SNAP CODE: **040202**

SOURCE ACTIVITY TITLE: **PROCESSES IN IRON & STEEL INDUSTRIES & COLLIERIES**
Blast Furnace Charging

NOSE CODE: **105.12.02**

NFR CODE: **2 C 1**

ISIC: **2410**

1 ACTIVITIES INCLUDED

The charging of iron smelters is part of the production process for primary iron and steel.

2 CONTRIBUTION TO TOTAL EMISSIONS.

Blast furnace charging is a potential source of heavy metal emissions. The contribution to total emissions indicated in Table 2.2 refers to blast furnace operation in general. Information concerning the contribution of blast furnace charging is currently not available.

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

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**										
Blast Furnace Charging	040202	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	0	0.7	0.1	-	-	0.092	0.171	0.201
Highest value										0.235	0.413	0.444
Lowest Value										0.005	0.012	0.020

* for total blast furnace process (cowpers, charging and tapping), 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

Table 2.2: Contribution to total heavy metal emissions of the OSPARCOM-HELCOM-UN/ECE inventory for 1990 (up to 38 countries)

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**							
		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Blast Furnace	040202	2.7	0.5	1.7	2.7	0.8	0.4	1.9	8.6

3 GENERAL

3.1 Description

In general, the blast furnace process can be subdivided into the following process steps:

- air heating (hot blast stove);
- blast furnace;
- tapping (casting bay);
- slag processing.

The *blast furnace* is a shaft furnace for producing pig iron from iron-containing raw materials, as iron sinter, pellets, and lump ore. The burden of the blast furnace, consisting of iron-containing raw materials and additives (Möller mixture), is fed alternately with coke through the top of the furnace in layers. For the production of a tonne of pig iron, 300-400 kg coke, and 1550-1600 kg of ore are needed. Air, heated up to 1,300°C, is blown through tuyeres into the lower part of the furnace. The combustion of the coke provides both the carbon monoxide (CO) needed for the reduction of iron oxide into iron and the additional heat needed to melt the iron and impurities. Auxiliary fuels such as fine coal, heavy oil, plastic waste and others may also be injected through the tuyeres. As the burden moves downward through the furnace, it is heated by the countercurrent upward flow of gases, that exit at the top of the furnace (Rentz et al., 1996).

The smelter is toploaded and works with an excess pressure of up to 2.5 bar depending on the type of furnace. To render possible energy recuperation, a dedusting of the top gas is necessary. With back-pressure furnaces the top gas is used in back-pressure turbines for power generation. The dedusted top gas is used as fuel for various applications in the iron and steel mill.

3.2 Definitions

Möller mixture — The complete package of basic materials for one smelter charge. A charge consists of a number of carriage loadings that are emptied into the smelter according to a specified scheme.

Pressure equalisation — The equalisation of pressure in the vapour lock at the blast furnace top with atmospheric pressure.

3.3 Techniques

The main techniques have been specified above in Section 3.1

3.4 Emissions

In the pressure equalisation stage some emissions of blast furnace top gas containing carbon monoxide, carbon dioxide, hydrogen, and hydrogen sulphide occur. The charging of the smelters produces a certain amount of dust during a short period of time. For CIS counties a dust content of 400 g/m^3 in the exhaust gas from the inter-cone space of the vapour lock is reported (Kakareka et al., 1998). The composition of the dust is related to the composition of the Möller mixture. It is a rather coarse dust with a particle size bigger than 10 micron. Although the dust contains heavy metals from the ore and the coke, the dust itself is rather inert due to the extensive pre-treatment activities like pelletising and sintering. In addition emissions may arise from conveying operations.

Table 3.1 shows selected values for the dust and heavy metal content of blast furnace top gas (Rentz et al., 1996).

Table 3.1: Dust and heavy metal content of blast furnace top gas (Rentz et al., 1996)

	Specific dust load $m_{Dust}/m_{Pig\ iron}$ [kg/Mg]	Specific waste gas volume $V_{Waste\ gas}/m_{Pig\ iron}$ [m^3/Mg]	Waste gas stream $V_{Waste\ gas}/t$ [m^3(STP)/h]	Dust load $m_{Dust}/V_{Waste\ gas}$ [g/m^3(STP)]	Weight composition of flue dust [wt.-%]
Blast furnace top gas	up to 17.5	1,400 - 1,700	100,000 - 550,000	up to 12.5	Pb up to 0.4 Zn up to 1.7

3.5 Controls

To reduce the escape of the basic materials during charging a vapour lock is installed on the top of the smelter. The lock is charged after pressure equalisation. Different constructions for this lock are in use. The sealed charging system can be a bell charging system or a bell-less charging system. In addition, the evacuation of gas at the top of the furnace and connection to the blast furnace gas treatment system can be used to control emissions (IPPC, 1999).

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.

[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.

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:

$$\text{Emission} = \text{AR x EF}$$

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.

The blast furnace charging is a part of the primary iron and steel industry. The simplest method of emissions estimation is their assessment on the basis of the pig iron production from individual iron and steel plants or country production of pig iron in blast furnaces and average emission factors. Appropriate emission factors referring to statistical information on iron and steel production at national level are currently not available.

5 DETAILED METHODOLOGY

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

6 RELEVANT ACTIVITIES STATISTICS

Information on the production of pig iron, 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 pig iron produced by various types of industrial technologies employed in the cement 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

Iron smelters in which the loading process is incorporated should be considered as point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

The emission factor for coarse dust is generally about 20g/Mg pig iron (range 15-25 g/Mg, depending on the construction of the vapour lock). This information is produced by the Emission Inventory in The Netherlands, based on estimations from the steel plant managers.
Emission factors taken from four blast furnaces from four different EU Member States are available in (IPPC, 1999). For dust emissions to air from the charging zone an emission factor of 25 g/Mg liquid steel (LS) is proposed (range: 5-38 g/Mg LS; mean value and standard deviation: 14±13). Other air pollutants are considered to be of low significance. In (IPPC, 1999) a conversion factor of 940 kg pig iron/Mg liquid steel is used as a weighted average of all European basic oxygen steelworks.

Concerning blast furnaces in CIS countries heavy metal emission factors for blast furnace charging are proposed in (Kakareka et al., 1998). Table 8.1 shows these factors related to the removal efficiency of control devices.

Table 8.1: Heavy metal emission factors for blast furnace charging (Kakareka, 1998)

	Abatement type and efficiency		
	No Abatement 0 % efficiency	Venturi scrubbers or ESP 95 % efficiency	Includes dust suppression systems such as pressure equalisation 99.6 % efficiency
Cd [g/Mg pig iron]	0.009	0.0004	0.00004
Pb [g/Mg pig iron]	0.028	0.001	0.0001
Zn [g/Mg pig iron]	0.58	0.029	0.002
Ni [g/Mg pig iron]	0.052	0.003	0.0002

Table 8.2 shows emission factors for particulate matter.

Table 8.2: Emission factors for particulate matter in kg / ton pig iron (furnace charging and tapping, CEPMEIP*)

Technology	Abatement	TSP	PM_{10}	$PM_{2.5}$	Uncertainty-factor
Modern plant (BAT)	High efficiency ESP or equivalent to control primary sources; fabric filters for fugitive emission;	0.04	0.038	0.036	3
Conventional plant	Installation with average age; conventional dedusting: ESP, wet scrubber; some capturing of fugitives	0,24	0,192	0,12	2
Older technology	multi-cyclones only	2	1	0,5	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 8.2): The uncertainty in the emission factor for $PM_{2.5}$ emissions from a modern plant is 3. The emission factor with uncertainty range will therefore be 0.036 kg per tonne pig iron with an uncertainty range of 0.012 (0.036 / 3) to 0.11 (0.036 x 3).

* Includes PM emission factors for the combination of both charging and tapping – see chapter B423 for Pig Iron tapping.

9 SPECIES PROFILES

A composition profile of used ore could give supporting information. No general profiles can be given.

Heavy metal content of dust collected in the charging zone of a blast furnace of a Russian iron and steel plant is given in Table 9.1 (Kakareka et al., 1998).

Table 9.1: Heavy metal content of dust from batch preparation (Kakareka et al., 1998)

	Cd [mg/kg]	Pb [mg/kg]	Zn [mg/kg]	Ni [mg/kg]	Cu [mg/kg]
Particulate matter from ESP (total sample)	0.15	900	14	5.26	12
Particulate matter from ESP (particle size < 4 µm)	2	7 - 10	145 - 200	10 - 13	15 - 20

10 UNCERTAINTY ESTIMATES

The uncertainty of the dust emission factors is estimated to be about 20%.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Information about emissions directly related to the individual process and the abatement methods is scarce. Emission factors for heavy metals should be improved.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Iron smelters should be considered as point sources (see section 7).

13 TEMPORAL DISAGGREGATION CRITERIA.

Emissions during charging are a discontinuous process. The temporal disaggregation depends on the production rate but quantitative information is not available.

14 ADDITIONAL COMMENTS

Charging of blast furnaces should be treated in connection with the pig iron tapping.

15 SUPPLEMENTARY DOCUMENTS.

US Environmental Protection Agency. Compilation of air pollutant emission factors AP-42

PARCOM (1992) Emission Factor Manual PARCOM-ATMOS. Emission factors for air pollutants 1992. P.F.J. van der Most and C. Veldt, eds., TNO Environmental and Energy Research, TNO Rept. 92-235, Apeldoorn, the Netherlands.

16 VERIFICATION PROCEDURES.

Comparing the composition profile of the ore used with the metal emissions calculated might serve as a verification process.

17 REFERENCES

European Commission Directorate-General Joint Research Centre, European IPPC Bureau (1999) Integrated Pollution Prevention and Control (IPPC), Best Available Techniques Reference Document on the Production of Iron and Steel, Seville, January 1999. Available at - http://eippcb.jrc.es.

Kakareka S., Khomich V., Kukharchyk T., Loginov V. (1998) Heavy Metal Emission Factors Assessment For The CIS Countries, Institute for Problems of Natural Resources Use and Ecology of the National Academy of Sciences of Belarus, Minsk 1998

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18 BIBLIOGRAPHY

No additional documents.

19 RELEASE VERSION, DATE AND SOURCE

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20 POINT OF ENQUIRY

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