

Contract project-2004
With Ministry of the Environment, Japan



環境省

Ministry of the Environment

Air Pollution Control Technology In Steel Industry

March 2005

Overseas Environmental Cooperation Center, Japan

Air Pollution Control Technology in Steel Industry

Committee Members

Chairman:

**Dr. K. Nishida, Researcher, Department of Urban and
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Member:

**Mr. S. Iwasaki, Director, Metocean Environment Inc.
Dr. S. Fujii (P.E.), Takuma Co., Ltd.
Mr. Y. Ogino (P.E.), Environment Technology L.R.C.**

Prepared by

Dr. A. Hogetsu (P.E.), Research Commissioner, OECC

An aerial photograph of the Kobe Steel Kakogawa Plant, showing a large industrial complex with various structures, pipes, and storage areas. The plant is situated near a body of water, and a dense urban area is visible in the background. The image is overlaid with white text labels identifying different parts of the facility.

Steel mill lives close together with neighboring people

(Kobe Steel Kakogawa Plant)

Steel manufacturing
processes

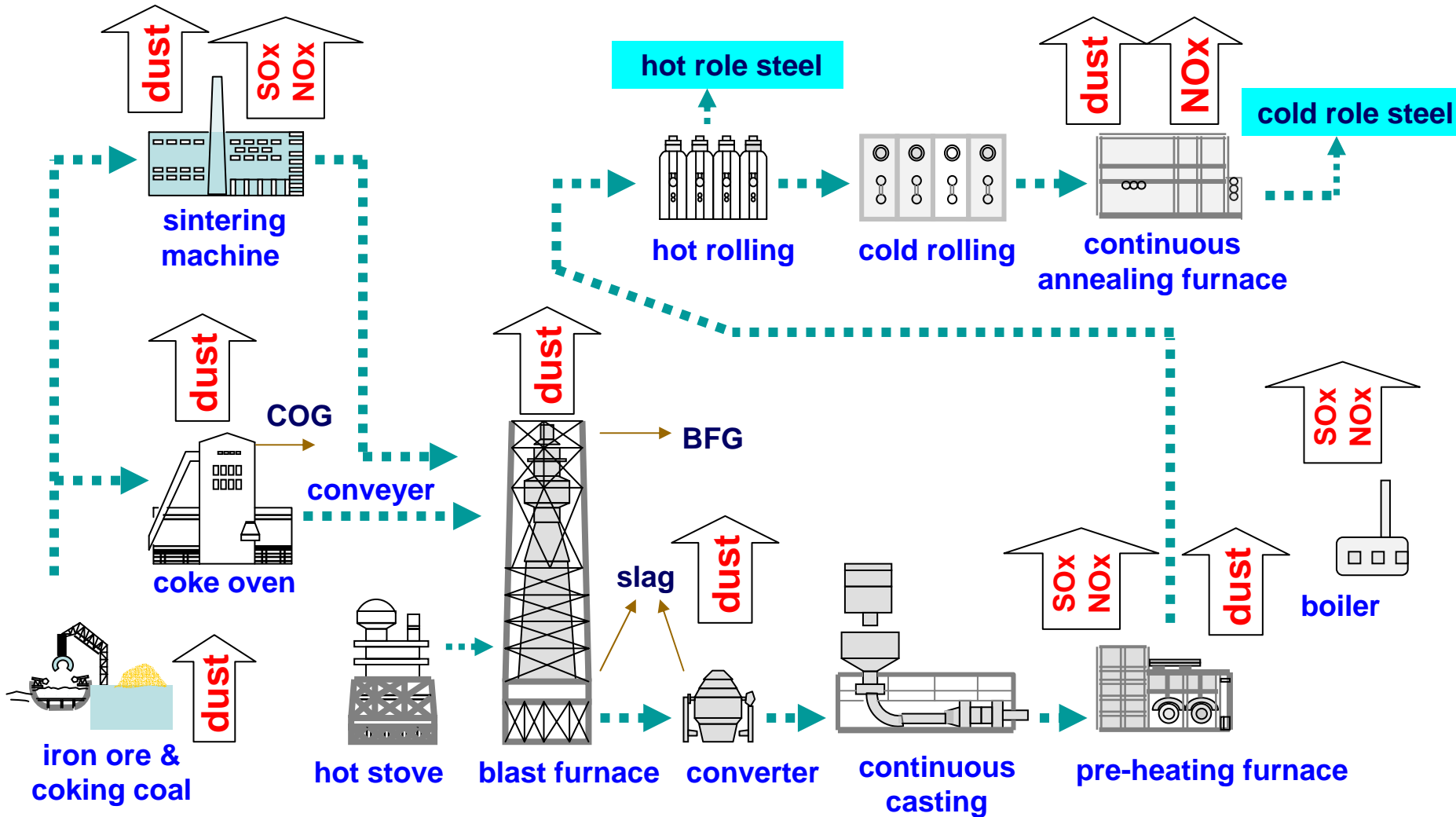
COG refinery

Coking

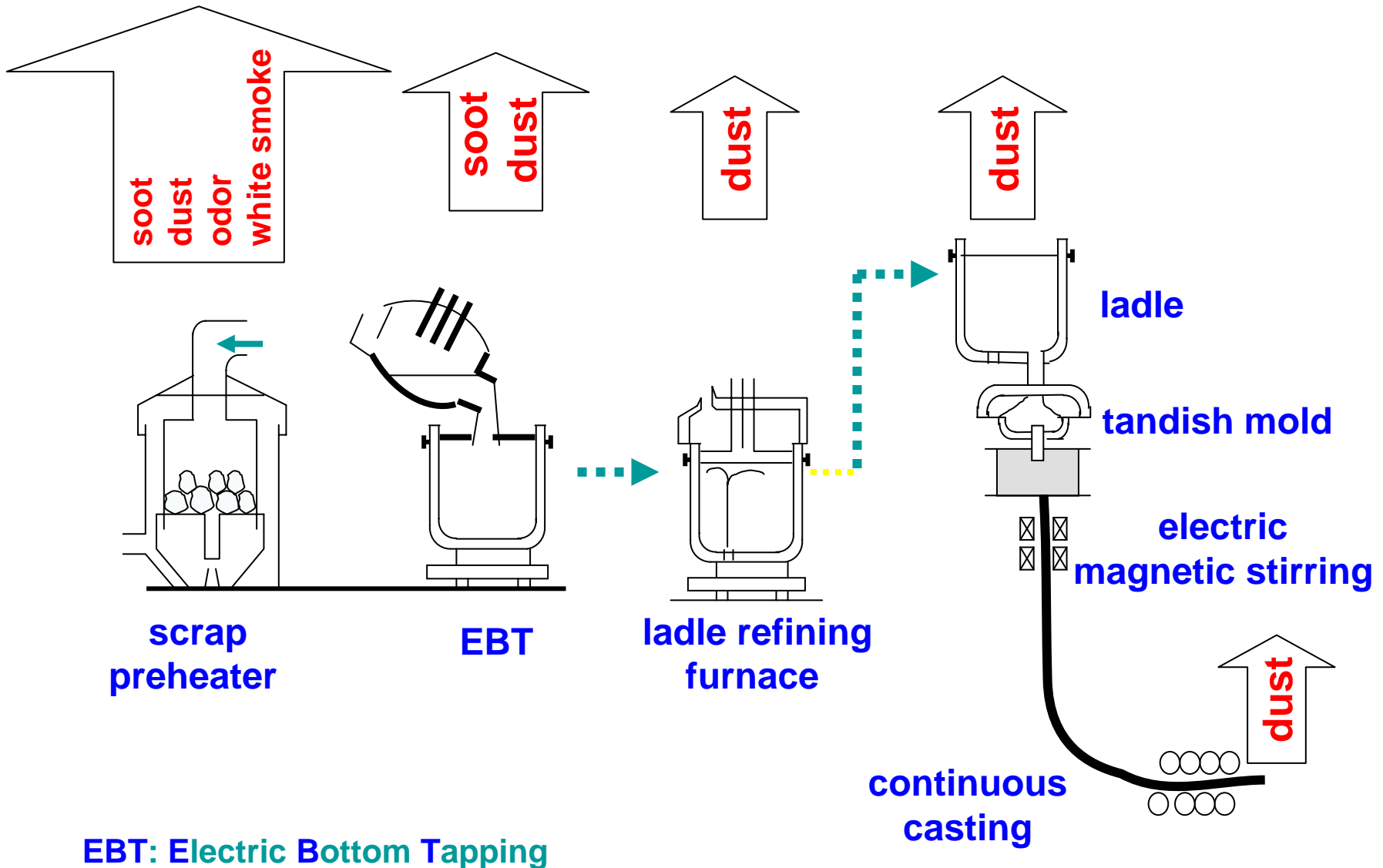
BF

Raw materials yard

1. Iron & Steel Making Process and Air Pollutants

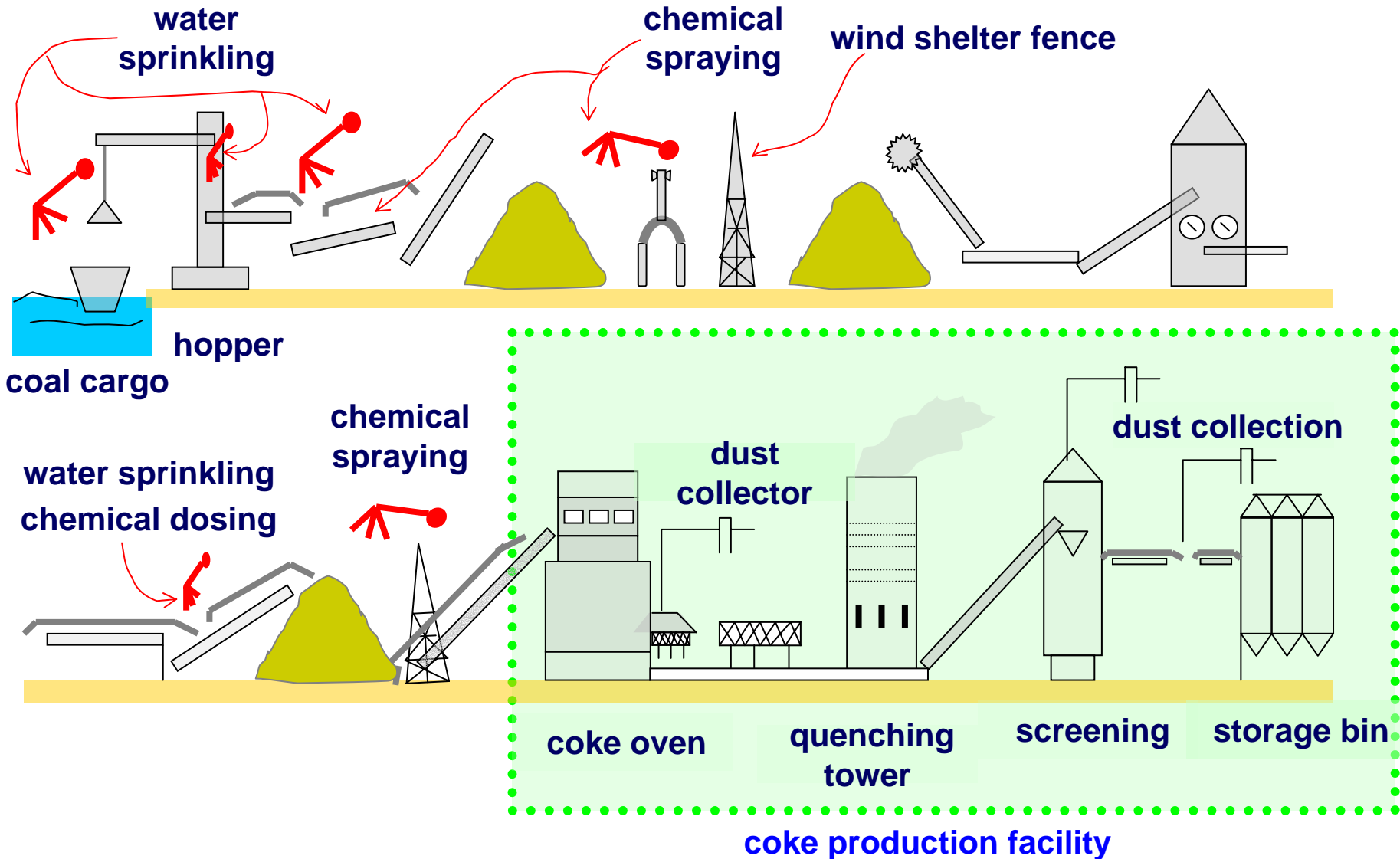


2. Process of Electric Furnace Plant and Air Pollutants



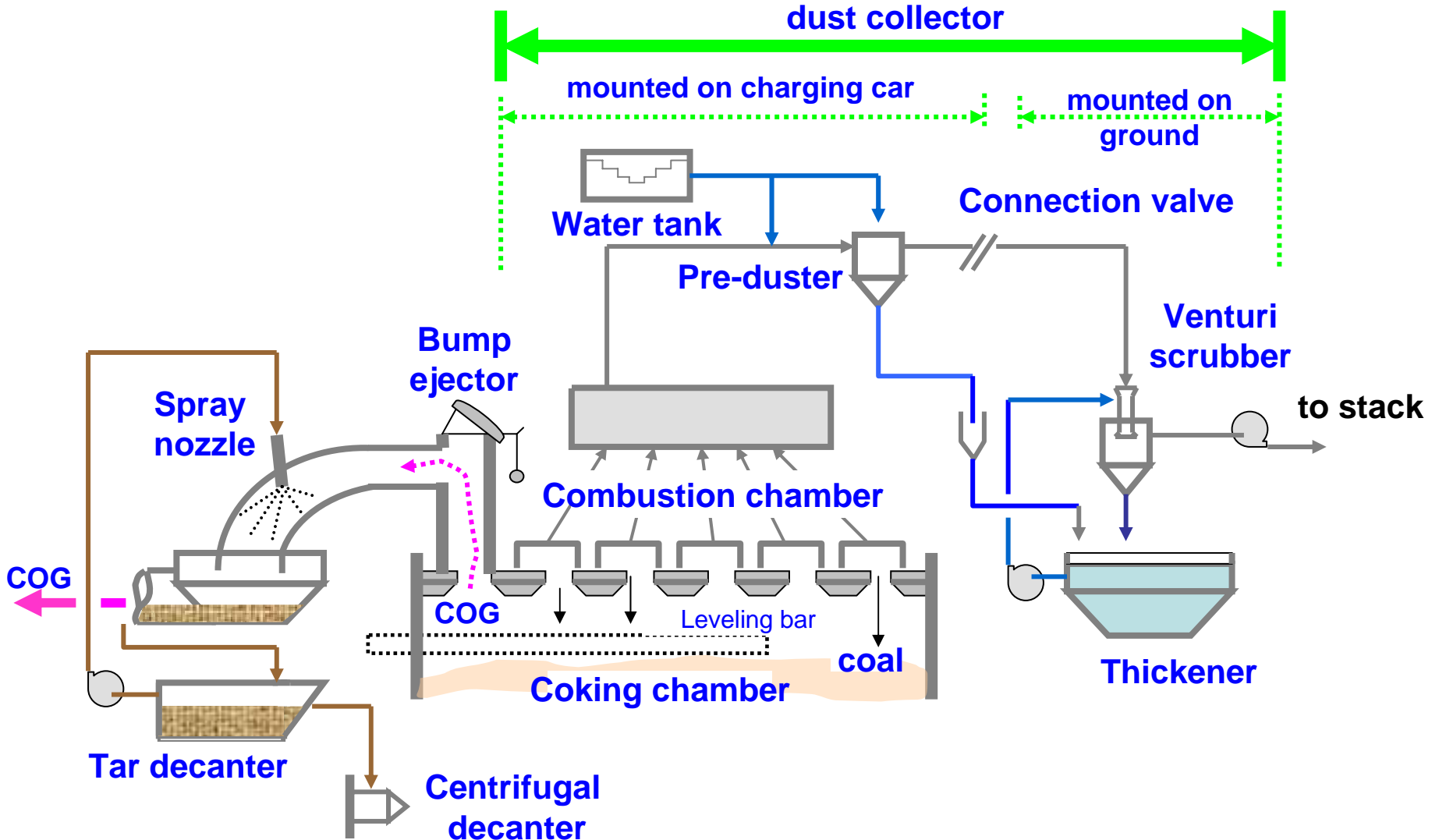
3. Coarse Particle Scattering Prevention

3-1 Coal Handling Process



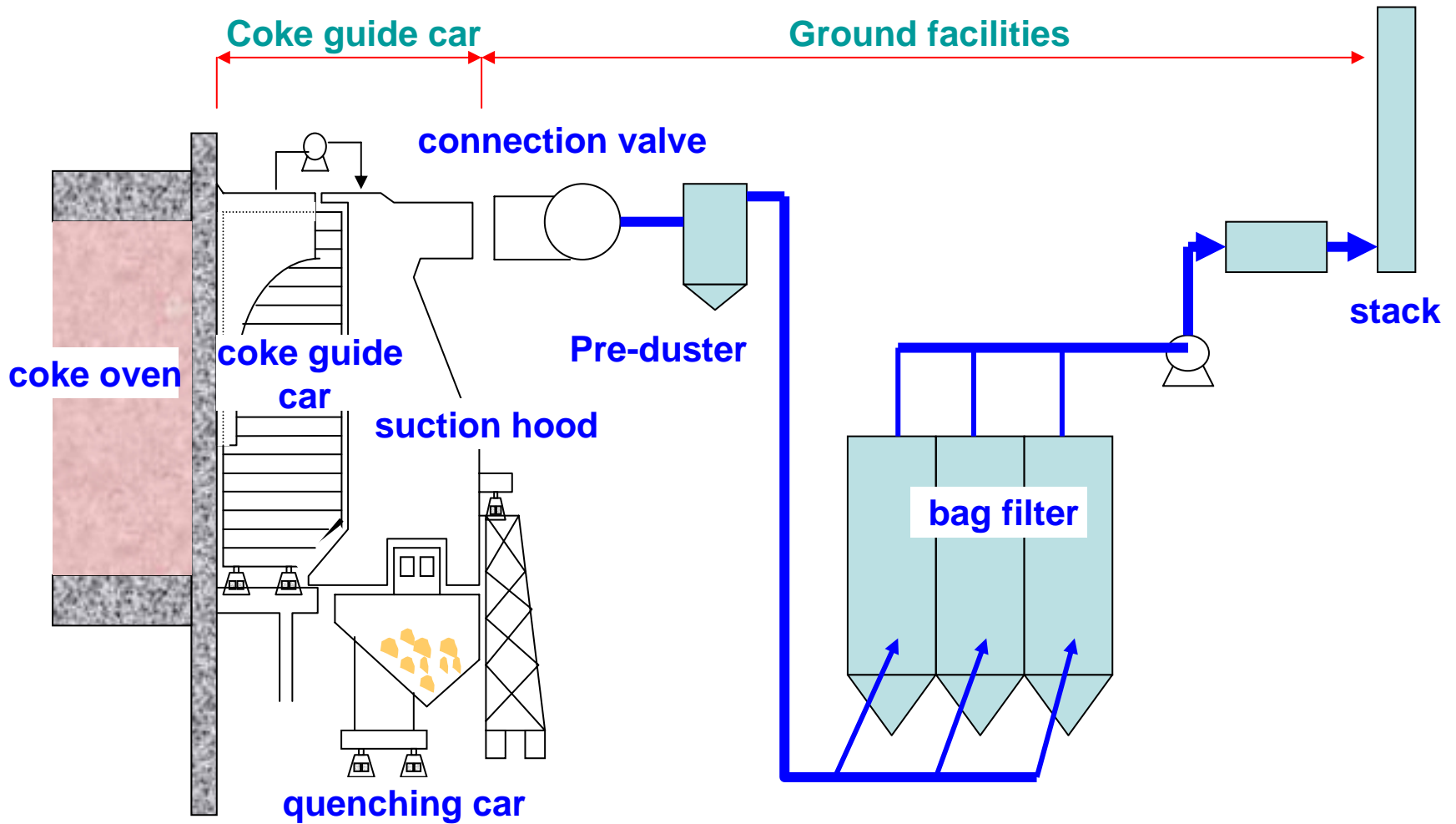
3. Coarse Particle Scattering Prevention

3-2-1 Coke Production Coal Charging Process



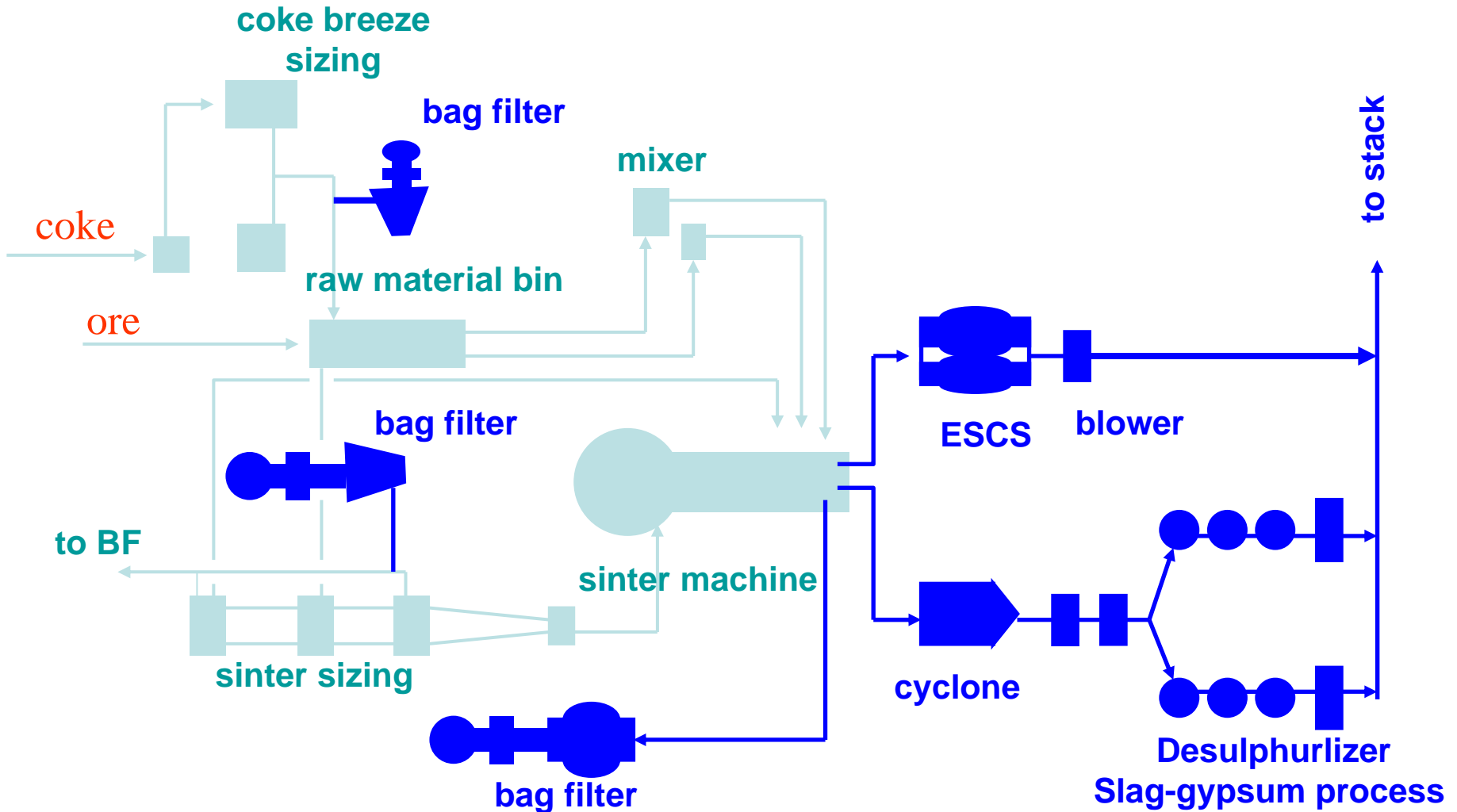
3. Coarse Particle Scattering Prevention

3-2-2 Coke Production Coke Discharging Process



3. Coarse Particle Scattering Prevention

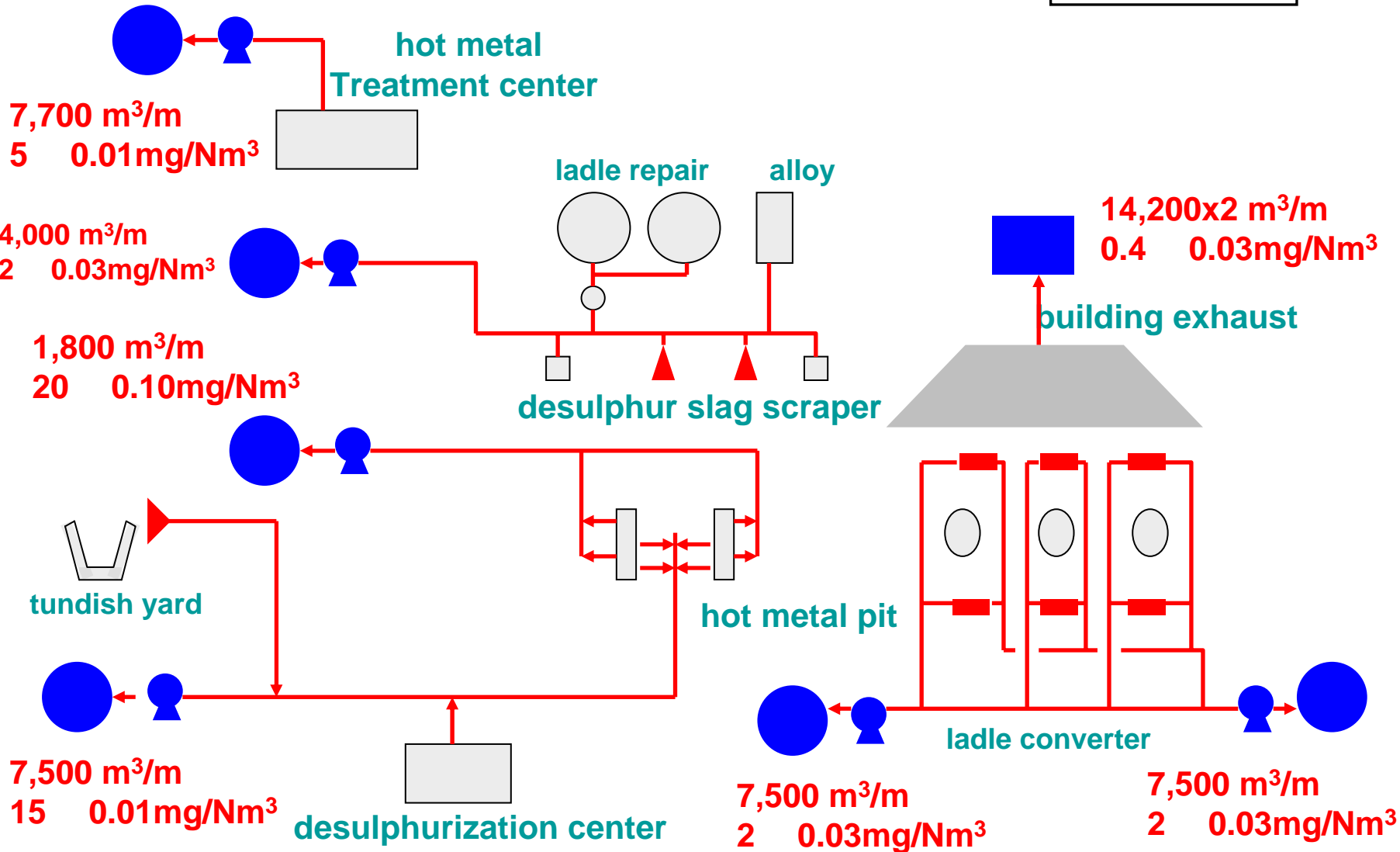
3-3 Sintering Process



ESCS: Electrostatic Space Clear Super

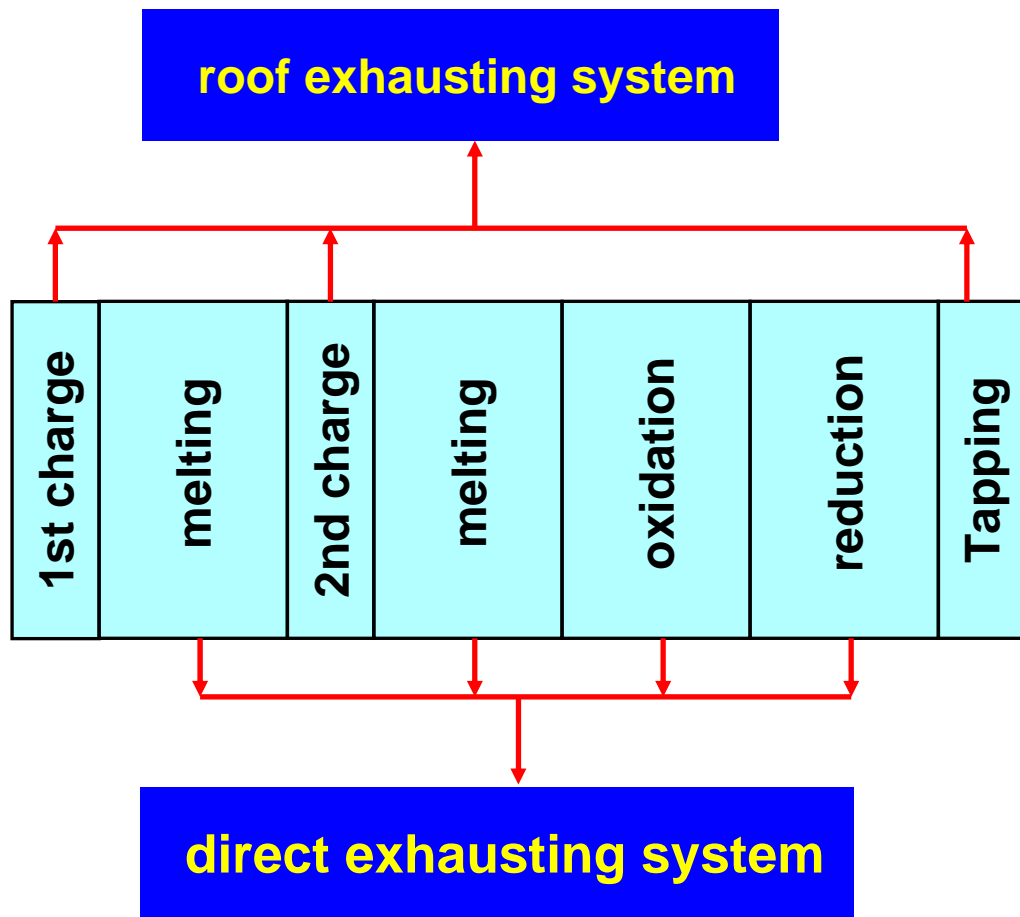
3. Coarse Particle Scattering Prevention

3-5 Steel Manufacturing Process (Converter)

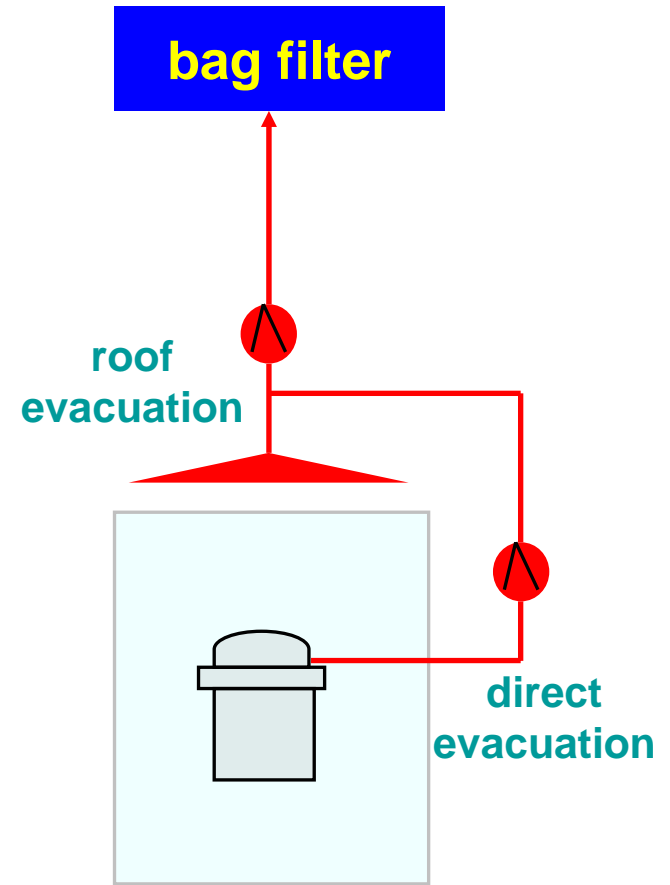


3. Coarse Particle Scattering Prevention

3-6 Electric Furnace



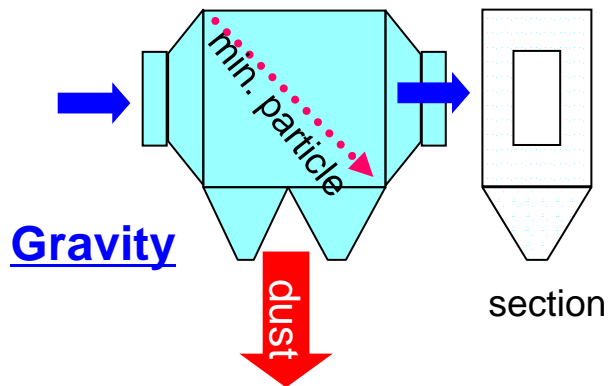
Conventional System



Doghouse System

4. Dust Collection System

4-1 Gravitational, Inertial & Centrifugal Dust Collector



Stokes' Law

$$V = \frac{g}{18\mu} (\rho_1 - \rho) D^2 \quad (\text{cm/s})$$

V: settling velocity (cm/sec)

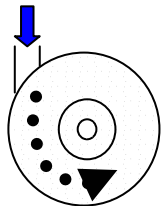
μ : gas viscosity (kg/ms)

g: gravitational acceleration (cm/s²)

ρ_1 : particle density (g/cm³)

ρ : gas density (g/cm³)

D: particle diameter (cm)



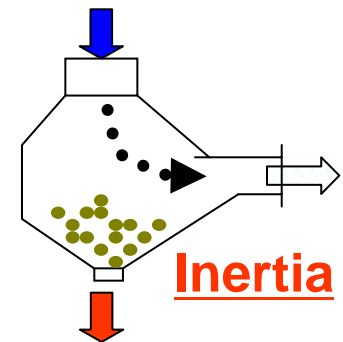
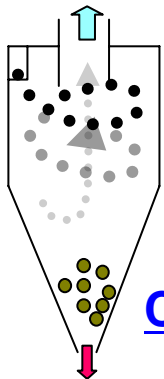
Principle of dust collection ;

$$\text{Centrifugal force (F)} = mv^2/R \quad (\text{N})$$

m: particle mass (kg)

V: particle velocity (m/s)

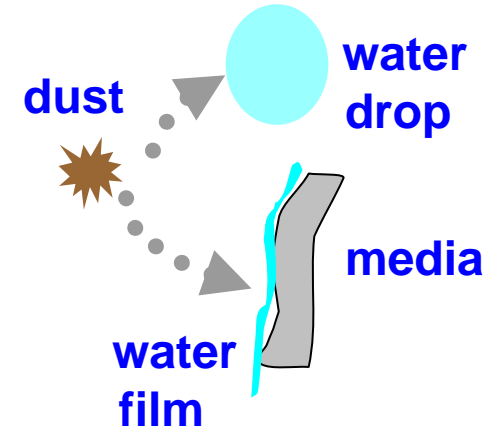
R: cyclone radius (m)



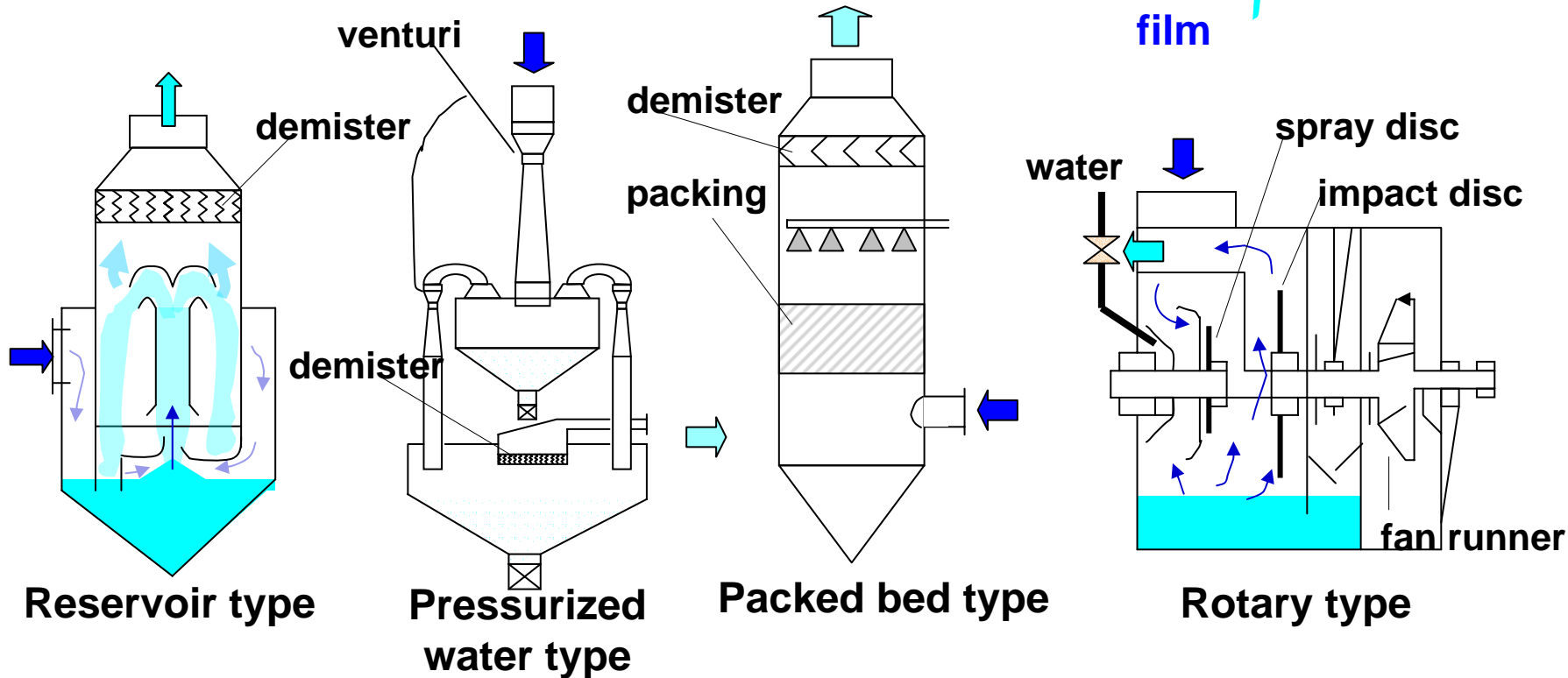
4. Dust Collection System

4-2 Scrubbing Dust collector

Principle of Scrubber Dust Collector ;

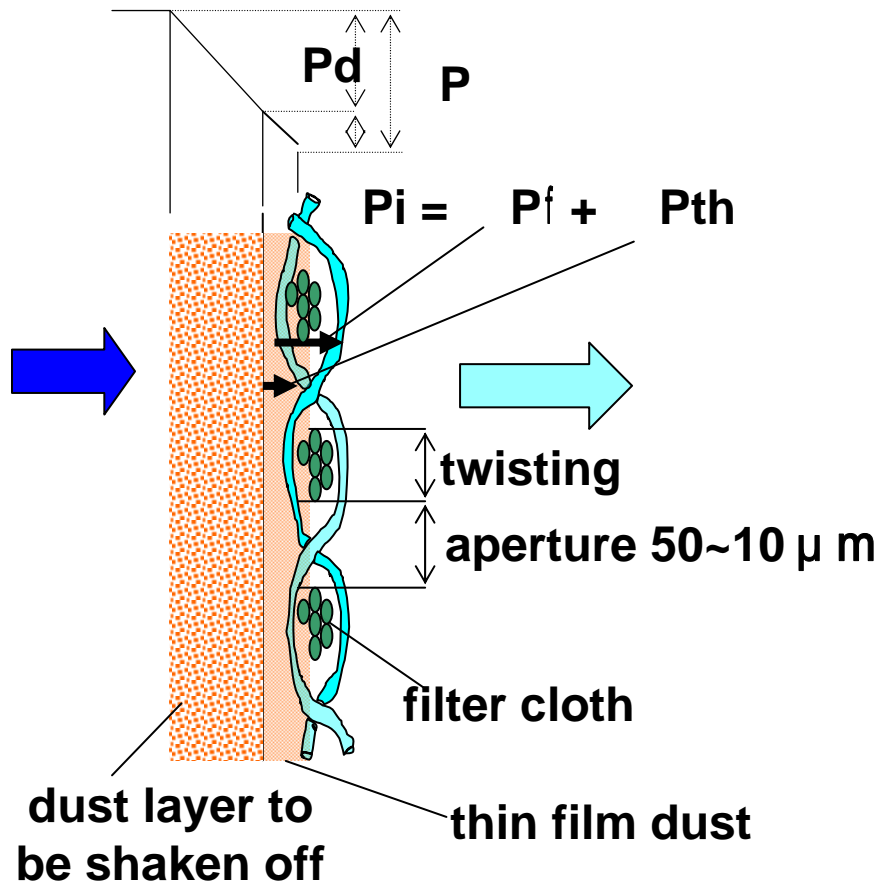


Scrubbers ;



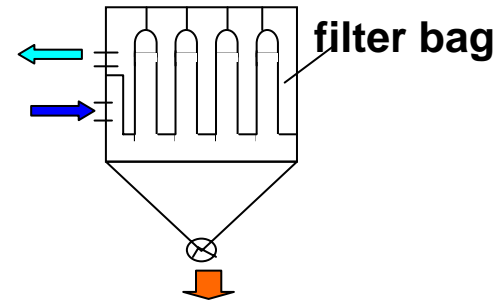
4. Dust Collection System

4-3 Filter Type Dust Collector



Filtration Mechanism

Schematic of typical bag filter unit



Type:

- (1) bag filter
- (2) cartridge filter

Filter cloth:

- (1) woven fabric
- (2) non-woven fabric

Dust shake-off:

- (1) intermittent
- (2) continuous

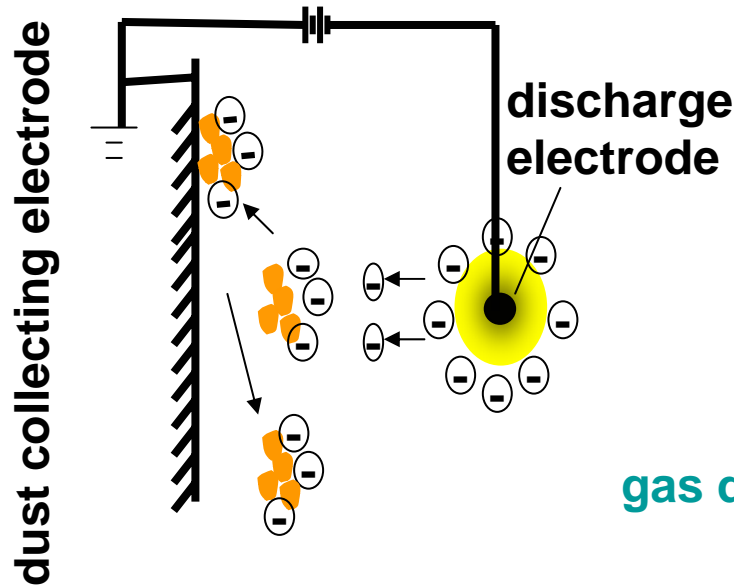
Apparent filtration rate:

0.3~10cm/s

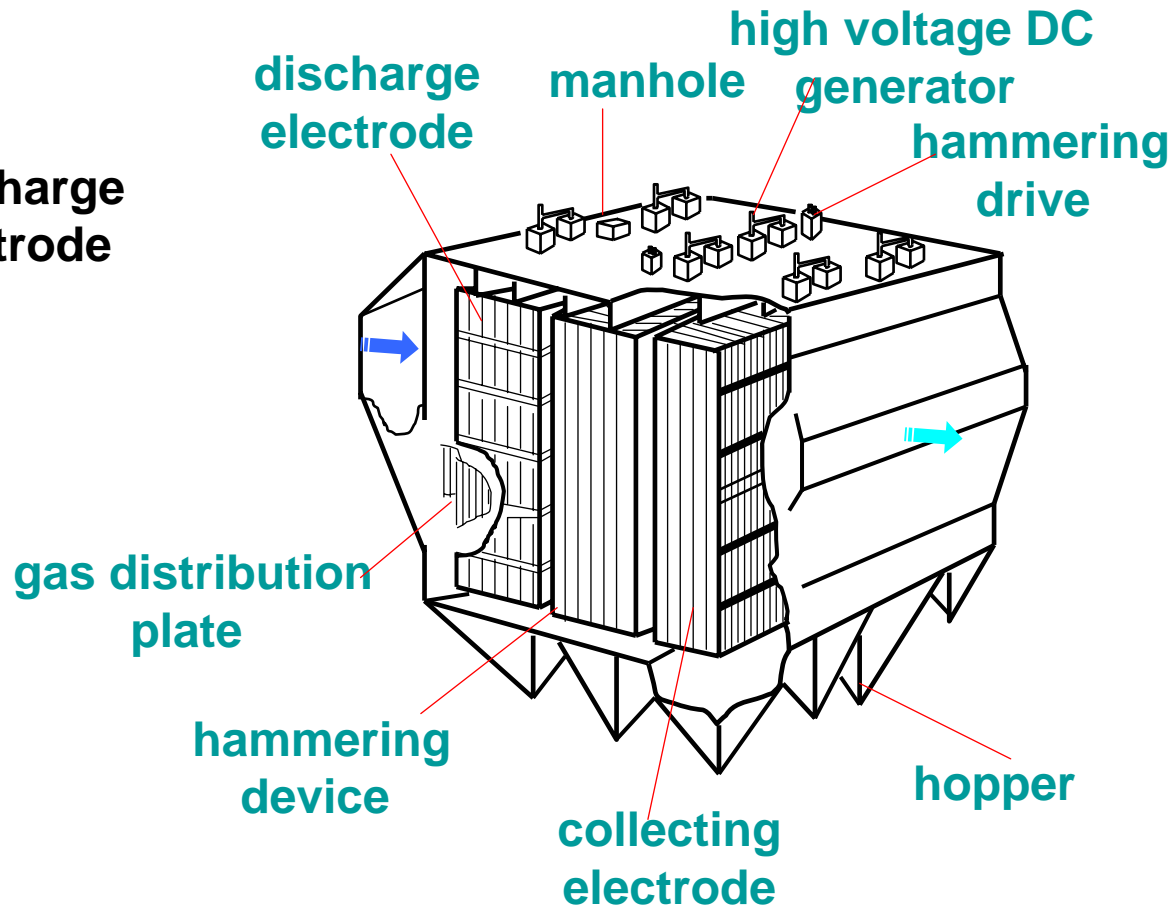
4. Dust Collection System

4-4 Electrostatic Precipitator

Principle of dust collection :



Structure of EP



4. Dust Collection System

4-5 Selection of Dust Collector

Parameter

- particle distribution
- dust concentration
- specific gravity
- electric resistnace rate
- flow rate
- due point
- gas temp.

Collector	Applicable Particle (μm)	ρ (mmH_2O)	Removal rate (%)	Equipment Cost ($\text{¥/y/Nm}^3/\text{h}$)	Operating Cost ($\text{¥/y/Nm}^3/\text{h}$)
Gravity	1,000~50	10~15	40~60		
Inertial	100~10	30~70	50~70		
Centrifugal	100~3	50~150	85~95	300~2,200	100~1,000
Scrubbing	100~0.1	300~900	80~95	400~2,200	100~1,300
Filter	20~0.1	100~200	90~99	300~2,100	300~1,100
EP	20~0.05	10~20	90~99.9	400~4,400	100~1,00

5. Desulphurization Technology

5-1 Flue Gas Desulphurization in Steel Mill

Method	Reaction	Byproduct
Activated carbon	$\text{SO}_2 + \text{H}_2\text{O} + 1/2\text{O}_2 \rightarrow \text{H}_2\text{SO}_4$	H_2SO_4
Caustic soda	$2\text{NaOH} + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$ $\text{Na}_2\text{SO}_3 + \text{H}_2\text{O} + \text{SO}_2 \rightarrow 2\text{NaHSO}_3$	Na_2SO_4
Ammonia	$2\text{NH}_4\text{OH} + \text{SO}_2 \rightarrow (\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{O}$ $(\text{NH}_4)_2\text{SO}_3 + \text{SO}_3 + \text{SO}_2 + \text{H}_2\text{O} \rightarrow 2\text{NH}_4\text{HSO}_3 + \text{H}_2$	$(\text{NH}_4)_2\text{SO}_4$
Slaked lime	$\text{CaO} + \text{SO}_2 \rightarrow \text{CaSO}_3$ $\text{CaSO}_3 + \text{O}_2 \rightarrow 2\text{CaSO}_4$	CaSO_4

Limestone - Gypsum Process

SO_x Rem. > 90%

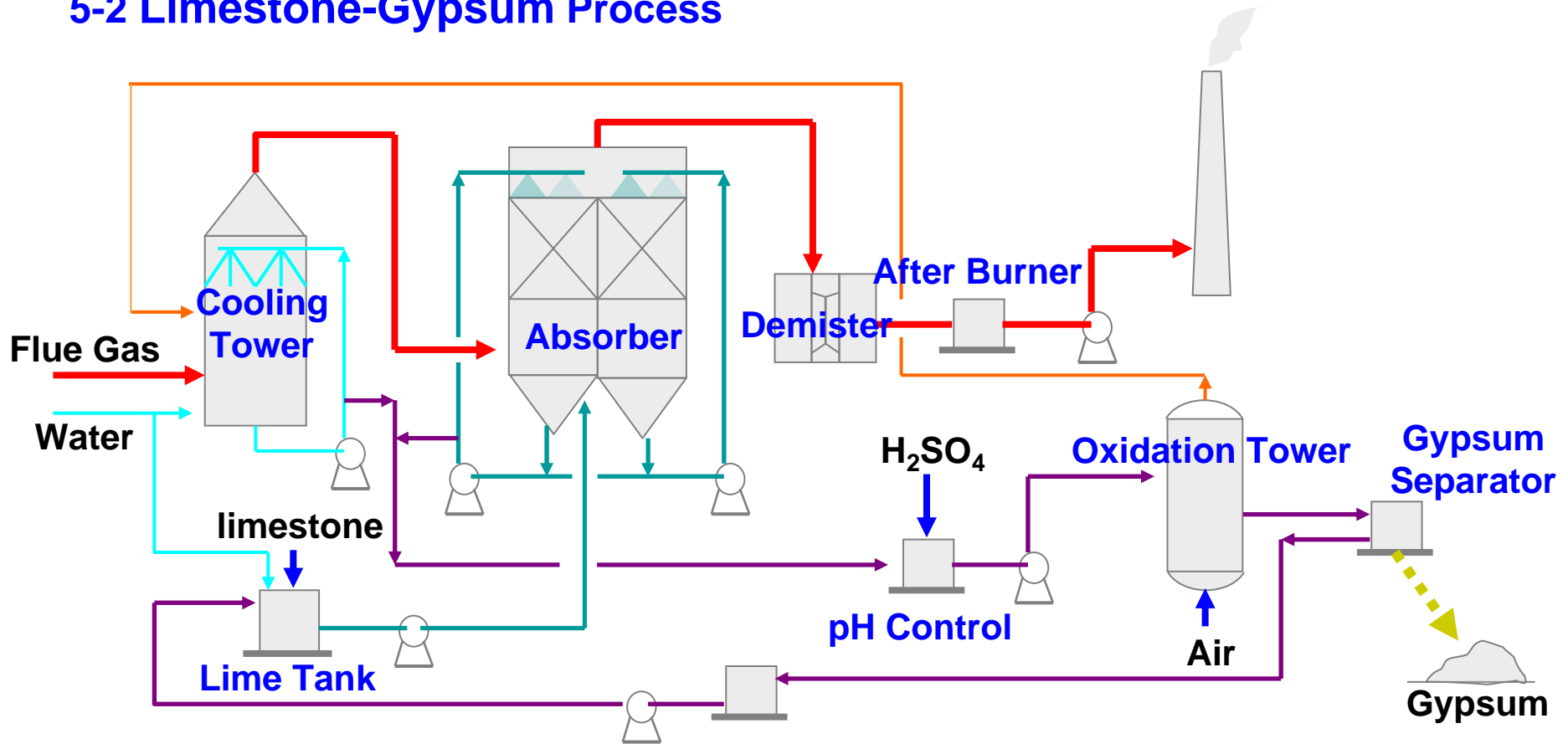
most popularly used method

In Japan

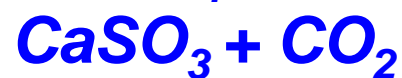
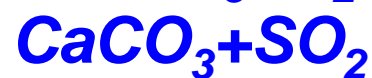
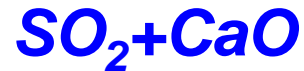
- limestone cheap
- initial & operating cost economical
- systems stability stable & safe
- gypsum marketable

5. Desulphurization Technology

5-2 Limestone-Gypsum Process



Reaction

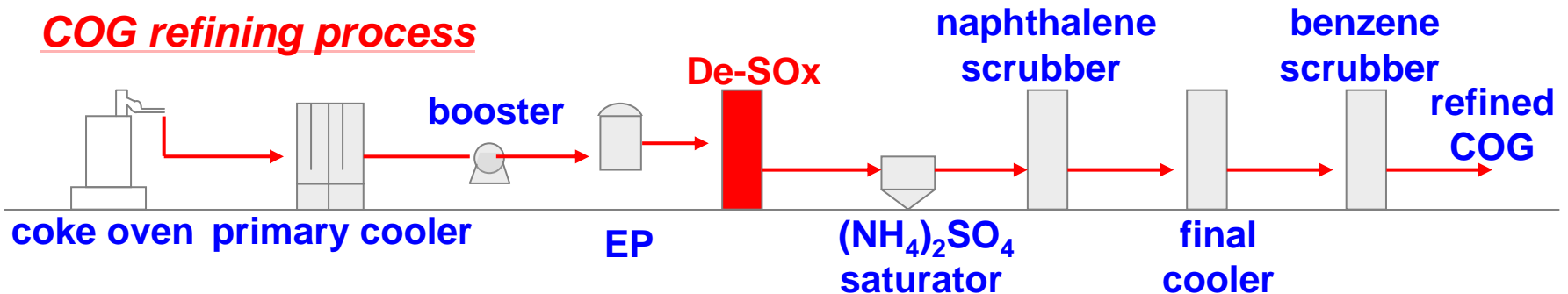


5. Desulphurization Technology

5-3 Coke Oven Gas Desulphurization Process

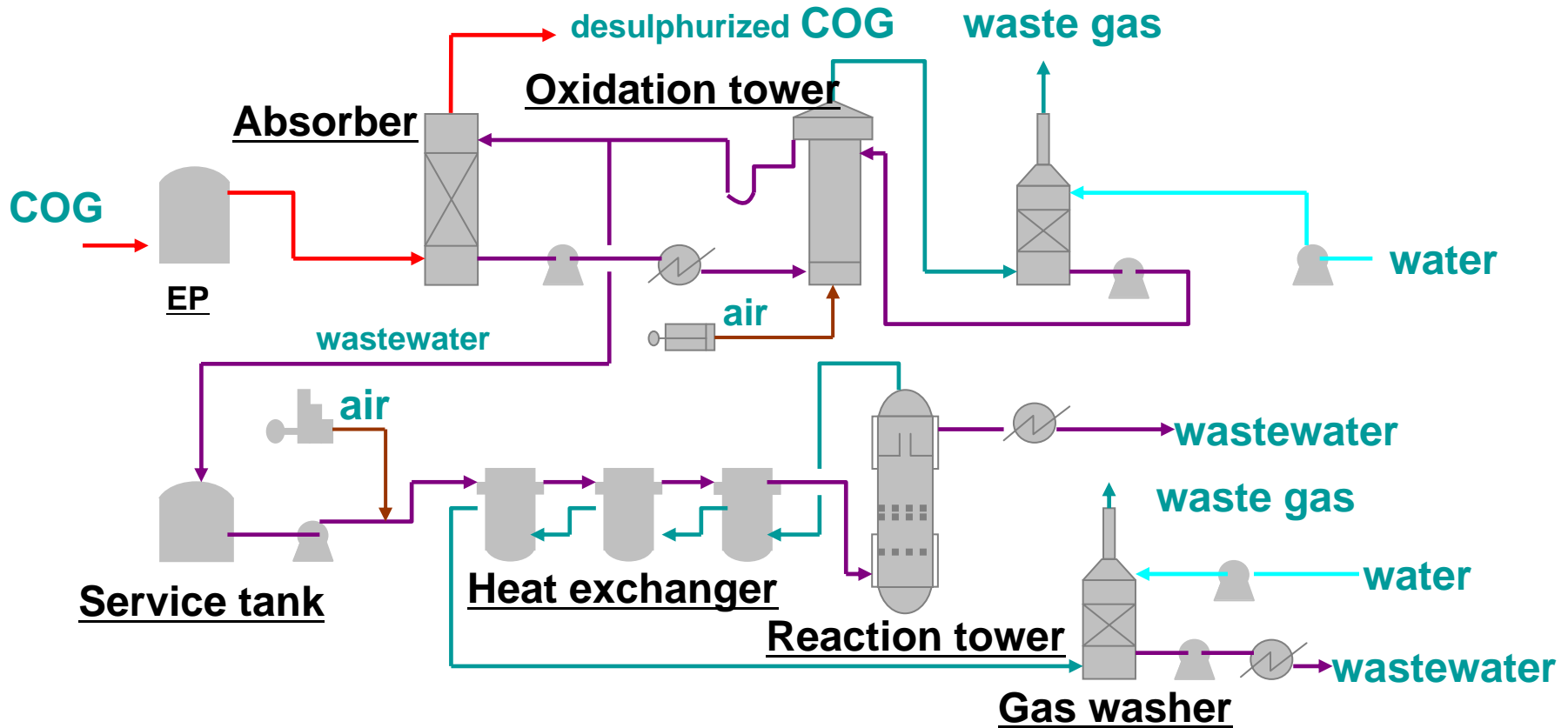
System	DeSOx-chemical	Catalyst	Byproduct
Takahax-Hirohax	NH ₃	naphthoquinone sulfonic acid soda	(NH ₄) ₂ SO ₄ + H ₂ SO ₄
Takahax-Reduction Decomposition	Na ₂ CO ₃	naphthoquinone sulfonic acid soda	crude S
Fumax-Hemibau	NH ₃	picric acid	H ₂ SO ₄
Stred Ford- Combax flue gas De-Sox	Na ₂ CO ₃	anthraquinone sulfonic acid soda metavanadate soda Tartaric acid soda	gypsum
Diamox-claus	NH ₃	none	pure S
Salfiban-claus	alkanol amine	none	pure S

COG refining process

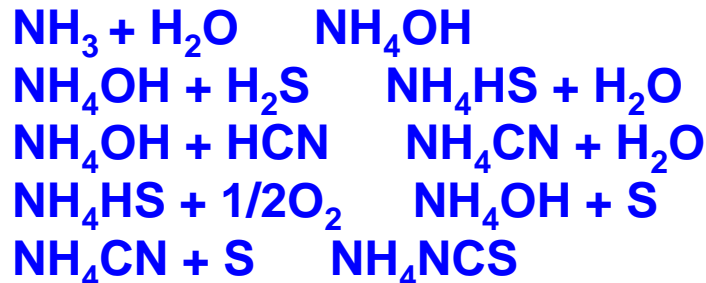


5. Desulphurization Technology

5-4 Takahax-Hirohax Process



Reaction

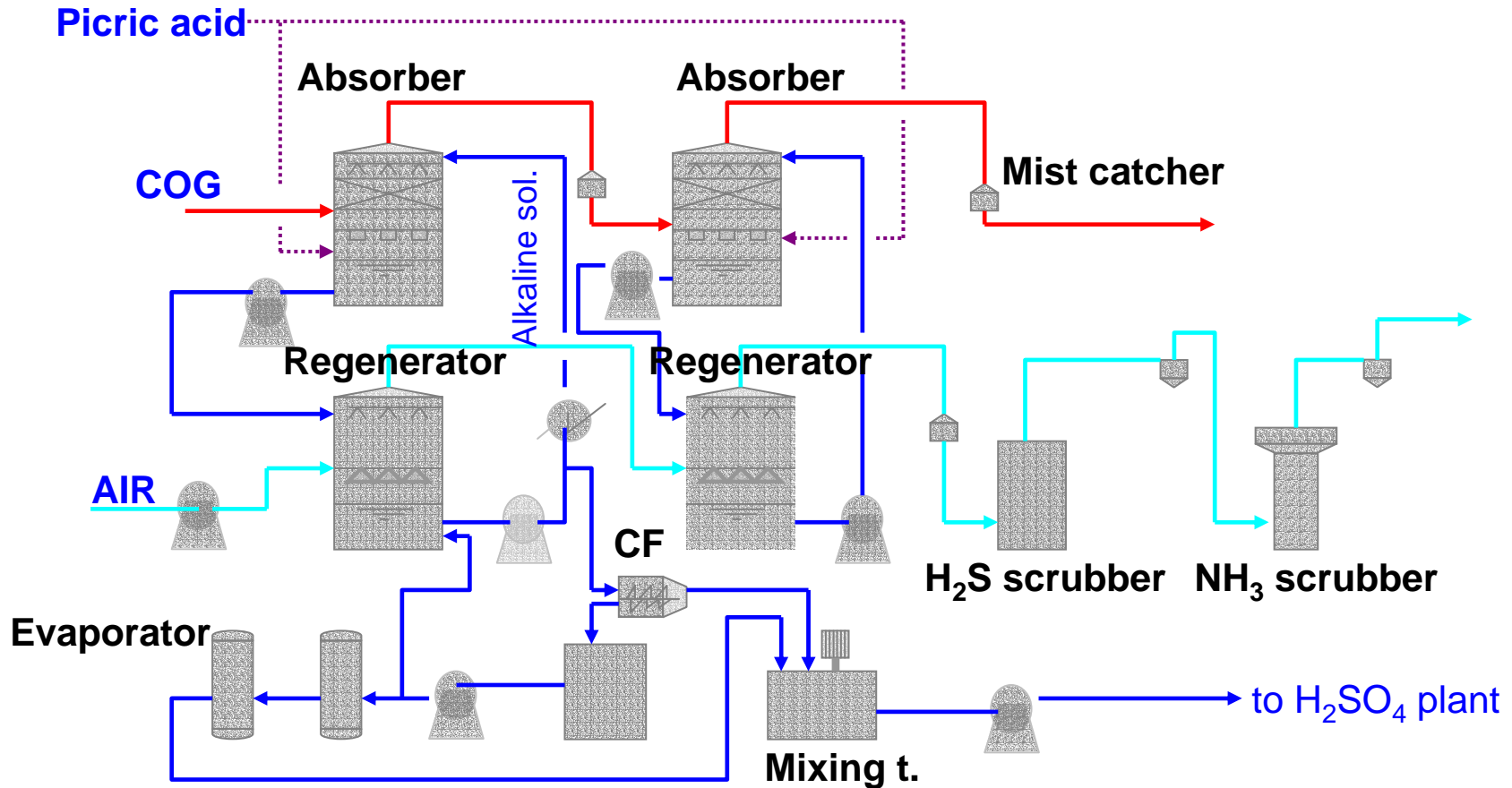


Removal rate

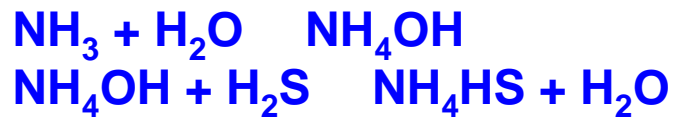
S, CN > 90~99%

5. Desulphurization Technology

5-5 Fumax Process



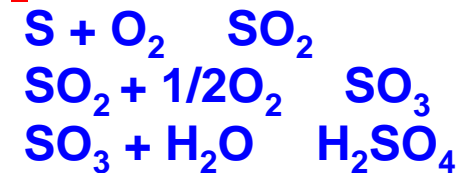
Absorption



Regeneration

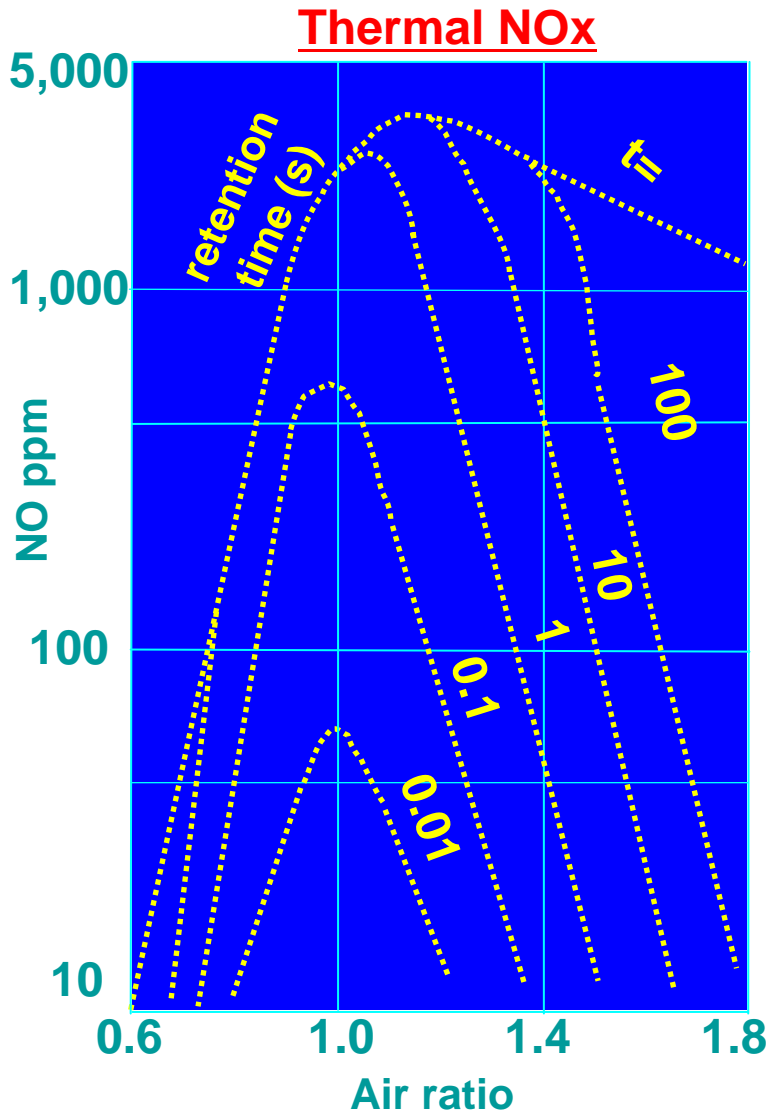


H₂SO₄ recovery



6. NOx Control Technology

6-1-1 NOx Generation



N & S Contents in Fuels

Fuel		N	S
Solid wt%	coal	0.7~2.2	0.3~2.6
	coke	0.6~1.4	0.2~1.0
Liquid wt%	crude oil	0.03~0.34	0.1~3.0
	C-oil	0.2~0.4	0.2~0.3
	B-oil	0.08~0.35	0.2~0.3
	A-oil	0.005~0.08	0.2~0.3
	light oil	0.004~0.006	0.03~0.5
	kerosene	0.0005~0.01	0.001~0.2
Gas g/Nm ³	COG-crude	0~9	1.5~7
	COG-fine	0.02~0.5	0.05~0.7
	BFG	tr	tr
	LDG	tr	tr
	LPG, LNG	tr	tr

JIS K2205 kinematic viscosity (cSt, mm²/s)

C-heavy oil: 50 ~1,000, B-heavy oil: 20~50, A-heavy oil: 20

6. NOx Control Technology

6-1-2 Factors in NOx Generation & Reduction

Causes of generation

Reduction methods

Fuel alternation

- Change of fuel
heavy oil light oil gas

Fuel denitrification

- Denitrification of COG

Changing operating conditions

- Low air ratio combustion
- Lowering dry hot air temperature
- Changing thermal load

Remodeling combustion system

- Multistage combustion
- Recirculation of exhaust gas
- Addition of steam or water
- Low NOx burner

N in fuel

O₂ con.

Flame temp.

Retention time

low N fuel

lower O₂

lower temp.

shorter retention

Improvement by Fuel
Improvement by combustion

6. NOx Control Technology

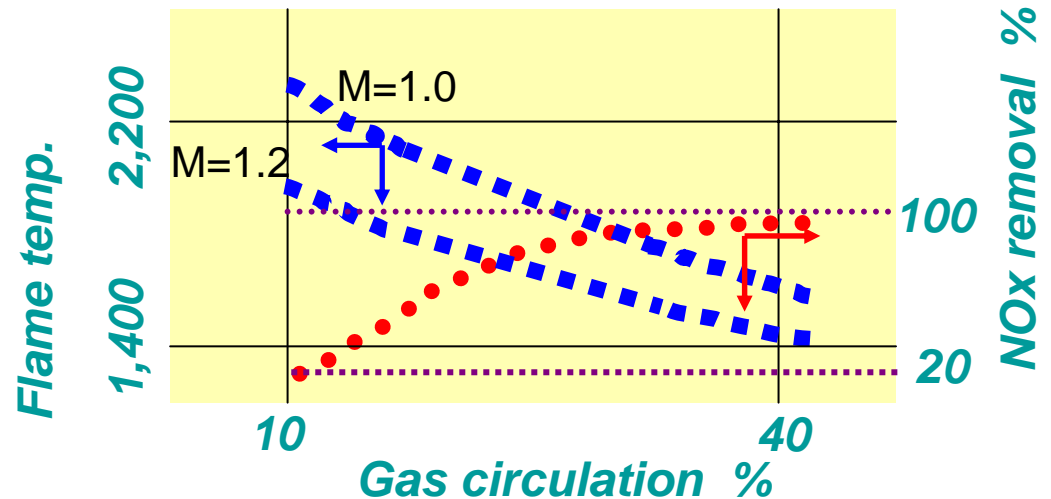
6-2-1 Fuel Improvement

1. Use of low N and low S fuel (S N)
2. Denitrification of COG N 1~9 g/m³ 800~1,000 , 4~6 sec.

6-2-2 Combustion Improvement

1. Low air ratio operation O₂ 1% NOx 10%
2. Multistage combustion 1st stage air ratio; 80~90% NOx 20%
rest air 2nd stage combustion
3. Steam or Water injection flame temp. Nox
no-change in generated calorific

4. Exhaust gas circulation

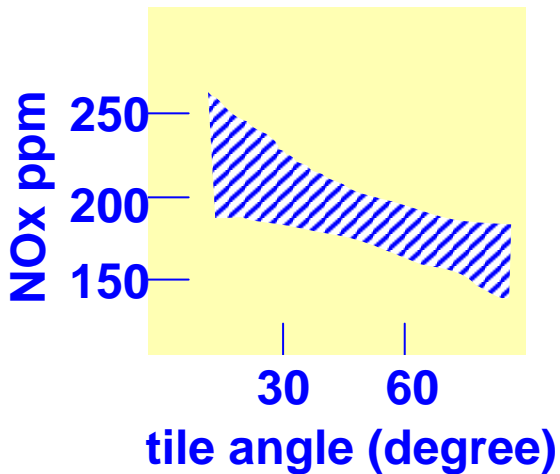
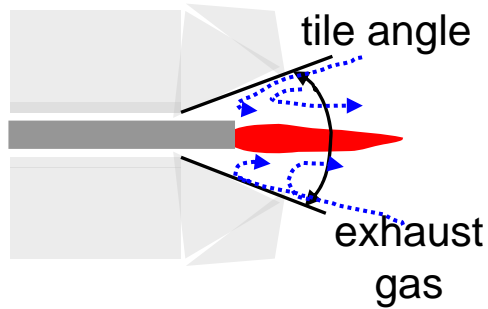


6. NOx Control Technology

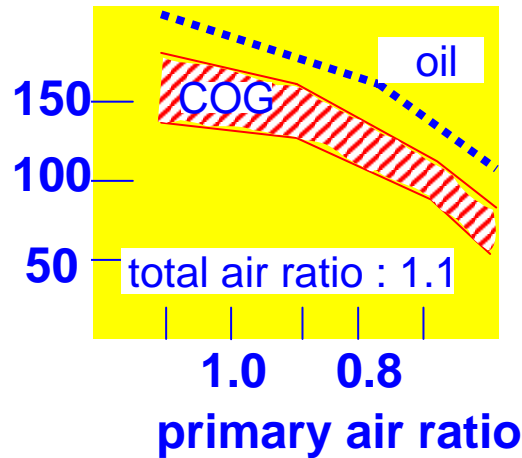
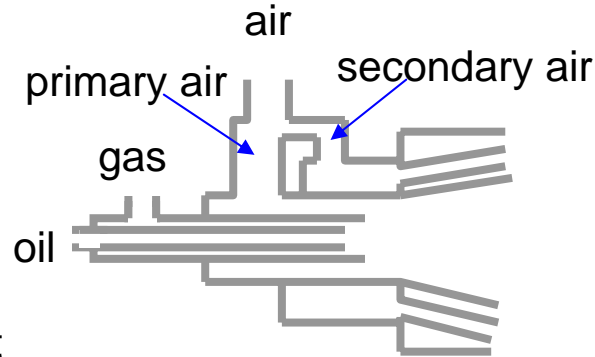
Continued from previous slide

5. Low- NOx burner

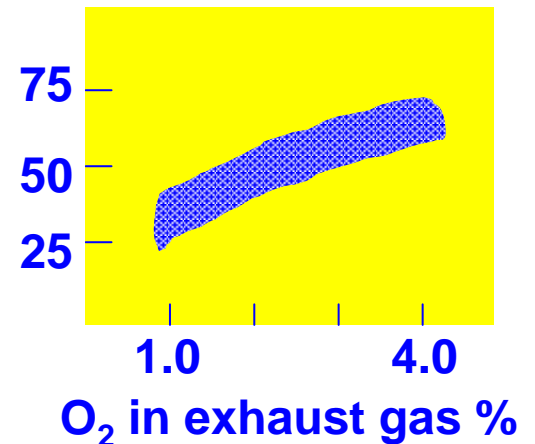
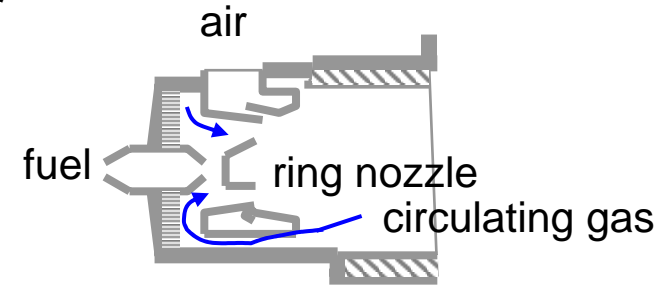
Wide-angle burner tile



Double-stage combustion burner

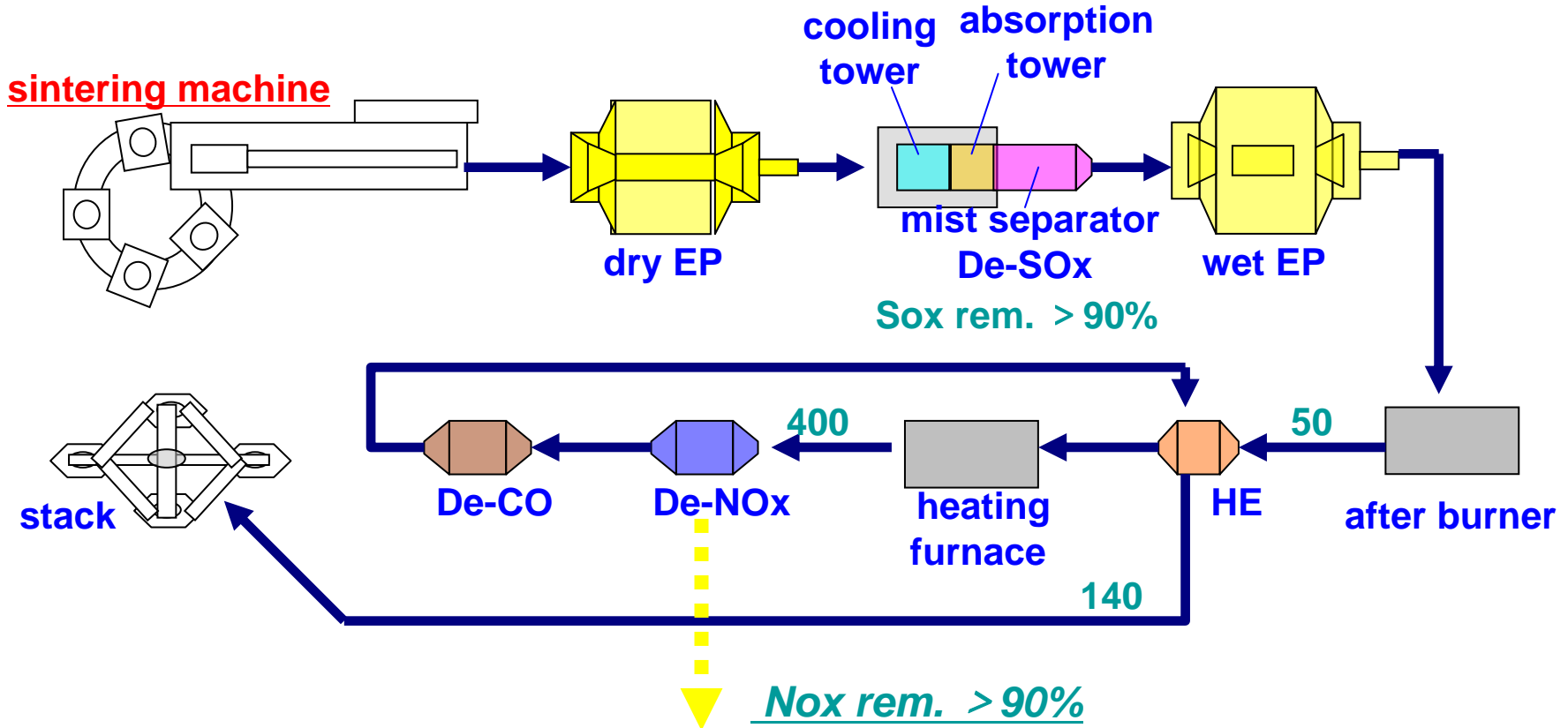


Self-circulate combustion burner

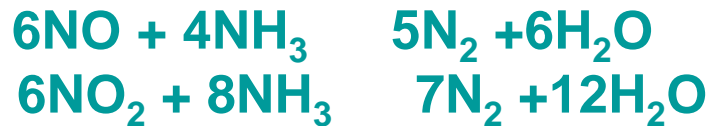


6. NOx Control Technology

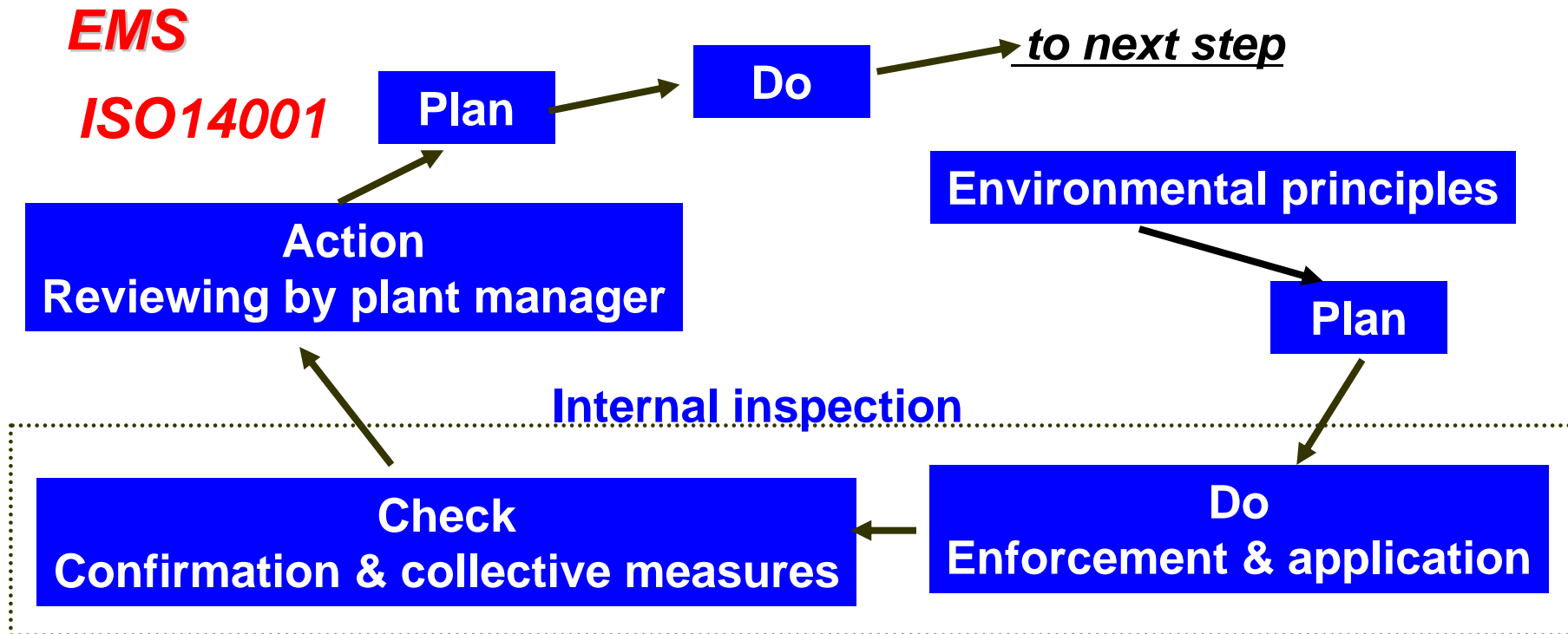
6-3 Denitrification of Exhaust Gas



De-NOx: Dry Type Selective Contact Reduction using NH₃



7. Environmental Management System(1/2)



Items to be considered at factory construction & operation

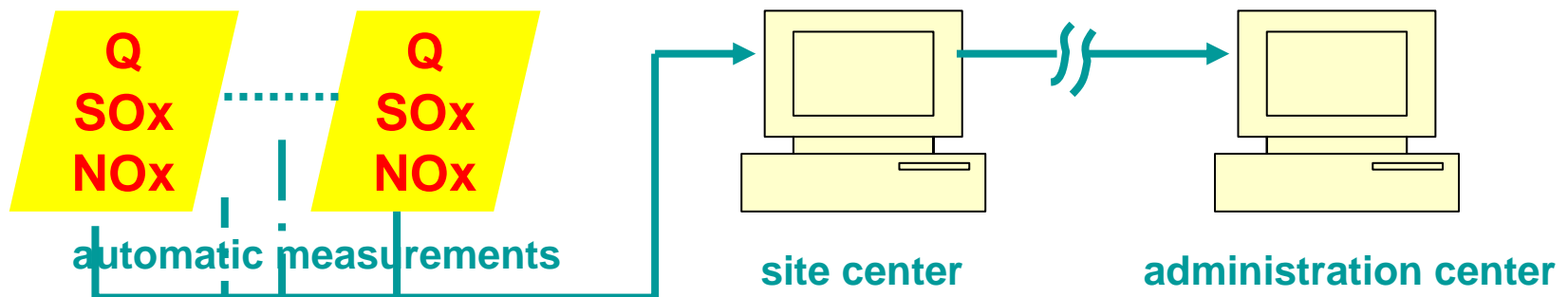
1. **Environmental impact assessment**
2. **Environmental standards & emission standards**
3. **Planning of plant & air pollution control equipment**
4. **Operation control & worker training**
5. **Environmental monitoring**
6. **Environmental management system**

7. Environmental Management System (2/2)

Measurement Items

	Emission Standard	EQS
Pollutants	dust sulfur oxide nitrogen oxide Cd, its compounds Cl, HCl F, HF, Si _n F _{2n+2} Pb, its compounds	Suspended particle matter SO ₂ (sulfur oxide) NO ₂ (nitrogen oxide) CO Photochemical oxidant

Telemeter System



8. Resources Saving

Dust Generation & Utilization

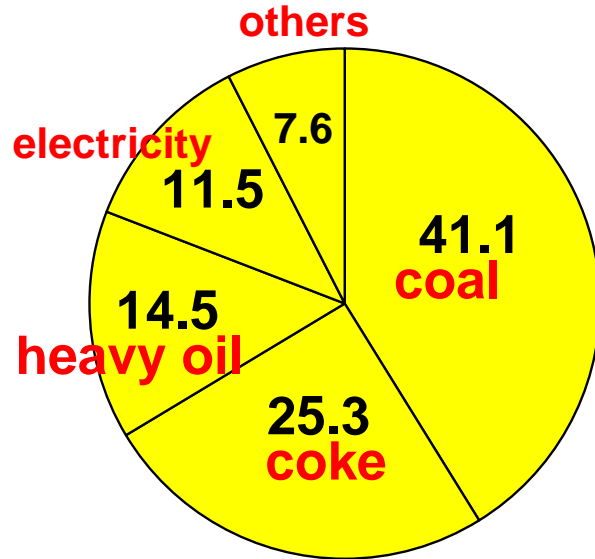
Dust Generation at 3 million-ton Crude Steel Production (t / y)

Process	Dry Dust Collector	Wet Dust Collector	Total
Material / Pig Iron	111,000	38,000	149,000 (61%)
Steel	33,000	60,000	93,000 (38%)
Rolling	2,700	300	3,000 (1%)
Total	146,700 (60%)	98,300 (40%)	245,000 (100%)

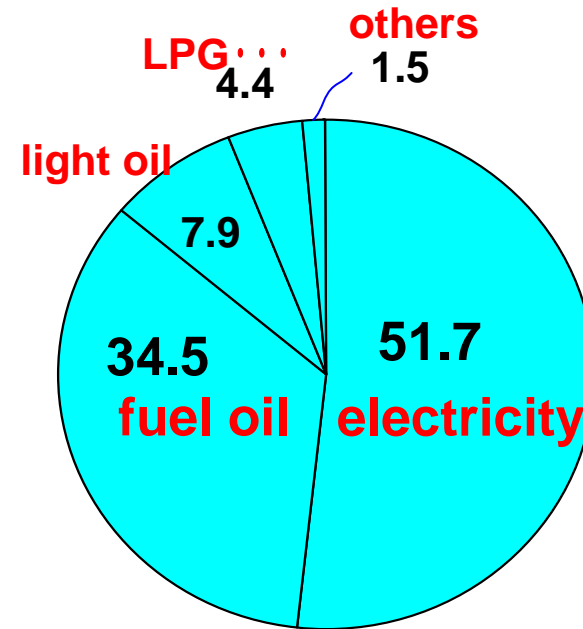
- Dust generation in Integrated Iron Works: **4.9% of crude steel**
- Ingredient of Dust: **Iron Oxide, Limestone, etc.**
- Utilization: **Raw Material for Sintering, Zn, ZnCO₃, Neutralizing wastewater, BF**

9. Energy Saving

Energy source ratio (%)



Integrated Steel Production



Non-Integrated Steel Production

Energy saving Method

high efficient equipment & improving operation
reducing the number of unit operations
& changing to continuous process
waste heat recovery