SNAP CODE: **040208**

SOURCE ACTIVITY: **PROCESSES IN IRON & STEEL INDUSTRIES & COLLIERIES**
Rolling Mills

NOSE CODE: **105.12.11**
105.12.12
105.12.13

NFR CODE: **2 C 1**

1 ACTIVITIES INCLUDED

Rolling mills are part of the production process from primary iron and steel. The products are sections and concrete reinforcing rods.

2 CONTRIBUTION TO TOTAL EMISSIONS.

Table 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
Rolling Mills	040208	0	0	0	-	0	0	-	-

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

The emissions from rolling mills are a relevant part of the primary iron and steel production on all geographical levels. For heavy metal emissions, specific figures for this source activity are available from Baart *et al.* (1995). /1/. The average relative contribution from the total iron and steel production industry and the rolling of iron to the total emission of heavy metals has been presented for European countries in table 2.

Table 2: Average relative contribution of the production of iron and steel and the production of pig iron to the total emission of heavy metals in European countries

Compound	Total iron & steel production (%)	Rolling mills (%)
Cadmium	22	-
Chromium	36	3.6
Copper	16	-
Nickel	14	0.8
Lead	12	-
Zinc	33	-

\- = not available

This activity is not believed to be a significant source of $PM_{2.5}$ (as of December 2006).

3 GENERAL

3.1 Description

Long products such as sections and concrete reinforcing rods can be produced by hot-rolling steel ingots. The huge reduction in thickness is accompanied by changes in structure and recrystallization, leading to a material with a very fine crystal structure. This is necessary in regard to the requirements for strength and deformability. This procedure is part of the traditional method of pouring molten steel into moulds to produce ingots which, when solidified, are reheated into slabs or billets. This method has in many cases been replaced by continuous casting.

However it is impossible to achieve these large degrees of re-rolling with continuously cast billets, and this applies also to the continuously cast strip. This problem can be solved by mounting conductive coils round the casting apertures. The electromagnetic stirring of the still molten core of the billet produces a very fine, homogeneous structure without segregation. This makes it possible to accept a lower degree of rolling without loss of quality.

The continuous cast slabs are transported to the hot strip mill without waiting for them to cool, and rolled immediately. The hot rolling of steel slabs has long been used as a “flattering process”. This term does not, however, apply to modern hot strip mills. By a subtle combination of chemical composition, reheating, deformation rate speed of cooling after hot rolling and strip temperature during coiling, a variety of steel grades can be produced, ranging from high-strength steel alloys to ultra-low carbon, super-deformable steel. In principle, it is even feasible to carry out heat treatment during hot rolling. This is achieved by cooling the strip rapidly to 200 - 300 ^{o}C after the last stage of deformation, producing a dual phase microstructure which ensures a unique combination of high strength and high deformability.

The hot slabs are prepared for rolling by heating in walking-beam furnaces to rolling temperature (about 1200 ^{o}C). The roughing mill train consists of five stands placed in tandem, where the slabs are rolled to achieve both the desired width and thickness. In a seven stands finishing train the product takes on the desired dimensions and shape and flatness of the strip are largely determined. As it passes over the run-out table, the strip is cooled to the desired temperature by means of water, after which it is coiled.

There are limits to the purposes for which thin sheet produced from hot-rolling mills can be used. Besides the fact that the requirements in terms of surface quality cannot be met by hot-rolling material, however carefully it is rolled, the thickness can be a physical problem. Therefore much of the hot-rolled strip is destined for further reduction of the thickness in cold rolling reduction mills.

As a first step it is put through the pickling line to remove the mill-scale. Immediately after pickling the necessary lubricant is applied by electrostatic machines. After cold reduction, which greatly improves the strength of the material, it is annealed to restore the desired deformability. This process is now largely carried out in continuous furnaces, but also batch annealing is used. Gradual heating and cooling results in recrystallization of the steel, restoring its deforming properties. During this process, which takes several days, nitrogen or hydrogen is passed through the furnace to prevent oxidation of the steel.

After annealing, the material is passed through the tempering mill and coiled for further processing.

3.2 Definitions

Continuous casting: Slabs or non-flat products (billets) are cast directly from molten metal. Continuous casting not only saves time and energy, but also improves the quality of the steel and increases the yield. Moreover, the process is more controllable.

At the end of the refining process the ladle filled with molten steel is conveyed to the continuous casting machine. From a ladle mounted above the caster, the molten steel enters the tundish, from whence it flows into the moulds. If necessary, certain alloying elements which become unstable when exposed to oxygen in the atmosphere, or which act only for a brief period, can be added at the last minute by introducing cored wire into the mould.

VHO-gas: Smelter gas enriched with coke oven gas with a varying composition. Both products contain small amounts of hydrogen sulfide, left over from cleaning processes.

3.3 Techniques

3.4 Emissions

Hot-rolling of slabs and non-flat products (billets) produces hydrocarbon emissions from lubricating oils. Preheating of material and annealing after rolling results in emissions of nitrogen oxides and carbon monoxide. When VHO gas is used some sulfurdioxide will also be emitted. Pickling before cold-rolling produces emissions of hydrochloric acid. Cold-rolling gives emissions of hydrocarbons and decomposition products of lubricant oil. Gradual heating and cooling gives emissions of nitrogen oxides and carbon monoxide. Protection gas contains polycyclic aromatic hydrocarbons.

3.5 Controls

Hydrochloric acid from pickling is removed by a washing tower. Hydrocarbon vapours from rolling are captured by lamelle filters. Protection gas containing PAH's can be burned in afterburners.

4 SIMPLER METHODOLOGY

A simpler method would be to relate emissions to economic or production statistics. However, information for using this default method is not yet available.

5 DETAILED METHODOLOGY

Extensive measurements related to the individual process and the applied abatement methods will give a more individual picture of the emissions.

6 RELEVANT STATISTICS

In the Netherlands natural gas is used. For batch annealing sometimes enriched smelter gas is used. (VHO-gas).

7 POINT SOURCE CRITERIA

The emissions from primary steel production of capacity greater than 3 million tonne steel per year should be considered as point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

• Pickling	Hydrochloric acid (HCl): 2 g/Mg	
• Hot-rolling, Billets	VOC: 1 g/Mg	
- Fuel	1 - 1.2 GJ/Mg ==>	NO_x: 80 - 120 g/Mg
		CO: 100 - 120 g/Mg
• Hot-rolling, Slabs	Lubricating oil 2 - 5 g/Mg	
- Fuel	1.5 - 2 GJ/ton ==>	NO_x: 100 - 150 g/Mg
		CO: 220 - 250 g/Mg
• Cold-rolling	Lubricating oil: 10 - 100 g/Mg	
	VOC: 20 - 30 g/Mg	
	Decomposition products of oil: 10 - 20 g/Mg	
- Fuel, natural gas	0.4 - 2 GJ/Mg ==>	NO_x: 40 - 100 g/Mg

- VHO gas	1 - 2 GJ/Mg ==>	CO: 40 - 200 g/Mg NO_x: 20 - 50 g/Mg CO: 0.3 - 1 g/Mg SO2: 30 - 60 g/Mg
• Annealing	PAH: 1.7 g/Mg (125 mg/Mg Borneff PAH).	

9 SPECIES PROFILES

No generally applicable species profile is available.

10 UNCERTAINTY ESTIMATES

The uncertainty in the emission factor is estimated to be C.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect is the lack of adequate measurements related to the abatement methods.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

The primary iron and steel industry is expected to be regarded as a point source.

13 TEMPORAL DISAGGREGATION CRITERIA

Most of the processes described are continuous.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

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

16 VERIFICATION PROCEDURES

The emissions of VOC and PAH as calculated can only be verified by representative measurements.

17 REFERENCES

/1/ A.C. Baart, J.J.M. Berdowski, J.A. van Jaarsveld; Calculation of atmospheric deposition of contaminants on the North Sea; IWAD; ref. TNO-MW-R 95/138; TNO MEP; Delft; The Netherlands; 1995

18 BIBLIOGRAPHY

No additional bibliography

19 RELEASE VERSION, DATE, AND SOURCE

Version : 2.1

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Source : J.J.M.Berdowski, P.F.J.van der Most, W.Mulder, P.Verhoeve
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20 POINT OF ENQUIRY

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