Worldwide Pollution Control Association

ESKOM Scrubber Seminar

April 12th – 13th, 2007

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GEA Niro A/S

WPCA Seminar for ESKOM

Semi-dry scrubber technologies: Spray Drying Absorption

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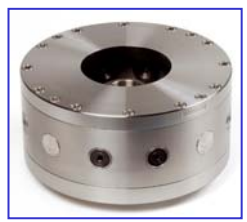
Niro A/S, Copenhagen, Denmark

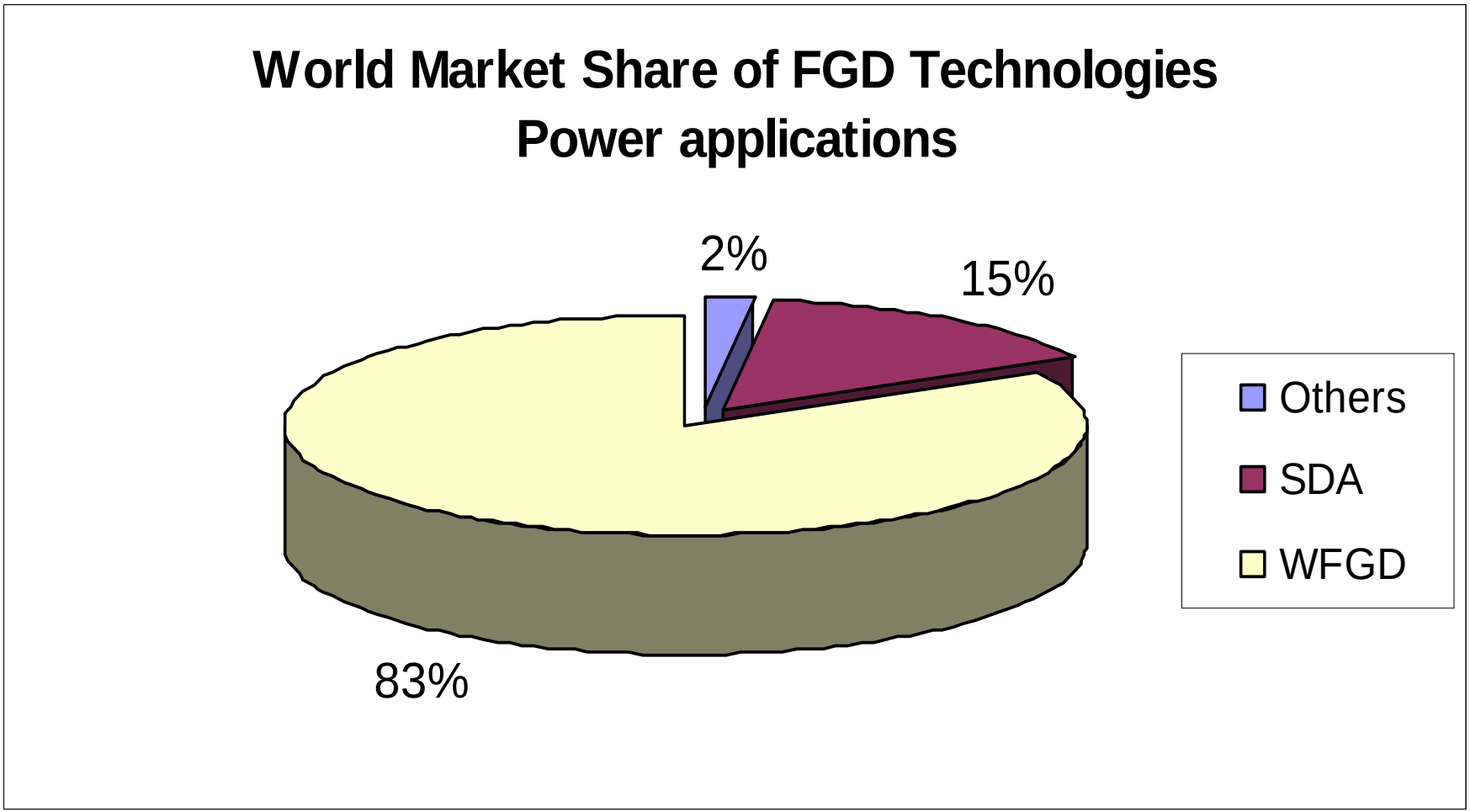
April 13, 2007

Spray Drying Absorption:

- Introduction
- Process Capabilities
- SDA Process
- Process Layout
- Main Components
- SDA Applications



Introduction

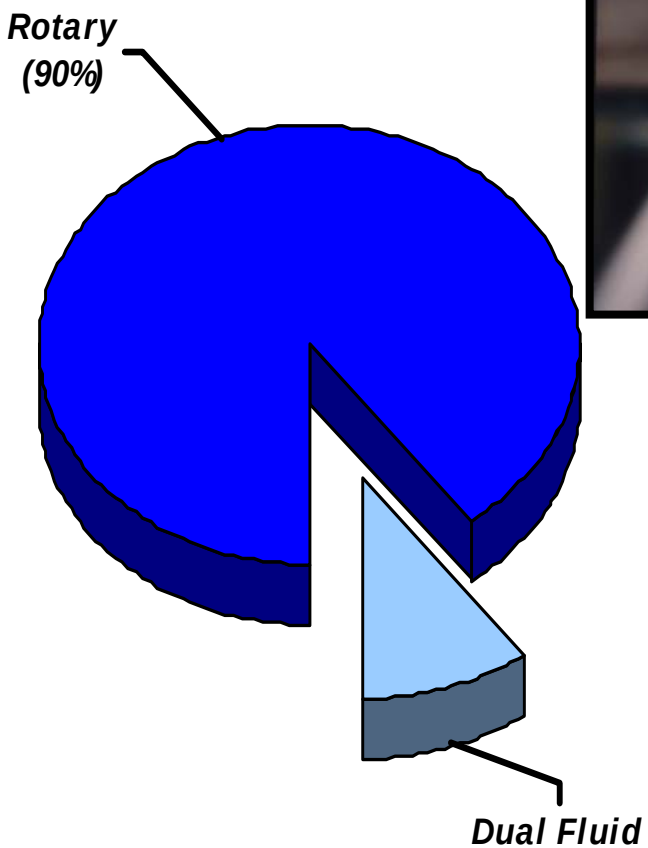

World Market Share of FGD Technologies
Power applications
2%
15%
83%
Others
SDA
WFGD

Introduction

Rotary Atomizer

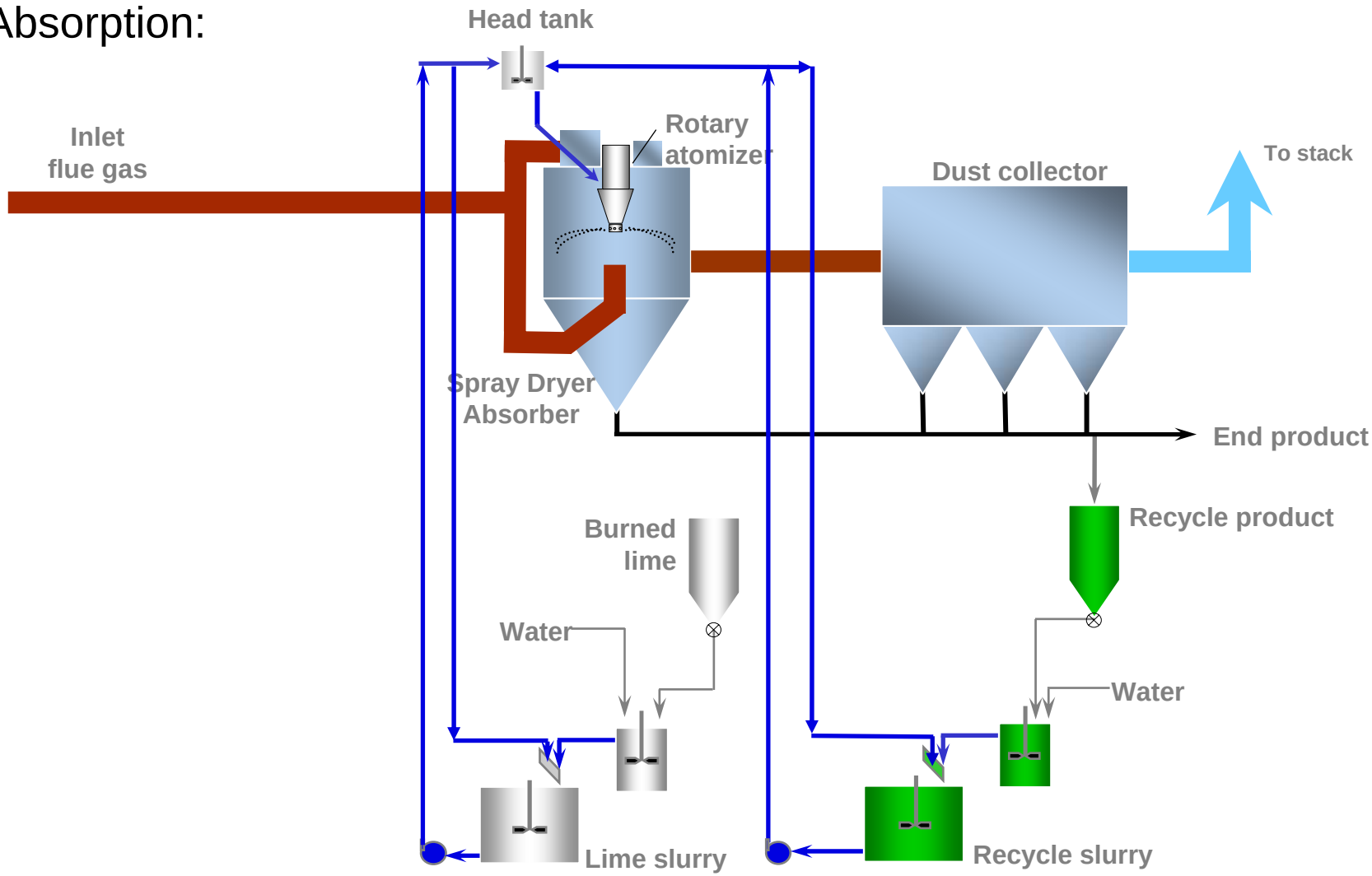
Dual Fluid

Installations share by atomizer type



Introduction

Spray Drying Absorption:



Process Capabilities

SDA – Especially applicable for:

- Medium to large size boilers, 100 MW and up
- Low to Medium Sulphur content in coal, 0 – 3 %
- Medium to high SO_2 removal rate requirement, up to 98%
- Extreme removal requirements of HCl, HF, SO_3 , > 99 %
- Plants with process water shortage and / or low quality process water supply (waste water, sea water brackish water)

SDA Main Design Parameters:

Plants	Power Plants, Waste Incinerators, Metal Processing Plants
Fuel	Coal, Lignite, Oil, Municipal Waste. Also applicable for industrial off-gases.
S-content in fuel	Optimized for coal S contents up to 3 %
SO2 – content in flue gas	Optimized for 0 – 7.000 mg/Nm3 (0 – 2.500 ppm)
Air toxics	The SDA can be designed for any load of SO3, HCl, HF, Hg etc.
Dust Load	< 15 g/Nm3: No precollection > 15 g/Nm3: Precollection considered
Flue Gas Inlet Temperature	Utility boilers: < 200 °C Industrial plants: < 450 °C
Process Water	The SDA makes use of any quality of process water, incl. sea water, brackish water, river water, waste water etc.

Actual experience ranges at power plants

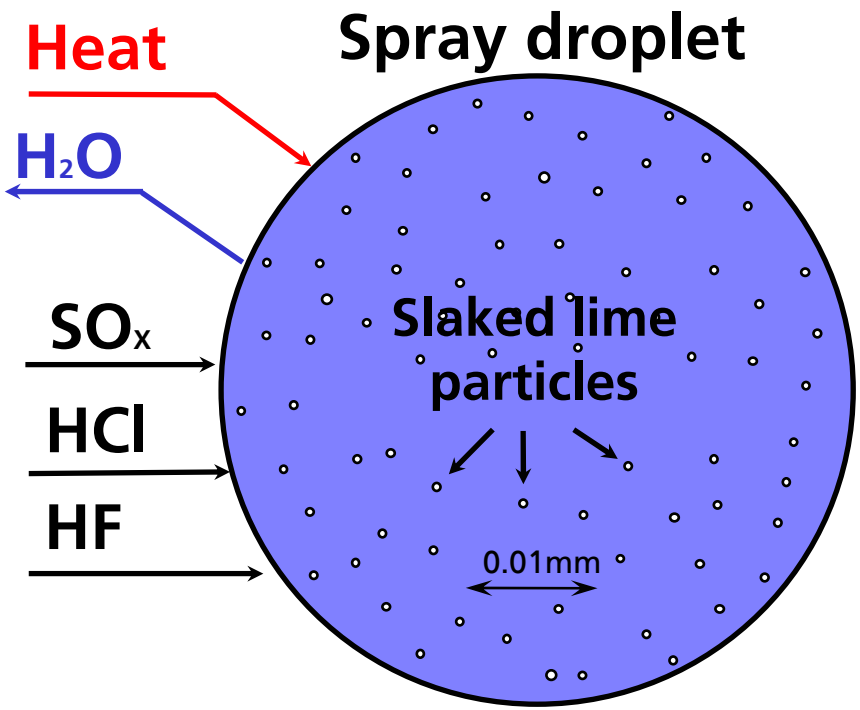
Parameter	Unit	Range
Total Flue Gas Flow rate	Nm^3/h	18.000 – 4.300.000
Max. Flow rate per absorber module	Nm^3/h	1.100.000 *)
Flue Gas Inlet temperature	°C	92 - 182
Coal Sulphur content	%wt.	0,2 – 3,5

*) SDA plant designed for 1.250.000 Nm3/h is under construction at Comanche Unit 3, USA. Latest Niro design accepts 1.600.000 Nm3/h per absorber.

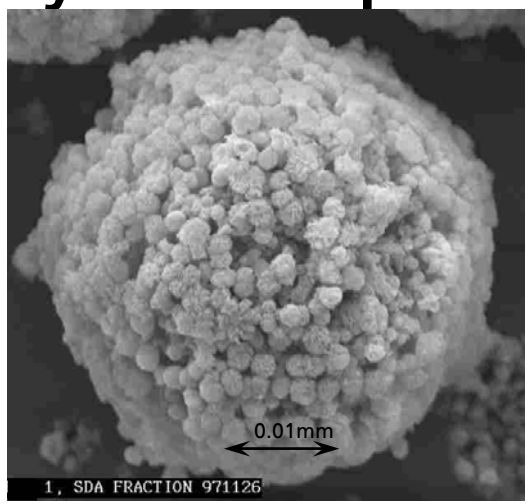
Parameter	Inlet Conc. [mg/Nm^3]	Removal rate [%]	Emission [mg/Nm^3]
SO2	800-7.000	> 99	< 10
SO3	< 10	> 99	< 1
HCl	< 125	> 99	< 1
HF	< 60	> 99	< 0,5
Hg	$2 – 10 \times 10^{-3}$	> 99	$< 0,03 \times 10^{-3}$

SDA Process

SPRAY DRYING ABSORPTION PROCESS



Dry reaction product



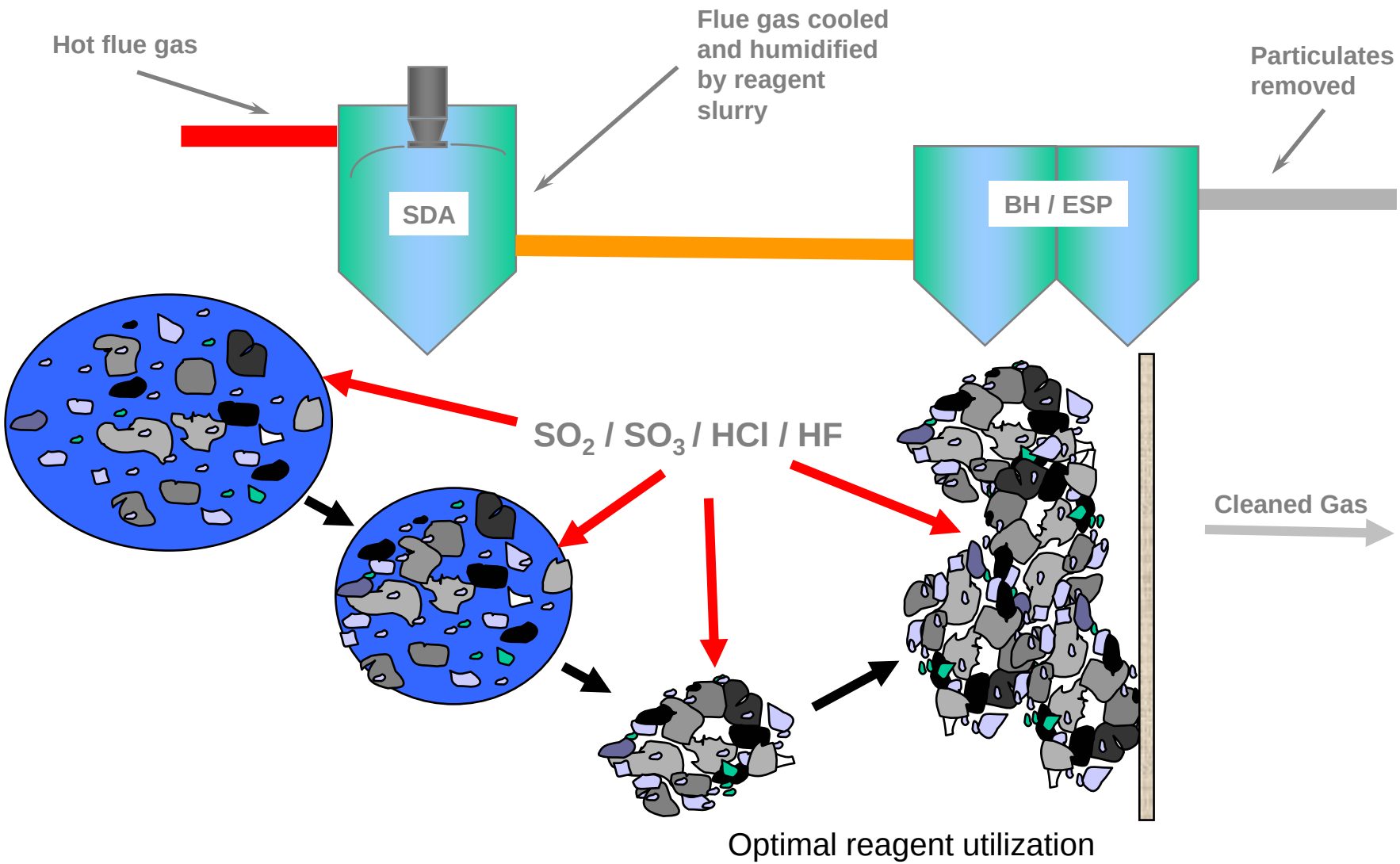
Main Reactions:

$SO_2 + Ca(OH)_2 \rightarrow CaSO_3 / CaSO_4 + H_2O$

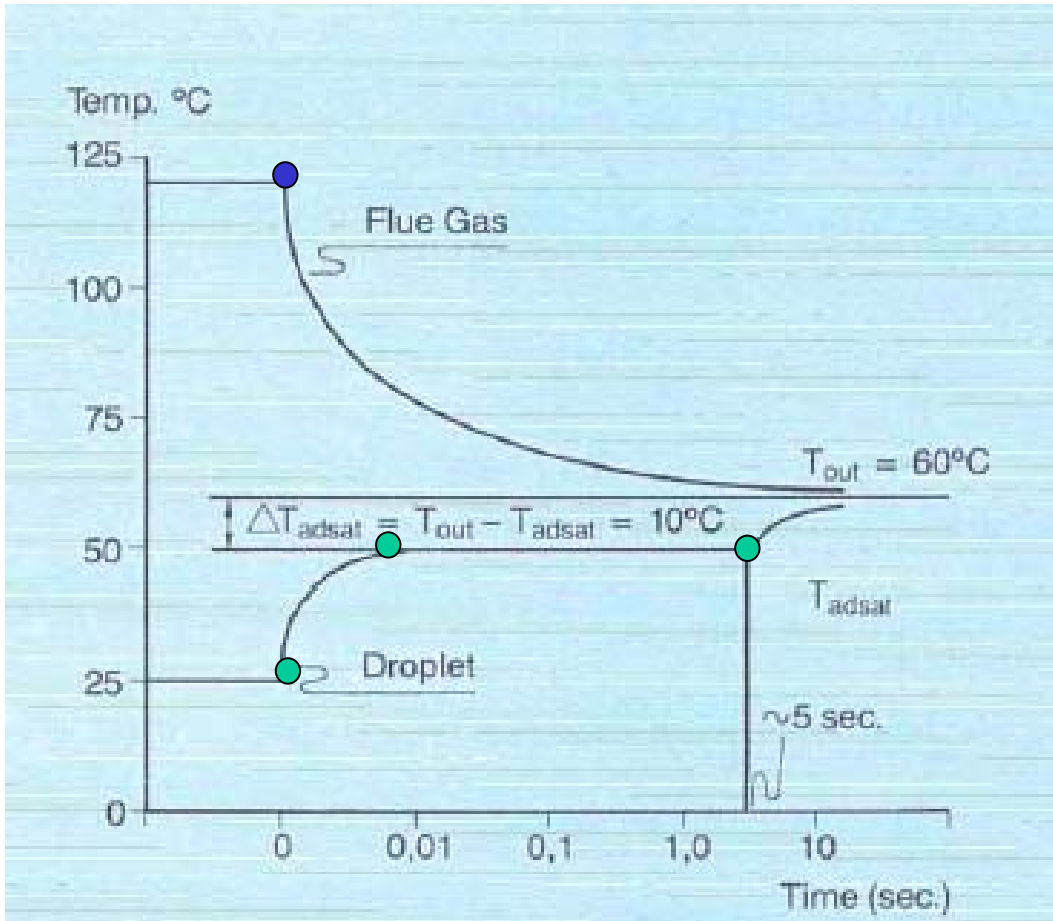
$2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$

$2HF + Ca(OH)_2 \rightarrow CaF_2 + 2H_2O$

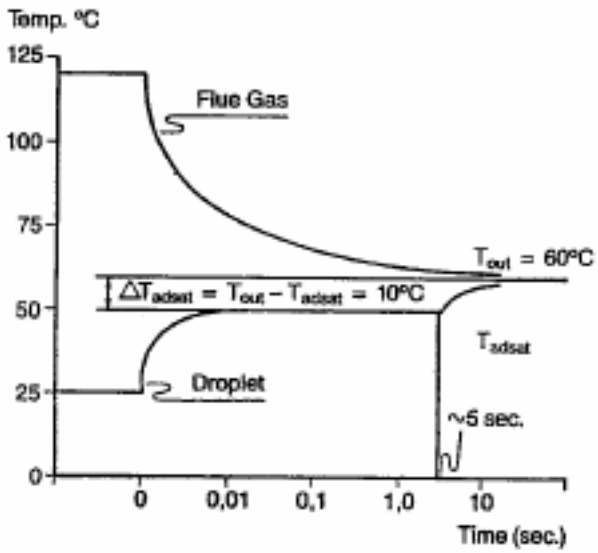
SDA - Two Stage Absorption Process

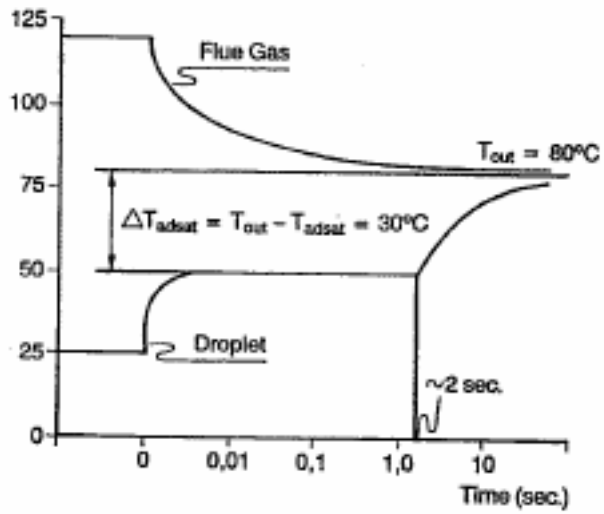


Influence of SDA outlet temperature



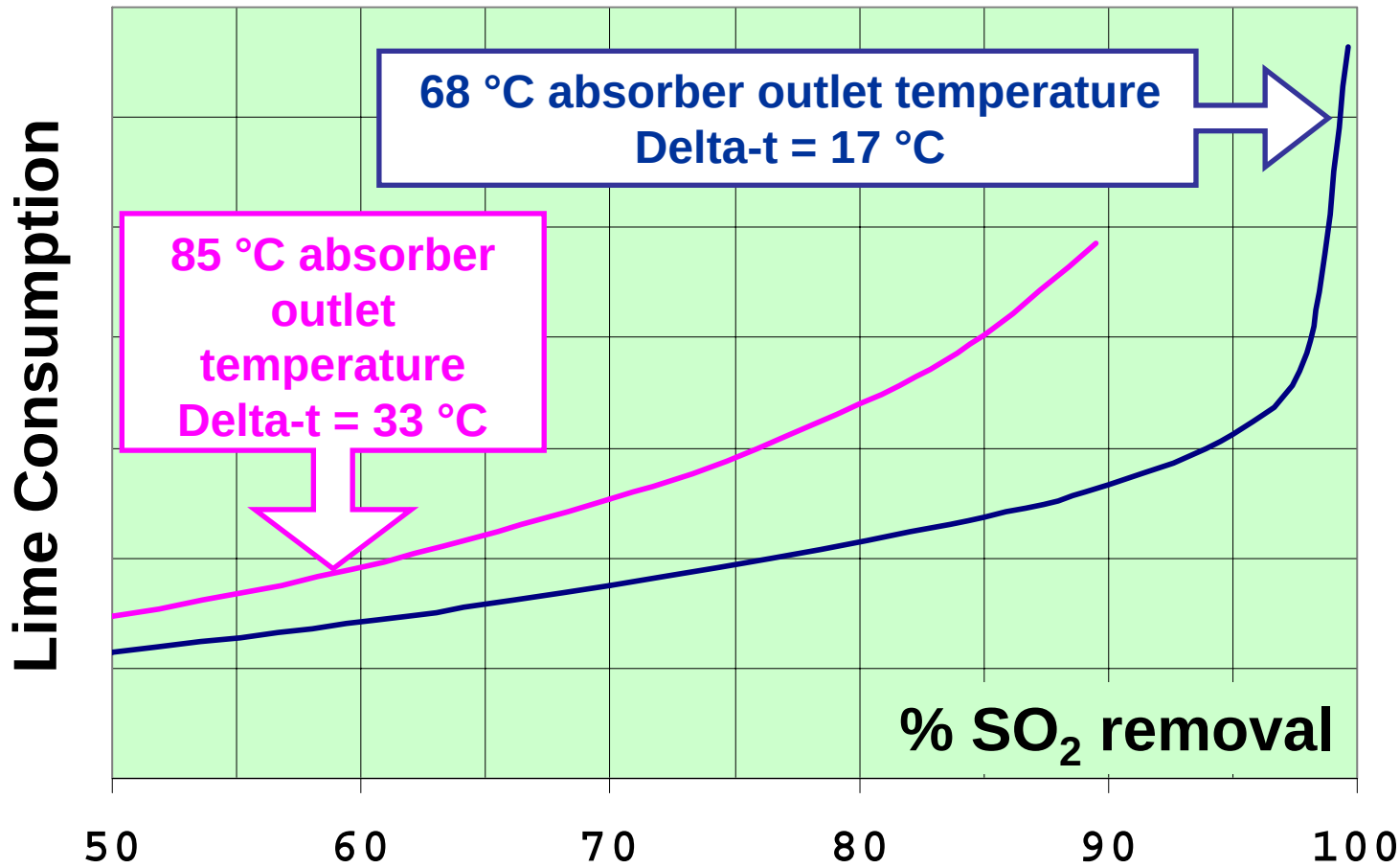
Approach to Adiabatic Saturation





Influence on drying time of difference between Spray Drying Absorber outlet temperature and adiabatic saturation temperature ($\Delta T_{adsat.}$).

Lime Consumption vs SO_2 Removal Efficiency



SDA Process

SDA Absorbents:

- Burned lime, CaO (aka quicklime)
- Hydrated lime $Ca(OH)_2$
- Carbide lime

- Calcination of limestone:

  $CaCO_3$ + Heat => CaO + CO_2

- Hydration of burned lime:

  CaO + H_2O => $Ca(OH)_2$ + Heat

SDA Process

Lime Quality:

- Purity
  Preferably > 80 % available CaO. Lime with low purity is acceptable for the SDA, but the consumption will increase.

- Reactivity
  Preferably T60 < 3 minutes, according to DIN 1080. If reactivity of the lime is lower, the consumption of lime may increase for maintained deSOx-performance.

- Particle Size Distribution
  The slaking process depends on the PSD of the available lime. Fine lime (< 1-3 mm) may be slaked in an ordinary tank or detention slaker. Paste slakers are widely used for optimum control of the slaking process. If lime particles are coarser, milling is an option.

SDA Process Water Quality:

Primary uses:	Lime slaking and cooling of the flue gas.
Introduced to:	The atomizer, via the lime slaking system (~20 %) and the recycle slurry system (~80 %).
Main parameters:	Chloride content, due to corrosivity and its process enhancing characteristics.
Other parameters:	For the lime slaking water, the sulphate content and the hardness are of importance to the detailed process design, due to sulphate's influence on the slaking process and the scaling potential of hard water.

Generally, river- or lake water is appropriate as lime slaking water source, and sea water is advantageous as water for the recycle slurry system.

Typical SDA Product composition

SDA Product Composition	Some precollection of fly ash	No precollection of fly ash
$CaSO_3$	35 - 60	15-30
$CaSO_4$	6 - 15	3-8
$CaCl_2$	0.1 – 2	0.1-1
CaCO3	1 – 5	0.5-3
$Ca(OH)_2$	2 – 10	2-10
Free water	1 – 3	1-3
Bound water (crystal water)	4 – 10	2-6
Fly ash	1 – 30	50-80

SDA Process

Use of SDA product:

1 **Disposal/use as filler:**

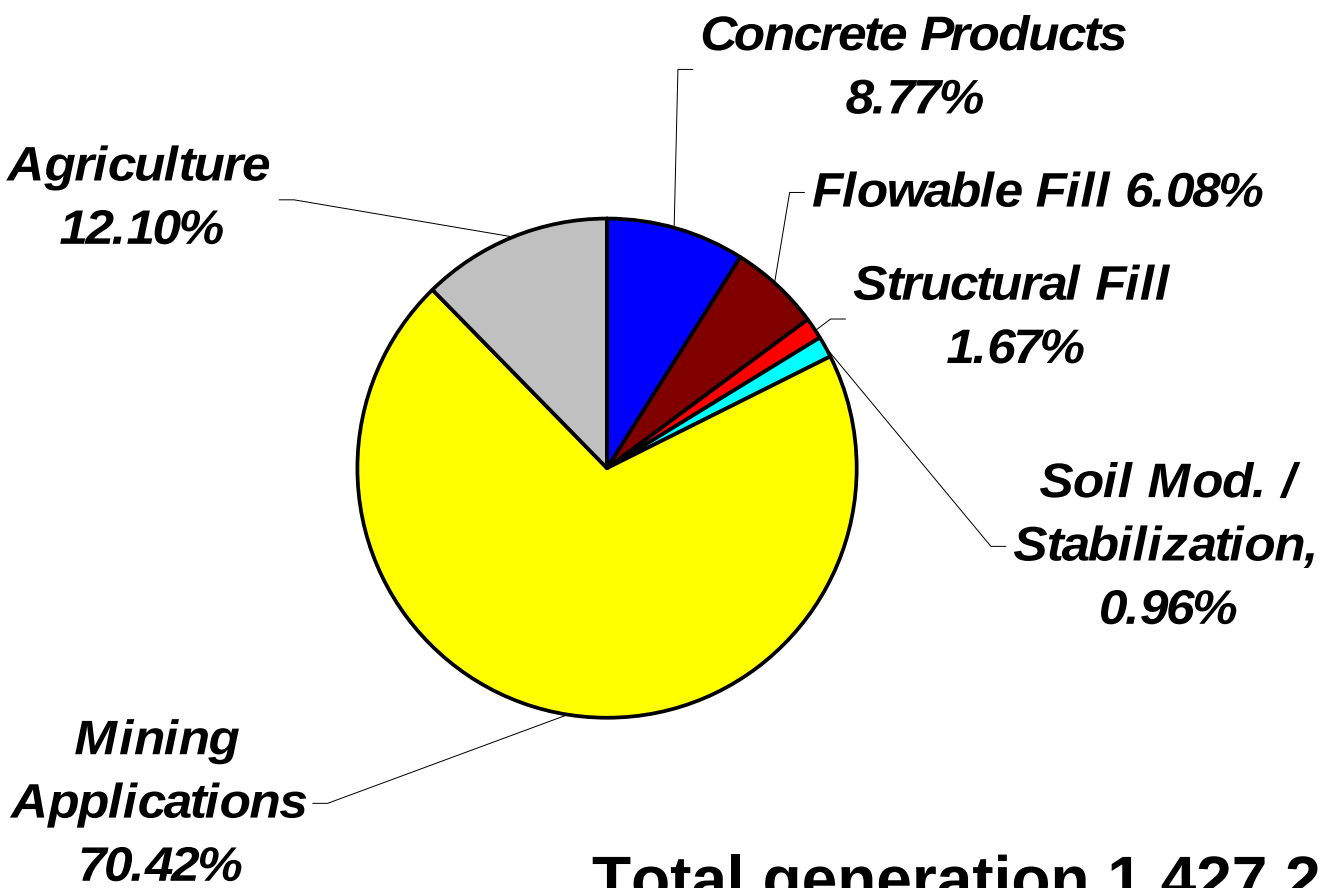
- Land reclamation
- Mining back-fill

2 **Utilization of SDA product:**

- Fertilizer
- Oxidation to gypsum.
- Building materials.
- Road construction base
- Noise and dust barriers
- Cat litter.
- Sulphuric acid.

SDA Process

SDA By-Product Solids Use (2005)

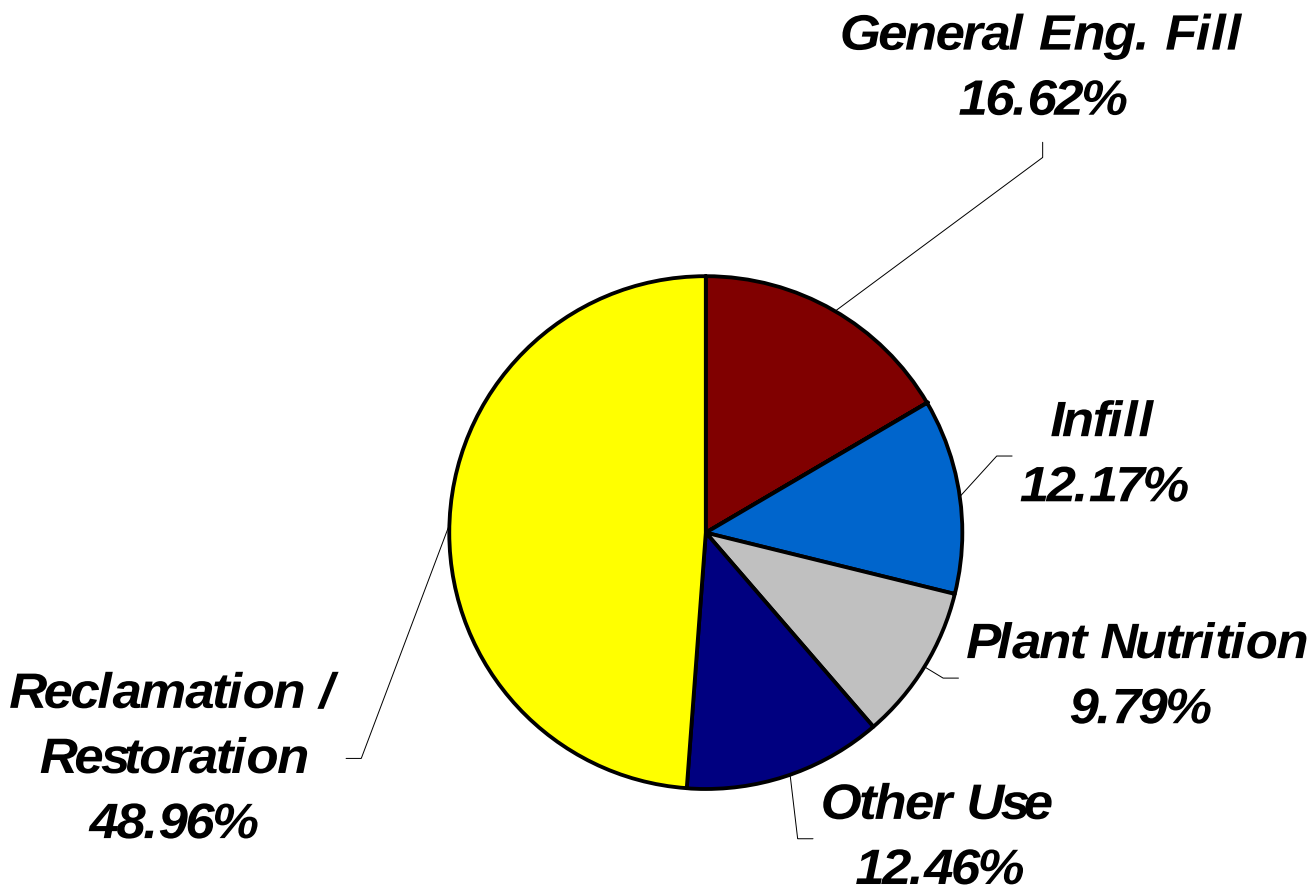


USA

Total generation 1,427,263 tons

SDA Process

SDA By-Product Solids Use (2004)

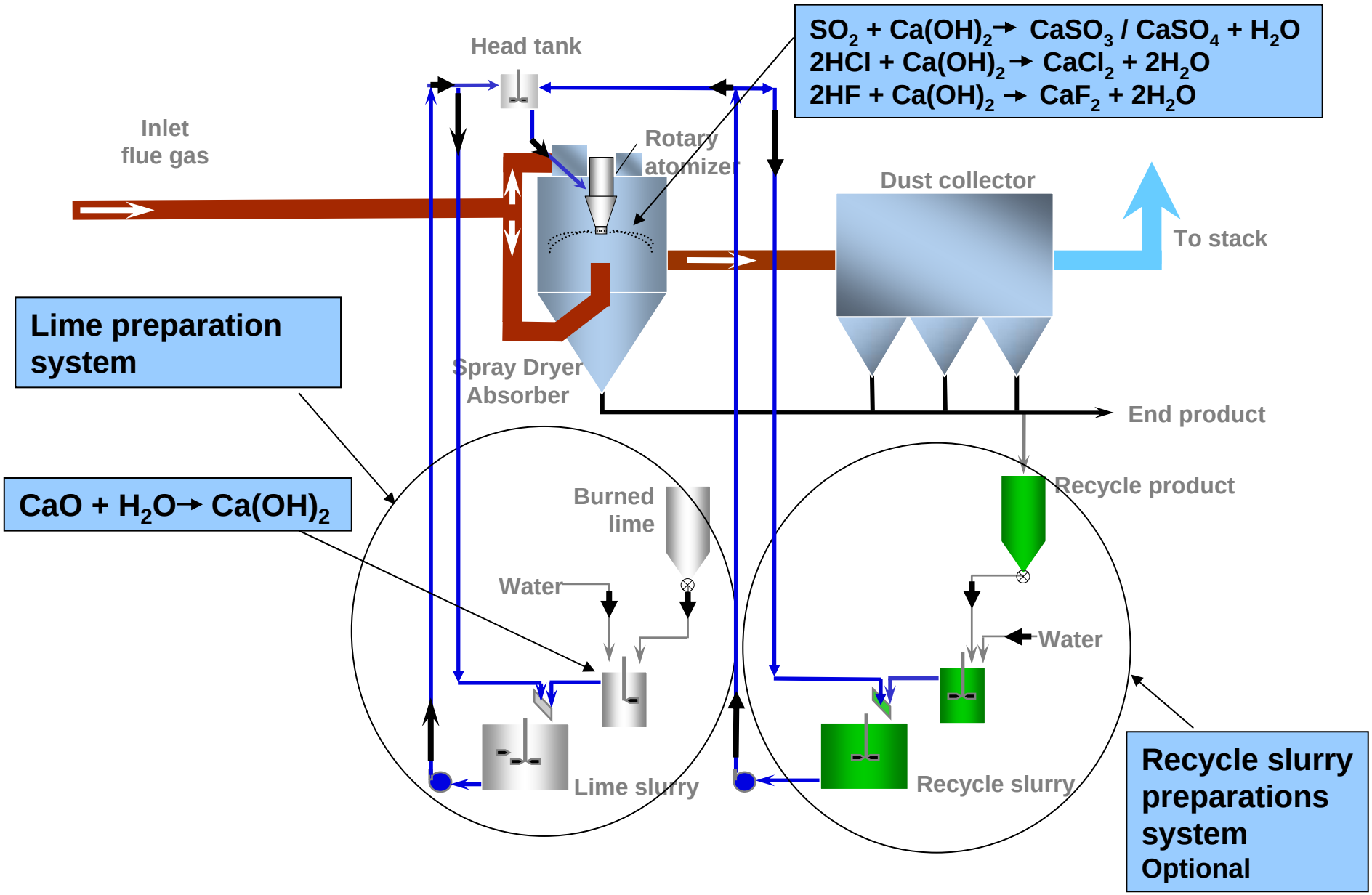


Europe

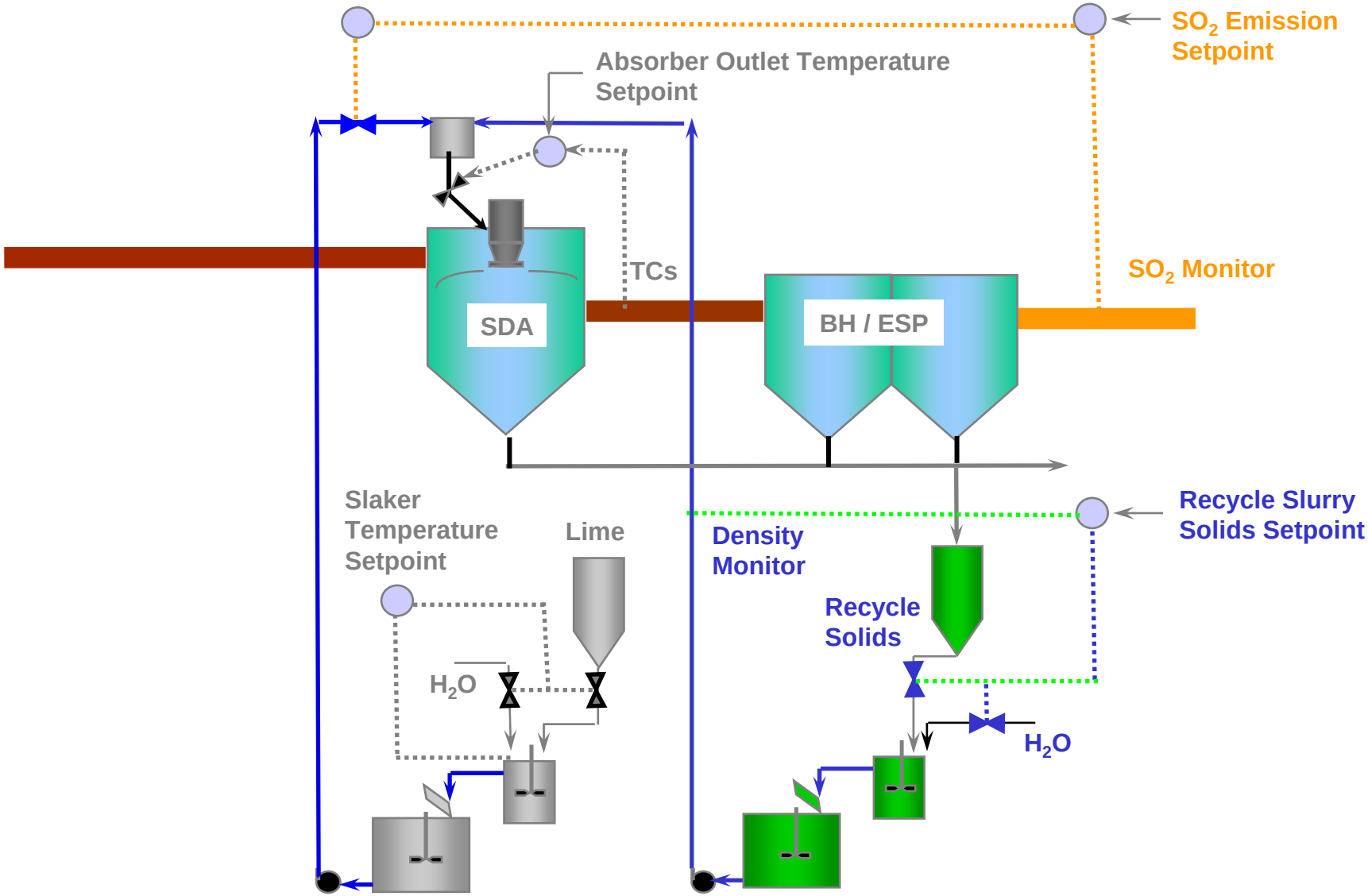
Total generation 464,152 tons

Process Lay-out

Process Lay-out

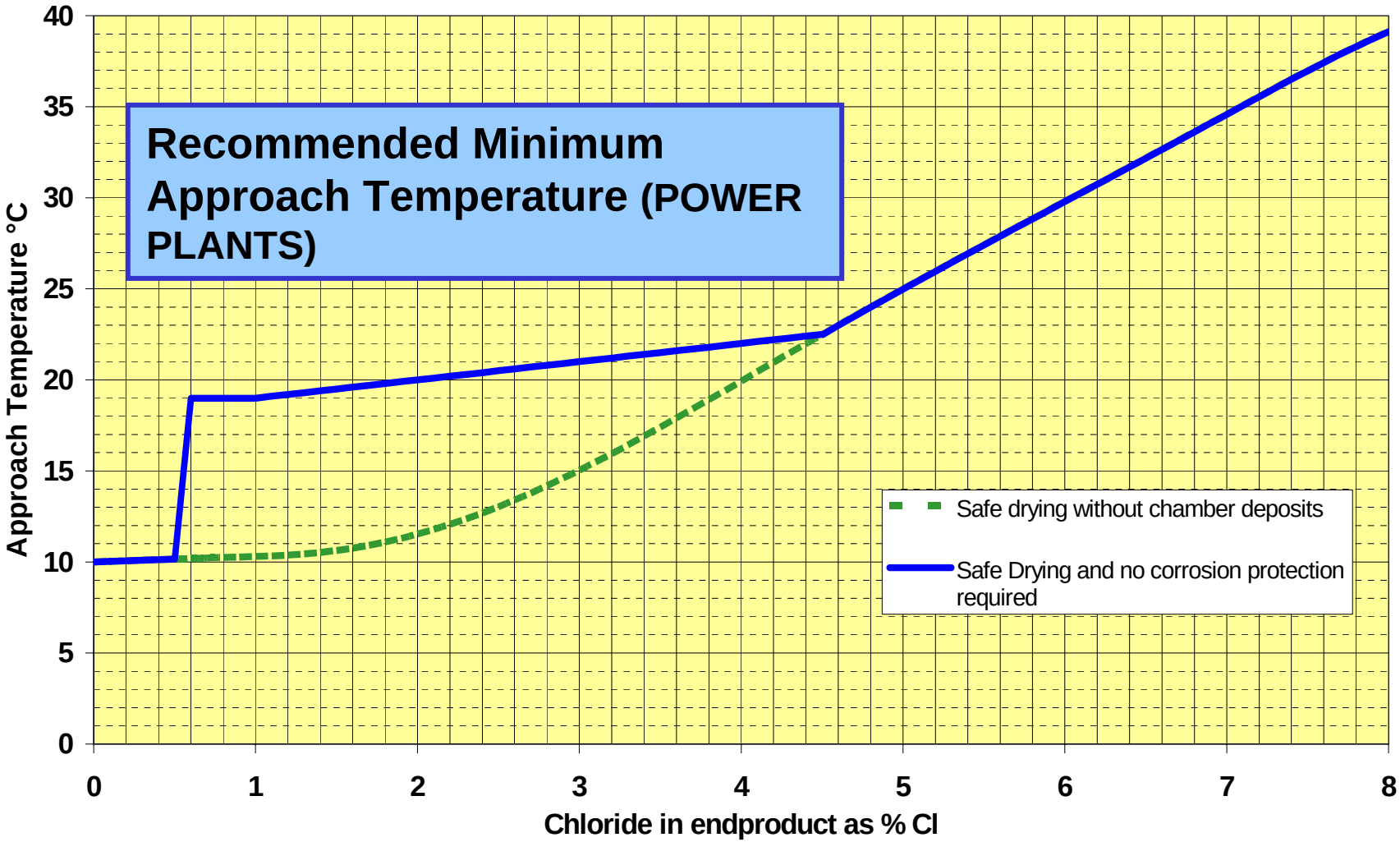


Process Layout



Recommended Operating Conditions

(Feed solids >30% and limited amount of soluble salts)



Main Components

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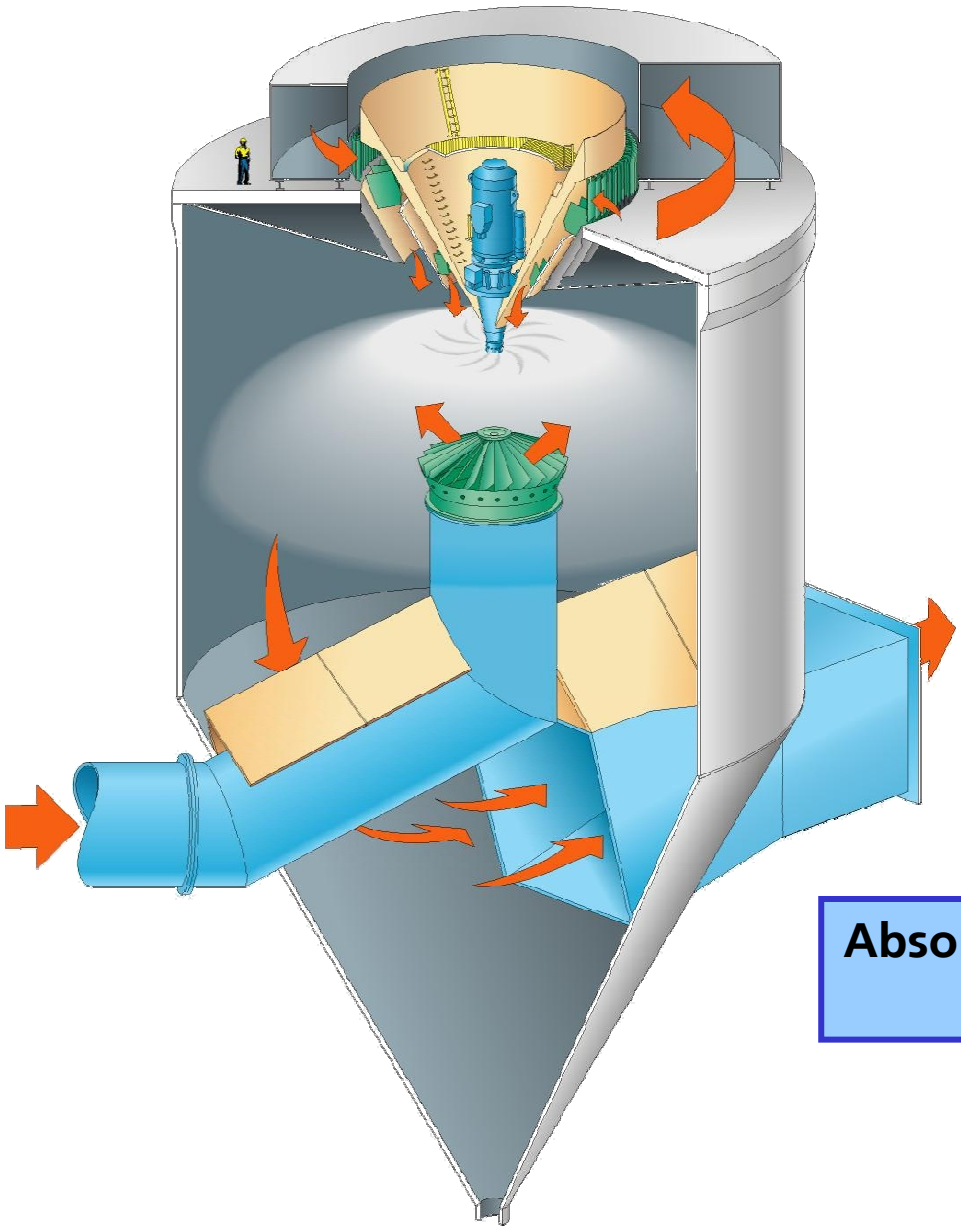
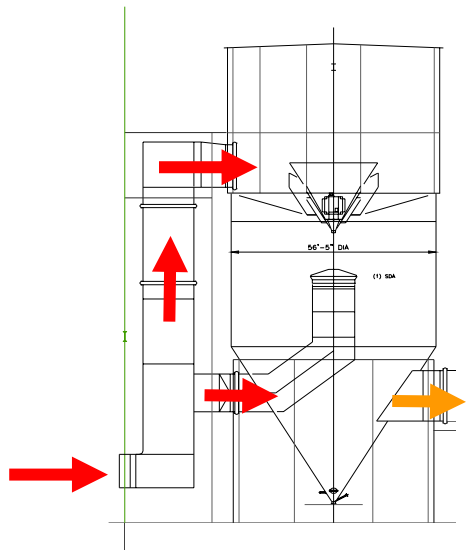
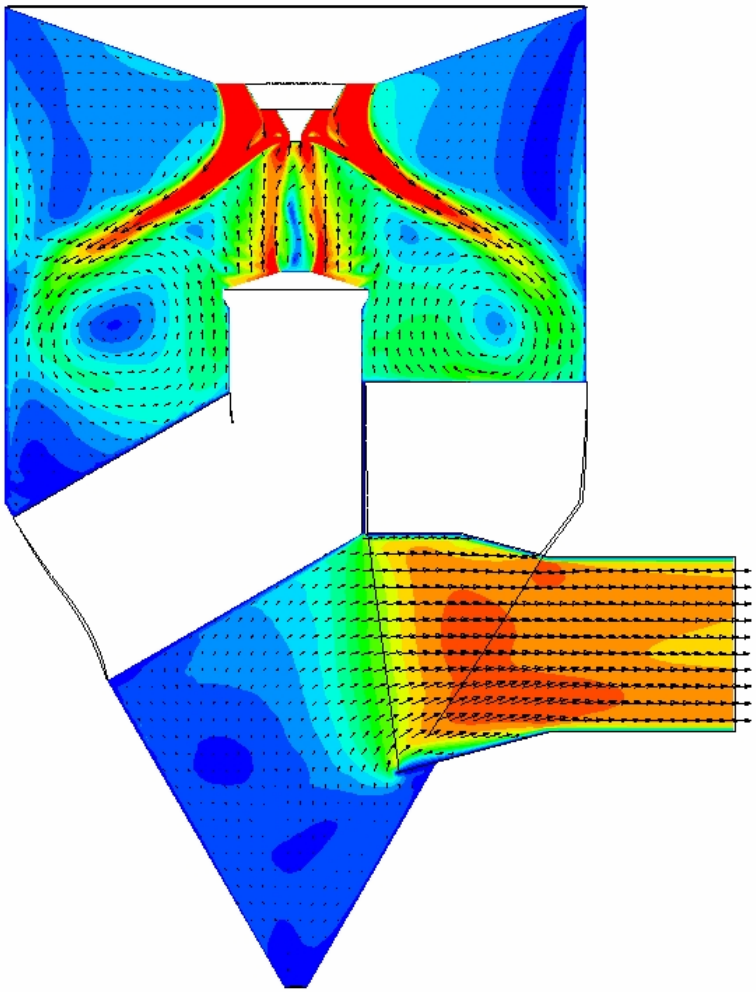


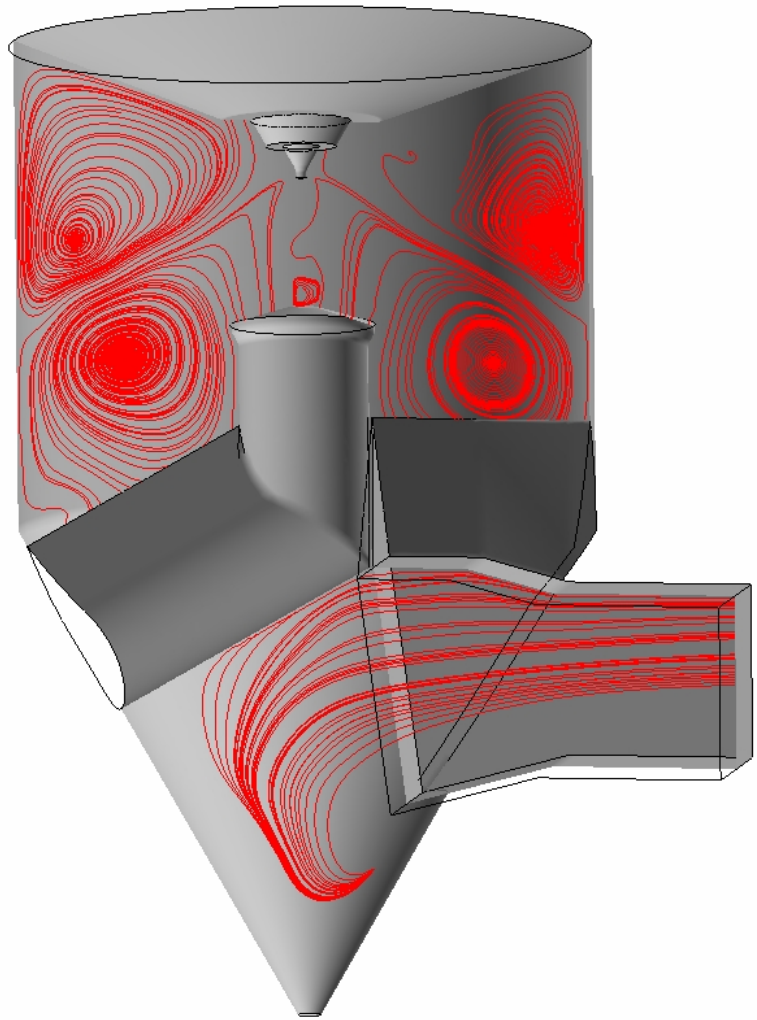
Large modules
Typical for Power Plants



Absorber diameter up to 20,3 m

CFD-modelling of Niro SDA size 20.000



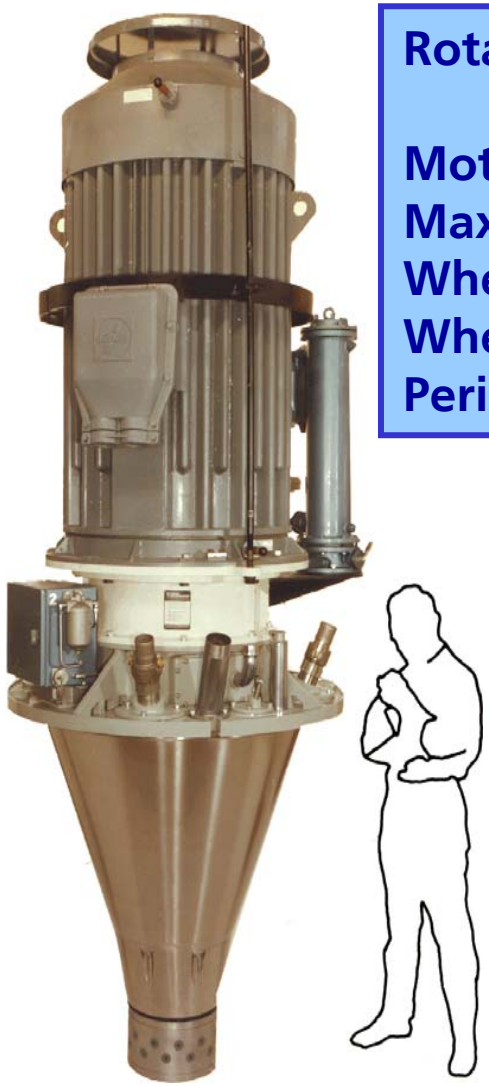


Main Components

Atomizer Design

Rotary Atomizer Type F-100

Motor max	75	kW
Max capacity	10	t/h
Wheel dia.	210	mm
Wheel rpm	13.500	
Periph. speed	148	m/s

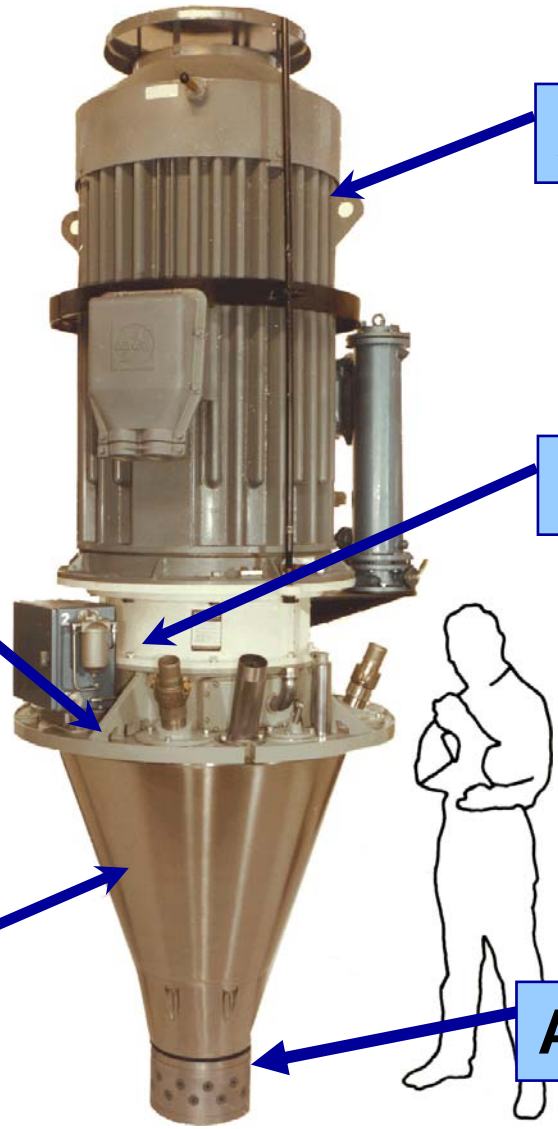


Rotary Atomizer Type F-800

Motor max	800	kW
Max capacity	91	t/h
Wheel dia.	350	mm
Wheel rpm	9.550	
Periph. speed	175	m/s

Main Components

Atomizer Design



Atomizer Motor

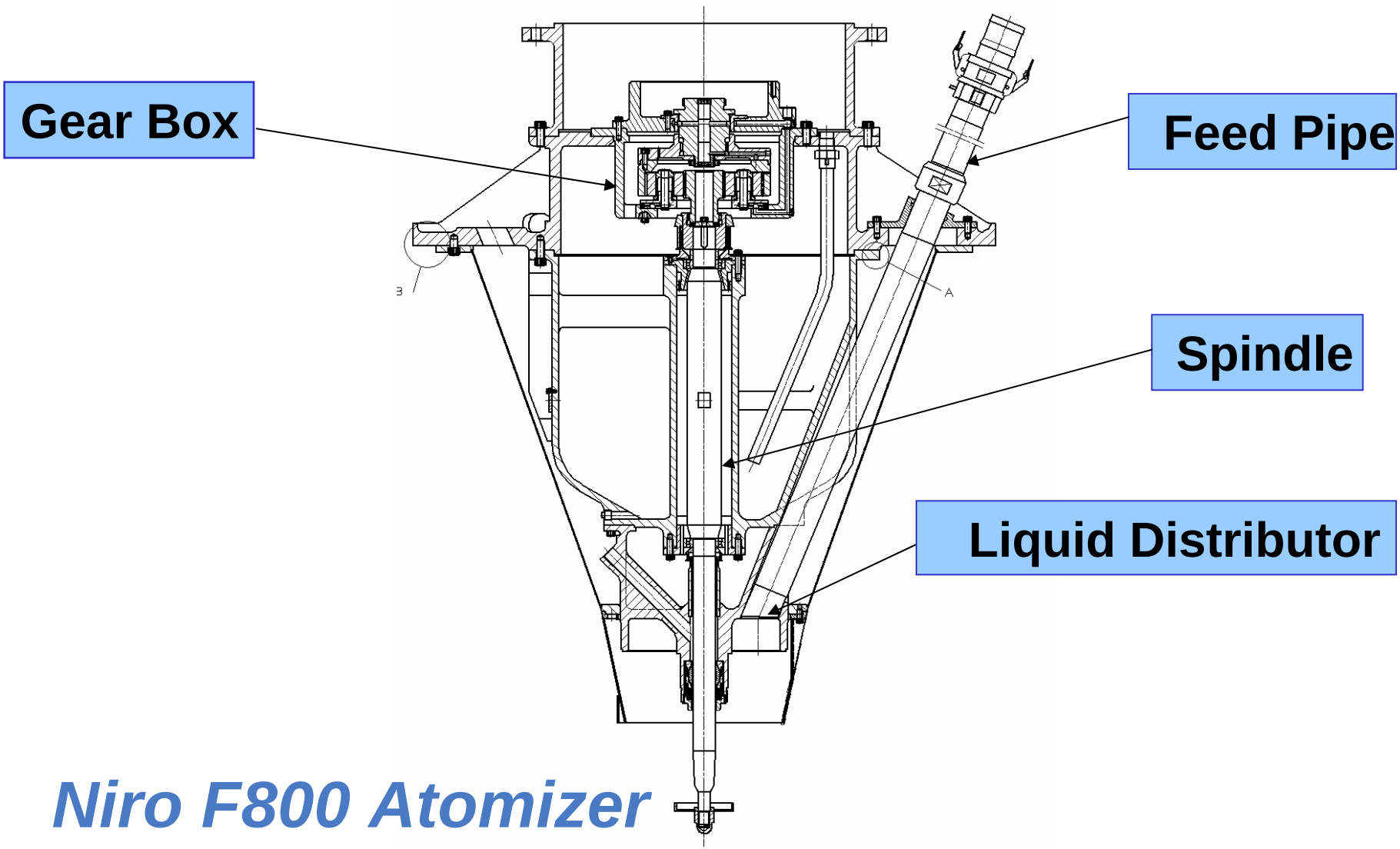
Atomizer Gearbox

Atomizer Baseplate

Atomizer Skirt

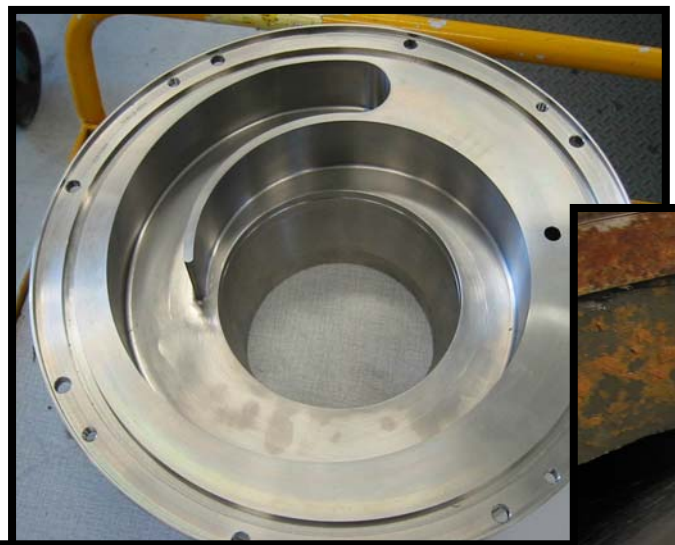
Atomizer Wheel

Main Components



Niro F800 Atomizer

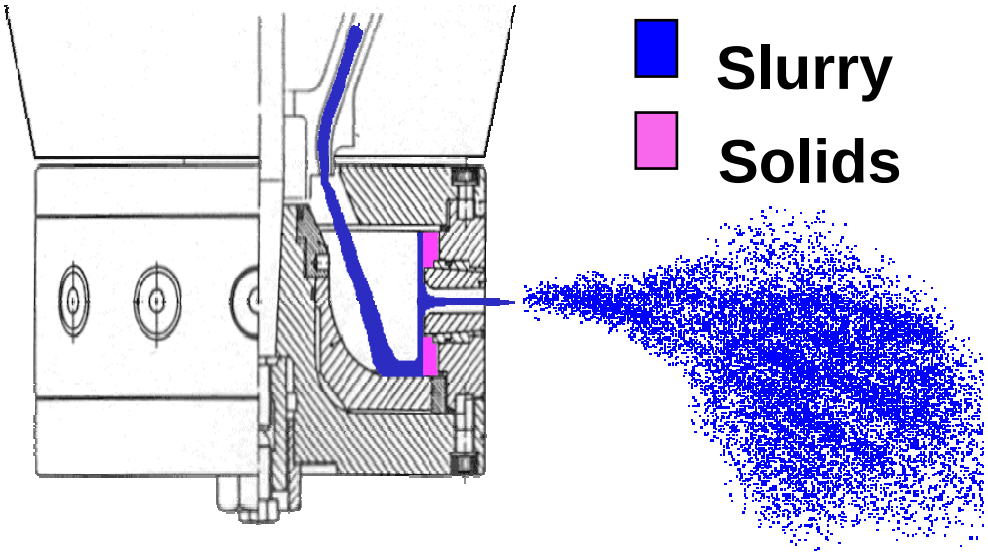
Niro Volute Liquid Distributor

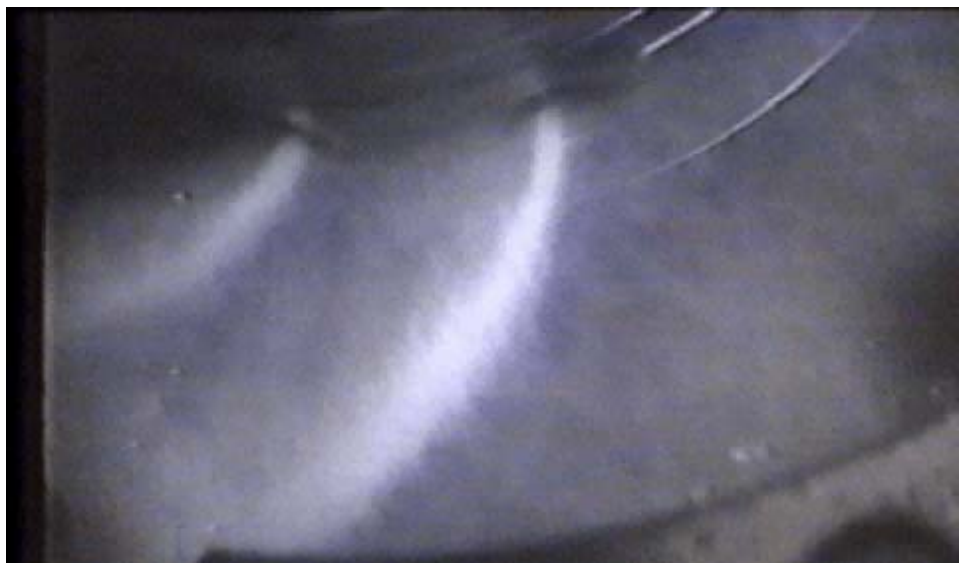


Even slurry flow to wheel prevents imbalance

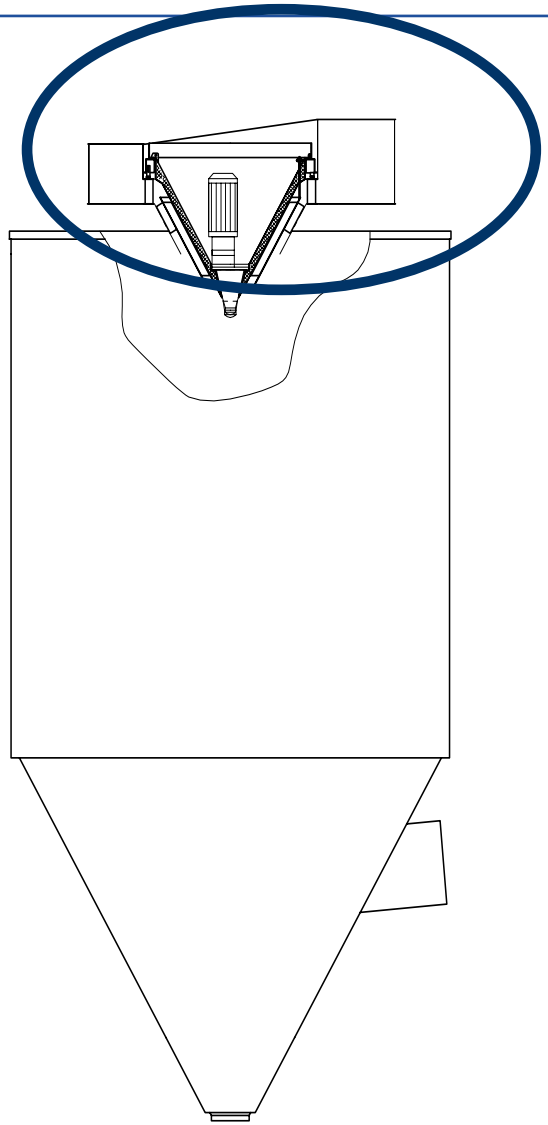
Main Components

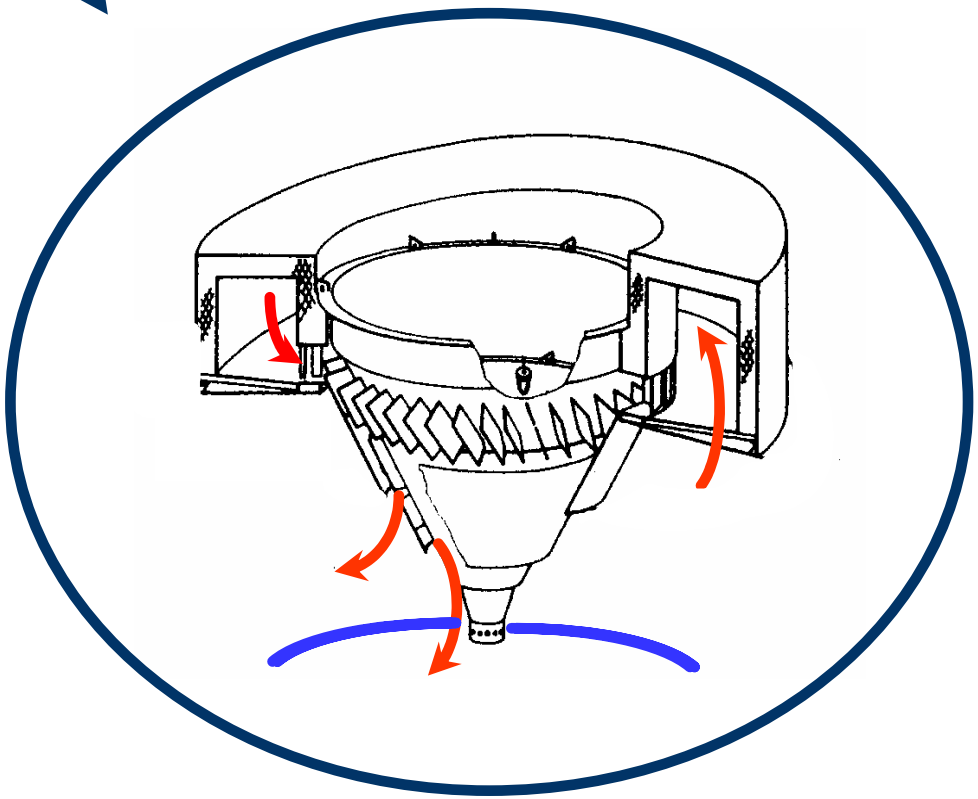
Atomizer Wheel





Main Components



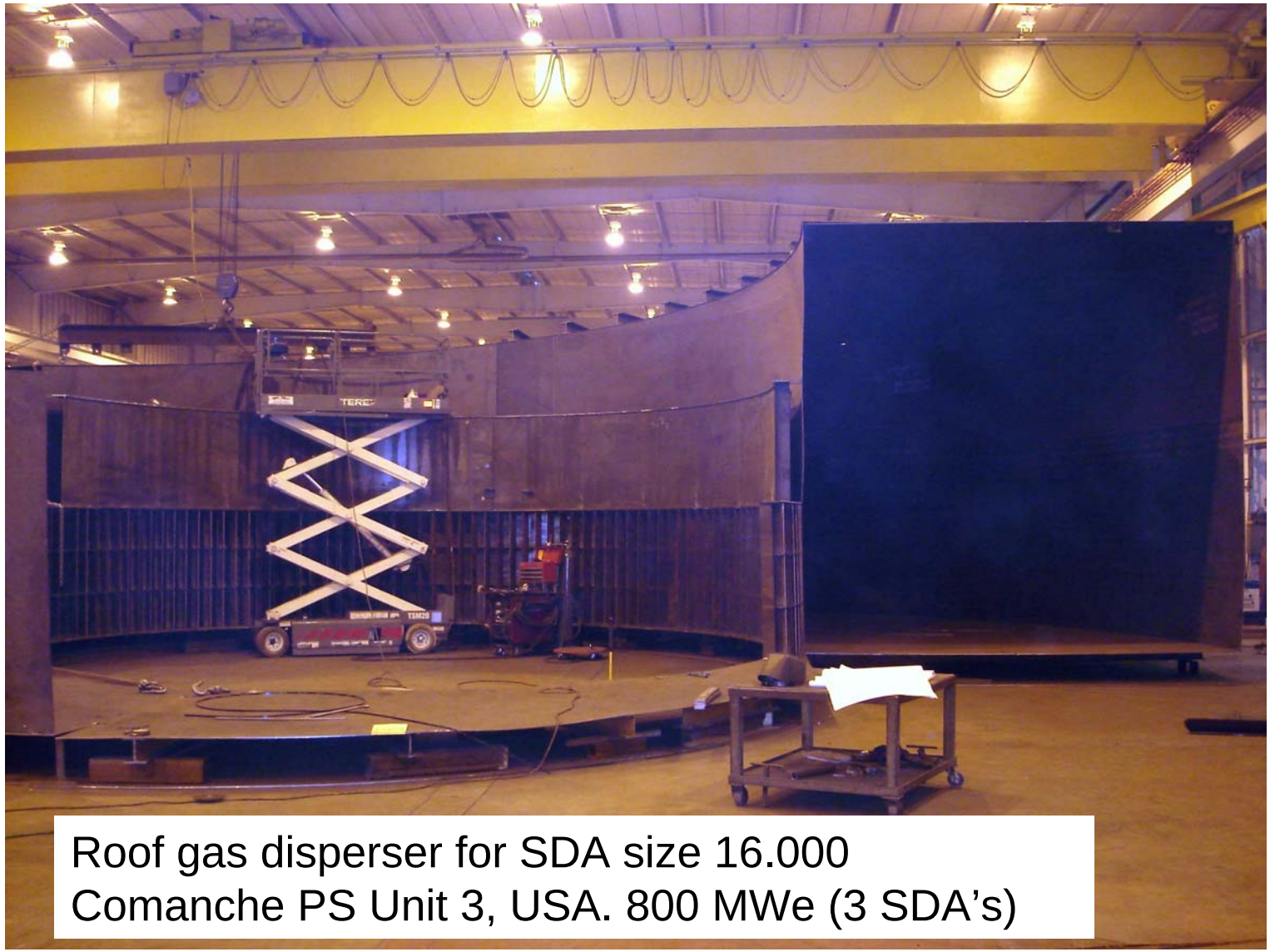


Roof Gas Disperser

Main Components

Roof Gas Disperser

Main Components



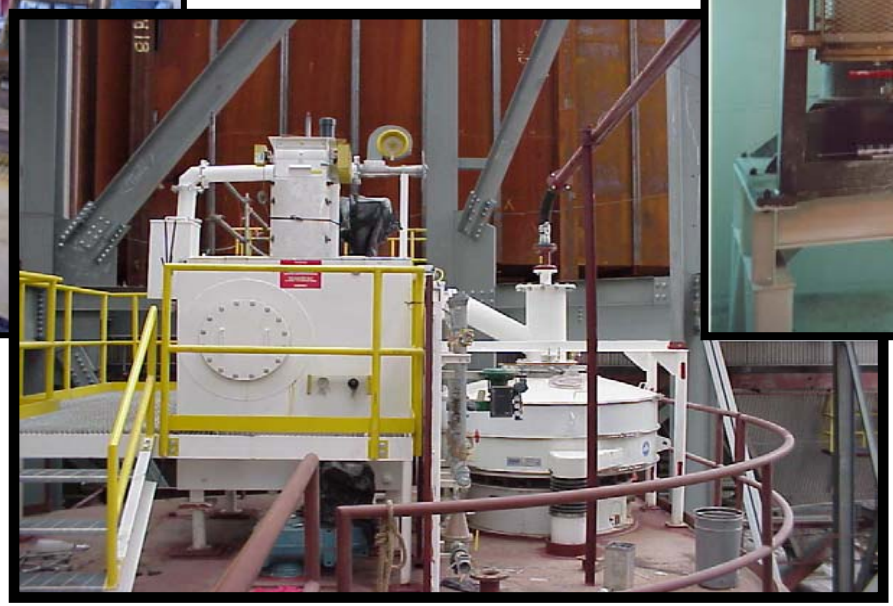
Roof gas disperser for SDA size 16.000
Comanche PS Unit 3, USA. 800 MWe (3 SDA's)

Main Components

Central Gas Disperser

Main Components

Lime Silo Bottom &
Paste Slaker



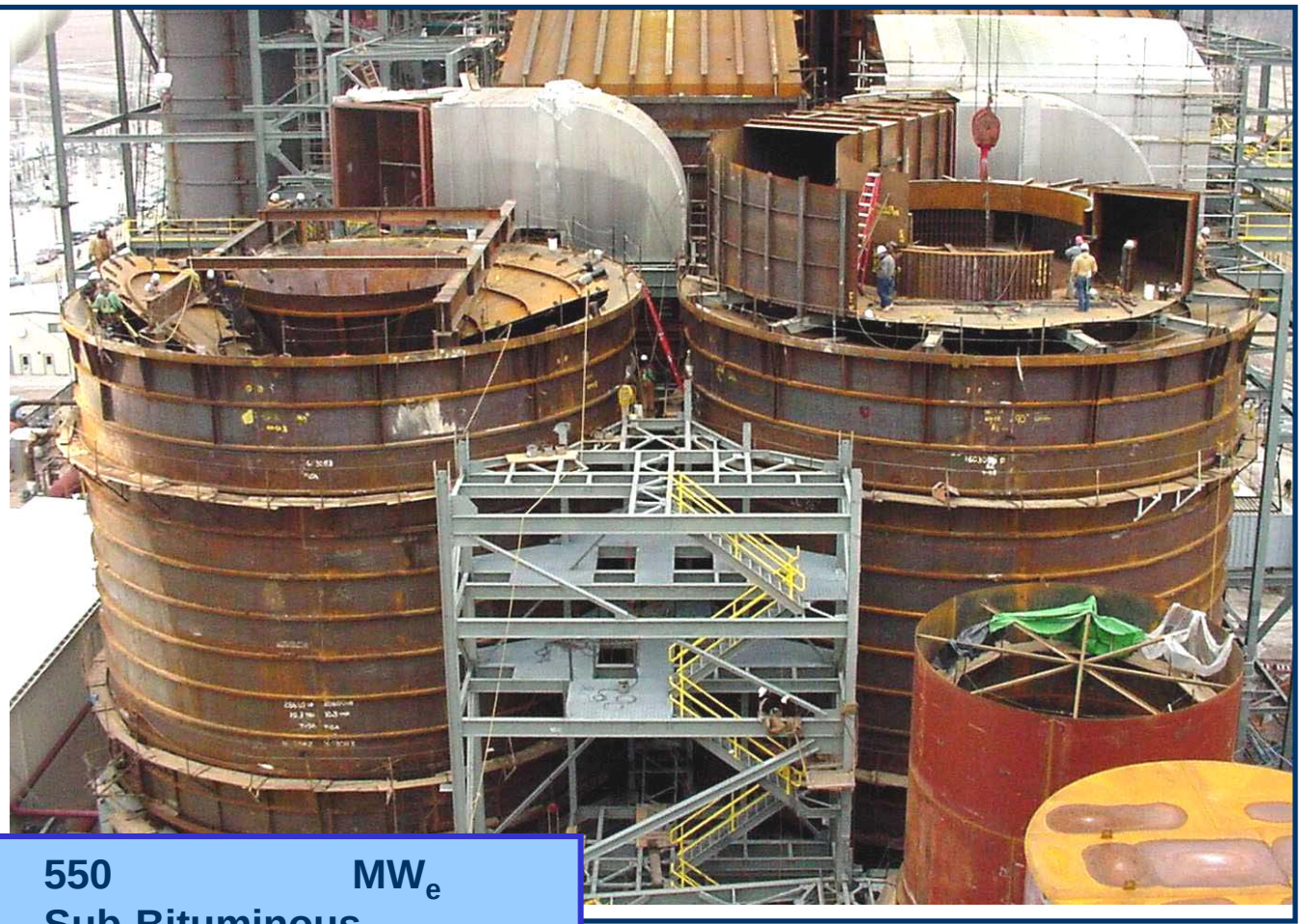
Detention
Slaker

Vertical Ball Mill

SDA Applications

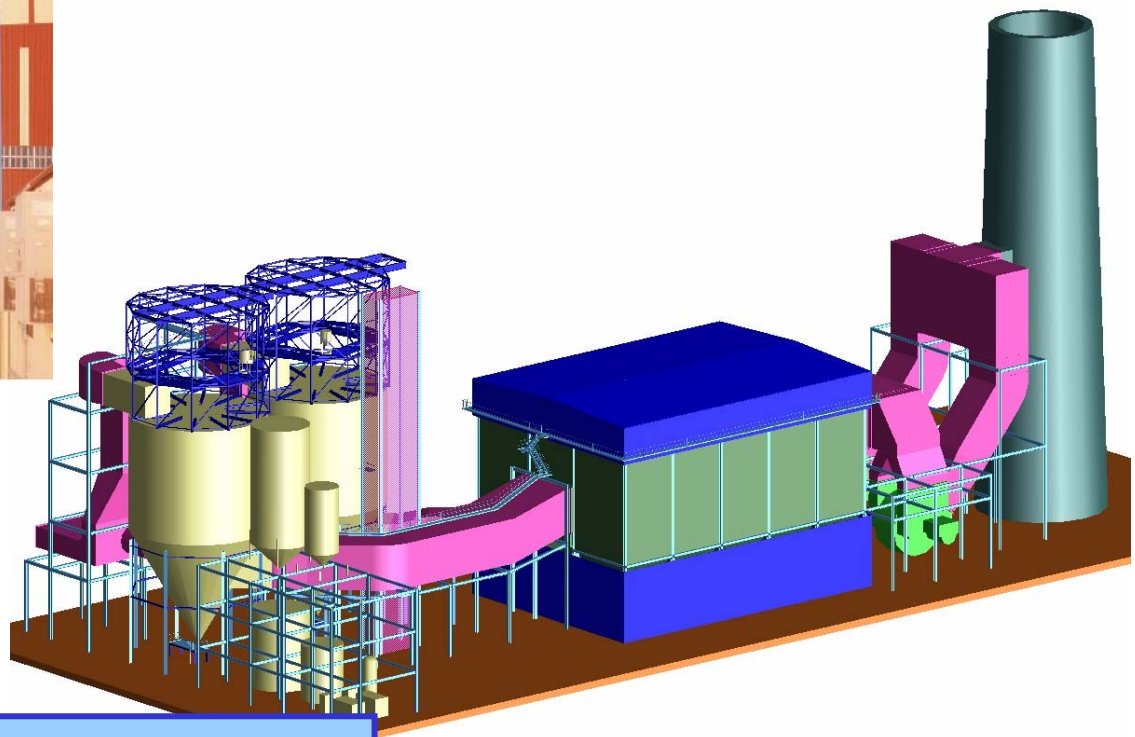
SDA Applications

Hawthorn Power Station, Unit 5, Kansas City, Missouri, USA



Boiler output	550	MW_e
Coal	Sub-Bituminous	
Sulfur content	0,2 - 0,7	%
Flue gas amount	1 x 2.150.000	Nm^3/h
Chamber Diam.	17.2	m
Dust collector	Pulse-jet	

Weston 4 – Wisconsin Public Service

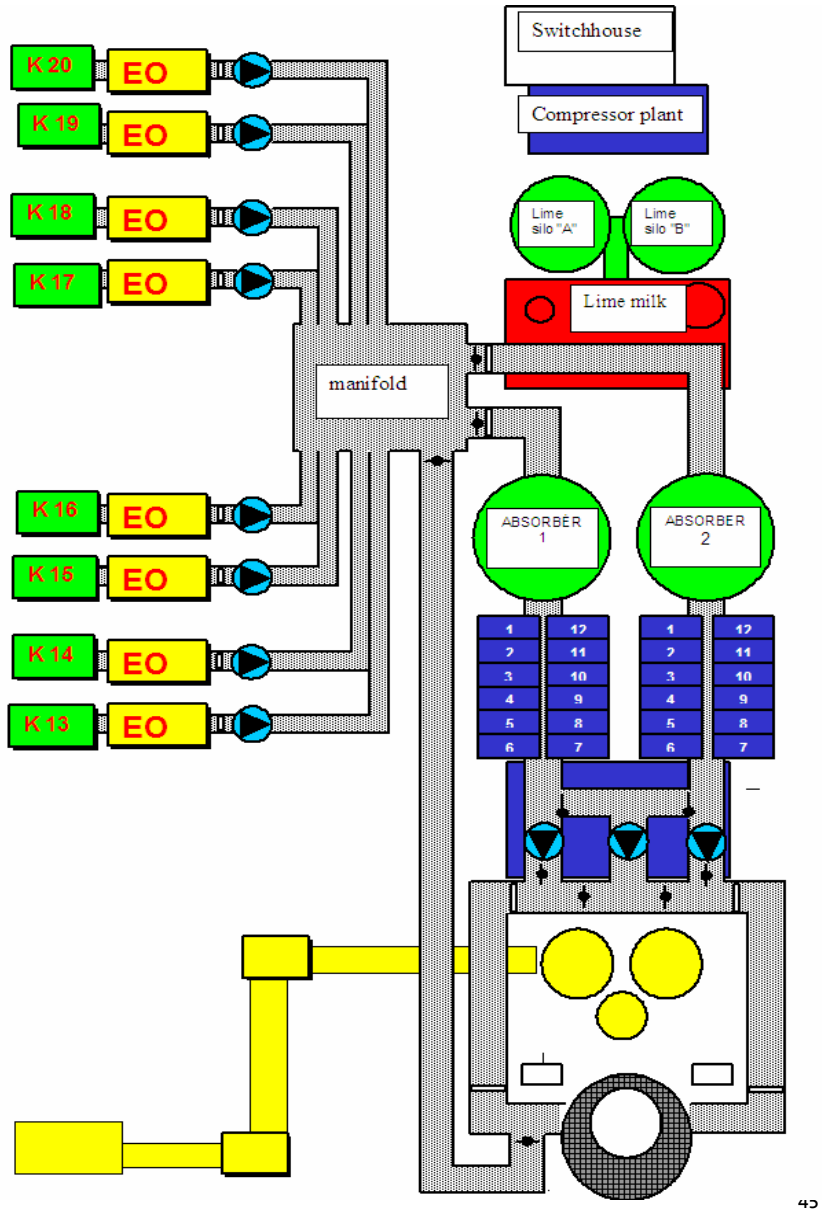


Boiler output	**500**	**MW_e**
Coal	**Sub-Bituminous**	
Sulfur content	**0,2 - 0,6**	**%**
Flue gas amount	**1 x 2.150.000**	**Nm^3/h**
Chamber Diam.	**17.2**	**m**
Dust collector	**Pulse-jet**	

SDA Applications

Layout,
Chemopetrol T700,
Czech Republic

440 MWe, total
8 parallel boilers
Precollection of fly ash
High turndown requirement
2 SDA's
2 Fabric filters
2 Booster fans +1 spare



SDA Applications

Kraftwerk Dürnrohr, Austria

Boiler output	390 + 335	MW_e
Coal	Mix	
Sulfur content	0,7-1	%
Fluegas amount	2 x1.100.000	Nm3/h
Chamber Diam.	13.2	m.
Dust collector	ESP	
Availability	>99	%

AVAILABILITY DATA

Installation			Year 1	Year 2
Studstrupvaerket MKS 3	Denmark	350 MWe	99.4	99.3
Studstrupvaerket MKS 4	Denmark	350 MWe	99.8	99.3
Duernrohr EVN	Austria	350 MWe	>99	100
Duernrohr VKG	Austria	410 MWe	>99	100
Salzburger Stadtwerke	Austria	112 MWt	99.3	>99
Mainkraftwerke	Germany	250 MWt	97.7	>97
Walheim	Germany	260 MWe	99.5	>99
Vaesteraas	Sweden	585 MWt	99.4	>99
Sherco, Unit 3	USA	900 MWe	100	>99
Rawhide, Unit 1	USA	275 MWe	100	>99
Holcomb Station, Unit 1	USA	280 MWe	98.7	98.2
Antelope Valley, Unit 1	USA	450 MWe	>99	>99
Antelope Valley, Unit 2	USA	450 MWe	>99	>99

Main features of spray drying absorption:

- High removal efficiency, SO_2, SO_3, HCl, HF etc.
- Low capital investment
- Entire flue gas path made of carbon steel
- No need for clean gas reheat
- Simple and robust system
- High availability
- Low water consumption
- Makes use of low quality process water
- No waste water production

Thank You !