secondary Aluminium 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. Within CORINAIR90 a range for the specific energy consumption of 1.7 up to 3.5 GJ/Mg product has been reported.

Technique related emission factors, mostly given in other units (e.g. g/Mg product, g/m^3), are presented in Tables 8.2 through 8.4 for SO_x, NO_x and NMVOC, respectively. No information exists on the type and efficiency of abatement techniques, but the factors in these tables seem to be valid for emissions from uncontrolled processes.

Table 8.1: Emission factors for secondary Aluminium production (based on CORINAIR)

	Type of fuel		NAPFUE code	Emission factors SO_2 [g/GJ]	NO_x [g/GJ]	NMVOC [g/GJ]	CH_4 [g/GJ]	CO [g/GJ]	CO_2 [kg/GJ]	N_2O [g/GJ]
l	oil	residual	203	143	100	3	5	12	73	10
l	oil	gas	204	1,410	100			12	75	
g	gas	natural	301						87-100	54-58

Table 8.2: Emission factors for SO_2 from secondary Aluminium production.

Process type	Abatement type	Abatement efficiency	Fuel type	Unit	Emission factor	Data Quality Code	Country of origin
Sweating furnace	N/A	N/A	N/A	kg/tonne Al	1.75	E	USA
Smelting Furnace:							
-crucible	N/A	N/A	N/A	kg/tonne Al	1.25	E	USA
-reverberatory	N/A	N/A	N/A	kg/tonne Al	0.45	E	USA
Burning, drying	N/A	N/A	N/A	kg/tonne Al	0.15	E	USA
Heavily contaminated scrap input	N/A	N/A	N/A	kg/tonne Al	0.54	E	USA
Pouring, casting	N/A	N/A	N/A	kg/tonne charged	0.01	E	USA
Process heaters	N/A	N/A	gas oil	kg/m^3 fuel	17.2 x S	E	USA
	N/A	N/A	residual oil	kg/m^3 fuel	19.0 x S	E	USA

N/A = Data not available
S = sulphur content of fuel

Table 8.3: Emission factors for NO_x from secondary aluminium production

Process type	Abatement type	Abatement efficiency	Fuel type	Unit	Emission factor	Data Quality Code	Country or region
Sweating furnace	N/A	N/A	N/A	kg/tonne Al	0.3	E	USA
Smelting furnace							
-crucible	N/A	N/A	N/A	kg/tonne Al	0.85	E	USA
-reverberatory	N/A	N/A	N/A	kg/tonne Al	0.38	E	USA
Burning, drying	N/A	N/A	N/A	kg/tonne Al	0.25	E	USA
Annealing furnace	N/A	N/A	N/A	kg/tonne Al	0.75	E	USA
Pouring, casting	N/A	N/A	N/A	kg/tonne Al	0.005	E	USA
Slab furnace	N/A	N/A	N/A	kg/tonne Al	0.75	E	USA
Can manufacture	N/A	N/A	N/A	kg/tonne Al	0.35	E	USA
Rolling, drawing, extruding	N/A	N/A	N/A	kg/tonne Al	0.35	E	USA
Process heaters	N/A	N/A	gas oil	kg/m^3 fuel	2.4	E	USA
	N/A	N/A	residual oil	kg/m^3 fuel	6.6	E	USA

N/A = Data not available

Table 8.4: Emission factors for NMVOCs from secondary aluminium production

Process type	Abatement type	Abatement efficiency	Fuel type	Unit	Emission factor	Data Quality Code	Country or region
Sweating furnace	N/A	N/A	N/A	kg/tonne Al	1.20	E	USA
Smelting furnace							
-crucible	N/A	N/A	N/A	kg/tonne Al	1.25	E	USA
-reverberatory	N/A	N/A	N/A	kg/tonne Al	0.10	E	USA
Burning, drying	N/A	N/A	N/A	kg/tonne Al	16.00	E	USA
Foil rolling	N/A	N/A	N/A	kg/tonne Al	0.65	E	USA
Foil converting	N/A	N/A	N/A	kg/tonne Al	1.20	E	USA
Annealing furnace	N/A	N/A	N/A	kg/tonne Al	0.002	E	USA
Slab furnace	N/A	N/A	N/A	kg/tonne Al	0.002	E	USA
Pouring, casting	N/A	N/A	N/A	kg/tonne Al	0.07	E	USA
Can manufacture	N/A	N/A	N/A	kg/tonne Al	150.0	E	USA
Rolling, drawing, extruding	N/A	N/A	N/A	kg/tonne Al	0.045	E	USA
Process heaters	N/A	N/A	gas oil	kg/m^3 fuel	0.024	E	USA
	N/A	N/A	residual oil	kg/m^3 fuel	0.034	E	USA
	N/A	N/A	natural gas	kg/m^3 fuel	44.85	E	USA
	N/A	N/A	process gas	kg/m^3 fuel	44.85	E	USA

N/A = Data not available

Fine particle emission factors cited in US EPA (1973) and Economopoulos (1993) are presented in Table 8.5.

Table 8.5. Emission factors for fine particles from secondary aluminium production (US EPA, 1973)

Process type	Abatement type	Abatement efficiency	Fuel type	Unit	Emission factor	Data Quality Code	Country or region
Sweating furnace	Uncontrolled	O	N/A	kg/tonne Al	7.25	D	USA
	Baghouse	N/A	N/A	kg/tonne Al	1.65	D	USA
Smelting furnace							
-crucible	Uncontrolled	O	N/A	kg/tonne Al	0.95	D	USA
-reverberatory	Uncontrolled	O	N/A	kg/tonne Al	2.15	D	USA
	Baghouse	N/A	N/A	kg/tonne Al	0.65	D	USA
	Electrostatic precipitator	N/A	N/A	kg/tonne Al	0.65	D	USA
Chlorination	Uncontrolled	O	N/A	kg/tonne chlorine used	500.0	D	USA
	Baghouse	N/A	N/A	kg/tonne chlorine used	25.0	D	USA

N/A = Data not available

Hexachloroethane has been used in the secondary Aluminium industry and in Aluminium foundries in the form of tablets for degassing purposes in refining operations, resulting in hexachlorobenzene (HCB) emissions. An emission factor of 5 g HCB/ tonne Aluminium produced has been reported (in PARCOM, 1992).

Concentrations of dioxins and furans in the flue gas passing the control equipment in the secondary Aluminium production are presented in Table 8.6 after a compilation of data by the Working Group of the Subcommittee on Air/Technology of the Federal Government /Federal States Emission Control Committee in Germany (Umweltbundesamt, 1996).

Table 8.6: Concentrations of dioxins and furans in the flue gas after passing the control devices, in ng TEQ/m^{3} *1

Process	Emission Control Device	PCDD/F Concentration	Data Quality Code
Drum furnace with convertors	Hydrated lime fabric filters	0.1 - 13.7	D
Hearth trough kiln	Hydrated lime fabric filter	0.01 - 0.7	D
Smelting and casting furnace	No treatment	0.06 - 0.09	D
Induction furnace	Fabric filters	0.01 - 0.3	D
Al smelting plant	Fabric filters	0.02 - 0.23	D

*1 TEQ = toxic equivalency factor established by NATO/CCMS

In general, concentrations of dioxins and furans in the flue gas after the control device vary substantially due to differences in operational processes employed.

Secondary Aluminium Also generates so called climate gases, including CF_4, C_2F_6, and SF_6. A temporal increase of about 2% per year in CF_4 has been measured in the global atmosphere (in Stordal and Myhre, 1991). The current concentration of SF_6 in the atmosphere is 1 to 2 ppt, and the rate of increase has recently been estimated to be 7.4 % per year in the period from 1979 to 1989 (Rinsland et Al., 1990). However, no data are available to the authors of this chapter regarding emission factors of these gases for the secondary Aluminium production.

9 SPECIES PROFILES

Not applicable.

10 UNCERTAINTY ESTIMATES

It is rather difficult to assess current uncertainties of emission estimates for pollutants emitted during the secondary Aluminium production. The uncertainties of SO2 emission estimates can be assessed in a similar way as the uncertainties of the estimates for the fossil fuel combustion (see chapter B 111).

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Improvement of emission factors is necessary in order to obtain more accurate emission estimates for the secondary aluminium production. This improvement should focus on preparing individual emission factors for major production techniques, currently employed in the secondary aluminium industry. In this way, a detailed approach methodology for emission estimates can be applied. Obviously, it will be necessary to obtain relevant statistical data on the production of aluminium in various secondary melting furnaces.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

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

13 TEMPORAL DISAGGREGATION CRITERIA

The secondary Aluminium production is a continuous process. No temporal disaggregation is needed.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

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.

16 VERIFICATION PROCEDURES

Estimated emission factors could be best verified by measurements at plants using different industrial technologies.

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18 BIBLIOGRAPHY

For a detailed bibliography the primary literature mentioned in AP42 or the PARCOM-ATMOS Manual can be used.

19 RELEASE VERSION, DATE AND SOURCE

Version : 2.2

Date : November 1997

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