Steel Production and BAT
ArcelorMittal Zenica

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Planmiljoe

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- The Kemira Case
- BAT and BREF-NOTE regime
- Steel Production
- General BAT recommendations for steel works
- BOF plant
- EAF plant
- BAT conclusions
- The ArcelorMittal Zenica permit
  - Part of the whole complex – How does it relate?
  - Air emissions
  - Water emissions

The Kemira story

The Kemira plant

- Fertilizer Plant – Developed from 1920'es
- Location - On harbor surrounded by city
- Few environmental measures before 1980
- Severe air and water pollution
- Company claimed harmless environmental impact – authorities tried to prove – who should have the benefit of the doubt?
- Environmental awareness arises in 1980'es
- Local pressure for environmental action – NGO protesting - but 600 working places!

Actions

- New legislation enforcement!
- Authorities and company start to act under the public and political pressure
- What was options for measures?
- Actions and Plan
  - New draft water permit – public meetings
  - Application for "IPPC" permit
- Public participation!! Meetings

Results

- New water permit with demands for pollution reduction stepwise – Reduces ELV – according to measures
- "IPPC" Permit issued in 1993!!! – after 9 years
- Atmosphere in society calms down – Accept by both industry and community
- Company closed for market reasons!!! 2004
- Leanings
  - Possible to improve both environment and industrial performance at same time
  - Pressure necessary – Public, political
  - Tools in place – Legislation – competent administration and industry
  - The BAT principle shows to be the dynamic key tool accepted by society and industry!

BAT

- What is the sense?
  - To ensure high environmental standards and allow competitive industry to operate
- BAT Included firstly in IPPC directive 1994, now
- The Industrial Emissions Directive (2010/75/EU)

Definition of BAT in the IED

***B**est*	Most effective in achieving a **high general level** of protection of the environment **as a whole**
***A**vailable*	Developed on a scale which allows implementation in the relevant industrial sector, under **economically and technically viable conditions**
***T**echniques*	**Both** the technology used and the way in which the installation is **designed, built, maintained, operated and decommissioned**

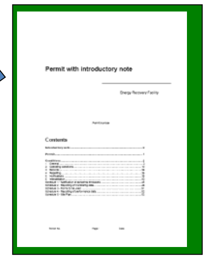
Role of BAT conclusions in IED permitting

BAT are determined by a Technical Working Group steered by the JRC (EIPPCB) and documented in BREFs

'BAT conclusions' are secondary legislation

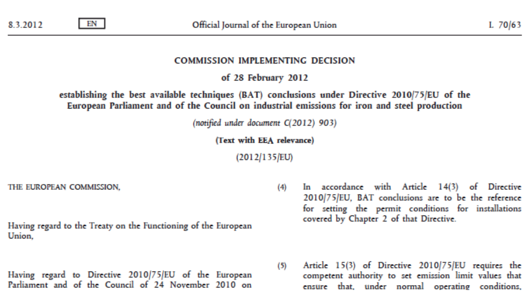
BAT conclusions are the reference for setting permit conditions

Permits to contain **emission limit values** (ELVs) to ensure that, under normal operating conditions, **emissions do not exceed BAT-associated emission levels (BAT-AELs)**



BAT and BREF for Steel Industry

- BREF Note 2013 – 627 pages
- BAT conclusions – 36 pages



8.3.2012 EN Official Journal of the European Union L 70/63

COMMISSION IMPLEMENTING DECISION

of 28 February 2012

establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for iron and steel production

(notified under document C(2012) 903)

(Text with EEA relevance)

(2012/135/EU)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on

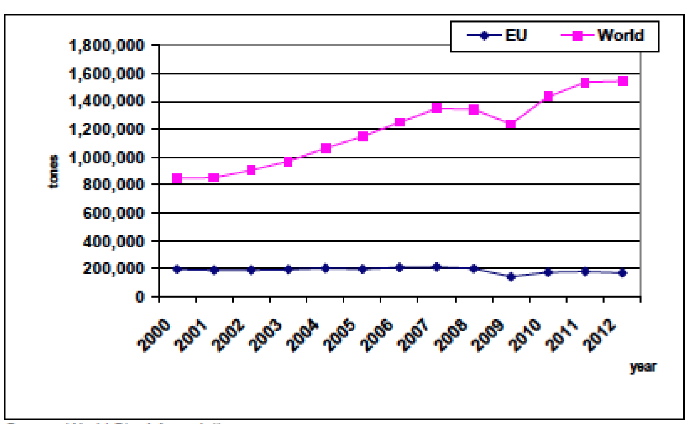
(4) In accordance with Article 14(3) of Directive 2010/75/EU, BAT conclusions are to be the reference for setting the permit conditions for installations covered by Chapter 2 of that Directive.

(5) Article 15(3) of Directive 2010/75/EU requires the competent authority to set emission limit values that ensure that, under normal operating conditions,

BREF note Steel Industry

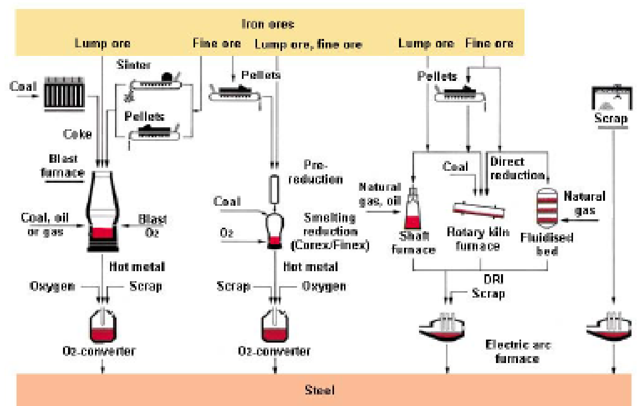
- 1 GENERAL INFORMATION
- 2 GENERAL PROCESSES AND TECHNIQUES
    - 3 SINTER PLANTS
    - 4 PELLETISATION PLANTS
    - 5 COKE OVEN PLANTS
    - 6 BLAST FURNACES
    - 7 BASIC OXYGEN STEELMAKING AND CASTING
    - 8 ELECTRIC ARC FURNACE STEELMAKING AND CASTING
- 9 BAT CONCLUSIONS FOR IRON AND STEEL PRODUCTION
- 10 ALTERNATIVE IRONMAKING TECHNIQUES
- 11 EMERGING TECHNIQUES
- 12 CONCLUDING REMARKS AND RECOMMENDATIONS FOR FUTURE WORK
- 13 ANNEXES

World Steel Production



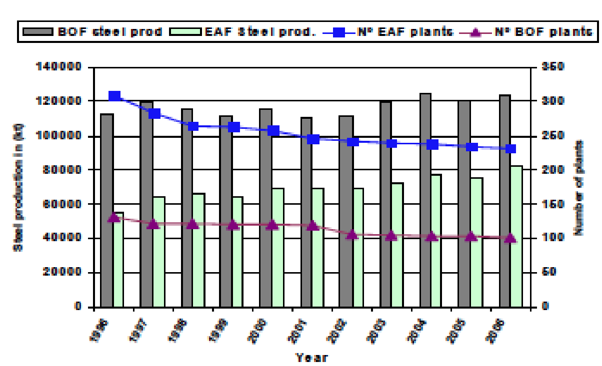
Source: World Steel Association

Production methods



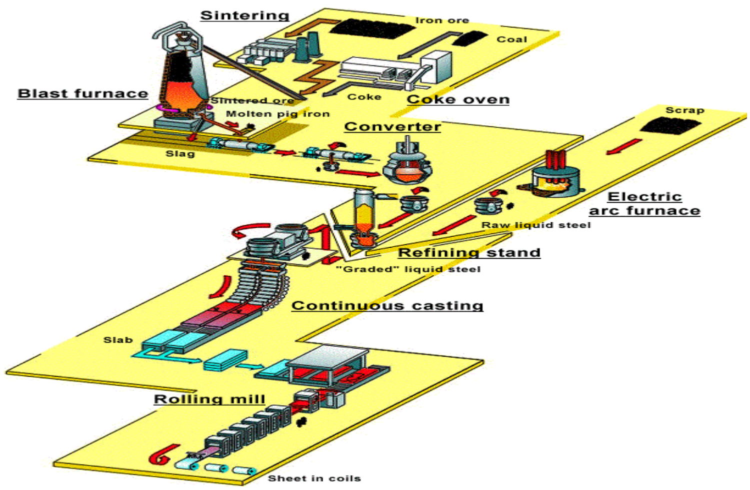
Source: [312, Dr. Michael Degner et al. 2008]

Production methods - development

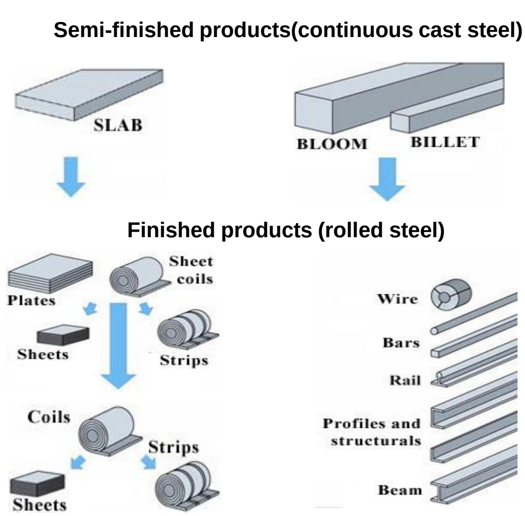


Source: [286, Stahl 2008]

How is steel made I



Steel Products



Integreated steelworks

- Coke plant
- Sinter plant

- Blast furnace
- Basic oxygen furnace

Electric Arc Furnace

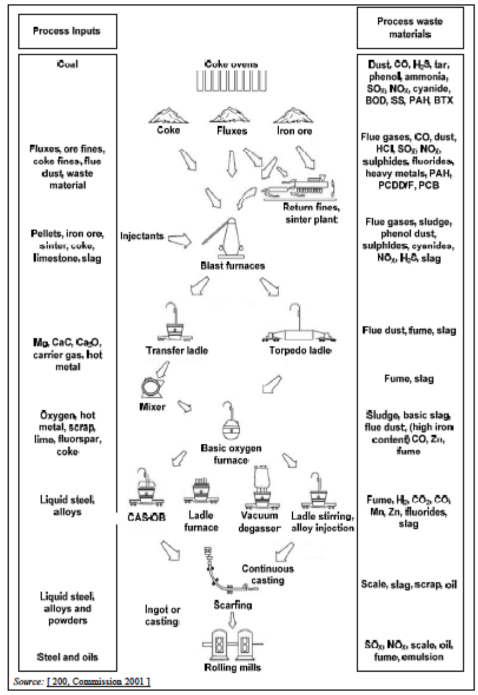
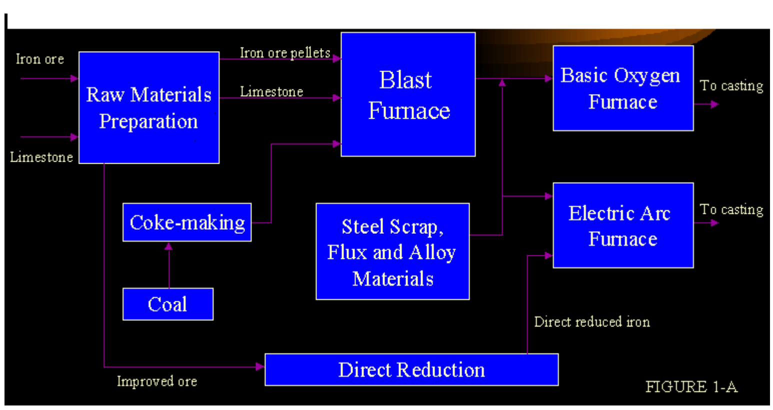
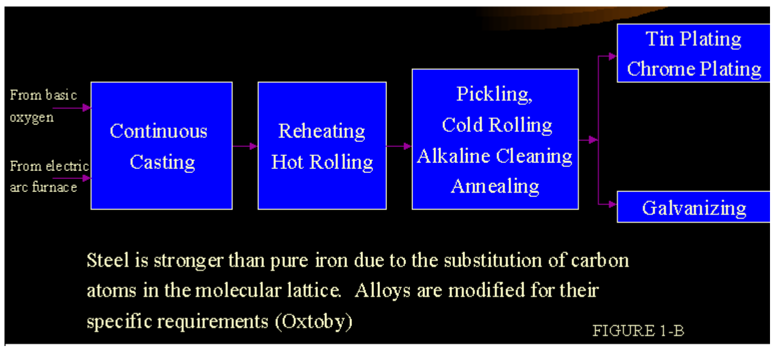


Figure 1.6: Overview of the process routes of an integrated steelworks

How is steel made II

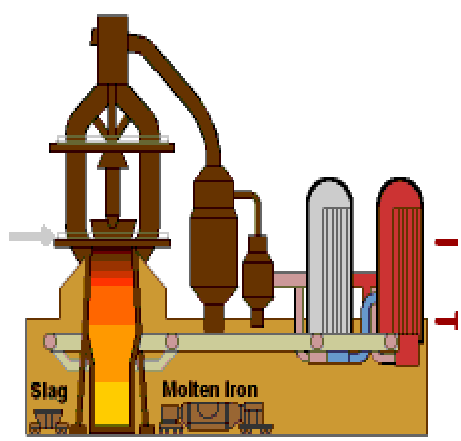


How is steel made III

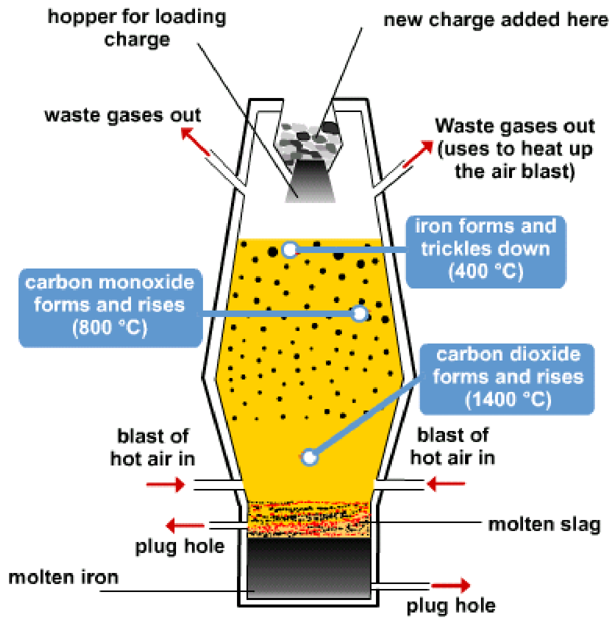


Blast furnace

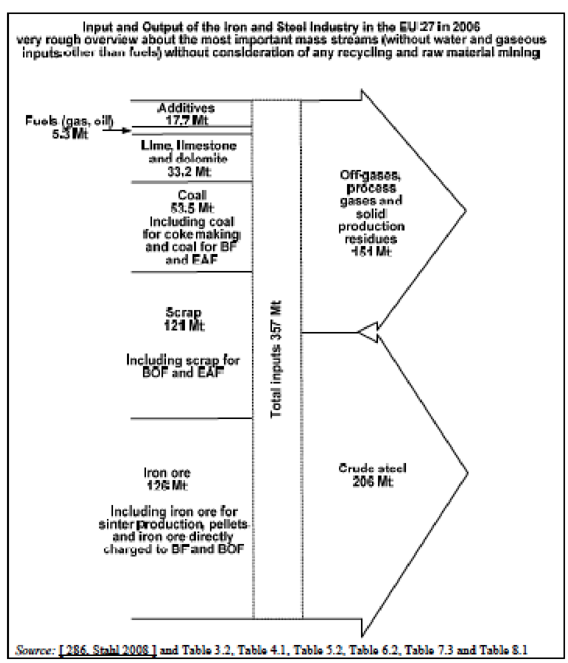
- The purpose of a blast furnace is to reduce and convert iron oxides into liquid iron called "hot metal".
- The blast furnace is a huge, steel stack lined with refractory brick.
- Iron ore, coke and limestone are put into the top, and preheated air is blown into the bottom.



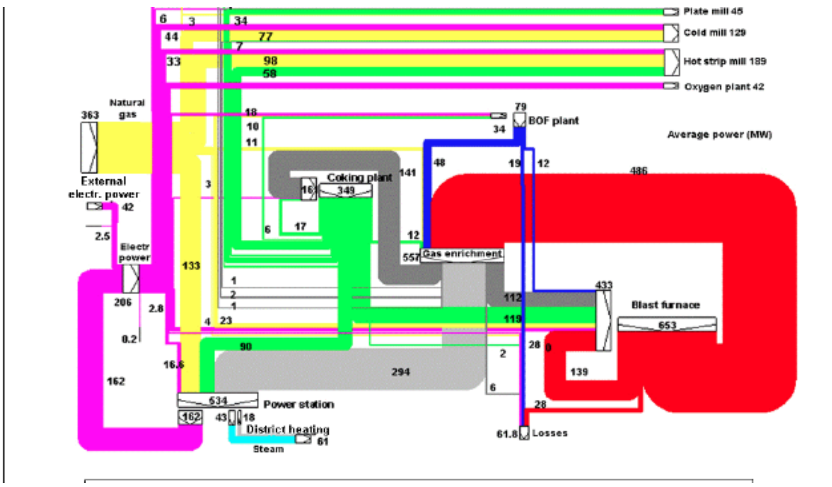
Blast Furnace
Produces molten pig iron from iron ore.



Input and output in steel industry

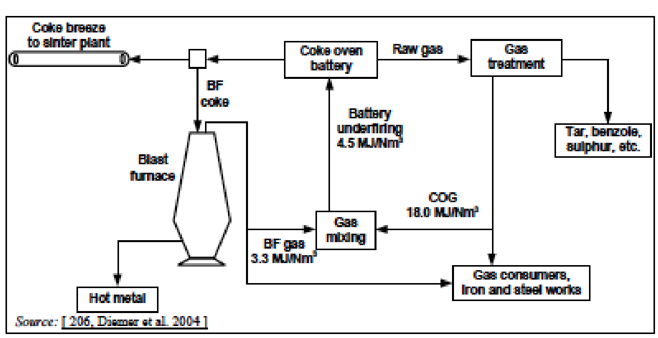


Example of energy flow

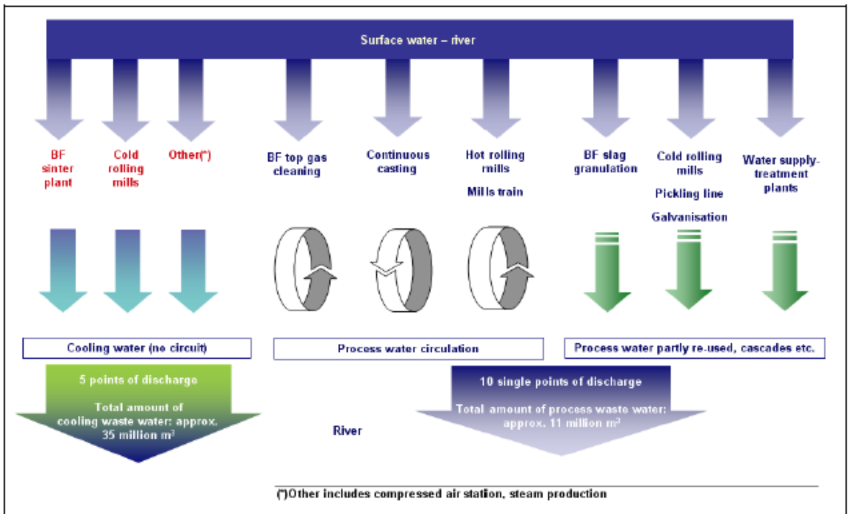


Energy management -gas utilization

Flow sheet of typical gas utilization of integrated sinter, coke and hot metal production



Water Management



Source: [316, Eurofer 2009]

Figure 2.13: Example for the water management of an integrated steelworks with separate circuits

Recirculation benefits

Table 2.8: Comparison in water intake required for integrated steelworks with once-through systems versus extensive recirculation

Water Use	Quality	Water intake			
		Once-through system		Extensive recirculation	
		(m^3/min)	(% of total)	(m^3/min)	(% of total)
Indirect cooling	General	675	70.7	7.4	32
Direct cooling	General	265	27.8	6.2	26.8
Process water	Low grade	7.7	0.8	5.1	22.1
Potable water	High grade	1.5	0.2	1.5	6.5
Evaporation losses		4.8	0.5	2.9	12.6
Total		954	100	23.1	100

NB: It is not known if this data also includes the water used in downstream operations (not included in this document, e.g. rolling).

Source: [279, IISI 2002].

General techniques BAT

- Environmental management systems
- Energy management
- Techniques to optimize process gas utilization
- Techniques to improve heat recovery

Example of a CHP plant to producing heat and electrical power for a community

Fuel input (GWh)		Energy output (GWh)	
Gas	2075	Total energy export	1472
Oil	82	Hot water to district heating	751
		Electric power export	613
		Steam export	27
		Drying gas export	81

Source: [208, Lindfors et al. 2006].

General techniques BAT

- Reduction of NOX by primary measures
  - deployment of low-NOX burners
  - flue-gas recirculation
  - upper air injection for the residual combustion with substoichiometric burners
  - injection of reduction fuel
  - air staging
  - fuel staging.
- Reduction of NOX by secondary measures
  - NOX reduction by selective catalytic reduction (SCR)
  - NOX reduction by selective non-catalytic reduction (SNCR) or

General techniques BAT

- Material management
  - Techniques to improve the use of scrap
  - Techniques to reduce diffuse emissions from materials storage
  - Techniques to control releases to water from raw materials
  - Specialized recycling facilities for iron-rich residues
  - Cold bonded pellets/briquettes

Monitoring in iron and steel plants

Important parameters which should be measured continuously from relevant sources of the iron and steel manufacturing processes include:

- pressure
- temperature
- O2 content
- CO
- input material flows
- output material flows.

Continuous air monitoring

Table 2.16: Examples for continuously measured air emissions at Voestalpine Stahl, Linz, Austria

Plant	Potential emissions source	Relevant pollutants						Reference O_2
		Dust	NO_x	SO_2	CO	H_2S	HF	
		mg/Nm^3						
Coke oven	H_2S in coke oven gas					X ([1])		
	Sulphuric acid plant			X				
Sinter plant ([2])	Sinter strand	X	X	X			X	
	Dedusting of building	X						
Blast furnaces	Cast house dedusting BF 5 & 6	X						
	Cast house dedusting BF A	X						
BOF plant	Dedusting unit 1	X		X ([3])				
	Secondary dedusting 2.1	X						
	Secondary dedusting 2.2	X						
Power plant	Unit 3		X	X	X			3 %
	Unit 4		X	X	X			3 %
	Unit 5		X	X	X			3 %
	Gas and steam turbine		X	X	X			15 %
	Unit 6		X	X				3 %

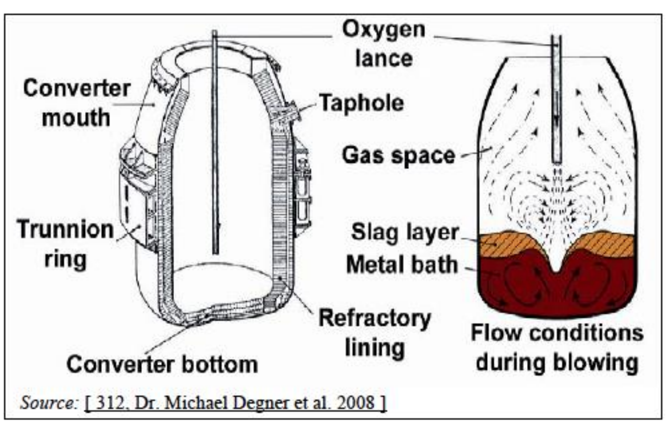
Discontinuous air monitoring

- Dust
- SO_2
- NO_x
- CO
- Heavy metals such as Hg, Tl, Cd, As, Co, Ni, Se, Te, Pb, Cr, Cu, Mn, V, Sn
- TOC
- VOC
- NMVOC
- BTX
- H_2S
- HCl
- HF
- CN
- NH_3
- PCDD/F
- PAH (e.g. EPA 16, Borneff 6)
- PCB (e.g. Ballschmiter PCB, WHO-TEF, total PCB).

BOF Process

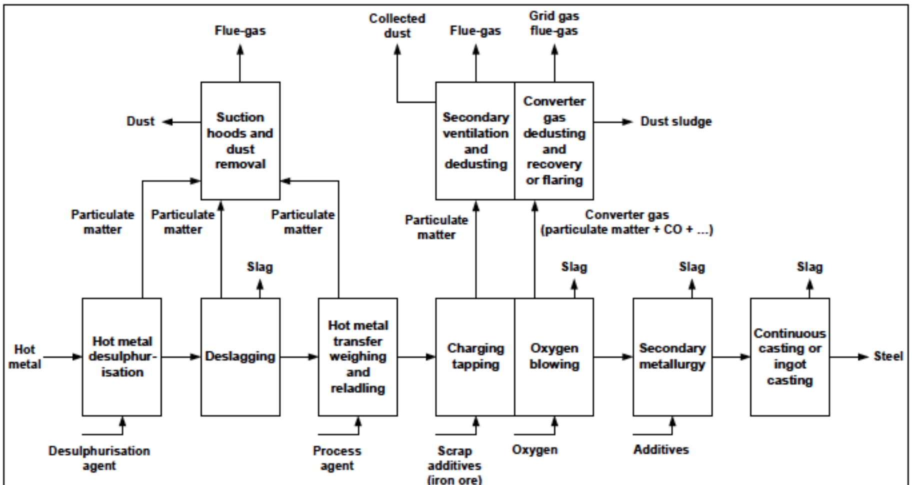
• transfer from the BF and discharge
• pretreatment of hot metal (desulphurisation, deslagging)
• transfer, weighing and reladling
• oxidation in the BOF (decarburisation and oxidation of impurities)
• secondary metallurgical treatment
• casting (continuous or/and ingot).

The Converter



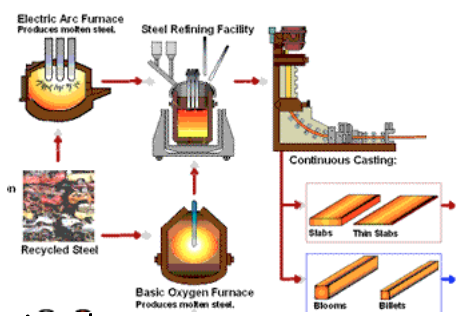
Basic oxygen steelmaking converter

BOF process



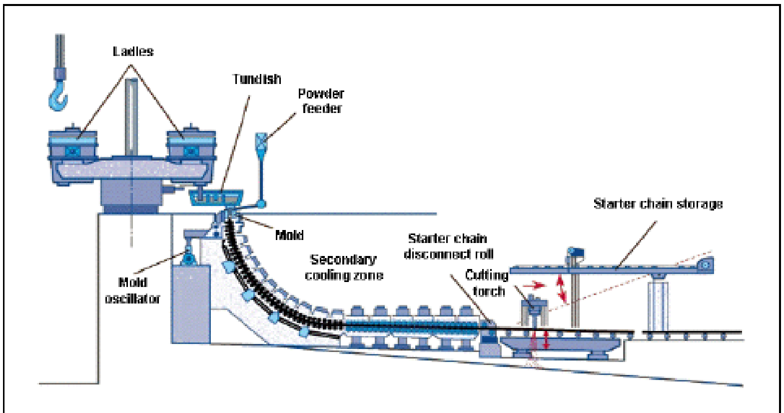
Source: [200, Commission 2001] [365, Eurofer 2007]

Secondary metallurgy



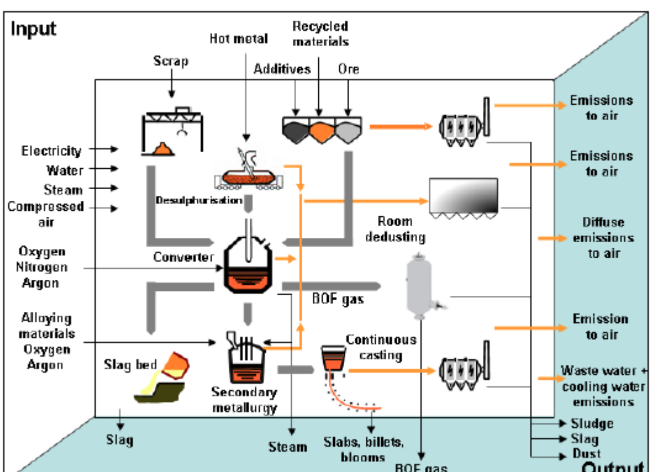
- mixing and homogenising
- adjustment of chemical compositions to close analysis tolerances
- temperature adjustment in time for the downstream casting process
- deoxidation
- removal of undesirable gases such as hydrogen and nitrogen
- improvement of the oxidic purity by separating non-metallic inclusions.

Continuous casting



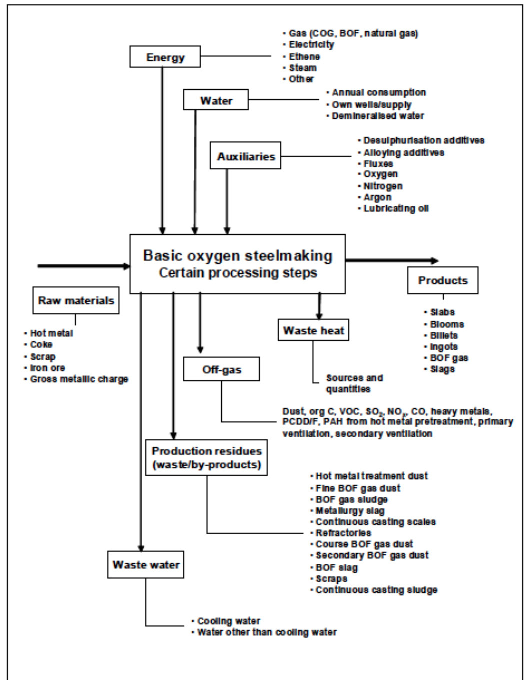
Source: [175, Eurofer 2009] [200, Commission 2001]

BOF proces – input/output



Source: [200, Commission 2001] [365, Eurofer 2007]

Mass stream overview



Source: [200, Commission 2001]

Input/output Steelworks

Table 7.3: Input/output-data from 21 existing basic oxygen steelmaking plants in different EU Member States

Input		
Raw materials		
Hot metal ( )	kg/t LS	788 – 931
Scrap	kg/t LS	101 – 340
Iron ore	kg/t LS	0.02 – 19.4
Other Fe material	kg/t LS	0 – 60
Coke	kg/t LS	0 – 0.4
Lime	kg/t LS	30 – 67
Dolomite	kg/t LS	0 – 28.4
Alloys ( )	kg/t LS	1.3 – 33
Gases		
Oxygen	m^3/t LS	49.5 – 70
Argon	m^3/t LS	0.55 – 1.1
Nitrogen	m^3/t LS	2.3 – 18.2
Energy ( )		
Natural gas	MJ/t LS	44 – 730
Electricity	MJ/t LS	35 – 216
COG	MJ/t LS	0 – 800
BF gas	m^3/t LS	1.84 – 17.6
Overall steam	MJ/t LS	13 – 150
Compressed air	Nm^3/t LS	8 – 26
Water	m^3/t LS	0.8 – 41.7

Output		
Products ( )	kg/t LS	1000.0
Slabs ( )		
Blooms		
Billets		
Ingots		
Foundry		
Energy		
BOF gas	MJ/t LS	(0 ( )) 350 – 700
Steam ( )	MJ/t LS	(0) 124 – 335
Emissions		
Dust ( ) ( )	g/t LS	14 – 143
Cr ( )	g/t LS	0.01 – 0.075
Fe	g/t LS	45.15
Cu ( )	g/t LS	<0.01 – 2.72
Pb ( )	g/t LS	0.17 – 0.98
Mn ( )	g/t LS	0.3 – 1.56
NO_X	g/t LS	8.2 – 55 (100)
CO (10)	g/t LS	393 – 7200 (18000)
CO_2 (11)	kg/t LS	22.6 – 174
PAH (12)	mg/t LS	10
PCDD/F	µg I-TEQ/t LS	0.043 – 0.094
Production residues (waste/by-products)		
Slag from desulphurisation	kg/t LS	3 – 40
BOF slag	kg/t LS	85 – 165
Slag from secondary metallurgy	kg/t LS	9 – 15
Spittings	kg/t LS	2.8 – 15
Dusts	kg/t LS	0.75 – 24
Slag from continuous casting	kg/t LS	4 – 5.7
Mill scale	kg/t LS	2.3 – 7.7
Rubble	kg/t LS	0.05 – 6.4
Waste water	m^3/t LS	0.3 – 6

Emission values for steelworks

Table 7.6: Specific emission values to air from a basic oxygen furnace with suppressed combustion after abatement, if there is no other indication

Component		Specific emission value	Unit
Flow of primary (BOF gas) ventilation	Flow of primary (BOF gas) ventilation	65000 – 300000	Nm^3/h
	Full combustion	500 – 1000	Nm^3/t LS
	Suppressed combustion	50 – 120	Nm^3/t LS
Dust from oxygen blowing	Unabated	15 – 20	kg/t LS
	After primary (BOF gas) dedusting	0.3 – 55	g/t LS
	Filtered dust/sludge	12 – 23	kg/t LS
Flow of secondary ventilation		1300 – 4800	Nm^3/t LS
		300000 – 3441000	Nm^3/h
Dust from charging and tapping	Unabated	200 – 1000	g/t LS
	After secondary dedusting	2 – 60	
	Not caught by enclosure	8 – 120	
Dust from secondary dedusting	Filtered dust/sludge	0.1 – 1.2	kg/t LS
(Heavy) metals	Al	0.60 – 0.68	g/t LS
	As	0.00 – 0.02	
	Cd	0.07 – 0.20	
	Cr	0.00 – 0.04	
	Cu	0.04	
	Fe	2.8 – 83	
	Hg	0.00 – 0.02	
	Mg	1.45 – 2.40	
	Mn	2.7 – 60	
	Pb	1.5 – 2.9	
	Zn	8.2	
Sulphur oxides (SO_2)		0.4 – 5.5	g/t LS
Nitrogen oxides (NO_X)		5.0 – 20	g/t LS
Carbon monoxide (CO)		7.0 – 16	kg/t LS
Hydrogen fluoride (*)		0.008 – 0.01	g/t LS
PAH (Borneff 6)		0.08 – 0.16	mg/t LS
PCDD/F		<0.001 – 0.11	µg I-TEQ/t LS

(*) Whenever fluorspar (CaF_2) is added as a flux in hot metal desulphurisation, emissions of fluorides may be much higher.

NB: LS = (Crude) Liquid steel.

Source: [65, InfoMil 1997] [365, Eurofer 2007] [372, Czech TWG member 2008].

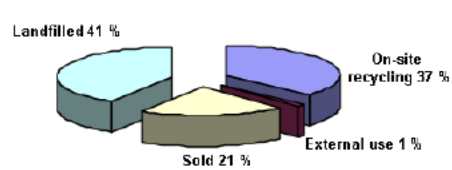
Slag

Table 7.8: Kind and specific quantity of solid residues resulting from oxygen steelmaking

Generated solid material (waste/by-product/residues)	Specific quantity (range) (kg/t LS)
Desulphurisation slag	3 – 21
BOF slag	85 – 165
Slag from secondary metallurgy	9 – 15
Slag from continuous casting	4.0 – 5
Spittings	2.8 – 15
Fine and coarse dusts	0.75 – 24
Mill scale from continuous casting	2.3 – 6.4
Rubble	0.05 – 6

NB: LS = Liquid steel.

Source: [363, Eurofer 2007] [365, Eurofer 2007].



Source: [30, Roederer et al. 1996]

Figure 7.12: Fate of slag from hot metal desulphurisation in the EU

Energy consumption - example

- Basic oxygen furnace (BOF)
- In the BOF (converter), fuel is consumed to preheat and dry the converters after relining and repair. This thermal energy consumption totals to approximately 0.051 GJ/t LS. Electricity
- consumption is estimated at 23 kWh/t LS or 0.08 GJ/t LS. This figure includes the production of oxygen and the operation of the converters.
- The process gas from the converter contains large amounts of carbon monoxide (CO) and is hot.
- When the energy from the BOF gas is recovered (waste heat recovery and/or BOF gas recovery), **the BOF becomes a net producer of energy**. In a modern plant, energy recovery can
- be as high as 0.7 GJ/t LS.

Primary dedusting

- Recovery of BOF gas for fuel
- Dry suppressed or wet scrubber dedusting
- Levels of dust 10-50 mg/Nm3

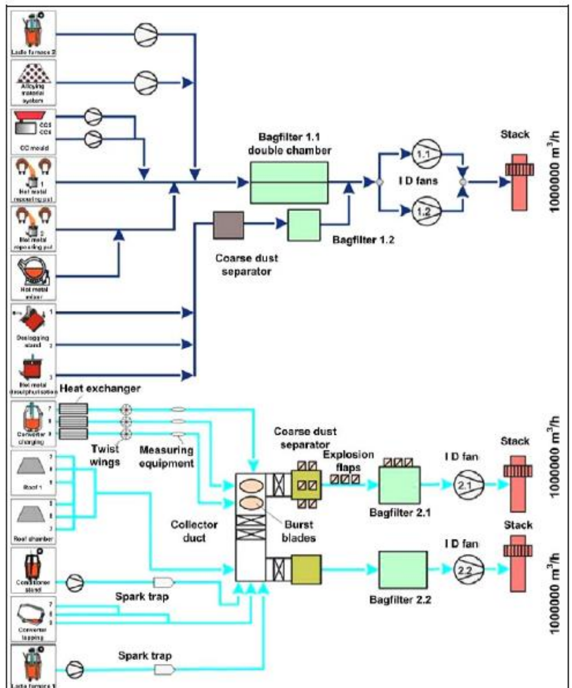
Table 7.18: Achieved emission concentrations when using wet air abatement techniques

Parameter	Scrubber and wet ESP	Scrubber
PM	32.5	<42
CO	15	2
NO_X	25	
Hg		0.002
Cd, Tl	0.003	
As, Co, Ni, Se, Te	0.02	
Pb, Cr, Cu, Mn, V	0.4	
Pb		0.3
PCDD/F	0.04	
HF	<0.5	

NB: Values are in mg/Nm^3 except for PCDD/F that are in ng I-TEQ/Nm^3. Values are annual averages.

Source: [244, Plickert 2007].

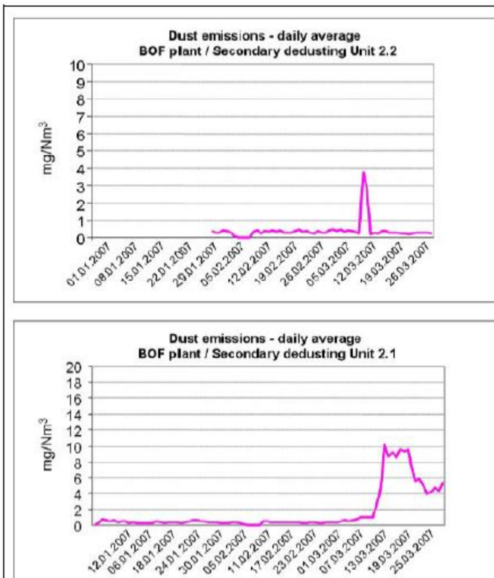
Secondary dedusting system



Source: [277, Wiesenberger 2007]

Emission results

Unit 2 at the basic oxygen furnace of Voestalpine Stahl GmbH, Linz, Austria



Source: [277, Wiesenberger 2007]

Waste water

From processes
1. Recycling
2. Treatment for purification

Example: From wet dedusting

Parameter	Units	Suppressed combustion systems		
		Corus IJmuiden, NL ([1])	Stelco LEW, Ontario, Canada	LTV Steel Cleveland Works, US
Discharge flow	m^3/t LS	0.52	1.1	0.002
Suspended solid	g/t LS	20	5.5	0.0083
Zinc (Zn)	mg/t LS	73	210	0.36
Lead (Pb)	mg/t LS	31	110	0.057

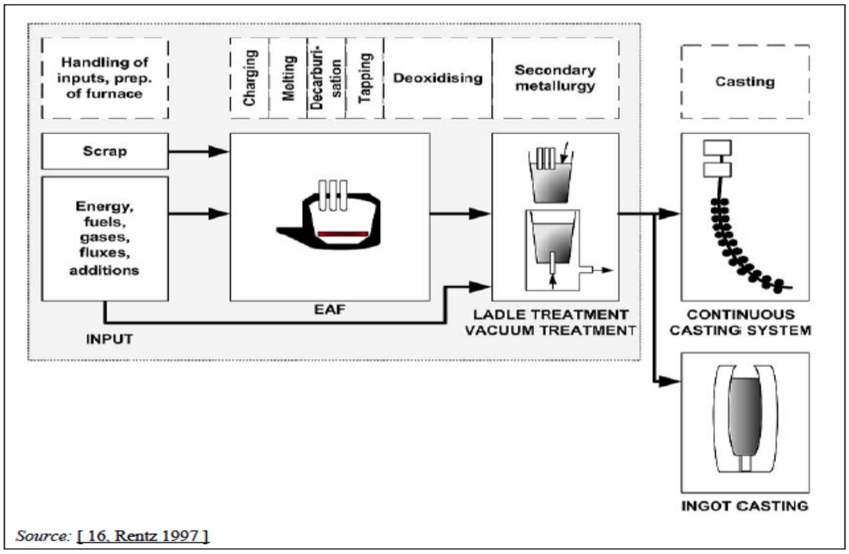
([1]) Emissions at Corus IJmuiden, the Netherlands relate to 1994 values.
Source: [65, InfoMil 1997].

The most effective measures for minimising waste water discharge
1. Increasing the recirculation rate of the scrubbing water
2.Treating the bleed

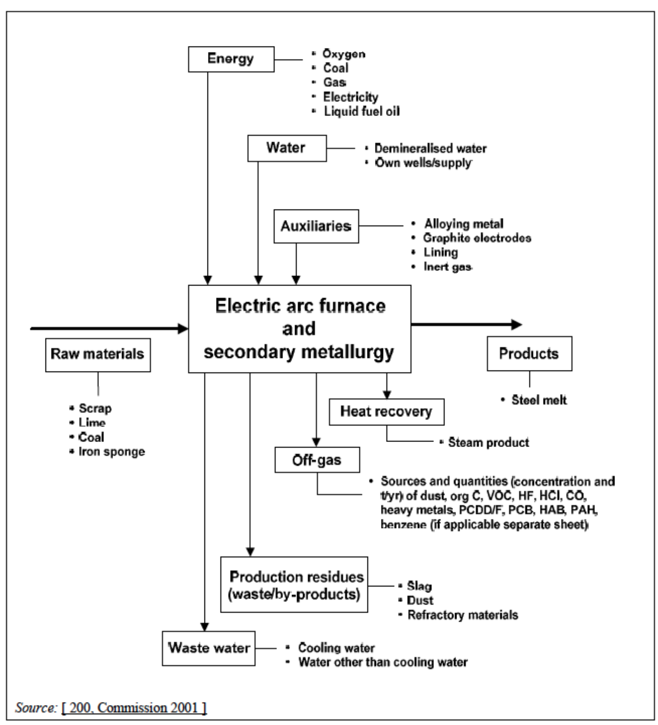
General BAT recommendations

- Dust hot briquetting and recycling with recovery of high zinc concentrated pellets for external reuse
- Energy recovery from the BOF gas
  - Combustion for steam production
  - Suppression of BOF gas combustion and buffering of the BOF gas in a gasholder for subsequent use
- Online sampling and steel analysis
- Increased energy efficiency in the steel shop by automatisation
- Direct tapping from BOF
- Near net shape strip casting

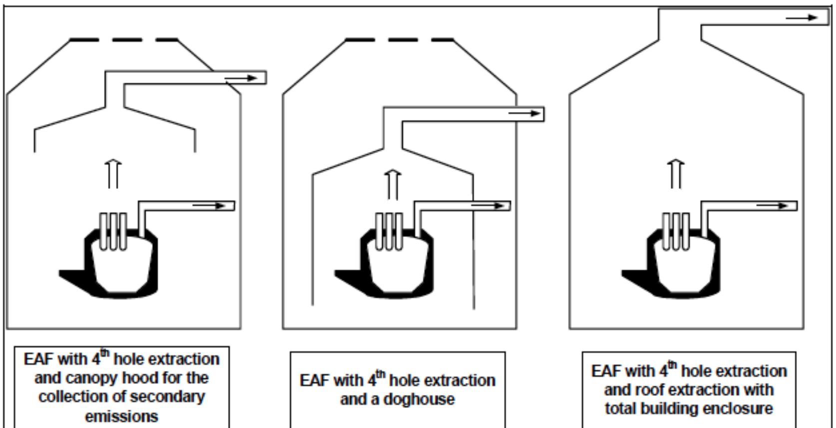
EAF - Process



EAF Flow diagram



Collection of primary emission



Source: based on [140, Eurofer 2009] [373, Eurofer 2007]

Table 8.3: Air emissions concentrations from the EAF process after abatement

Parameter		Bag filter	Electrostatic precipitator (1)	Unit
Dust		0.35 – 3.4	1.8	mg/Nm^3
CO		88 – 256		mg/Nm^3
NO_X		0.97 – 70		mg/Nm^3
SO_X		8 – 17		mg/Nm^3
Metals:	Hg	0.016 – 0.019	<0.0003	mg/Nm^3
	Total (including Sb, Pb, Cr, CN, F, Cu, Mn, V, Se, Te, Ni, Co, Sn)	0.006 – 0.022	0.01 – 0.07	mg/Nm^3
	Cr (except Cr (VI)	0.013		
	Mn	0.036		
	Ni	0.003		
PAH		<0.00001	<0.001	mg/Nm^3
PCDD/F		0.0015 – 0.1 (2)		ng/Nm^3
HF		0.085 – 0.2		mg/Nm^3
HCl		3 – 5.4		mg/Nm^3
Cl_2		<3		mg/Nm^3

(1) Values relate to one German stainless steel plant.
(2) Upper end of the range relates to measurements carried out in 1997.
NB: — Values are annual averages and relate to the central dedusting system.
— PAH contain benzo(a)pyrene and dibenzo-(a,h)-anthracene.
Source: [244, Plickert 2007] [277, Wiesenberger 2007].

BAT Conclusions For Basic Oxygen Steelmaking And Casting

Air emissions

75. BAT for basic oxygen furnace (BOF) gas recovery by **suppressed combustion** is to extract the BOF gas during blowing as much as possible and to clean it by using the following techniques in combination:

I. use of a suppressed combustion process

II. prededusting to remove coarse dust by means of **dry separation techniques** (e.g. deflector, cyclone) or **wetseparators**

III. dust abatement by means of:

(i) **dry dedusting**(e.g. electrostatic precipitator) for new and existing plants

(ii) **wet dedusting** (e.g. wet electrostatic precipitator or scrubber) for existing plants.

The residual dust concentrations associated with BAT, after buffering the BOF gas, are:

10 – 30 mg/Nm3 for BAT III.i

< 50 mg/Nm3 for BAT III.ii.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

76. BAT for basic oxygen furnace(BOF) gas recovery during oxygen blowing in the case of **full combustion** is to reduce dust emissions by using one of the following techniques:

I. dry dedusting (e.g. ESP or bag filter) for new and existing plants

II. wet dedusting (e.g. wet ESP or scrubber) for existing plants.

The BAT-associated emission levels for dust, determined as the average over the sampling period (discontinuous measurement, spot samples for at least half an hour), are:

10 – 30 mg/Nm3 for BAT I

< 50 mg/Nm3 for BAT II.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

77. BAT is to minimise dust emissions from the oxygen lance hole by using one or a combination of the following techniques:

I. covering the lance hole during oxygen blowing

II. inert gas or steam injection into the lance hole to dissipate the dust

III. use of other alternative sealing designs combined with lance cleaning devices.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

78. BAT for secondary dedusting, including the emissions from the following processes (mentioned specific)

is to minimise dust emissions by means of **process integrated techniques**, such as general techniques to prevent or control diffuse or fugitive emissions, and by **using appropriate enclosures** and hoods with efficient extraction **and a subsequent off-gas cleaning by means of a bag filter or an ESP.**

BAT Conclusions For Basic Oxygen Steelmaking And Casting

The overall average dust collection efficiency associated with BAT is > 90 %

The BAT-associated emission level for dust, as a daily mean value, for all dedusted off-gases is < 1 – 15 mg/Nm 3 in the case of bag filters and < 20 mg/Nm 3 in the case of electrostatic precipitators.

More specific details!!

BAT Conclusions For Basic Oxygen Steelmaking And Casting

79. BAT for **on-site slag processing is to reduce dust emissions** by using one or a combination of the following techniques:

- I. efficient extraction of the slag crusher and screening devices with subsequent off-gas cleaning, if relevant
- II. transport of untreated slag by shovel loaders
- III. extraction or wetting of conveyor transfer points for broken material
- IV. wetting of slag storage heaps
- V. use of water fogs when broken slag is loaded.
- The BAT-associated emission level for dust in the case of using BAT I is < 10 – 20 mg/Nm 3 , determined as the average over the sampling period (discontinuous measurement, spot samples for at least half an hour).

BAT Conclusions For Basic Oxygen Steelmaking And Casting

Water and waste water

80. BAT is to prevent or reduce water use and waste water emissions from primary dedusting of basic oxygen furnace (BOF) gas by using one of the following techniques as set out in BAT 75 and BAT 76:

- dry dedusting of basic oxygen furnace (BOF) gas;
- minimising scrubbing water and reusing it as much as possible(e.g. for slag granulation) in case wet dedusting is applied.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

81. BAT is to minimise the waste water discharge from continuous casting by using the following techniques in combination:

- I. the removal of solids by flocculation, sedimentation and/or filtration
- II. the removal of oil in skimming tanks or any other effective device
- III. the recirculation of cooling water and water from vacuum generation as much as possible.

The BAT-associated emission levels, based on a qualified random sample or a 24-hour composite sample, for waste water from continuous casting machines are:

- Suspended solids < 20 mg/l
- Iron < 5 mg/l
- Zinc < 2 mg/l
- Nickel < 0,5 mg/l
- Total chromium < 0,5 mg/l
- Total hydrocarbons< 5 mg/l.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

Production residues (dust and slag)

82. BAT is to prevent waste generation by using one or a combination of the following techniques (see BAT 8):

- I. appropriate **collection and storage** to facilitate a specific treatment
- II. on-site **recycling of dust** from basic oxygen furnace (BOF) gas treatment, dust from secondary dedusting and mill scale from continuous casting back to the steelmaking processes with due regard for the effect of emissions from the plant where they are recycled
- III. on-site **recycling of BOF slag** and BOF slag fines in various applications
- IV. **slag treatment** where market conditions allow for the external use of slag (e.g. as an aggregate in materials or for construction)
- V. use of **filter dusts and sludge for external recovery** of iron and non-ferrous metals such as zinc in the non-ferrous metals industry
- VI. use of a **settling tank for sludge with the subsequent recycling** of the coarse fraction in the sinter/blast furnace or cement industry when grain size distribution allows for a reasonable separation.

BAT Conclusions For Basic Oxygen Steelmaking And Casting

Energy

83. BAT is to collect, clean and buffer BOF gas for subsequent use as a fuel.

84. BAT is to reduce energy consumption by **using ladle-lid systems**.

85. BAT is to optimise the process and reduce energy consumption by **using a direct tapping process** after blowing.

86. BAT is to reduce energy consumption by using **continuous near net shape strip casting**, if the quality and the product mix of the produced steel grades justify it

Note: Applicability remarks

BAT conclusions for EAF

88. BAT for the electric arc furnace (EAF) primary and secondary dedusting (including scrap preheating, charging, melting, tapping, ladle furnace and secondary metallurgy) is to achieve an **efficient extraction of all emission sources by using one of the techniques listed** below and to use subsequent dedusting by means of a bag filter:

- I. a combination of direct off-gas extraction (4th or 2nd hole) and hood systems
- II. direct gas extraction and doghouse systems
- III. direct gas extraction and total building evacuation (low-capacity electric arc furnaces (EAF) may not require direct gas extraction to achieve the same extraction efficiency).

The overall average collection efficiency associated with BAT is > 98 %.

- The BAT-associated emission level for dust is < **5 mg/Nm3**, determined as a daily mean value.
- The BAT-associated emission level for mercury is < 0,05 mg/Nm3, determined as the average over the sampling period (discontinuous measurement, spot samples for at least four hours).

BAT conclusions for EAF

Parallel with BOF for slag and waste water, despite

Focus on emissions from

- mercury emission
- polychlorinated dibenzodioxins/furans (PCDD/F) and polychlorinated biphenyls (PCB) or their precursors
- Noise

ArcelorMittal Zenica permit

The delivered permit cover

- BOF converter - 1,1 million t per year
- EAF 100 t/ 800.000 t per year

Input

	Unit	BAT	AMZ 2013	AMZ 2014
Raw material				
Liquid iron	kg/t LS	788 - 931	924	918
Scrap	kg/t LS	101 - 340	174	149
Iron ore	kg/t LS	0,02 - 19,4	0,08	0
Other Fe materials	kg/t LS	0 - 60	26	53
Coke	kg/t LS	0 - 0,4	0,03	0
Lime	kg/t LS	30 - 67	60	51
Dolomite	kg/t LS	0 - 28,4	10	9
Alloyed materials	kg/t LS	1,3 - 33	6,2	6,6
Gases				
Oxygen	m3/t LS	49,5 - 70	54,7	55,7
Argon	m3/t LS	0,55 - 1,1	1,6	1,2
Nitrogen	m3/t LS	2,3 - 18,2	0,001	0
Energy				
Electricity	MJ/t LS	35 - 216	544	497
Natural gas	MJ/t LS	44 - 730	117,2	110,7
Coke gas	MJ/t LS	0 - 800	96	127
BF gas	m3/t LS	1,84 - 17,6	57	65
Steam	MJ/t LS	13 - 150	144	58
Compressed air	Nm3/t LS	8 - 26	0	0
Water	m3/t LS	0,8 - 41,7	3,4	4,3

Output

	Unit	BAT	AMZ 2013	AMZ 2014
Products				
Liquid steel	kg	1000	743.226.000	815.355.000
Energy				
BOF gas	MJ/t LS	350 - 700	-	-
Steam	MJ/t LS	124 - 335	-	-
Emissions				
Dust	g/t LS	14 - 143	48	55
Cr	g/t LS	0,01 - 0,075	0	0,001
Fe	g/t LS	45,15	-	-
Cu	g/t LS	0,01 - 2,72	0,07	0,01
Pb	g/tLS	0,17 - 0,98	0,20	0,14
Mn	g/t LS	0,3 - 1,56	0,10	0,44
NO2	g/t LS	8,2 - 55 (100)	185	194
CO	g/t LS	393 - 7200 (18000)	324	517
CO2	kg/t LS	22,6 - 174	-	-
PAH	mg/t LS	10	8	10
PCDD/F	µg I-TEQ/t LS	0,043 - 0,094	0	0,028
Waste materials				
BOF slag	kg/t LS	85 - 165	179	151
LF slag	kg/t LS	9 - 15	-	-
Dust	kg/t LS	0,75 - 24	0,22	0,29
CC slag	kg/t LS	4 - 5,7 (13 - 20,7)	11	9
Refractory material	kg/tLS	0,05 - 6	2,5	3,4
Waste water	m3/t LS	0,3 - 6	3,00	2,4

Remark:

LS = Liquid Steel
AMZ = ArcelorMittal Zenica

ArcelorMittal Zenica permit

Air emissions from BOF are produced in following processes:

- In Mixer during hot metal charging and tapping hot metal;
- In convertor during charging, oxygen blowing (BOF gas production and burning) discharging liquid steel and slag from BOF convertor,
- During operation of EAF-100t and LF (ladle processing) and during ladle slag discharging,
- during unloading, transporting and dosing fluxes,
- during ferroalloys handling;
- during processing and drying sludge in DHD system
- In a ladle bay when heating ladles and tundish

Diffuse air emissions are produced in some of these processes and the processes related to the technological process, are **not controlled or covered by suction hoods** or other treatment processes before release to the atmosphere.

ArcelorMittal Zenica permit

- **Air emissions from EAF and LF** are divided into: primary emisions produced during EAF and LF operation and secondary emissions generated during preparation of scrap, transportation of fluxes and ferroalloys and charging process of EAF and liquid steel tapping .
- Primary and secondary emissions, and emissions from **LF are treated in the same bag filter with extraction hoods and fans**. The primary waste gases represent 95% of total emissions from EAF.
- Secondary waste gases are **extracted with a hood installed** on the roof of bay, above EAF. This hood also extracts primary emissions that are not captured by primary system.
- Emissions from LF: waste gases from LF are cleaned in same bag filter, as well as primary and secondary emissions from EAF.

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Table 3 Installed equipment, de-dusting system type and suction points

Mark of installed De-duster	Type of cleaner	Suction place
Mixer		
Kappa filter	Bag filter	Inlet &pouring side of mixer and hall deck Of mixer
Fluxes and Ferro-alloys bey in BOF		
ATU-1	Bag filter	Conveyer belt: reloading station
ATU-3	Bag filter	Conveyer belt: reloading station
ATU-4	Bag filter	Conveyer belt: reloading station
ATU-6	Bag filter	Conveyer belt: reloading station
ATU-7	Bag filter	Conveyer belt: reloading station
convertor		
GAZOČISTKA 1	Rough scrubber ventur Fine srubber	converter 1
GAZOČISTKA 2	Rough scrubber ventur Fine scrubber	converter 2
DHD system		
ATU-1	Venturi	Rotating furncace
EAF-100t, LF & MHS		
Danieli filter	bag filter	EAF, secondary metallurgy (LF), transport of non-metallic additives Ferro-alloys (MHS) & roof of EAF bay

Waste water and slag

- Waste water is cleaned and recycled – rest discharged to river
- Slag for different processes is recycled or deposited on landfill

Overview of measures already taken – extract

1. Preventive activities and measures			
1.1. Have monitoring over waste material and emissions make reports, analyse them and take actions.	2008	Reducing waste material quantities, low disposal at landfill Rača and possibility to place it outside AMZ	**Closed** Steel plant has procedures on waste management and mechanism for waste material management supervision system. AMZ has contracts with authorized operators for disposing certain types of material. It appointed a person for waste disposal in Steel plant. Locations for collection of some material are defined prior to its final disposal.

2. MEASURES WITHIN CAPEX INVESTMENT PROGRAM (2007/2008)			
2.1. Mixer section equipment overhauling (de-dusting), code: BOF-8-2	2007/8	Equipment operation as per designed parameters	**Closed** Repair of equipment completed, FENIX project underway to restart Steel plant

3. TECHNICAL MEASURES FOR ADJUSTMENT TO FBIH AND BAT NORMS			
3.1. Reconstruction of de-dusting system in mixer section (pouring into mixer, tapping, slag removal)	2 years	Mixer unit emission reduction to allowed range (<50mg/m3)	**Closed** Project implement4ed in November 2011. Emissions below 20 mg/Nm3.

The impact on population

The plants are located in the industrial zone, on location of ArcelorMittal (the current name) steelworks exists over a hundred years, the **impact on population, primarily through air pollution has an adverse, negative impact**, especially during temperature inversions is harmful, and in this sense the requirements and criteria on which competent authorities are issuing approvals are specific. For this reason, harmonization of regulations on environmental protection, needs of operators and obligations to the population / environment protection **requires for a special treatment** in which it is necessary to harmonize the many seemingly unrelated elements.

Zenica valley is a serious problem in air pollution because orography is a big limiting factor for all simple models of meteorology influence on air pollution. One should take into account the complex meteorology areas appropriately. All measurement results show that they are difficult to comply, to defend significance of the results and bring them into contact with real conditions, which why it is necessary to work with tools that are appropriate to the problem.

Permit measures action plan - extract

Environment protection actions	Deadline
1. PREVENTIVE ACTIVITIES AND ACTIONS	
1.1 Make annual maintenance plan for installed equipment for reducing emissions into air at annual level and follow up maintenance realization. As a part of maintenance also regularly perform vibrations measurements on the installed equipment.	Permanent activity. The implementation of the annual maintenance schedule. Measurement of vibrations will be performed by Central service department as per Plan.
1.2 Define continuous improvement plan (CIP) and follow up realization of the same	Permanent activity. Monthly and annual reviews and analysis of the CIP Plan

Permit measures action plan - extract

2. TECHNICAL- TECHNOLOGICAL MEASURES FOR TO REGULATION IN FB&H & BAT	
2.1 Manage production process according to ISO 9001 i ISO 14001	Permanent activity. The method of proving performance: renewed certification system ISO 9001 & ISO 14001
2.2 Limit speed of hot metal charging into mixer in order to increase the suction efficiency of mixer's system	Permanent activity Define speed and instruct operators Deadline: end 2015.
2.3 Consider possibility to reduce or replace CaF fluxes with other material in order to reduce fluoride emissions	Define trial period and analyse the results. Deadline: 2018.

3. CAPEX MEASURES	
3.1 Install BOF convertor secondary de-dusting system	Deadline: end 2016.
3.1.1 Contract signed	19/12/2014
3.1.2 Official Start – Up of the project	16/01/2015
3.1.3 Delivery of the documentation - Basic design documentation approved	June 2015
3.1.4 Delivery of the documentation - Detail design documentation approved	July - August 2015
3.1.5 Civil works on site	July – Sep 2015
3.1.6 Manufacturing and delivery of equipment	Q3 – Q4 2015
3.1.7 Erection of equipment on site of the works	Q3 – Q4 2015
3.1.8 End of the erection on site of the works and ready for initial operation of first BOF	Q1 2016
3.1.9 End of the erection on site of the works and ready for initial operation of second BOF	Q2 2016
3.1.10 Industrial commissioning	Q3 2016
3.1.11 Provisional acceptance	Q4 2016
3.1.12 Final acceptance	end 2016
3.2 Implement project on using BOF steam in order to increase energy efficiency and this will directly reduce emissions from ArcelorMittal Zenica plants	Deadline: 2017.
3.3 Consider alternative ways to de-dust conveyer systems for non-metal additions and ferroalloys.	Consider the possibility till end of 2016. If it turns out it is possible define the terms in accordance with the technical offers

Monitoring and ELV

Table 6 Air emission monitoring plan and limit values of emissions for BOF convertor

Source of emissions	Pollutant	Method of follow up	Place	Dynamics	Limit value
Mixer unit	Dust	Measuring concentration in fumes	Filter chimney	2 x per annum	50 mg/Nm^3
convertor – primary system	Dust	Measuring concentration in fumes	Convertor chimney	Continuous monitoring	50 mg/Nm^3
	SO_2	Measuring concentration in fumes	Convertor chimney	Continuous monitoring	800 mg/Nm^3
	NOx	Measuring concentration in fumes	Convertor chimney	Continuous monitoring	300 mg/Nm^3
	Cr	Measuring concentration in fumes	Convertor chimney	2 x per annum	0,2 mg/Nm3
	Cu	Measuring concentration in fumes	Convertor chimney	2 x per annum	5 mg/Nm3
	Pb	Measuring concentration in fumes	Convertor chimney	2 x per annum	1 mg/Nm3
	Mn	Measuring concentration in fumes	Convertor chimney	2 x per annum	5 mg/Nm3
	Cd	Measuring concentration in fumes	Convertor chimney	2 x per annum	0,2 mg/Nm3
	Ni	Measuring concentration in fumes	Convertor chimney	2 x per annum	0,2 mg/Nm3
	Zn	Measuring concentration in fumes	Convertor chimney	2 x per annum	5 mg/Nm3
	PAH	Measuring concentration in fumes	Convertor chimney	2 x per annum	Compare measured values with data from table 1
	PCDD/F	Measuring concentration in fumes	Convertor chimney	2 x per annum	
convertor – secondary system	Dust	Measuring concentration in fumes	Convertor chimney	2 x per annum	50 mg/Nm^3
Transport of non-metal additives and ferroalloys	Dust	Measuring concentration in fumes	ATU-1 chimney	2 x per annum	50 mg/Nm^3

Monitoring and ELV II

Table 7 Air emission monitoring plan and limit values of emissions for EAF-100t

Source of emissions	Pollutant	Method of follow up	Place	Dynamics	Limit value
Filter chimney	Dust	Measuring concentration in fumes	Filter chimney	2 x per annum	50 mg/Nm3
	SO2	Measuring concentration in fumes	Filter chimney	2 x per annum	500 mg/Nm3
	NO2	Measuring concentration in fumes	Filter chimney	2 x per annum	500 mg/N,3
	Hg	Measuring concentration in fumes	Filter chimney	2 x per annum	0,2 mg/Nm3
	Pb	Measuring concentration in fumes	Filter chimney	2 x per annum	1 mg/Nm3
	Cr	Measuring concentration in fumes	Filter chimney	2 x per annum	0,2 mg/Nm3
	Ni	Measuring concentration in fumes	Filter chimney	2 x per annum	0,2 mg/Nm3
	Zn	Measuring concentration in fumes	Filter chimney	2 x per annum	5 mg/Nm3
	Cd	Measuring concentration in fumes	Filter chimney	2 x per annum	0,2 mg/Nm3
	Cu	Measuring concentration in fumes	Filter chimney	2 x per annum	5 mg/Nm3
	HF	Measuring concentration in fumes	Filter chimney	2 x per annum	30 mg/Nm3
	HCl	Measuring concentration in fumes	Filter chimney	2 x per annum	30 mg/Nm3
	PAH	Measuring concentration in fumes	Filter chimney	2 x per annum	Compare measured values with data from table 2
	PCDD/F	Measuring concentration in fumes	Filter chimney	2 x per annum	
	Benzene	Measuring concentration in fumes	Filter chimney	2 x per annum	5 mg/Nm3

Water monitoring

Parameters	Method	Place	Dynamics
water flow	flow Measurement	Entrance to plant	once a month
The flow of waste water	flow Measurement	discharging manhole (OV-10)	once a month
Analysis of the basic parameters of the quality of waste water	Physical-chemical analysis	discharging manhole (OV-10)	once a month
Analysis of specific quality parameters of wastewater: Fe, Ni, Zn, Cu, Pb, Cd, Cr, Mn and Hg	physical-chemical analysis	discharging manhole (OV-10)	once a month
The flow of waste water	flow Measurement	discharging point AMZ (ŽZ-2)	once a month
Analysis of the basic parameters of the quality of waste water	physical-chemical analysis	discharging point AMZ (ŽZ-2)	once a month
Analysis of specific quality parameters of wastewater: total oils and fats, PAH, Fe, Ni, Zn, Cu, Pb, Cr, Cd, Hg, Mn, Cl	physical-chemical analysis	discharging point AMZ (ŽZ-2)	once a month

Water discharge ELV

Parameters		Unit measure	Limit values of emissions of industrial waste water quality discharged into	
			Surface waters	Public sewer
A General parameters				
1	Max temperature	0C	30	40
2	pH		6,5 - 9,0	6,5 - 9,5
3	Sediment solids	ml/l	0,5	10,0
4	Total suspended solids	mg/l	35,0	400,0
B Inorganic parameters				
1	Aluminium, Al	mg/l	3,0	3,0
2	Antimony, Sb	mg/l	0,3	0,3
3	Arsen, As	mg/l	0,1	0,1
4	Copper , Cu	mg/l	0,5	0.5
5	Barium, Ba	mg/l	5.0	5,0
6	Boron, B	mg/l	1,0	10,0
7	Cyanide free	mg/l	0,1	0,1
8	Cyanide total	mg/l	0,5	10,0
9	zinc, Zn	mg/l	2,0	2,0
10	Fluoride	mg/l	10,0	20,0
11	chlorine free	mg/l	0,2	0.5
12	chlorine total	mg/l	0.5	1,0
13	Chloride	mg/l	250,0	250,0
14	Chromium hexavalent, Cr6+	mg/l	0,1	0,1
15	Chromium total, Cr	mg/l	0,5	0.5
16	Cadmium, Cd	mg/l	0,1	0,1
17	Tin Sn	mg/l	2.0	2,0
18	Cobalt, Co	mg/l	1.0	1,0
19	Manganese, Mn	mg/l	1,0	1.0
20	Molybdenum, Mo	mg/l	1,0	1.0
21	Nickel, Ni	mg/l	0,5	0.5
22	Lead , Pb	mg/l	0,5	0,5
23	Selene, Se	mg/l	0,1	0,1
24	Silver , Ag	mg/l	0,1	0,1
25	Sulphate, SO4	mg/l	200,0	300,0
26	Sulfidic, S	mg/l	0,1	1,0
27	Sulphite, SO3	mg/l	1,0	10,0
28	Thallium	mg/l	0,5	0,5
29	Vanadium	mg/l	0,5	0,5
30	tungsten	mg/l	5,0	5,0
31	Fe	mg/l	2,0	2,0
32	Mercury Hg	mg/l	0,01	0,01

Water discharge ELV II

C Nutrients				
1	Ammonia nitrogen, NH4-N	mg/l	10,0	40,0
2	Nitrate nitrogen NO3-N	mg/l	10,0	50,0
3	Total nitrogen	mg/l	15,0	100,0
4	Total phosphorus, P	mg/l	2,0 (a)	5,0
D Organic parameters				
1	Absorbable organic halogens (AOX)	mg/l	0.5	0.5
2	BPK5	mgO2/l	25	250
3	Hexachlorobenzene (HCB)	mg/l	0,03	0,03
4	KPK-Cr	mgO2/l	125	700
5	Volatile aromatic hydrocarbons (BTX)	mg/l	0,1	1,0
6	Volatile chlorinated hydrocarbons (LKCH)	mg/l	0.1	1,0
7	Mineral oils	mg/l	10,0	20,0
8	Non-volatile lipophilic substances (total oil and grease))	mg/l	20	100
9	Total surfactants (detergents, etc.)	mg/l	1,0	10,0
10	Total aromatic hydrocarbons (PAHs	mg/l	0,01	0,01
11	Total phenol (C6H5OH)	mg/l	0,1	10,0
12	Total chlorinated biphenyls (PCBs)	mg/l	0,01	0,01
13	The total organophosphorus and carbamate pesticides	mg/l	0,05	0,05
14	Total organochlorine pesticides	mg/l	0,025	0,025
15	Total organic carbon (TOC)	mg/l	30,0	50,0
E Radioactivity				
1	Total beta radioactivity	mBq/l	500	500,0
F Toxicity				
1	Toxically bio test Daphnia magna Straus, 48hEC50	% of wastewater in dissolvent	> 50%	

Reporting

The report	deadline for reporting	to whom the report submitted
Report on measurements of pollutants in the air (in accordance with Article 33 of the Rulebook on monitoring emissions of pollutants into the air ((„Of Gazette F B&H, No.9 / 14))	March 31 of the current year for the previous year of reporting	Federal Ministry of Environment and Tourism and Environmental Protection Fund
Report on implementation of the annual maintenance plan	March 31 of the current year for the previous year of reporting	Federal Ministry of Environment
Report on the implementation of the plan for continuous improvement	March 31 of the current year for the previous year of reporting	Federal Ministry of Environment
Report on conducted measurements of quality of industrial waste water	After performed measurements	Authorized laboratory performing measurements to submit the Report to the Agency for the Sava River Basin, Sarajevo
A report on the quantities of waste materials	No later than 30.06. for the previous year	Federal Ministry of Environment
A report on noise measurements	After performed measurements	Federal Ministry of Environment
Summary report under the Rulebook on registries of plants and pollution ("Official Gazette of BiH" No. 82/07	No later than 30.06. for the previous year	Federal Ministry of Environment

Process

- Permit application announced on website
- ECO forum Zenica and others commented on the application
- Permit issued – final
- Appeal possible to court

Group questions

- How does permit for BOF and EAF comply with BAT conclusions?
  1. For air
  2. For waste
  3. For waste water
- Focus points for inspection?
- Questions to company?