7.8 Ferrous metals processing including iron foundries

7.8.1 Coverage

This section on ferrous metals processing comprises iron foundries (for continuous and ingot casting see chapter “Iron and steel production”) with a capacity exceeding 20 tonnes/day, as well as installations for “hot and cold forming”, including hot rolling, cold rolling, wire drawing, installations for “continuous coating”, including hot dip coating and coating of wire, and installations for “batch galvanizing”. [1] [2]

7.8.2 Emission sources

7.8.2.1 Foundries

Foundries melt metals and alloys (only ferrous metals regarded in the following) and reshape them into products at or near their finished shape through the pouring and solidification of the liquid metal into a mould. Fluxes and fuels are similar as in pig iron processing. The industry consists of a wide range of installations, most of them comprising the process steps: melting and metal treatment, preparation of moulds and core, casting the molten metal in the mould, cooling for solidification and removing, finishing the raw casting. The main environmental issues of this industry are emissions to air (dust, acidifying compounds, products of incomplete combustion and volatile organic compounds). [2] [3]

7.8.2.2 Hot and cold forming

In **hot rolling**, the size, shape and metallurgical properties of steel are changed by repeatedly compressing the hot metal (1050-1300 °C) between rollers. The steel input varies in form and shape – cast ingots, slabs, blooms, billets, beam blanks – depending on the product, generally classified in the basic types flat and long products. Hot rolling mills usually comprise the following process steps: conditioning of the input (scarfing, grinding); heating to the rolling temperature; descaling; rolling and finishing. The main environmental issues of hot rolling are emissions to air, especially NO_X and SO_2, energy consumption and dust emissions.

In **cold rolling**, the properties of hot rolled strip products (thickness, mechanical and technological characteristics) are changed by compression between rollers without previous heating. The process steps for low alloy steel (carbon steel) are pickling, rolling for reduction in thickness, annealing or heat treatment to regenerate the crystalline structure, temper rolling or skin pass rolling of annealed strip to give desired mechanical properties and finishing. The process steps for high alloy steel (stainless steel) involves additional steps, the main stages are: hot band annealing and pickling, cold rolling, final annealing and pickling (or bright annealing), skin pass rolling and finishing. The main environmental issues of cold rolling are acidic waste and waste water, degreaser fume acidic and oil mist emissions to air, dust and NO_X (mixed acid pickling and furnace firing).

Wire drawing is a process in which wire rods/wires are reduced in size by drawing them through cone-shaped openings of a smaller cross section, called dies. A typical plant comprises the following process lines: pre-treatment (descaling, pickling), dry or wet drawing, heat treatment and finishing. The main environmental aspects of wire drawing are air emissions from pickling, acidic wastes and waste water, fugitive soap dusts, spent lubricants and combustion gases. [1]

7.8.2.3 Continuous hot dip coating

In the hot dip coating process, steel sheet or wire is continuously passed through molten metal. An alloying reaction between the two metals takes place, leading to a good bond between coating and substrate. Continuous coating lines for sheet comprise the steps surface cleaning (chemical or thermal treatment), heat treatment, immersion in a bath of molten metal, and finishing treatment. Continuous wire galvanizing plants involve the steps pickling, fluxing, galvanizing, finishing. Main environmental issues are acidic air emissions, waste and wastewater and energy consumption. [1]

7.8.2.4 Batch galvanizing

Hot dip galvanization is a corrosion protection process in which iron and steel fabrications are coated with zinc. Prevalent in this sector is job galvanizing, in which a great variety of products are treated for different customers; batch galvanizing usually comprises the steps degreasing, pickling, fluxing, galvanizing, finishing. The main environmental issues are emissions to air (HCl, dust) spent process solutions and oily wastes and zinc containing residues. [1]

7.8.3 BAT, Associated Emission Levels (AEL)

7.8.3.1 SO2

For re-heating and heat treatment furnaces in **hot rolling** installations, a careful choice of fuel and implementation of furnace automation/control to optimise the firing conditions is considered BAT. Process waste gases are commonly used at reheating furnaces in place of fossil fuels. Fuels with low S content are commonly used. [1]

Table 1: SO_2 emission levels associated with BAT for ferrous metals production

Emission Source	BAT associated emission levels[1] mg/Nm^3 or (kg/tonne)	Comments
Foundries: ferrous metal melting [2]	20-100 100-400 70-130	Hot blast cupola Cold blast cupola Rotary arc furnace
Moulding and casting using lost moulds (regeneration units) [2]	120	
Hot rolling: re-heating and heat treatment furnaces [1]	100 400 1700[2]	For natural gas For all other gases and gas mixtures for fuel oil <1%S
Cold rolling: H_2SO_4-pickling Cold rolling: HCl-pickling [1]	8-20 50-100	Recovery of the free acid by crystallisation; air scrubbing devices for recovery plant. Regeneration of the acid by spray roasting or fluidised bed (or equivalent system)

[1] The BAT associated emission levels are based on a daily average, standard conditions and represents a typical load situation. For peak load, start up and shut down periods, as well as for operational problems of the flue gas cleaning systems, short-term peak values, which could be higher, have to be regarded.

[2] EU-BREF split view if fuel oil <1%S is BAT or additional SO2 reduction measures are necessary

7.8.3.2 NO_X

For re-heating and heat treatment furnaces in **hot rolling** installations, the use of second generation low-NO_X burners is considered BAT. [comment: BREF2001 split view on whether SCR and SNCR are BAT for re-heating and heat treatment furnaces in hot rolling installations]

For mixed acid pickling in **cold rolling** installations, it is considered BAT to use either free acid reclamation (by side-stream or ion exchange or dialysis) or acid regeneration by spray roasting or acid regeneration by evaporation process. In general for mixed acid pickling in cold rolling installations, enclosed equipment/hoods and scrubbing should be used, and additionally for high alloy steels either scrubbing with H_2O_2, urea, etc. or NO_X suppression by adding H_2O_2 or urea to the pickling bath or by

use of SCR. An alternative is to use nitric acid-free pickling plus enclosed equipment or equipment fitted with hoods and scrubbing. For annealing furnaces in cold rolling installations, it is BAT to use low NO_X burners for continuous furnaces, combustion air preheating by regenerative or recuperative burners or pre-heating of stock by waste gas.

For **continuous hot dip coating**, it is considered BAT to use low-NO_X burners and regenerative or recuperative burner for heat treatment furnaces and galvannealing. For heat treatment furnaces, it is additionally BAT to use pre-heating of the strip and steam production to recover heat from waste gas where there is a need for steam. [1]

Table 2: NO_X emission levels associated with BAT for ferrous metals production

Emission Source	BAT associated emission levels[1] mg/Nm^3 or (kg/tonne)	Comments
Foundries: ferrous metal melting [2]	10-200 20-70 160-400 10-50 50-250	Hot blast cupola Cold blast cupola Cokeless cupola Electric arc furnace Rotary arc furnace
Moulding and casting using lost moulds (regeneration units) [2]	150	
Hot rolling: re-heating and heat treatment furnaces [1]	390 1100 250-400	Fuel: blast furnace gas; low NO_X burner Fuel: coke oven gas, heavy fuel oil; low NO_X burner Fuel: natural gas, gas oil; low NO_X burner 3% O_2 for gas, 6% O_2 for liquid fuel
Hot rolling: re-heating and heat treatment furnaces using SCR[2] and SNCR[2] [1]	320[3] 205[3]	SCR[2] SNCR[2], ammonia slip 5 mg/Nm^3 3% O_2 for gas, 6% O_2 for liquid fuel
Cold rolling: HCl pickling [1]	300-370	
Cold rolling: mixed acid pickling [1]	200-650 200 100	 Acid regeneration by spray roasting Acid regeneration by evaporation process
Cold rolling: annealing furnaces [1]	250-400	Without air pre-heating, 3% O_2, reduction rates of 60% for NO_X
Hot dip coating: heat treatment furnaces and galvannealing [1]	250-400	Without air pre-heating, 3% O_2

[1] The BAT associated emission levels are based on a daily average, standard conditions and represents a typical load situation. For peak load, start up and shut down periods, as well as for operational problems of the flue gas cleaning systems, short-term peak values, which could be higher, have to be regarded.

[2] EU-BREF split view if SCR and SNCR are BAT (only one of each installation exists in Europe)

[3] These are emission levels reported for the one existing SCR plant (walking beam furnace) and the one existing SNCR plant (walking beam furnace).

7.8.3.3 Dust

For **foundries**, a key issue in emission reduction is not only to treat the exhaust and off-gas flow, but also to capture it. BAT is to minimize fugitive emissions arising from various non-contained sources in the process chain like from furnaces during opening or tapping by optimizing capture and cleaning, clean furnace off-gas by subsequent collection, cooling and dust removal. For cupola furnace melting of cast iron, BAT for dust reduction is to improve thermal efficiency and use a fabric filters or wet scrubbers.
For the operation of induction furnaces, BAT is, amongst others, use a hood, lip extraction or cover extraction on each induction furnace to capture the furnace off-gas and to use dry flue-gas cleaning. [2]
For finishing techniques like abrasive cutting, shot blasting and fettling, BAT is to collect and treat the finishing off gas using a wet or dry system. For heat treatment, BAT is to use clean fuels (i.e. natural gas or low-level sulphur content fuel), automated furnace operation and burner/heater control and also to capture and evacuate the exhaust gas from the heat treatment furnaces. [2]

For **hot rolling**, it is considered BAT to use enclosures for machine scarfing and dust abatement with fabric filters or electrostatic precipitators, where fabric filters cannot be operated because of wet fume. For machine grinding operations in hot rolling installations, BAT is to use enclosures for machine grinding and dedicated booths, equipped with collection hoods for manual grinding and dust abatement by fabric filters. In the finishing train, exhaust systems with treatment of extracted air by fabric filters and recycling of collected dust is considered BAT. For levelling and welding, suction hoods and subsequent abatement by fabric filters are considered BAT.
For **cold rolling**, it is BAT to use extraction hoods with dust abatement by fabric filters in levelling and welding operations.
For **coating of wire**, it is considered BAT to use good housekeeping measures[1] for hot dipping. [1]

[1] Cf. EIPPCB BREF 2001, Chapter B.4

Table 3: Dust emission levels associated with BAT for ferrous metals production

Emission Source	**BAT associated emission levels[1] mg/Nm^3 or (kg/tonne)**	**Comments**
Iron Foundries	5-20 [2]	daily average, standard conditions
Iron foundries: induction furnaces	(0.2) [2]	
Hot rolling: machine scarfing [1]	5 / 20[2] 10 / 20-50[2]	Fabric filters ESP, where FF cannot be operated because of wet fume
Hot rolling: grinding [1]	5 / 20[2]	
Hot rolling: finishing train and levelling and welding [1]	5/ 20[2]	
Cold rolling: decoiling [1]	5 / 20[2]	
Cold rolling: HCl pickling [1]	20-50	
Cold rolling: levelling and welding [1]	5 / 20[2]	
Coating of wire: hot dipping [1]	10	
Galvanizing baths [4]	15	

[1] The BAT associated emission levels are based on a daily average, standard conditions and represents a typical load situation. For peak load, start up and shut down periods, as well as for operational problems of the flue gas cleaning systems, short-term peak values, which could be higher, have to be regarded.

[2] EU-BREF 2001 split view

7.8.3.4 VOC

In foundries, various additives are used to bind the sand in the making of moulds and cores; These include organic and inorganic compounds (solvents, BTEX, phenol, formaldehyde, etc.): the generation of decomposition products further continues during the casting cooling and de-moulding operations. As the process involves various emission sources (hot castings, sand, hot metal), a key issue is not only to treat the off-gas, but also to capture it.[5]

Hydrocarbons and misted oil emissions may arise from the cold rolling mill operations, advanced emission collection and demisting systems like precoated fabric filters can be used to reduce them. [6]

Table 4: VOC emission levels associated with BAT for ferrous metal processing

Emission Source	BAT associated emission levels[1] mg/Nm3 or (kg/tonne)	Comments
Foundries: Ferrous metal melting	10-20	Cold blast cupola
[1] The BAT associated emission levels are based on a daily average, standard conditions and represents a typical load situation. For peak load, start up and shut down periods, as well as for operational problems of the flue gas cleaning systems, short-term peak values, which could be higher, have to be regarded.		

7.8.3.5 Cross Media Effects

For all mentioned emission reduction and abatement techniques, the cross-media transfer of pollutants and the full range of environmental effects and improvements should be considered. For example additional energy consumption and increased quantities of waste or wastewater residuals may result from individual efforts for pollutant prevention, reduction, or removal.

7.8.4 Emerging techniques

For hot and cold rolling, the flameless burner or diffuse flame maximises recirculation of the flue gas and has punctually achieved NO_X emission levels of 100 mg/m³, however no industrial application exists until now. Reductions of NOX emissions are also aimed at by the ultra low-NOX burner (complete mixing of fuel and combustion air in the furnace, thus no anchoring of the flame in the furnace) and water injection (reduction of temperature and thus thermal NOX formation). [1]

7.8.5 Cost data for emission reduction techniques

Table 5: Cost information for different NO_X reduction techniques for a 50 MW furnace [1]

Technique	Typical range of NO_X reduction	capital cost (GBP '000)	Operating cost (GBP/GJ)	Total cost of technique (GBP '000/year for 50 MW furnace)		
				2000 hours/year	4000 hours/year	8000 hours/year
Low-NO_X burners	Up to 97%	328	0.0	53.7	53.7	53.7
Limiting air preheat		NA	0.0257 for 50 % NO_X reduction	92.5	185	370
Flue gas recirculation	Up to 93% (44.74 15 % FGR)	75.6 (631)*	0.098 (0.072)*	47.6 (129)*	82.9 (154)*	153 (206)*
SCR	up to 95% (Typically 70 - 90)	1100 - 2530	0.0722	205 - 438	231 - 464	283 - 516
SNCR (with NH_3)	up to 85% (Typically 50 - 60)	350 - 650	0.0361	69.9 - 119	82.9 - 132	109 - 158

Cost given in 1996 British Pounds

NA Not available and, for the purposes of calculation, assumed to be small compared with operating cost.

* Figures in brackets refer to case where burners and regenerators would need to be uprated.

NB1 Flue gas recirculation operating cost figures all based on 15 % FGR.
Estimated fuel consumption penalty = 3.2 %
Increased fan running costs (based on regenerative burners) = 1.6 % of fuel costs (0.32 % if burners and regeneratoars were uprated).

NB2 Water injection cost figures all based on 15 kg (water)/GJ (fuel):
Estimated fuel cost penalty = 11.8 %

Cost of water not included

7.8.6 References used in chapter 7.8

[1] European Commission. 2001: “Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry.” http://eippcb.jrc.es/pages/FActivities.htm

[2] European Commission. 2005: “Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Smitheries and Foundries Industry.” http://eippcb.jrc.es/pages/FActivities.htm

[3] IIASA 2004: International Institute for Applied Systems Analysis. Interim Report IR-04-079 „Primary Emissions of Submicron and Carbonaceous Particles in Europe and the Potential for their Control“.

[4] DEFRA 2006: Sector Guidance Note IPPC SG5 - Secretary of State's Guidance for A2 Activities in the Galvanising Sector. http://www.defra.gov.uk

[5] IFC 2007. International Finance Corporation (World Bank Group): “Environmental, Health, and Safety Guidelines for Foundries”

[6] IFC 2007. International Finance Corporation (World Bank Group): “Environmental, Health, and Safety Guidelines for Integrated Steel Mills”