TFTEI

Under the Convention on Long Range Transboundary Air Pollution

Analysis of abatement measures in the Cement and Aluminum Sectors

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Agenda

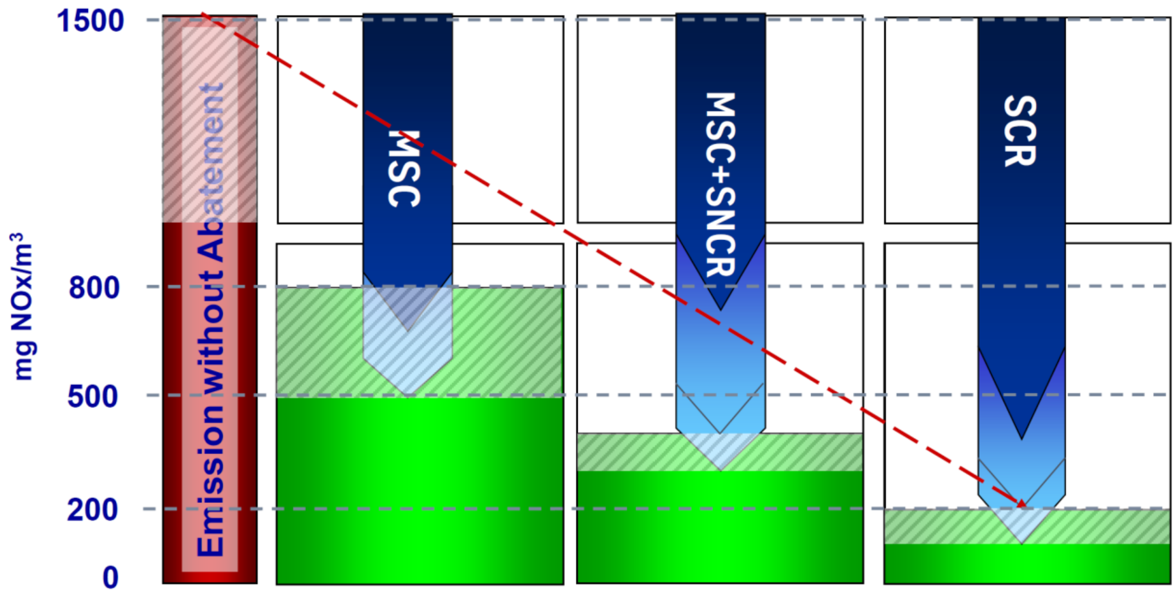
- Abatement measures in the cement industries
  - Overview of TFTEI work on cement production
  - Informal technical document on BATs in the cement sector
- Abatement measures in the aluminium industries
  - Overview of TFTEI work on aluminium production
  - Informal technical document on BATs in the Aluminium sector

Overview of the work

- ✓ Limit values and emission reduction commitments in the Amended Gothenburg Protocol
- ✓ A document providing information on reduction techniques for SO2, NOx and PM and their costs
- ✓ Update an existing document from 2005 and information developed for the revision of the Gothenburg Protocol

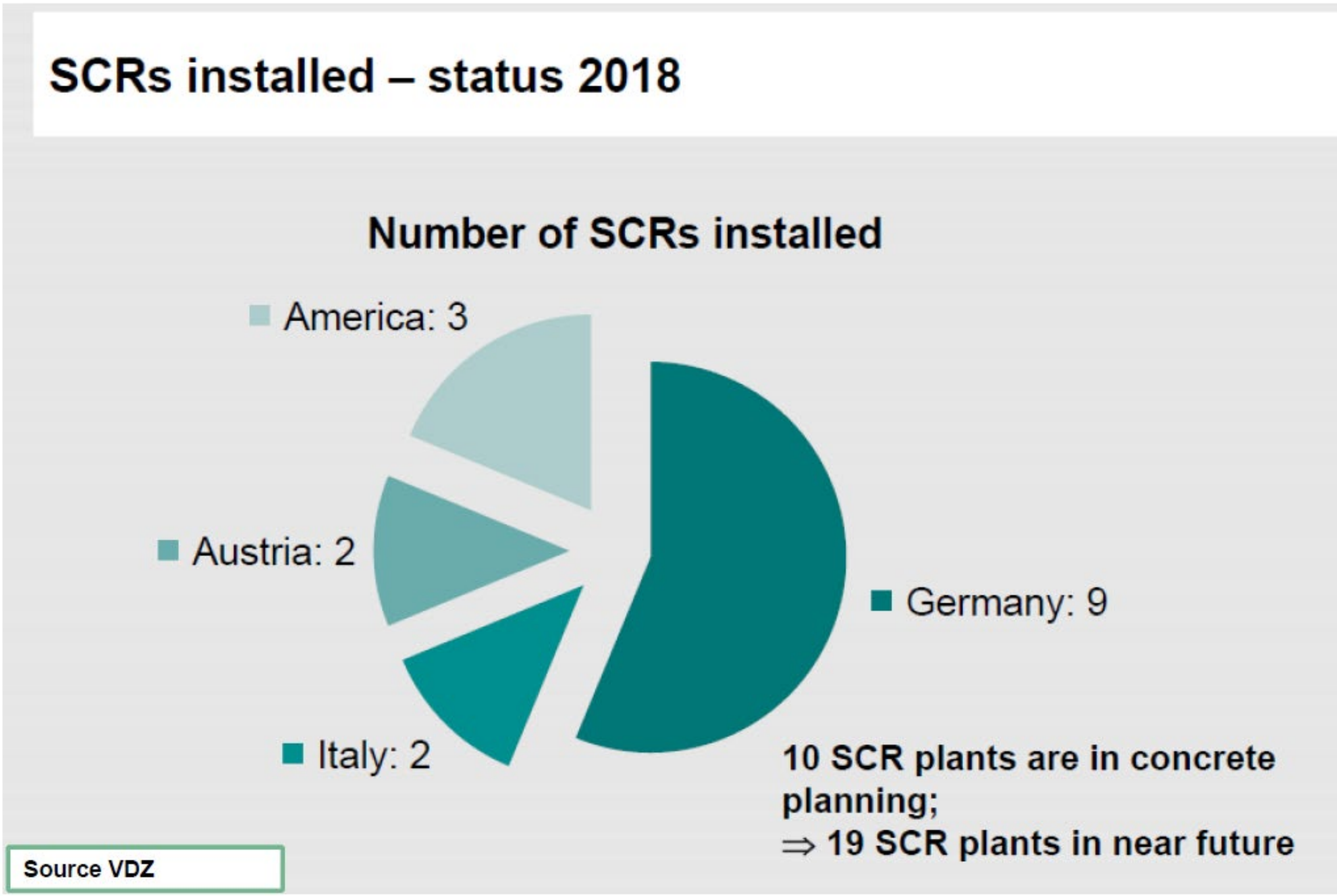
Reduction techniques for NOx

- ✓ Primary measures such as "Multi-Stage Combustion (MSC)":
  - o 500-800 mg/Nm^3 at 10%O_2 daily average
- ✓ SNCR (Selective Non-Catalytic Reduction)
  - o Les than 500 mg/Nm^3 up to possibly 300 mg/Nm^3 in some specific cases
- ✓ SCR (Selective Catalytic Reduction)
  - o 200 mg/Nm^3 at 10% O_2 daily average, can be obtained



Beilmann R. 2016. NOx in Cement Clinker Production

Equipment in NOx emission reduction techniques



Source: Cinti J. Experience on NOx emission reduction- TFTEI berlin workshop 2019

Costs of SCR for cement plants

SCR		Updated cost data
Average daily NOx concentrations to be abated	mg/Nm3 at 10%O2	1200
Outlet daily NOx concentrations reached	mg/Nm3 at 10%O2	200
Investments (Capex)	kEuros	5000-15000
Operational cost (Opex)	Euro per t clinker	0.3-1.1
Electricity consumption	kWh per t clinker	3-7

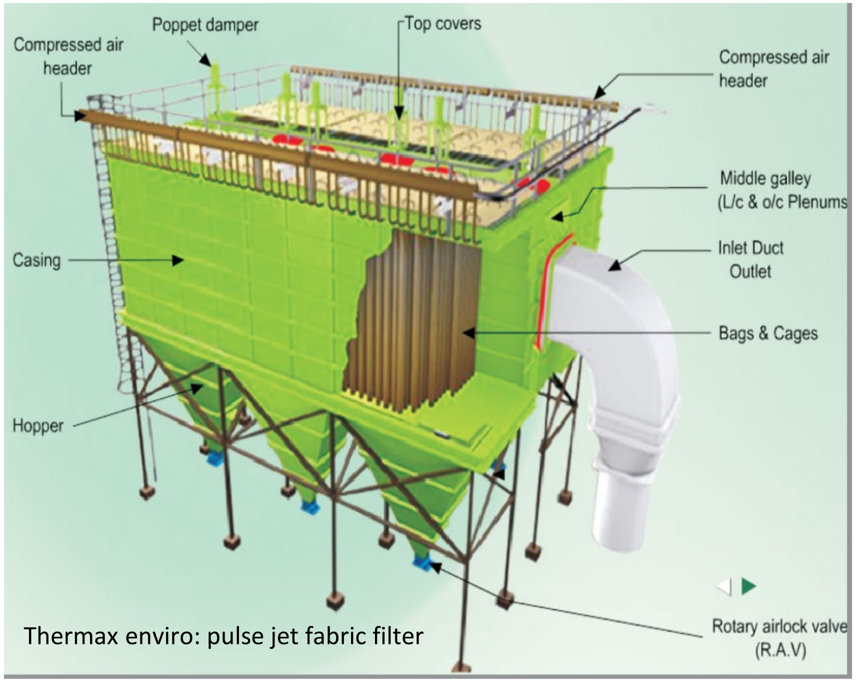
For a plant of 3000 t clinker per day :

- Emissions are reduced from 2650 t/year to 440 t

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 655 k€/y to 2160 k€/year
- **0.70 to 2.15 €/t clinker**
- **300 to 980 €/t NOx abated**

Reduction techniques for dust emissions

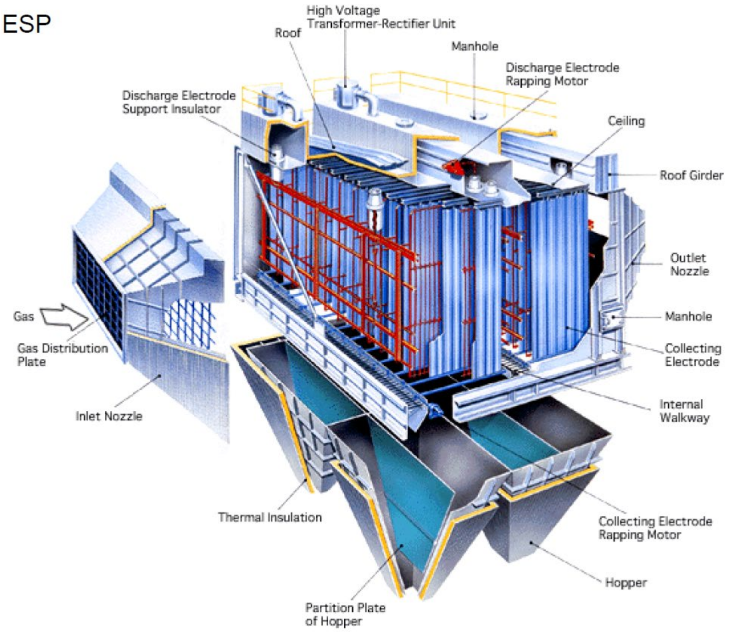


Thermax enviro: pulse jet fabric filter

For the kiln firing processes and cooling and milling processes, BAT associated emission levels range from <10 – 20 mg/Nm3 , as the daily average value. ESP and fabric filters are used.

For diffuse emissions from dusty operations, reduction measures can be encapsulation of some operations, covering conveyors…

Inside an ESP



(https://www.indiamart.com/proddetail/retrofiring-of-electrostatic-precipitator-esp-6650529130.html)

Costs of a fabric filter for cement plants

Fabric filter		Updated cost data
Average daily PM concentrations to be abated	mg/Nm3 at 10%O2	56
Outlet daily PM concentrations reached	mg/Nm3 at 10%O2	5
Investments (Capex)	kEuros	4000 - 10.000
Operational cost (Opex)	Euro per t clinker	0,3
Electricity consumption	kWh per t clinker	4,0

For a plant of 3000 t clinker per day :

- Emissions are reduced from 124 t/year to 11 t/year

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 580 k€/y to 1020 k€/year
- **0.60 to 1.10 €/t clinker**
- **5170 to 9100 €/t dust abated**

Reduction techniques for SO_2

SO2 emissions from cement plants depend on the total input of sulphur compounds and the type of process used and are primarily determined by the content of the volatile sulphur in the raw materials and possibly by the fuels.

- ✓ Primary measures:
  - optimisation techniques, such as optimising the clinker burning process including the smoothing of kiln operation,
  - uniform distribution of the hot meal in the kiln riser
  - prevention of reducing conditions in the burning process
  - choice of raw materials and fuels

- ✓ Secondary measures when SO_2 emission are high:
  - Addition of absorbent such as slaked lime, quick lime…to the raw material
  - Dry adsorption in a dry scrubber
  - Wet scrubber

The BAT AEL as daily average value, ranges from < 50 to 400 mg/Nm3

Costs of adsorbent injection for cement plants

Adsorbent injection		Updated cost data
Average dailySO2 concentrations to be abated	mg/Nm3 at 10%O2	600-1000
Outlet daily SO2 concentrations reached	mg/Nm3 at 10%O2	400
Investments (Capex)	kEuros	200-750
Operational cost (Opex)	Euro per t clinker	0.3 - 0.7
Electricity consumption	kWh per t clinker	0.1 - 0.3

For a plant of 3000 t clinker per day :

- Emissions are reduced by 440 to 1320 t /y

Considering a lifetime of 20 y and 4% interest rate, the annual costs range between:

- 300 k€/y to 730 k€/year
- **0.30 to 0.80 €/t clinker**
- **700 to 1650 €/t SO_2 abated**

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BAT reference document (BREF) for non-ferrous metals

- ✓ Comprehensive description and specification of emission abatement technologies for major non-ferrous metals
  - ✓ copper and its alloys;
  - ✓ aluminium and its alloys;
  - ✓ lead and tin;
  - ✓ zinc and cadmium;
  - ✓ precious metals;
  - ✓ ferro-alloys (e.g. FeCr, FeSi, FeMn,);
  - ✓ nickel and cobalt;
  - ✓ carbon and graphite electrodes.
- ✓ > 1000 pages of partly site specific data
- ✓ Skipping between different abatement technologies and sections necessary to extract information

Specific document on BAT for primary aluminium processing


Background informal technical document on techniques to reduce emission from aluminium production

TFTEI informal background technical document

December 2020

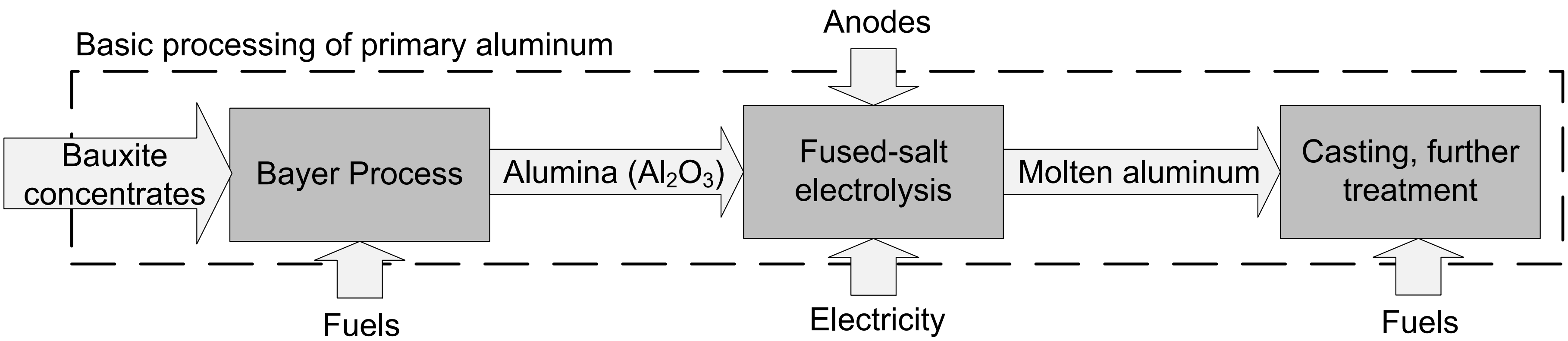
Prepared by KIT DFIU - TFTEI Technical Secretariat

Simon Glöser-Chahoud and Carmen Schiel

- ✓ Development of a short but comprehensive document on BAT for aluminium production
- ✓ Focus on primary aluminium production in a first step
  - ✓ Secondary aluminium processing strongly depends on properties of scrap
  - ✓ Higher variation in design of processes and related abatement technologies

➡ Informal technical document was revised after expert input from the TFTEI network and industry partners

Basic processing steps in primary aluminium production



1. Calcination of Bauxite to produce Alumina (Bayer Process)
2. Production of electrode materials for fused-salt electrolysis
3. Fused-salt electrolysis (Hall-Héroult Process)
    1. Prebake cell
    2. Soderberg cell
4. Casting, further treatment

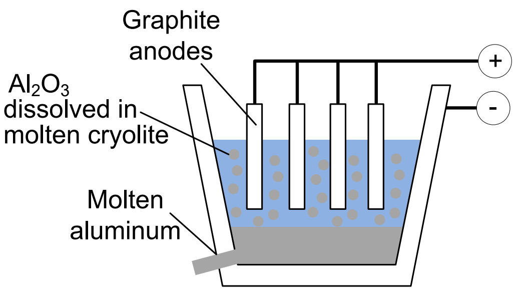
Main technologies for aluminium electrolysis

Cell technology	Cell type	Anode configuration	Alumina feed configuration	Acronym	Breakdown in Europe
Prebake cell	Centre worked	Vertical	Bar broken centre feed	CWPB (*)	None
		Vertical	Point centre feed	PFPB	90 %
	Side-worked	Vertical	Manual side feed	SWPB (*)	None
Søderberg cell	Vertical stud	Vertical	Manual side feed	SWVSS (*)	None
			Point feed	PFVSS	10 %
	Horizontal stud	Horizontal	Manual side feed	HSS (*)	None
			Bar broken feed		
			Point feed		

(*): No longer in operation in Europe.

- ✓ The Søderberg technology uses a continuous anode, which is introduced into the cell as a paste and then bakes in the cell itself.
- ✓ The Prebake technology uses multiple anodes in each cell, which are baked in a separate facility.

Source: USGS (2018), German Environmental Agency UBA (2018)



Fused-salt electrolysis (Hall-Héroult Process)

Total emissions to air from primary aluminium production (smelting and electrolysis) with the currently highest levels of abatement technologies (Cusano et al., 2017).

Emission parameter	Prebake (PFPB)	Søderberg
Total fluorides (kg/kg Al)	250-450*10^{-6}	300-600*10^{-6}
Dust (kg/kg Al)	200-600*10^{-6}	800-1400*10^{-6}
SO_2 (kg/kg Al)	0.01-0.025	not reported

Key abatement technologies

- ✓ Avoidance of „anode effect“ in which PFCs are formed
  - ✓ Point feeding of anodes and alumina, computer controlled voltage
  - ✓ Efficient gas collection from electrolytic cells
- ✓ Fluoride “scrubbing systems” use alumina to extract gaseous fluoride from pot gases (alternative scrubbing with crushed limestone or water).
- ✓ Wet scrubbing for the Søderberg process and boosted suction systems in combination with dry alumina scrubbing for the Prebake process.

Emission levels and abatement technologies in the EU BAT conclusions

- Emission levels for aluminium smelting and electrolysis
- Wet scrubbers are only used in case of very high off-gas flow rates, due to cross-media effects and in case of the availability of large volumes of water

Emission parameter	BAT defined in the European conclusions	Emission level kg/kg Al	
		existing	new plant
Dust	Dry scrubber using alumina as the adsorbent agent followed by a bag filter (and potentially an additional wet scrubber if applicable)	$1200*10^{-6}$	$600*10^{-6}$
Total fluorides, mainly HF		$600*10^{-6}$	$350*10^{-6}$
SO_2	Use of low-sulphur anodes and wet scrubbing system if applicable	0,0025-0,015	0,0025-0,015
Perfluorocarbons, mainly Perfluoroethane and Perfluormethane	• Automatic multiple point feeding of alumina • Automatic anode effect suppression • Computer control of the electrolysis process based on active cell databases and monitoring of cell operating parameters	not reported	not reported

➡ The BREF document provides a vast and up-to-date collection of relevant abatement technologies that meet current EU emission levels

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BACKUP

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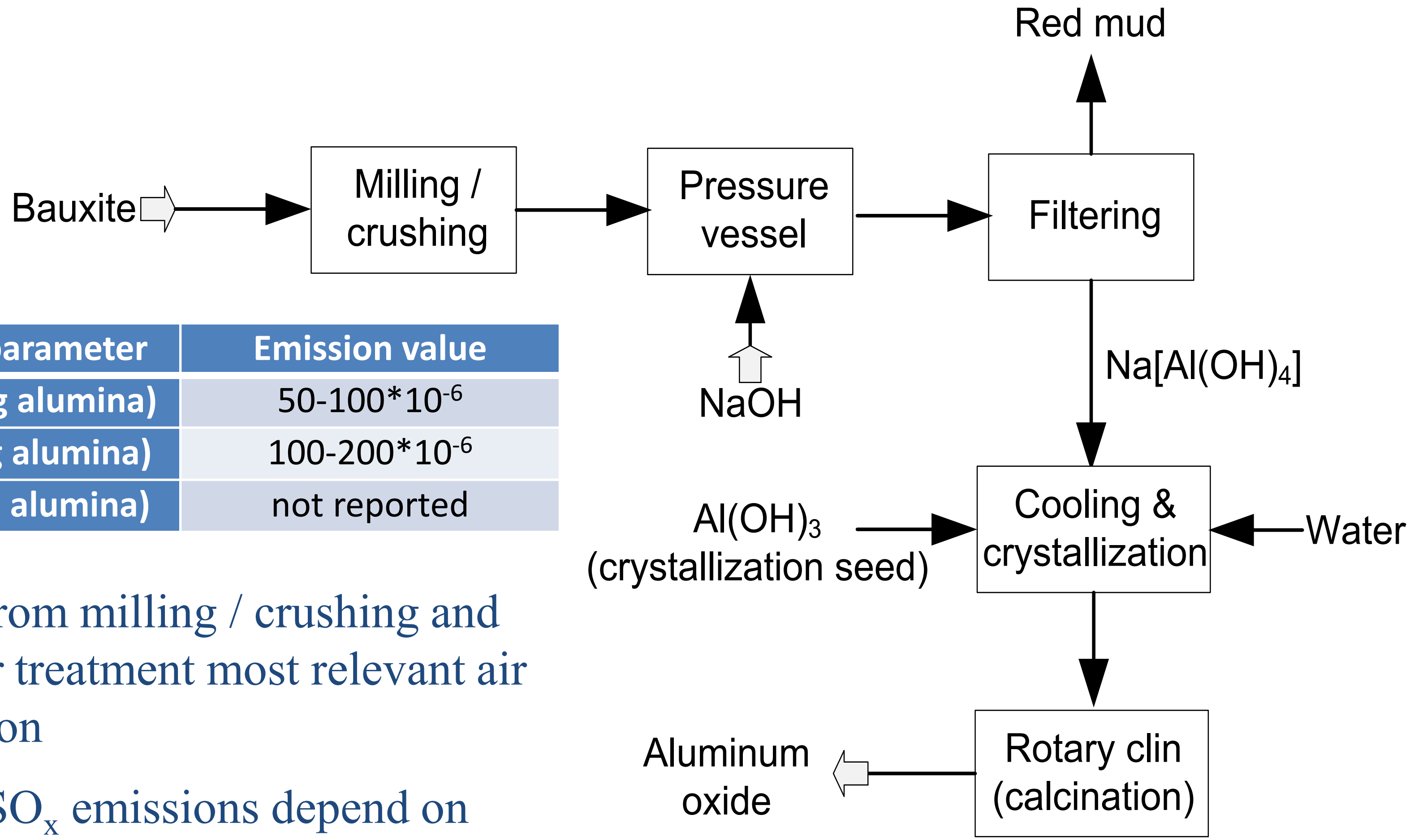
Alumina production and related emissions (Bayer Process)

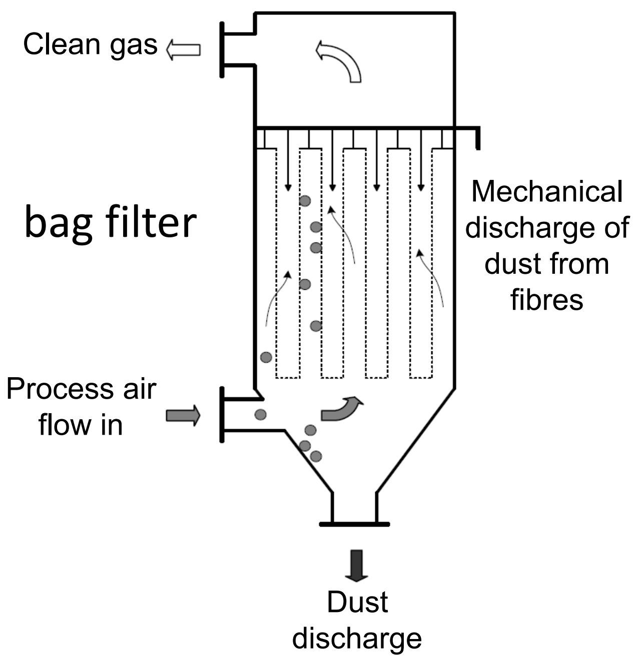


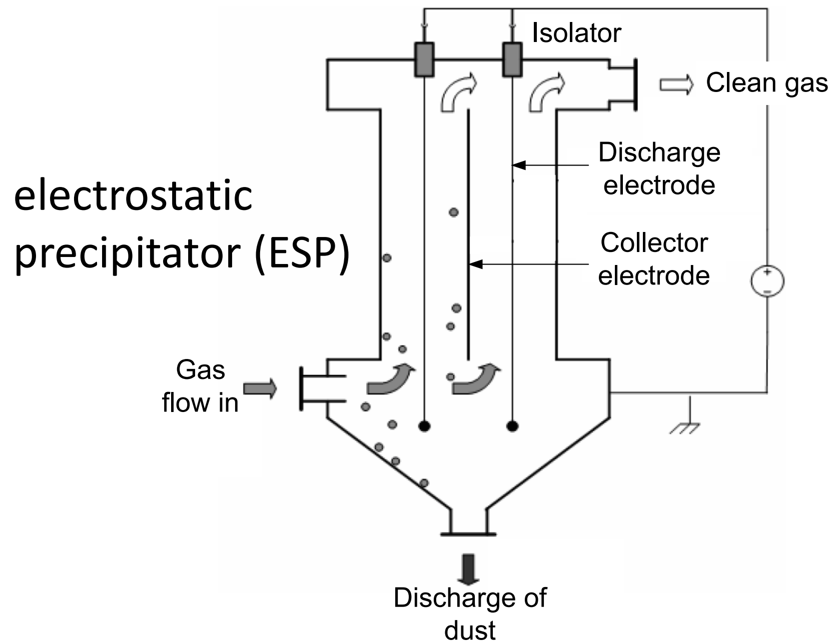
Emission parameter	Emission value
Dust (kg/kg alumina)	$50\text{-}100*10^{-6}$
NO_x (kg/kg alumina)	$100\text{-}200*10^{-6}$
CO_2 (kg/kg alumina)	not reported

- ✓ Dust from milling / crushing and further treatment most relevant air emission
- ✓ NO_x, SO_x emissions depend on fuel and combustion technologies

Emission ranges for different plants taken from the BAT document

Emission abatement technologies for alumina production





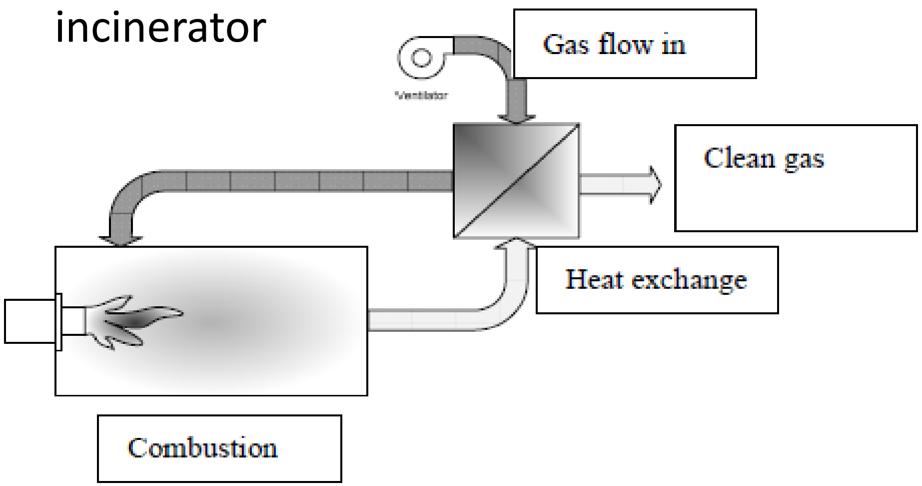
Average flue gas flow (Nm^3/h)	Abatement technology	Average emission value of dust	
		mg/Nm^3	(kg/t alumina)
220 000	ESP	68	0.1
300 000	ESP	23	0.01
107 000	Fabric filter	23	0.07
93 000	Fabric filter	23	0.05

Exemplary values for different plants taken from the BAT document

Anode production

Emission parameter	Emission value
Total fluoride (kg/kg anode)	$10\text{-}100*10^{-6}$
Dust (kg/kg anode)	$10\text{-}1000*10^{-6}$
SO_2 (kg/kg anode)	$100 - 6000*10^{-6}$
NO_x (kg/kg anode)	$100 - 400*10^{-6}$
BaP (kg/kg anode)	$0\text{-}3*10^{-6}$

Concept of a recuperative incinerator



Emission ranges for different plants taken from the BAT document

Production process:

- ✓ Raw materials: petroleum coke, coal tar bits or recycled anode butts
- ✓ Distinction between Prebake and Soderberg anodes
- ✓ Forming and baking at around 1200°C
- ✓ Graphitization

Proposed abatement technologies

- ✓ Bag filters for dust (alternatively ESP with cyclone)
- ✓ Recuperative incinerators for VOC
- ✓ Coke scrubbers for pitch vapors
- ✓ Treatment of fluorides in case of the use of recycled anode butts