Category		Title
NFR	2.C.7.b	Nickel production
SNAP	040305	Nickel production (except 030324)
ISIC	2720	Manufacture of basic precious and non-ferrous metals
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Contents

1 Overview

Nickel is produced from oxidic (laterite and saprolite) or sulphidic ore. About 60% of nickel comes from sulphide deposits and 40% from oxide deposits. There are several variations in the processes used to produce nickel from these ores and these variations are dependent on the grade of the concentrate and also on the other metals that are present in the material.

Emissions from combustion in the metal production process are to be reported under source category 1.A.2.b (Combustion in Non-Ferrous Metal Production). However, the present version of the Guidebook also provides default emission factors for process-related emissions from source category 2.C.7.b Nickel production, based on referenced or non-referenced literature values or, if no literature is available, expert judgement.
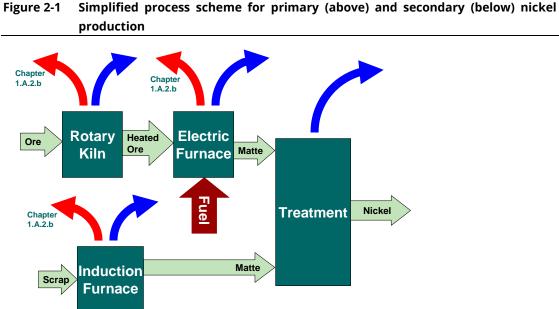
The present chapter provides a very simple process description and a Tier 1 approach to estimate emissions from source category 2.C.7.b.
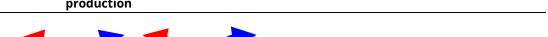
2 Description of sources

2.1 Process description

In the production of nickel, primary and secondary nickel production can be distinguished. Primary nickel production uses sulphidic or oxide ore, while secondary nickel production uses scrap as input. However, in many cases scrap containing nickel is used to produce stainless steel at ferrous industry plants instead of pure nickel production.

The various steps in the process of nickel production are illustrated in **Error! Reference source not found.**. More information on the different techniques used for the production of nickel (Ni) can be found in the Best Available Techniques Reference (BREF) and revised BREF documents on non-ferrous metal industries (European Commission, 2001; 2014).

Figure 2-1   Simplified process scheme for primary (above) and secondary (below) nickel production

The energy consumed for the production of matte from sulphidic ores is reported to be in the range of 25–65 GJ per tonne of nickel for ores containing 4–15 % Ni. The energy consumed in the various refining stages is reported to be 17–20 GJ per tonne of nickel.

2.2 Techniques

This document does not identify different techniques in the nickel production process.

2.3 Emissions and controls

The potential emissions of concern to air from nickel production are:

- sulphur oxide (SO_X) and other acid gases;
- oxides of nitrogen (NO_X) and other nitrogen compounds;
- metals and their compounds including As;
- dust;
- chlorine;
- VOCs and odours;
- CO and carbonyls (alarm levels set at 80 parts per billion).

The major sources of sulphur dioxide emissions are diffuse emissions from the roaster or smelter. Uncaptured emissions from the ladle transfer and blowing stages of the converter and direct emissions from the sulphuric acid plant are also significant. Good extraction and sealing of the furnaces prevents diffuse emissions and the collected gases are passed to a gas-cleaning plant and then to the sulphuric acid plant.

Dust carry-over from the roasting, smelting and converting processes are potential sources of direct and diffuse emissions of dust and metals. In some processes, the gases are collected and treated in scrubbers and fabric filters or in the gas-cleaning processes of a sulphuric acid plant. Dust is removed and returned to the leaching process. Fabric filters and scrubbers are used to remove dust and large particles.

More information on emissions and control techniques used in nickel production can be found in the revised BREF on non-ferrous metal industries (European Commission, 2014).

As part of the 2015 Guidebook review, selected Tier 1 and/or Tier 2 PM emission factors have been reviewed to identify if the data represent filterable or total (filterable and condensable) 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, PM_{10} and $PM_{2.5}$) represent total PM, filterable PM or whether the basis of the emission factor cannot be determined (see individual emission factor tables).

3 Methods

3.1 Choice of method

This subsection provides default emission factors for this source category. Since it is only a minor source of emissions and not a key category, only Tier 1 default emission factors are provided for this source category and the decision tree has been omitted. However, facility data may be used if they meet the criteria for quality as explained in the guidance chapter on QA/QC in Part A of the Guidebook.

3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \qquad (1)$$

where:

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

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

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

The Tier 1 emission factors assume an 'averaged' or typical technology and abatement implementation in the country and integrate all sub-processes.

3.2.2 Default emission factors

Default emission factors are provided in **Error! Reference source not found.**. Emissions of nitrogen oxides (NO_x) and carbon monoxide (CO) are assumed to be mainly due to combustion activities and are thus addressed in source category 1.A.2.b Combustion in Non-Ferrous Metal Production. Emitted sulphur oxides (SO_x) are to a large extent from the ore and therefore are described in the present chapter (and not in the related combustion chapter 1.A.2.b (Combustion in Non-Ferrous Metal Production)).

Besides the emissions presented, fugitive emissions can also occur. However, these are only important if ventilation gases are not collected and treated (European Commission, 2014).

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

Table 3-1   Tier 1 emission factors for source category 2.C.7.b Nickel production

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.C.7.b	Nickel production			
Fuel	NA				
Not applicable	HCH, PCB Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCP, SCCP				
Not estimated	NOx, CO, NMVOC, NH3, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Se, Zn, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
SOx	18	kg/Mg nickel produced	9	36	European Commission (2014)
TSP	0.3	kg/Mg nickel produced	0.15	0.6	European Commission (2014)
Ni	0.025	kg/Mg nickel produced	0.013	0.05	European Commission (2014)

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

3.2.3   Activity data

A lot of information on production statistics (for various source categories) is available from United Nations statistical yearbooks or national statistics.

Further guidance might also be provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

3.3   Tier 2 technology-specific approach

No Tier 2 technology-specific emission factors are provided here. For nickel production, the suggested approach for applying a Tier 2 method is therefore the same as the Tier 1 approach.

3.4   Tier 3 emission modelling and use of facility data

3.4.1   Algorithm

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

• detailed modelling of the nickel 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 of nickel.

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

If facility-level data cover all nickel production in the country, it is good practice to compare the implied emission factors (reported emissions divided by the national nickel 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 nickel 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:

$$E_{Total,pollutant} = \sum_{Facilities} E_{Facility,pollutant} + \left(National\ Production - \sum_{Facilities} Production_{Facility} \right) \times EF \qquad (2)$$

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 nickel 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:

$$EF = \left. \sum_{Facilities} E_{Facility,pollutant} \middle/ \sum_{Facilities} Production_{Facility} \right. \qquad (3)$$

- 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

Nickel production plants can be major industrial facilities and emission 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 nickel 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 nickel industry. Such models however could be developed 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 PRTR 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 on 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.7.b 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.7.b 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 nickel 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.

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 s specific technology
AR $_{production, technology}$	The production rate within the source category, using s specific technology
AR$_{production}$	The activity rate for the nickel 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

European Commission, 2001. Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques (BREF) in the Non-Ferrous Metal Industries, December 2001, (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.

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.