Gas Suspension Absorber Technology for Multi-pollutant Control of Boiler Flue Gas Emissions
• A recirculating bed dry scrubber technology capable of efficient acid gas control
  – \( \text{SO}_2 \), HCl, and H2SO4.
• 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

1. Active carbon silo
2. Reactor
3. Cyclone
4. Re circulation box
5. Nozzle lance
6. Pump
7. Water tank
8. Air compressor
9. Blower
10. Ca(OH)₂ silo
11. Fabric filter
12. Flue gas
13. Re-circulated sorbent
14. By-product to silo or disposal
Elevation Drawing A - Gas Flow

Gas path
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

- **High particle density.**
- **Venturi inlet generates high turbulence.**
- **Conditioned sorbent across the full reactor cross section.**
- **Recirculated sorbent achieves a high apparent SR.**

[Diagram of Gas Suspension Absorber]
Gas Suspension Absorber
Dual Fluid Nozzles
Gas Suspension Absorber
Semi-dry system With lime slurry injection

1 Active carbon silo
2 Reactor
3 Cyclone
4 Re-circulation box
5 Nozzle lance
6 Pump or blower
7 Water tank
8 Air compressor
9 Lime slurry
10 Lime silo
11 ESP or FF filter
12 Water inlet
13 Flue gas
14 Re-circulated sorbent
15 By-product

Carbon dosage
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.
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
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.
Plot Plan – Gas Flow
• 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

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

EUROPE – 28
ASIA – 15
N. AMERICA - 7
<table>
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<th>KC Cottrell GSA Installations</th>
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<tr>
<td><strong>Fuel</strong></td>
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<tr>
<td>Nine Dragons China</td>
</tr>
<tr>
<td>Coal</td>
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<tr>
<td>Petcoke or PRB</td>
</tr>
<tr>
<td>Coal or Coal + Sludge</td>
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<tr>
<td>Coal or Petcoke</td>
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<tr>
<td>Coal or Petcoke</td>
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- **Dimensions**: 16.6 ft Dia 69 ft Height
- **Dimensions**: 14.3 ft Dia 91 ft Height
- **Dimensions**: 11.4 ft Dia 51.5 ft Height
- **Dimensions**: 11.75 ft Dia 62 ft Height
- **Dimensions**: 11.75 ft Dia 62 ft Height

*Note: ACFM stands for cubic feet per minute.*
Gas Suspension Absorber
Nine Dragons, China
Gas Suspension Absorber
Point Comfort, TX
GSA Under Construction
Petron Refinery, Philippines
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
- SO2, 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 SO2 = 0.19 lb/MMBtu (pet coke);
  0.08 lb/MMBtu (PRB)
- Outlet PM = 44 mg/Nm3 (0.03 lb/MMBtu)
- Removal Efficiencies:
  - HCl = 95%, HF = 95%, SAM = 92%, Hg (90+%)
• GSA Reactors: 14’ dia. x 91’ ht.
• Dry hydrated lime injection for Acid gas control (SO\(_2\), HCl, H\(_2\)SO\(_4\).)
• 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
Both boilers are at full load
  – Fire pet coke (6% S), natural gas

GSA systems are on-line and controlling emissions.
  – Outlet SO$_2$ 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
• SO2 removal tested at 95-97 %
  – Design guarantee = 93%
• No difference between using dry lime injection vs. lime slurry
Benefits of the GSA Dry Scrubber

- Economical
- Low outlet emissions of HCl, SO2, 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 (SO₂, SO₃, HCl, HF)
Thank you!

Questions?

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