SNAP CODE: **040206**

SOURCE ACTIVITY TITLE: **PROCESSES IN IRON & STEEL INDUSTRIES & COLLERIES**
Basic Oxygen Furnace Steel Plant

NOSE CODE: **105.12.06**

NFR CODE: **2 C 1**

ISIC: **2410**

1 ACTIVITIES INCLUDED

The basic oxygen furnace is a part of the production process of primary iron and steel.

2 CONTRIBUTION TO TOTAL EMISSIONS

The emissions from the basic oxygen process are part of the primary iron and steel production.

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

Source-activity	SNAP-code	Contribution to total emissions [%]										
Basic Oxygen Furnace Steel Plant	040206	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP*	PM_{10}*	$PM_{2.5}$*
Typical contribution		0.2	0	0	-	1.5	0	-	-	1.05	2.16	3.69
Highest value										2.86	5.65	11.53
Lowest value										0.141	0.254	0.404

* contribution to total national emissions, excluding agricultural soils, EU $PM_{2.5}$ Inventory project for EU25 for the year 2000 (TNO, 2006)
0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
\- = no emissions are reported

However, this chapter currently addresses only heavy metal and PM emissions.

3 GENERAL

3.1 Description

Pig iron contains 4 - 4.5 weight % carbon. In its solid state pig iron is hard and brittle, and rolling or forging is impossible. This can only be done by lowering the carbon content to below 1.9 weight %. This is the steel production process.

The first step in the conversion of iron steel is the removal of carbon.

This is feasible thanks to the strong attraction between carbon and oxygen. In the blast furnace process, the carbon released from the coke breaks the iron/oxygen bond in the ore by binding itself to CO and CO_2.

In the steel making process, the opposite occurs, the oxygen causing the carbon to leave the iron. It disappears from the converter in the form of carbon monoxide gas.

The oxygen-blown steel making process takes place in a pear-shaped vessel called a converter. This has a refractory lining and is mounted in such a manner that it can be tilted. Inside iron is turned into steel by blowing almost pure oxygen on to the surface of the molten metal, causing undesirable substances to be combusted. The refining process can be enhanced, where necessary, by “bottom stirring” with argon gas by porous bricks in the bottom lining in certain phases of the process. This produces a more intensive circulation of the molten steel and an improved reaction between the gas and the molten metal. The oxidation (combustion) of the various elements which escape from the bath is accompanied by the release of a great deal of heat. In many cases steel scrap is added at a rate of 10% - 20% to cool the metal. The gas, which is rich in carbon monoxide, is removed and used as a fuel.

A complete cycle consists of the following phases: charging scrap and molten iron, blowing, sampling and temperature recording, and tapping. In a modern steelwork, 300 tonnes of steel are produced in a 30 minute cycle.

At the end of the refining process the ladle filled with molten steel is conveyed to the continuous casting machine. Continuous casting, in which billets or slabs are cast direct from molten metal, replaces the traditional method of pouring molten steel into moulds to produce ingots which, when solidified, are reheated and rolled into slabs or billets.

Continuous casting not only saves time and energy, but also improves the quality of the steel and increases the yield.

3.2 Definitions

Primary dust removal	Oxygen blowing with a vertical converter
Secondary dust removal	Oxygen blowing with a tilted converter during loading and tapping

Unabated emissions	Emissions from roof ventilation with a tilted converter with no secondary dust removal
Refractory lining	Fire-resistant coating of the converter. The coating contains tar.

3.3 Emissions

The primary dust abatement produces in addition to CO and CO_2 mainly dust emissions. When the converter is provided with a fire resistant coating, this coating has to be preheated, producing PAH containing aromatic hydrocarbons. The amount of PAH is usually below the detection limit of the measuring technique. The dust contains a small amount of heavy metals. The secondary dust abatement produces dust with a higher heavy metal content than the primary dust. The same applies to the unabated dust emissions from ventilation through the roof.

The main part of the dust emissions consists of particles with a size smaller then 10 micron. For the dust emitted through the roof this is more than 50 %.

3.4 Controls

Primary dust abatement consists of a vapour cooler for separation of coarse dust and a washer for fine dust abatement. The secondary dust abatement is usually a fabric filter.

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. 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

[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.

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:

Emission = AR x 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

The detailed methodology (equivalent to Tier 3), to estimate emissions of gaseous pollutants from the steel 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.

For a local situation, the best approach would be to use extensive measurements, including the effects of abatement approaches. Reference emission factors for comparison with User's own estimates, are provided for selected pollutant releases, in Section 8.2

6 RELEVANT ACTIVITY STATISTICS

Information on the production of steel, 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 steel produced by various types of industrial technologies employed in the iron and steel 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

Primary iron and steel industry with a capacity above 3 million tonnes per year should be considered as a point source.

8 EMISSION FACTORS

8.1 Default Emission Factors For Use With Simpler Methodology

Table 8.1: Default Emission Factors (abatement type unknown/not specified)

Compound	Emission factor (g/Mg)	Compound	Emission factor (g/Mg)
Arsenic	0.015	Lead	1.5
Cadmium	0.025	Selenium	0.003
Chromium	0.1	Zinc	4
Copper	0.1	Dust	-
Mercury	0.003		
Nickel	0.05		

8.2 Reference Emission Factors For Use With Detailed Methodology

The data provided in Table 8.2 are based on a combination of six sources with abatement and two without abatement. The combination of this information is related to total production.

Table 8.2: Emission factors for dust and heavy metals from basic oxygen furnace production as reported by several countries/authors (in g/Mg)

Compound	Germany [1]	Netherlands		France [4]	Pacyna [5]	Sweden [6,7]		Poland [8]
abatement	partially abated	wet scrubbers fabric filters [2]	partially abated [3]	unknown	unknown	wet scrubbers	fabric filters	abated
Arsenic	0.0040	0.02	0.0001	0.02	-	-	-	
Cadmium	0.031	0.003	0.024	0.002-0.05	0.02	0.04	0.04	
Chromium	0.50	0.04	0.011	0.07	-	-	0.026	0.04-0.07
Copper	0.13	0.04	0.010	0.25	-	-	0.066	0.01-0.04
Mercury	-	0.004	0.002	-	-	0.001	0.00033	
Nickel	0.09	-	-	0.05	-	-	0.024	
Lead	1.30	2.3	1.08	0.9	1.6	4	4.6	0.08-0.14
Selenium	-	-	-	-	-	-	-	
Zinc	3.3	4.1	2.7	4.1	3.9	6	6.4	0.4-0.8
Dust	-	100	53	-	-	-	-	

- unknown

Table 8.3 lists emission factors for particulate matter (TSP, PM_{10} and $PM_{2.5}$) for different types of oxygen blow steel furnaces, derived from CEPMEIP (9).

Table 8.3 Emission factors for dust and heavy metals from basic oxygen furnace production as reported by several countries/authors (in kg/ton oxygen steel)

Technology	**Abatement**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Uncertainty**
Conventional installation of average age	Primary dedusting by ESP, wet scrubbing; limited capturing of secondary dust emission	0.35	0.3325	0.315	2
Modern plant (BAT)	High efficiency ESP or added fabric filter to control primary sources; extensive secondary dedusting using fabric filters	0.12	0.12	0.12	5
Older plant	Primary dedusting by scrubber with removal efficiency around 97%; limited capturing of secondary dust emission	0.6	0.57	0.54	2

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 $PM_{2.5}$ from a conventional plant is 2. The emission factor with uncertainty range will therefore be 0.315 gram per tonne steel with an uncertainty range of 0.158 (0.315 / 2) to 0.630 (0.315 x 2).

9 SPECIES PROFILES

Information about the profile of the used ores might provide extra information. Generalised ore profiles are not relevant.

10 UNCERTAINTY ESTIMATES

The uncertainty in the emission factors may be estimated at about 50 %

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect in the methodology is the lack of sufficient information in relation to details of the processes used.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Not relevant if considered as point source.

13 TEMPORAL DISAGGREGATION CRITERIA

Although the different processes are discontinuous, steel production as such is a continuous process. Therefore for most purposes no temporal disaggregation is necessary.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

Environmental Protection Agency. Compilation of air pollutant emission factors AP-42
PARCOM-ATMOS Emission Factors Manual

16 VERIFICATION PROCEDURES

Verification of the heavy metal emissions by comparing with the profile of the ore could be useful.

17 REFERENCES

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18 BIBLIOGRAPHY

No additional bibliography.

19 RELEASE VERSION, DATE AND SOURCE

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TNO
The Netherlands

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Tinus Pulles and Wilfred Appelman
TNO
The Netherlands
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20 POINT OF ENQUIRY

Any comments on this chapter or enquiries should be directed to:

Pieter van der Most

HIMH-MI-Netherlands
Inspectorate for the Environment
Dept for Monitoring and Information Management
PO Box 30945
2500 GX Den Haag
The Netherlands

Tel: +31 70 339 4606
Fax: +31 70 339 1988
Email: pieter.vandermost@minvrom.nl