

7.9 Non ferrous metal processing industry¹

Aluminium

7.9.1 Coverage

Aluminium industry is the largest non ferrous metal industry. This chapter covers primary and secondary aluminium production.

7.9.2 Emission sources

Aluminium production is divided into 2 types of production, the primary production and the secondary production.

In **primary production**, alumina is the raw material used to produce aluminium. Alumina is produced from the bauxite, extracted from mines. Caustic soda is used to extract alumina from bauxite, using a standard process at high temperature and pressure. Aluminium is then produced by electrolytic reduction of alumina. During this process the exhaust gases are collected and treated by a dry alumina scrubber and dust treatment system such as ESP or bag filters. Further abatement systems might be considered on a case-by-case basis.

The obtained aluminium is then refined to remove impurities by injection of gas in the molten metal. The choice of the gas depends on the type of impurities. These processes are sources of dust, SO₂ and NO_x emissions. [1].

In **secondary production**, aluminium comes from scraps. These scraps can be pre-treated (swarf drying or thermal de-coating) before being processed to produce aluminium.

Different furnaces, mainly rotary or reverberatory furnaces can be used to melt the raw material. Natural gas, which does not contain sulphur, is the fuel most commonly used. The obtained aluminium is then refined in a holding furnace as in the primary aluminium production. These processes are sources of dust, SO₂ and NO_x emissions. [1].

7.9.3 BAT, Associated Emission Levels (AEL)

If not stated otherwise, emission levels given in this section are given as daily average based on continuous monitoring and standard conditions of 273 K, 101.3 kPa, measured oxygen content and dry gas without dilution of the gases with air.

SO₂:

In primary aluminium production, SO₂ emissions are influenced by the sulphur content of the anodes used during the electrolytic reduction. In secondary production, and in the production of carbone anodes for the Prebake primary production, the possible source of SO₂ emissions is the sulphur content of the fuel used. SO₂ emissions do not generally cause the greatest concern during the aluminium production process, however this has to be considered on a case-by-case basis, depending on the local and environmental conditions.

In primary aluminium production, BAT to reduce SO₂ emissions is to limit sulphur content fuel and anodes, subject to their market availability. For secondary aluminium production, wet or semi-dry alkaline scrubbers are considered BAT to reduce SO₂ emissions from the holding and degassing of molten metal process, material pretreatment process, and melting and smelting processes.

The applicability of SO₂ abatement systems has to be assessed on a case-by-case basis, taking into account the technical characteristics of the plant, the geographical location and the local conditions, with particular reference to possible cross-media effects

¹ The informations included in subchapter are based on the NFM BREF, which is currently under revision.

Table 1: Associated SO₂ emission levels with BAT to reduce emissions in aluminium industry.^{a/}
[1] [10]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
Holding and degassing of molten metal in primary and secondary aluminium production	wet or semi-dry alkaline scrubber (if needed)	< 50 – 200
Materials pre-treatment, melting and smelting in secondary aluminium production		< 50 – 100
Grinding, mixing and baking stages (if sulphur is added to the blend or the fuel contains high %S) [1]		< 50 - 200

a/ The information included in Tab. 1 is currently under discussion in the context of the NFM BREF revision, whose conclusion is anticipated in Q1 2010. It would be advisable not to include this table to avoid possible confusion once the new NFM BREF is adopted or, at least, to clarify that this information, including BAT-AELs, is under revision.

NO_x:

In aluminium production NO_x emissions come from the combustion processes used to melt the raw materials. Emissions are influenced by different parameters: the type of fuel, the type of combustion, the combustion air-ratio and the flame temperature. Oxy-fuel burner and low NO_x burners are the measures considered BAT to reduce NO_x emission in aluminium production. [1].

The following table gives an overview of achievable NO_x emission levels in aluminium production.

Table 2: Associated NO_x emission levels with BAT to reduce emissions in aluminium industry.
[1]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
furnaces from primary and secondary aluminium and swarf drying	Low NO _x burner Oxy-fuel burner	< 100 < 100 - 300

Dust:

In primary aluminium production, dust emissions come mainly from alumina production process, electrolysis, smelting and casting processes.

Flue gases from production of alumina need to be collected and a fabric filter or ESP can be used to remove calcined alumina and dust. Collected gases from other processes need to be dedusted. A fabric filter can be used. A wet scrubber can also be used depending on local conditions. [6]

In secondary aluminium production, pre-treatment, secondary smelting and holding are sources of dust emissions. Ceramic or fabric filters can be used to remove dust from the collected gases of secondary smelting process. For the other processes, flue gases need to be collected and can be filtered using a fabric filter when it is needed. [1].

The collected dust from the filters has to be reused when it is possible.

The material reception, handling and storage are sources of fugitive dust emissions. These emissions have to be minimized by a good handling and protections from the wind of raw material.

The following table gives an overview of achievable dust emission levels in aluminium production. [3]

The preferred technique for dust abatement is the use of a fabric filter or a ceramic filter.

Table 3: Associated dust emission levels with BAT to reduce emissions in aluminium industry.
[1] [4]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
Electrolysis, Pre-treatment	Fabric filter	Dust: 1 – 5
Primary & secondary smelting	Ceramic or fabric filter	

Copper

7.9.4 Coverage

Copper is largely used for its very high thermal and electrical conductivity, its relative resistance to corrosion and its easiness to be recycled. This category covers copper production from primary and secondary processing.

7.9.5 Emission sources

Copper production is divided into 2 productions, the primary production and the secondary production.

Primary production

The concentrates used to produce primary copper are mainly sulphides and contain other metal than copper. Therefore several processes are used to separate the different compounds and recover them as far as possible. Due to the composition of the concentrates (sulphides), SO₂ emission level is high during these processes.

2 methods are used to produce primary copper: pyrometallurgical and hydrometallurgical processes.

The **pyrometallurgical process** is made of several steps: roasting, smelting, converting, refining and electro-refining.

The roasting is a major source of SO₂ emissions. During the roasting, the sulphides are heated to become sulphur. The flue gases need then to be desulphurized; they are usually directed to on-site acid plants to produce sulphuric acid or liquid SO₂.

The smelting step enables the separation between copper sulphides from other compounds contained in the ore. Roasting and smelting steps are realised in a unique furnace at high temperatures enabling the separation between the matte mainly containing copper sulphides and the slag mainly containing iron sulphides. [1].

The converting steps consist in injecting air and oxygen in the matte formerly obtained during the smelting step. The converting processes can be batch, the most used, or continuous. During these processes, SO₂ emissions are also relevant.

The copper needs then to be refined; a fire refining process is first applied. During the fire refining process, air is injected to the smelting metal so as to oxidize the impurities and remove the last traces of sulphur. A small reducing agent can be added but it increases NO_x emissions.

The electro-refining process takes place in an electrolytic cell using a cast copper anode and a cathode. The cell is placed in an electrolyte containing copper sulphate and sulphuric acid.

The hydrometallurgical process is mainly applied to oxide ores, oxide/sulphide ores or ores hard to concentrate. The ores are first crushed and then leached by sulphuric acid. The liquor produced during the leaching is then clarified, purified and concentrated using a solvent extraction. Copper is finally removed by electro-winning. It only differs from electro-refining in the anode form. [1].

Secondary production

The secondary copper is produced using pyrometallurgical processes. The steps of these processes depend on the copper content of the secondary feed material. It can contain other organic material like coatings. Therefore, secondary smelting and secondary refining are designed depending on the feed material. [1].

7.9.6 BAT, Associated Emission Levels (AEL)

If not stated otherwise, emission levels given in this section are given as daily average based on continuous monitoring and standard conditions of 273 K, 101.3 kPa, measured oxygen content and dry gas without dilution of the gases with air.

SO₂:

In copper production, SO₂ emissions cause the greatest concern. Sulphur comes mainly from the ores used to produce copper. Hence SO₂ emissions are more concerning during primary production than during secondary production. Roasting, smelting and converting are the major sources of sulphur dioxide. SO₂ comes from the copper sulphides used to produce copper. The roasting and smelting steps are realised in the same furnace. It needs to be sealed to enable a better collection of the gases. Oxygen enrichment is used to produce high sulphur dioxide concentration. It enables the reduction of the flue gas volumes. Sulphuric acid plants are used to convert these gases.

The converting process is also a source of SO₂ emissions, but the gas collection is not totally efficient when using batch processes, due to the variation of sulphur dioxide concentration. Then SO₂ removal systems need to be designed consequently. [1].

The sulphur dioxide emissions from the roasting, smelting and converting process are removed from the flue gases using a sulphuric acid plant.

The following table gives an overview of achievable SO₂ emissions levels in copper production.

Table 4: Associated SO₂ emission levels with BAT to reduce emissions in copper industry. [1] [11]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
<i>SO₂-rich off-stream gas (> 5 %)</i> Primary roasting, smelting and converting	Double contact sulphuric acid plant	99.7 – 99.92 % (conversion factor)
Secondary smelting and converting, primary and secondary fire-refining, electric slag cleaning and melting.	Alkali semi-dry scrubber and fabric filter. Wet alkali or double alkali scrubbers using lime, magnesium hydroxide, sodium hydroxide. Combinations of sodium or alumina/aluminium sulphate in combination with lime to regenerate the reagent and form gypsum	< 50 – 200
Secondary fume collection systems and drying processes	Fabric filter with dry lime injection into a cool gas	< 500
	Alkaline wet scrubber for SO ₂ collection from hot gases (from dryer gases after dust removal)	< 50 – 200

NO_x:

In copper production, the use of oxygen and the high temperature processes are responsible for NO_x emissions. During the primary production, nitrogen oxides are mainly absorbed in the sulphuric acid produced. Thus NO_x emissions are not a major issue. BAT to reduce these emissions are the use of oxy-fuel burners and low NO_x burners. [1].

The following table gives an overview of achievable NO_x emissions levels in copper production. [1]

Table 5: Associated NO_x emission levels with BAT to reduce emissions in copper industry.

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
primary and secondary copper production	Low NO _x burner Oxy-fuel burner	< 100 < 100 - 300

Dust:

In copper production, smelting, converting and refining processes are major sources of dust emissions. In these production processes, flue gases are collected, cooled and filtered using ESP and fabric filters to control dust emissions and volatile metals contained in dust. [1], [2].

The following table gives an overview of achievable dust emissions levels in copper production. The preferred technique for dust abatement is the use of a fabric filter or a ceramic filter. Electrostatic precipitators should be used for gases containing too much moist, for hot gases, or when the dust is too sticky. Scrubbers should be used as the temperature or the nature of the gases precludes the use of other techniques, or when gases or acids have to be removed simultaneously with dust.

Table 6: Associated dust emission levels with BAT to reduce emissions in copper industry. [1] [3]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
Smelting, converting and refining processes	Fabric filters ESP Scrubbers	Dust: 1 – 5

Lead and Zinc

7.9.7 Coverage

This category covers both lead and zinc production, from primary and secondary production. These metals are often associated together in ores and concentrates. As it is in the other non ferrous metal processing industry, SO₂ and dust emissions are the more concerning. However NO_x emission reductions are also detailed in this category.

7.9.8 Emission sources

As for copper or aluminium production, lead and zinc can be produced from primary or secondary processes.

There are 2 **primary lead** production processes: the sintering/smelting process and the direct smelting process. Primary zinc process is on the wane as a production method. [6], [8]

The **Sintering/smelting** process involves of the agglomeration of lead and zinc concentrates, recycled sinter fines, secondary materials and other process materials.

The agglomeration product is then crushed, screened and charged into an Imperial Smelting Furnace where the smelting process takes place. Lead is directly recovered from this furnace as by product and then refined. A mixing of zinc and lead is also recovered. Zinc needs to be separated from lead before being refined. [1].

The separation of zinc from lead takes place in a splash condenser in which a molten lead shower enables the lead absorption. The resulting alloy is then cooled and zinc is recovered floating on the surface. It is then refined.

In the **direct smelting** process, lead concentrates and other material are directly charged into the furnace, melted and oxidised before being refined.

Secondary lead is produced from recycled lead wastes and scraps. Battery is a major source of lead. Batteries can be crushed and separated into different fractions before going to the furnace. The lead recovery process from automotive batteries starts with the drainage of the acid of the batteries before further processing.[10]

Lead contained in other material can be recovered using simple smelting processes. [1].

There are 2 refining process for lead: the **electrolytic refining** and the **pyrometallurgical refining**.

The electrolytic refining is a high cost process, hence it is used where electricity is cheap (e.g. hydroelectricity).

During the pyrometallurgical refining cells are heated, it enables the removal of the impurities. First copper is removed by mechanical skimming, then arsenic, antimony and tin are removed by oxidation associated with mechanical skimming. [1].

The primary zinc obtained during the primary lead production is refined using a **distillation process**. It enables during a first step the separation of zinc and cadmium from lead and during a second step the separation of zinc from cadmium is realised. Finally zinc is treated with sodium to remove arsenic and antimony.

In Europe, primary zinc is marginally produced from the primary lead process (~5%), it is essentially produced from **hydrometallurgical process**. This process is used principally for treating zinc sulphides, but also oxides, carbonates or silicates. It involves first the roasting of materials in fluidised bed roasters, which produces sulphur dioxide and a calcine (zinc oxide). The Zinc calcine is then cooled and leached by sulphuric acid. This process is similar to the copper hydrometallurgical process. The Zinc solution obtained is then purified, refined and sent to the cellhouse. Here zinc is extracted by means electrowinning. [6]

Secondary zinc production, when treating metallic scrap, consists in physical separation, melting and other high temperature treatment. [1]. End-of-life galvanized products are recycled for steel recovery and zinc oxide reports to fumes (Electric Arc Furnace (EAF)-dust) that are further treated pyrometallurgically (Waelz kilns or other furnaces) to recover a 'Zinc oxide'-rich fraction that is further processed for zinc or zinc oxide recovery. [6]

7.9.9 BAT, Associated Emission Levels (AEL)

If not stated otherwise, emission levels given in this section are given as daily average based on continuous monitoring and standard conditions of 273 K, 101.3 kPa, measured oxygen content and dry gas without dilution of the gases with air.

SO₂:

During lead and zinc production process, the sulphur contained in materials is oxidised and sulphur dioxide is emitted. Flue gases need then to be desulphurized. Sulphuric acid plants can be used, where there is no pre-treatment of sulphur compounds, to convert these gases. Depending on the flue gas SO₂ content, a single or double contact sulphuric acid plant is considered as BAT to reduce emission levels. Emissions from refining, material pre-treatment and secondary smelting are reduced with SO₂ scrubber. Wet alkaline scrubber or Alkali semi-dry scrubber and fabric filter is considered BAT. [1].

For secondary lead plants furnace feed materials can be desulphurized before smelting to reduce SO₂ emissions and enable the plant to meet its emission limits. [6]

The following table gives an overview of achievable SO₂ emissions levels in zinc and lead production.

Table 7: Associated SO₂ emission levels with BAT to reduce emissions in lead and zinc industry. [1] [11]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
<i>Low SO₂ off-stream gas (< 5 %)</i> Primary roasting, smelting and sintering	Single contact sulphuric acid plant or wet gas sulphuric acid plant.	> 99.1 % (conversion factor)
<i>SO₂-rich off-stream gas (> 5 %)</i> Primary roasting, smelting and sintering	Double contact sulphuric acid plant	99.7 – 99.92 % (conversion factor)
Pre-treatment, secondary smelting, thermal refining, melting secondary zinc processes and slag fuming [9]	Wet alkali scrubbers Alkali semi-dry scrubber and fabric filter.	< 50-200

NO_x:

In zinc and lead production, the roasting and the smelting processes are the main sources of NO_x emissions. Nitrogen oxides are mainly absorbed in the sulphuric acid produced during the primary roasting, smelting and sintering flue gas treatment. Thus NO_x emissions are not a major issue. BAT to reduce NO_x emissions at other process steps are the use of oxy-fuel burners and low NO_x burners. [1].

The following table gives an overview of achievable NO_x emissions levels in zinc and lead production.

Table 8: Associated NO_x emission levels with BAT to reduce emissions in lead and zinc industry. [1]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
Lead and zinc production	Low NO _x burner Oxy-fuel burner	< 100 < 100 - 300

Dust:

The roasting and smelting processes are the major point sources of dust emissions for lead and zinc industry. The gases need to be collected and treated to reduce dust emission levels. In these production processes, flue gases are collected, cooled and filtered using ESP and fabric filters to control dust emissions and volatile metals contained in dust. [1]. The preferred technique for dust abatement is the use of a fabric filter or a ceramic filter. Electrostatic precipitators should be used for gases containing too much moist, for hot gases, or when the dust is too sticky. Scrubbers should be used as the temperature or the nature of the gases precludes the use of other techniques, or when gases or acids have to be removed simultaneously with dust.

Emissions associated with the use of BAT to reduce dust emissions are presented in the following table.

Table 9: Associated dust emission levels with BAT to reduce emissions in lead and zinc industry. [1] [5]

Emission source	Techniques	Associated emission level with BAT (mg/Nm ³)
Roasting and smelting	Fabric filters ESP	Dust: 1 – 5

7.9.10 Emerging techniques

There is no emerging technique available in the Nitric acid production to reduce NO_x emissions. [1]

7.9.11 References used in chapter 7.9

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