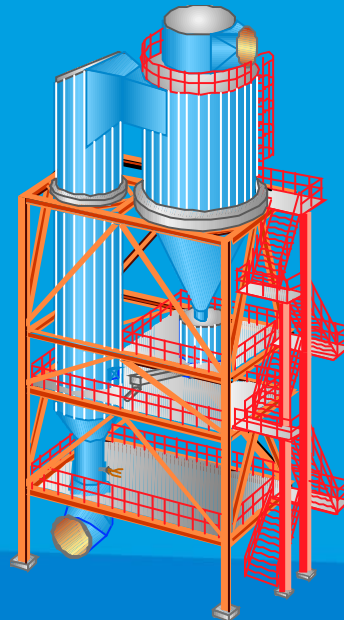
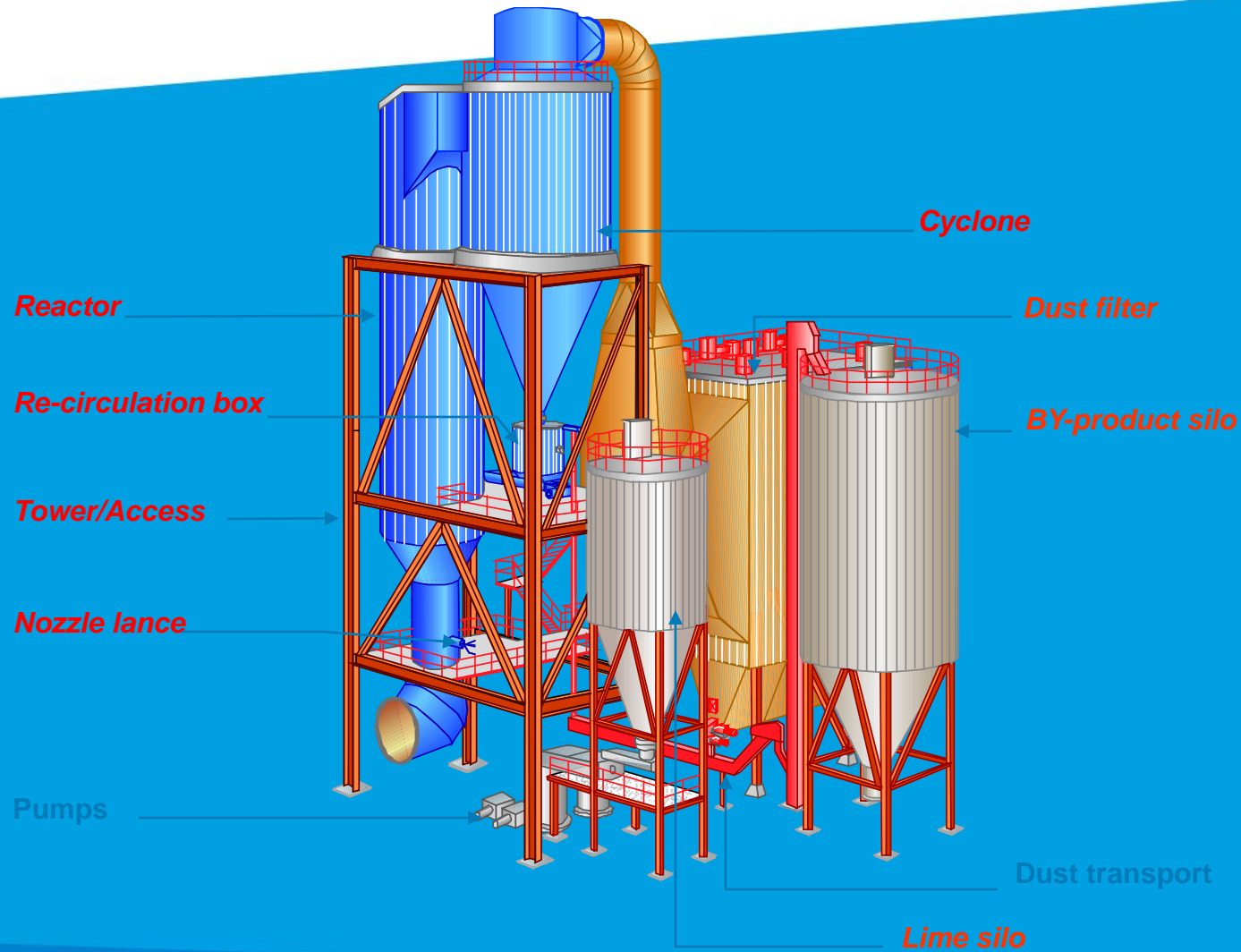


# Gas Suspension Absorber Technology for Multi-pollutant Control of Boiler Flue Gas Emissions



# Gas Suspension Absorber



## Gas Suspension Absorber Technology

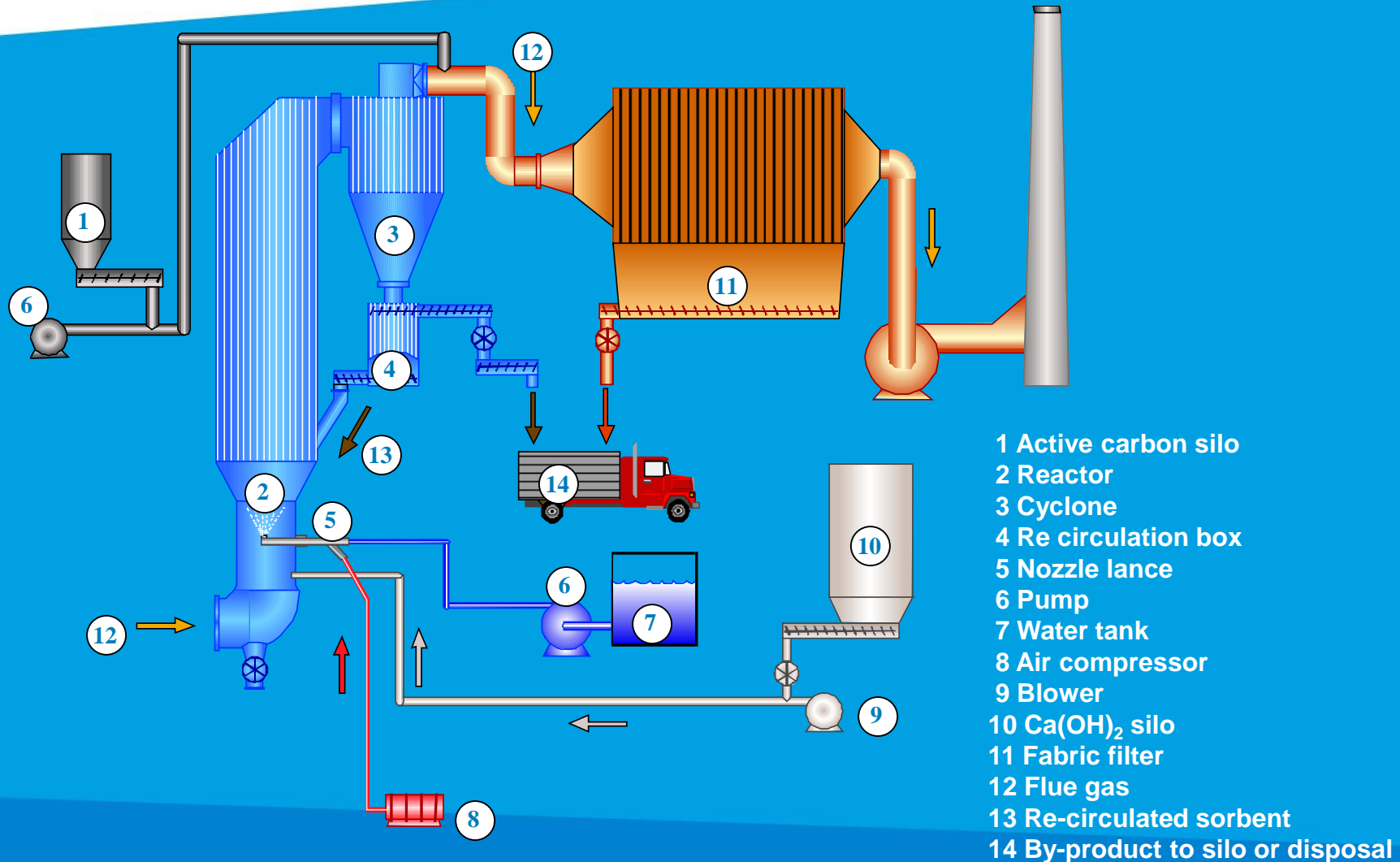
- A recirculating bed dry scrubber technology capable of efficient acid gas control
  - $\text{SO}_2$ , HCl, and  $\text{H}_2\text{SO}_4$ .
- Utilizes lime reagent either as dry hydrate or as lime slurry.
- Coupled with ESP or FF for control of PM and PM-10 emissions.
- Can incorporate ACI for control of Hg and dioxins/furans.
- Emissions of HCl, PM, Hg below MACT requirements.

# Unique Features of the GSA

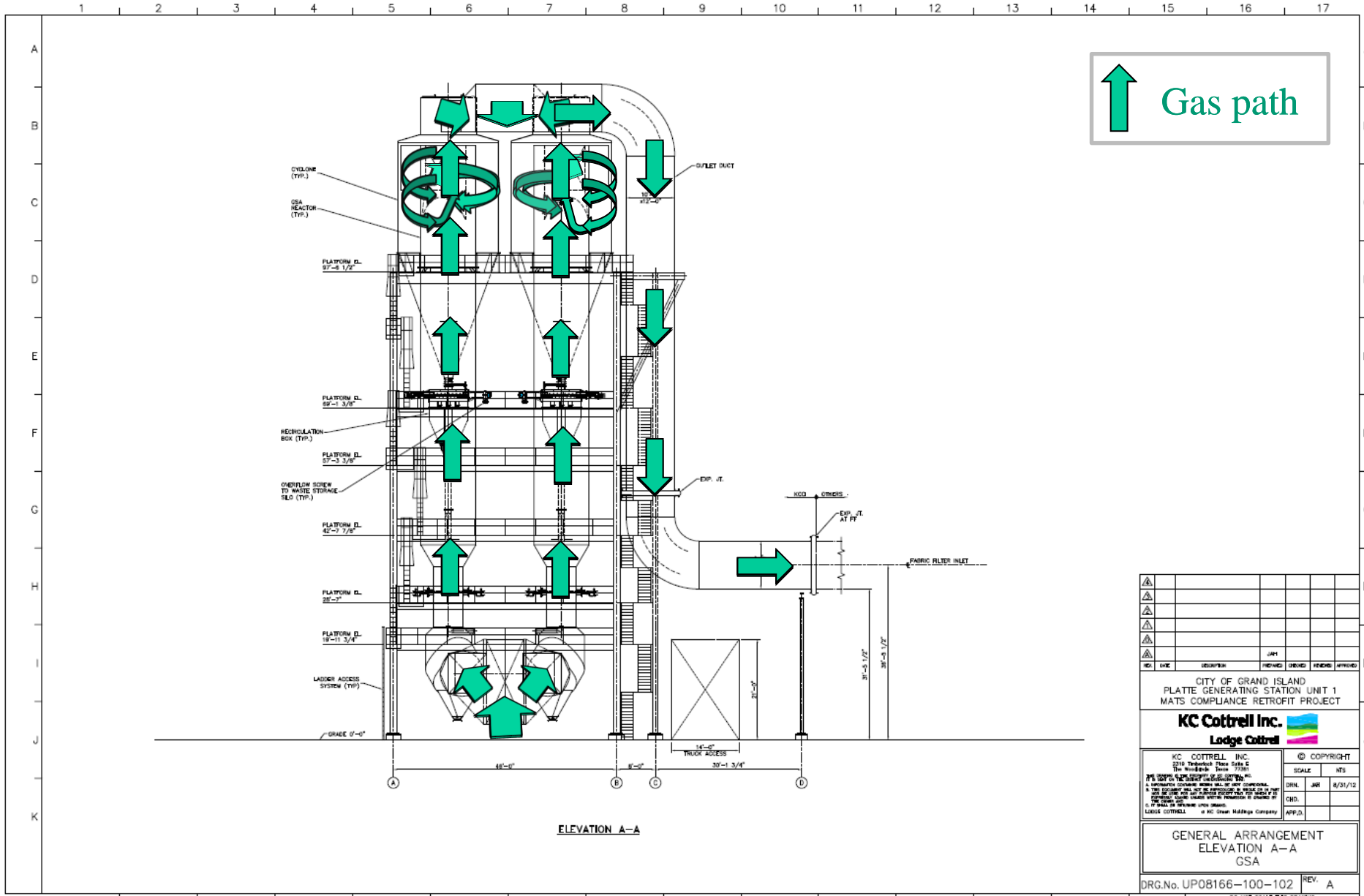
- Excellent for retrofitting existing plants
- Experience with various combustor types
- Cyclone captures majority of bed material
- Recirculation box returns captured material to bed
- Can utilize typical filter or ESP
  - Not elevated or oversized
- Slim footprint
- Modularized Approach
  - Pre-engineered sizes
- Can utilize either dry lime injection or lime slurry
  - Low consumption rates.

# Gas Suspension Absorber

With dry lime injection




# Elevation Drawing A- Gas Flow



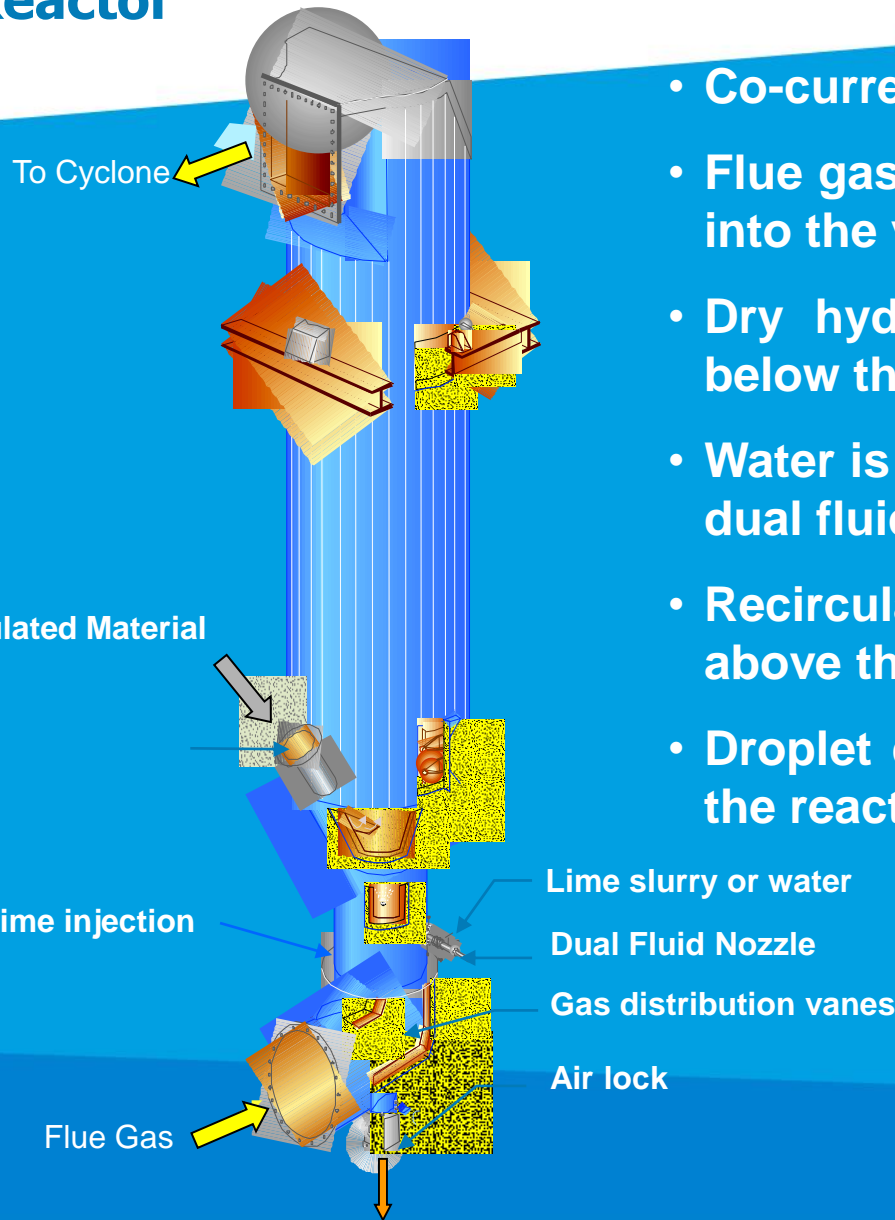
 Gas path

ELEVATION A-A

△					
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NO.	SIZE	DESIGNER	ISSUED	REVISED	APPROVED
CITY OF GRAND ISLAND PLATTE GENERATING STATION UNIT 1 MATS COMPLIANCE RETROFIT PROJECT					
<b>KC Cottrell Inc.</b> Lodge Cottrell					
KC COTTRELL, INC. 5218 Timberloch Stone Circle C The Woodlands, Texas 77380			© COPYRIGHT SCALE: NTS		
<small>                     ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED ARE IN INCHES.                      ALL DIMENSIONS SHALL BE TO FACE UNLESS OTHERWISE SPECIFIED.                      A TRUE COPY OF THIS DRAWING IS AVAILABLE TO THE PUBLIC FOR A FEE OF \$10.00 PER COPY AND A FEE OF \$20.00 PER HOUR OF REPRODUCTION COSTS.                      © 2012 KC COTTRELL, INC. ALL RIGHTS RESERVED.                 </small>			DRN. JAN 8/31/12	APP.D.	
GENERAL ARRANGEMENT ELEVATION A-A GSA					
DRG.No. UP08166-100-102					REV. A
<small>DO NOT SCALE THIS DRAWING</small>					

# Gas Suspension Absorber

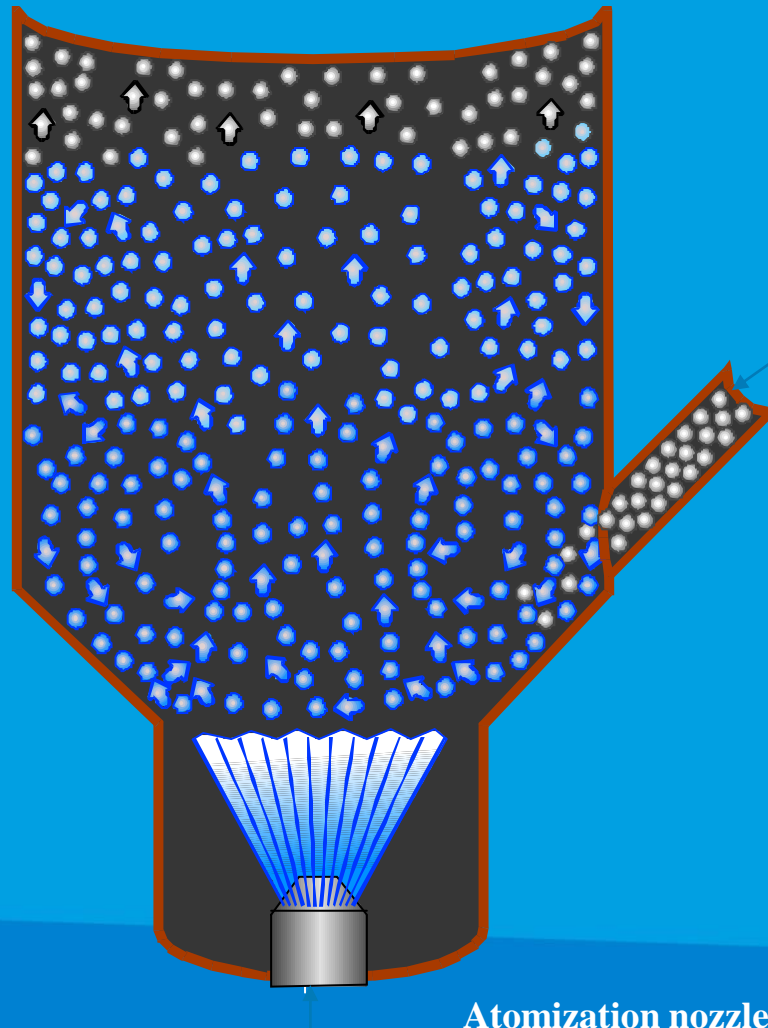
## Reactor



- Co-current upflow reactor
- Flue gas enters at the bottom and is turned up into the venturi stage.
- Dry hydrated lime is pneumatically injected below the venturi.
- Water is injected at the periphery of venturi via dual fluid nozzles.
- Recirculated material is returned to the reactor above the venturi.
- Droplet drying and acid gas removal occur in the reactor.

# Gas Suspension Absorber

## Mass transfer principle in the reactor



Recirculated material

**High particle density.**

**Venturi inlet generates high turbulence.**

**Conditioned sorbent across the full reactor cross section.**

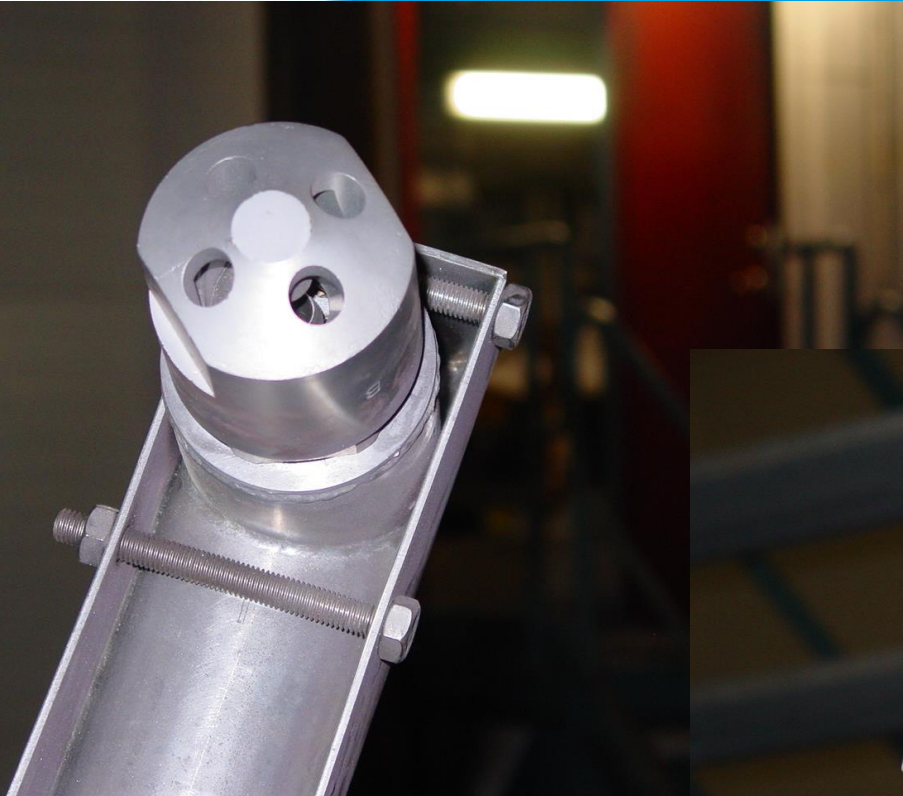
**Recirculated sorbent achieves a high apparent SR.**

Atomization nozzle



# Gas Suspension Absorber

## Dual Fluid Nozzles



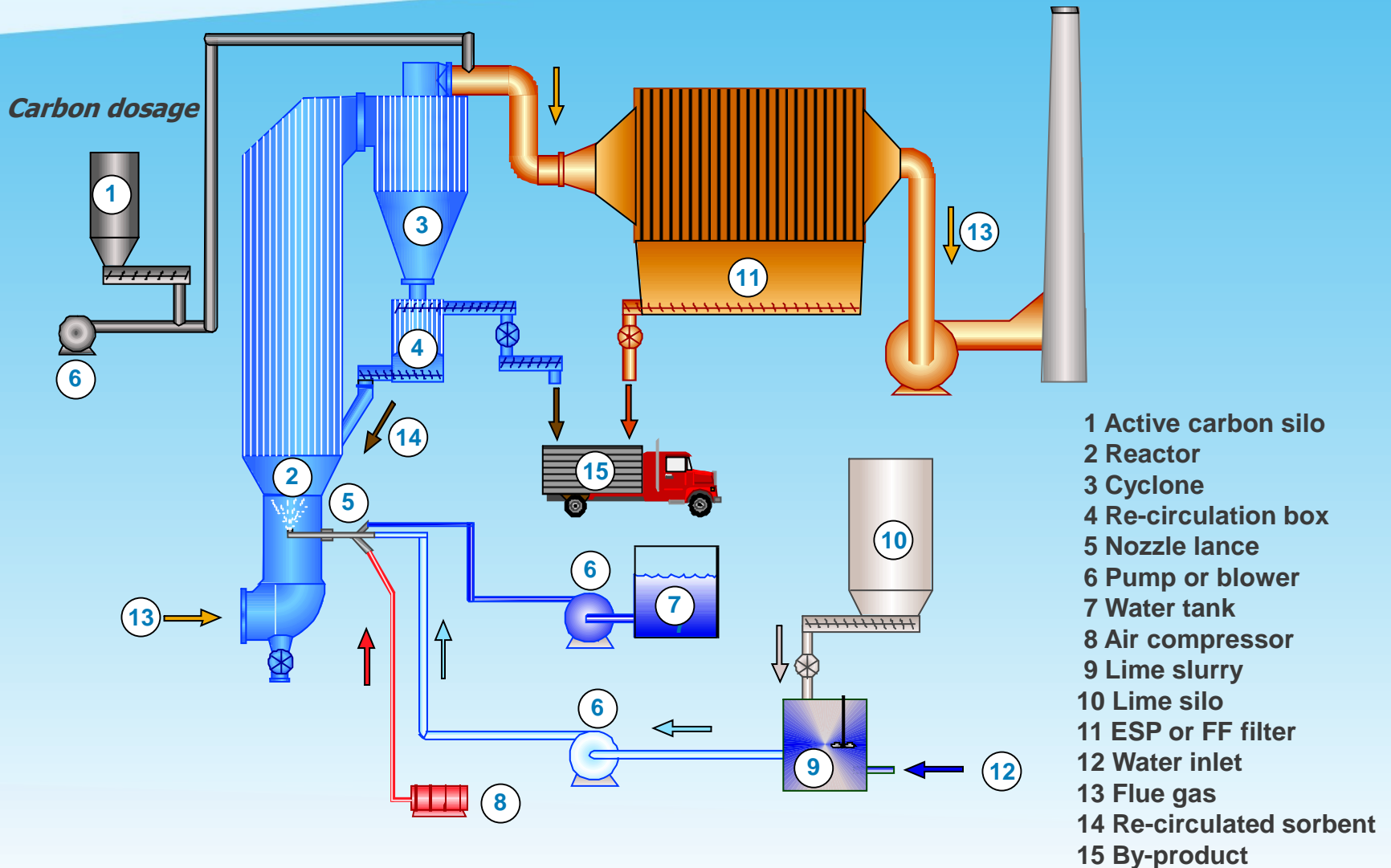
# GSA Nozzle

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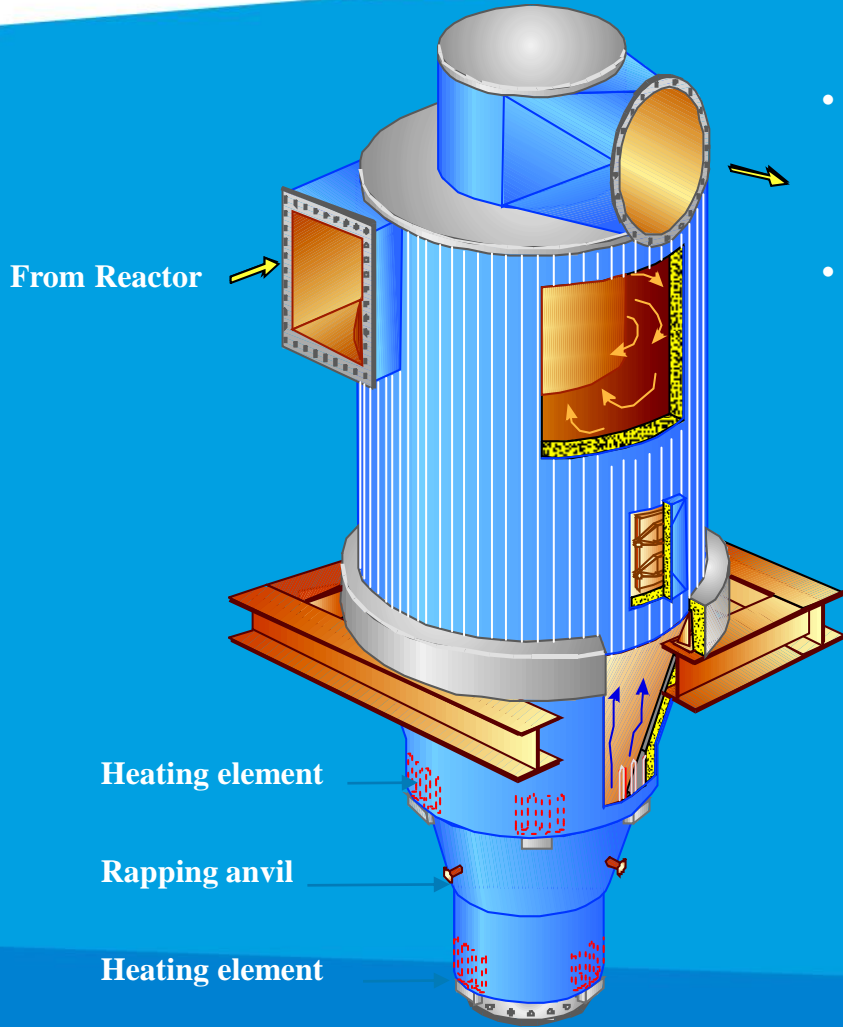
# Gas Suspension Absorber

Semi-dry system **With lime slurry injection**

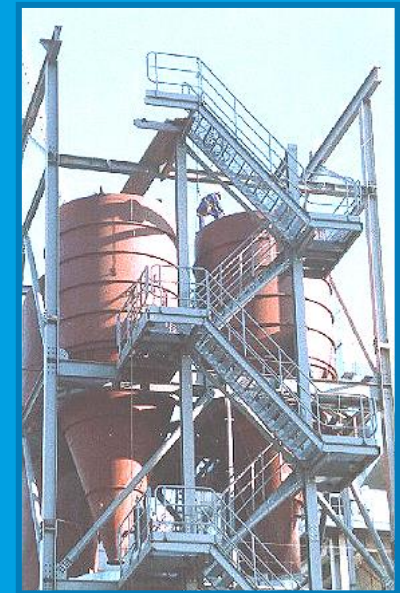
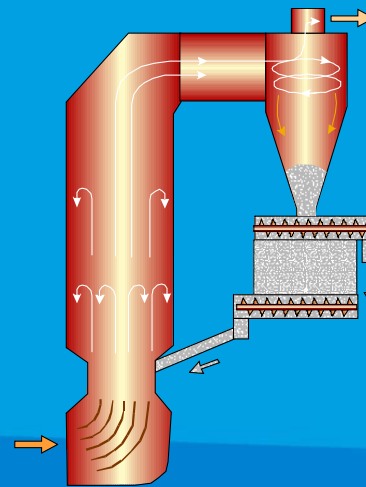


# Gas Suspension Absorber

## Cyclone



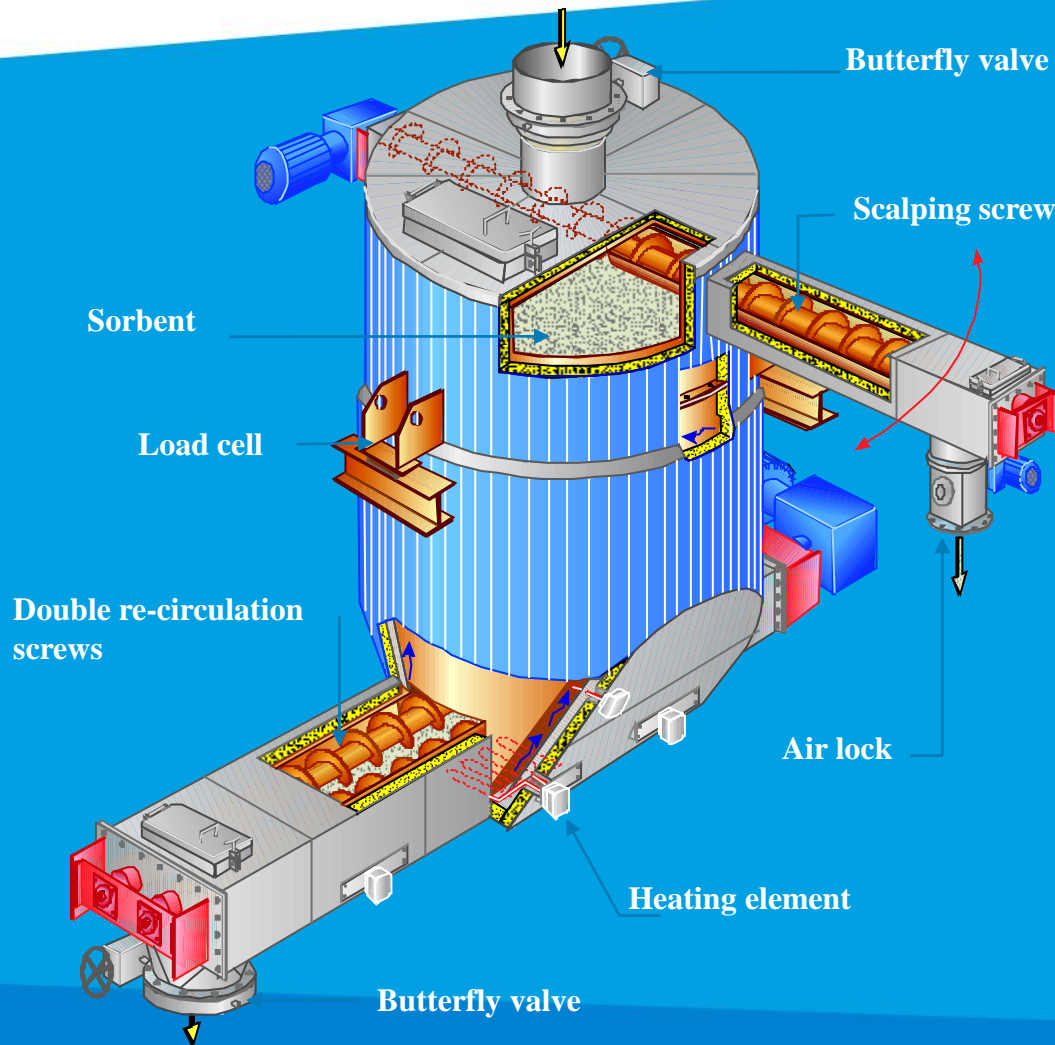
- Solid particles are transported out of the top of the reactor and into the cyclone(s).
- In the cyclone, the majority of the particles are separated from the flue gas and directly returned to the reactor via the re-circulation box(es).
- Up to 99% of the particles are captured; only the smaller lighter particles are transferred over to the filter.



Two parallel cyclones

# Gas Suspension Absorber

## Recirculation Box (1 per cyclone)



- The recirculation box returns material to the reactor via screw conveyors.
- A constant level is achieved by extracting by-product residue via the scalping screw.
- Material from the scalping conveyor is suitable for pneumatic transport.

# Gas Suspension Absorber

## Recirculation Box



Scalping Screw



Recirculation Screws



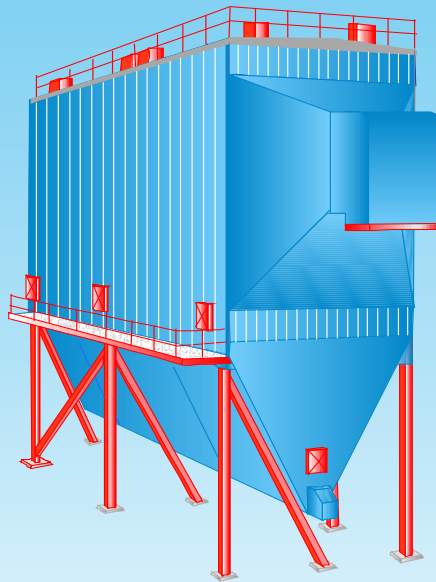
# Gas Suspension Absorber

## Particulate Collection

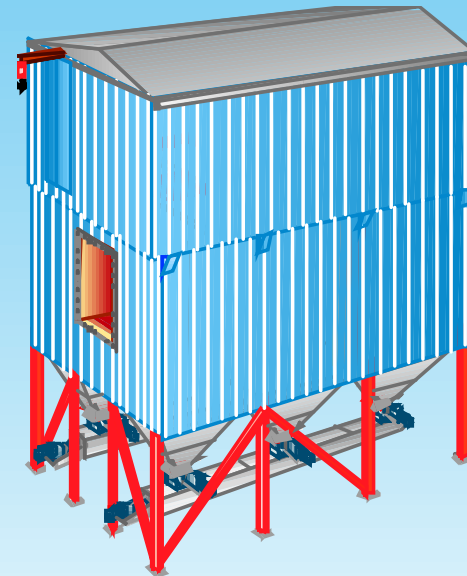
The flue gas containing residual solids enters the final particulate collector, which can be either a fabric filter or an electrostatic precipitator.

The collector chosen depends on the contents of the flue gas and the extent of acid gas cleaning required.

Fabric filters are best for high efficiencies because all of the gas must pass through the sorbent bearing dust.

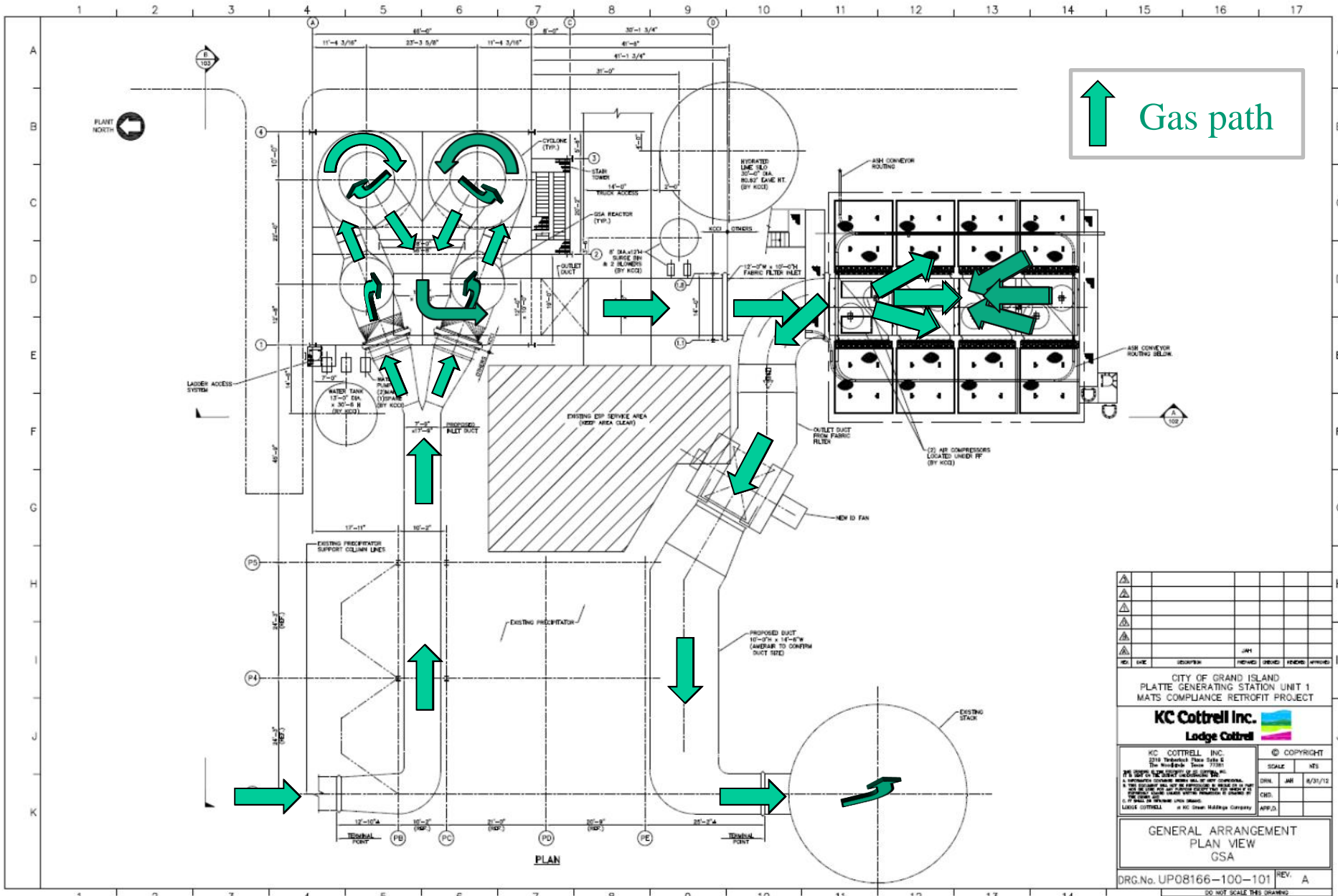


**Electrostatic Precipitator**



**Fabric Filter**

# Plot Plan – Gas Flow



 Gas path

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A																
B																
C																
D																
E																
F																
G																
H																
I																
J																
K																

CITY OF GRAND ISLAND  
PLATTE GENERATING STATION UNIT 1  
MATS COMPLIANCE RETROFIT PROJECT

**KC Cottrell Inc.**  
Lodge Cottrell 

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GENERAL ARRANGEMENT  
PLAN VIEW  
GSA

DRG.No. UP08166-100-101 REV. A  
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- Used extensively for power and incineration applications for more than 20 years
- Numerous installations in North America, Europe and Asia
- Five projects (nine industrial boilers) executed since KC licensed the technology in 2005

# Gas Suspension Absorber

## Installations



● Single GSA Location  
● Multiple GSA Location



### GSA Applications

- Power
  - Coal - 14
  - Oil - 1
- MSW - 20
- HazWaste - 10
- Metals - 2
- Biomass - 3

# KC Cottrell GSA Installations



	Nine Dragons China	Pt. Comfort Texas	Cheng Loong Taiwan	Petron 1&2 Philippines	Petron 3&4 Philippines
Fuel	Coal	Petcoke or PRB	Coal or Coal + Sludge	Coal or Petcoke	Coal or Petcoke
Flue Gas (per Boiler)	258,188 ACFM x 2	526,194 ACFM x 2	144,403 ACFM	185,545 ACFM x 2	185,545 ACFM x 2
Arrangement	2 Boilers 2 GSA	2 Boilers 4 GSA	1 Boiler 1 GSA	2 Boilers 2 GSA	2 Boilers 2 GSA
Operational	2008	2011	2012	2013	2015
Inlet / Outlet SO <sub>2</sub>	4,000 / 800 ppm	250 / 75 ppm 45 / 34 ppm	630 / 40 ppm	250 /90 ppm	250 /90 ppm
Reactor Dimensions	16.6 ft Dia 69 ft Height	14.3 ft Dia 91 ft Height	11.4 ft Dia 51.5 ft Height	11.75 ft Dia 62 ft Height	11.75 ft Dia 62 ft Height

# Gas Suspension Absorber

Nine Dragons, China

KC Cottrell



# Gas Suspension Absorber

Point Comfort, TX

KC Cottrell



# Gas Suspension Absorber

Cheng Loong, Taiwan

KC Cottrell



# GSA Under Construction

## Petron Refinery, Philippines

KC Cottrell 



# The Point Comfort Project

- Two New CFB Boilers (1.1 MM lb/hr each) designed to fire PRB and Pet Coke.
  - Fuel sulfur content up to 6%
- Equipped with Gas Suspension Absorbers and Fabric Filters for emissions control
  - SO<sub>2</sub>, Acid gases, PM, Hg
- Purchase Order placed in 2007
- Equipment delivered in 2008
- Startup in 2011



# Gas Suspension Absorbers

Point Comfort, TX

- Two Pet coke / PRB Fired Boilers (143 MWe each)
- Two trains per boiler: each with GSA/PJFF
- Inlet Gas Flow (per GSA): 300,000 ACFM @ 295F
- Outlet SO<sub>2</sub> = 0.19 lb/MMBtu (pet coke);  
0.08 lb/MMBtu (PRB)
- Outlet PM = 44 mg/Nm<sup>3</sup> (0.03 lb/MMBtu)
- Removal Efficiencies:
  - HCl = 95%, HF = 95%, SAM = 92%, Hg (90+%)

# Gas Suspension Absorbers

Point Comfort, TX

- GSA Reactors: 14' dia. x 91' ht.
- Dry hydrated lime injection for Acid gas control (SO<sub>2</sub>, HCl, H<sub>2</sub>SO<sub>4</sub>.)
- Water injection for temperature control & humidification
  - Three atomizing nozzles per reactor
- PAC injection for Hg control
- PJFF: 8 compartments, 285 bags
  - Bags: 6" dia. x 22' long, PPS

- Hydrated lime
  - One silo per boiler (14.5' diameter x 30 ft. each)
  - Equipped with bin activator and table feeder
  - Pneumatically transported & injected into GSA
  - Particle size: 95% thru 325 mesh
- Water
  - Plant water quality for cooling
  - One cylindrical tank per boiler
  - Redundant supply pumps

# Mercury Reduction System

- Sorbent Injection upstream of PJFF
- Current sorbent = Brominated PAC
- One system per boiler
- Storage silo (7.5' dia. x 16' ht. each)
- Sorbent pneumatically conveyed to ductwork

# Gas Suspension Absorber

Reference Project : Point Comfort, TX



Dry Scrubber, Baghouse

# Gas Suspension Absorber

Point Comfort, TX

KC Cottrell





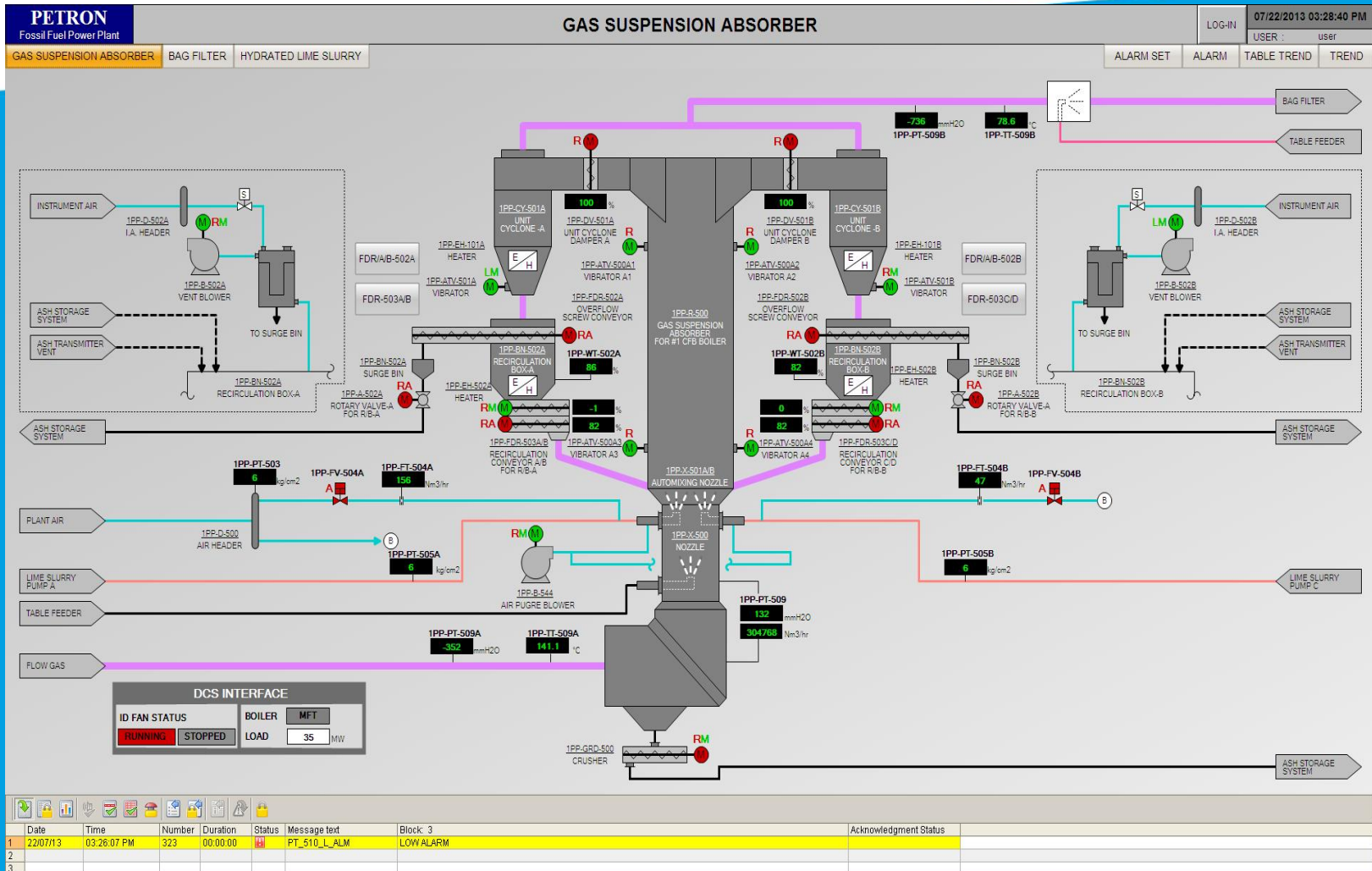
- Both boilers are at full load
  - Fire pet coke (6% S), natural gas
- GSA systems are on-line and controlling emissions.
  - Outlet SO<sub>2</sub> emissions < 10 ppm @ 100% pet coke firing
  - HCl emissions < 0.022 lb/MMBtu
  - PM emissions < 0.03 lb/MMBtu
  - Hg emissions < 1 lb/Tbtu

# Chengloong Test Results

- Unit in operation for 1 year
- SCR + GSA + FF
- GSA = 11.5' dia. x 52' height
- SO<sub>2</sub> removal tested at 95-97 %
  - Design guarantee = 93%
- No difference between using dry lime injection vs. lime slurry



# GSA - Sample Control Screen



# Benefits of the GSA Dry Scrubber

---

- Economical
- Low outlet emissions of HCl, SO<sub>2</sub>, PM, Hg
- Low reagent usage
- Ability to use existing collector (ESP, FF)
- Minimal plan area requirement
- Modular configuration
- Shorter erection period
- No internal moving parts

# Benefits of Working with KC Cottrell



- Broad Experience
- EP or EPC offerings
- Global resources
- Over 4500 reference installations
- Manufacturing Capability
- Comprehensive clean air solutions for
  - Particulate control (PM, PM-10, PM-2.5)
  - Acid Gas Control (SO<sub>2</sub>, SO<sub>3</sub>, HCl, HF)

Thank you!

Questions?

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908-304-2004

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