REINHOLD ENVIRONMENTAL Ltd.

# 2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

# FGD Dry Scrubbers 101

## 2018 Reinhold APC & Waste Water Conference
## July 24, 2018, Lexington, KY

# Introduction

# Speakers

**Jurgen Dopatka, PE**
Customer Applications Engineering,
GE Power
US

# DFGD Overview

# DFGD Overview

- Over 25,000 MW operating on US coal-fired utility boilers
- First units commissioned in late 1970s
- Technology options:
  - SDA (Spray Dryer)
  - NID / CDS (Circulating Dryer)
- High efficiency capture of sulfur dioxide ($SO_2$), sulfur trioxide ($SO_3$), HAPS, and particulate
- Traditionally employed on low sulfur western coals
- New designs expanding applicability to high sulfur coals

# SDA Technology

# SDA Experience

- About 20,000 MW operating on US coal-fired utility boilers
- Technology options:
  - Rotary atomizers
  - Dual-fluid nozzles
- Rotary atomizers predominant in US power industry

Rotary Atomizer SDA

Dual-Fluid Nozzle SDA

# SDA Fundamentals

**Key Process Steps**

- Atomize slurry droplets
- Absorb acid gases
- Dry particles
- Collect byproduct
- Recycle byproduct

**Slaking Reaction**

- $CaO + H_2O \rightarrow Ca(OH)_2 + HEAT$

**Absorption / Drying Reactions**

- $SO_{2(g)} + Ca(OH)_2 \rightarrow CaSO_3 \bullet ½\ H_2O(s) + ½\ H_2O(g)$

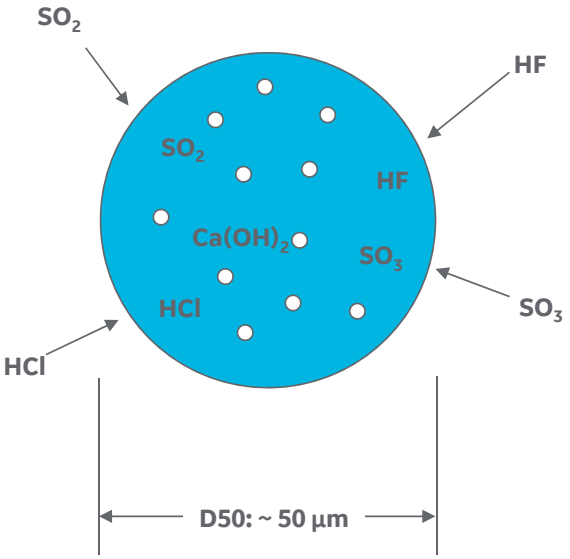
  $CaSO_3 \bullet ½\ H_2O(s) + ½\ O_2 + 1.5\ H_2O(g) \rightarrow CaSO_4 \bullet 2\ H_2O\ (s)$
- $SO_3(g) + Ca(OH)2 + H_2O \rightarrow CaSO_4 \bullet 2\ H_2O(s)$
- $2\ HCl(g) + Ca(OH)2 \rightarrow CaCl_2 \bullet 2\ H_2O(s)$
- $2\ HF(g) + Ca(OH)2 \rightarrow CaF_2 + 2\ H_2O(s)$

# SDA Fundamentals

# Atomization

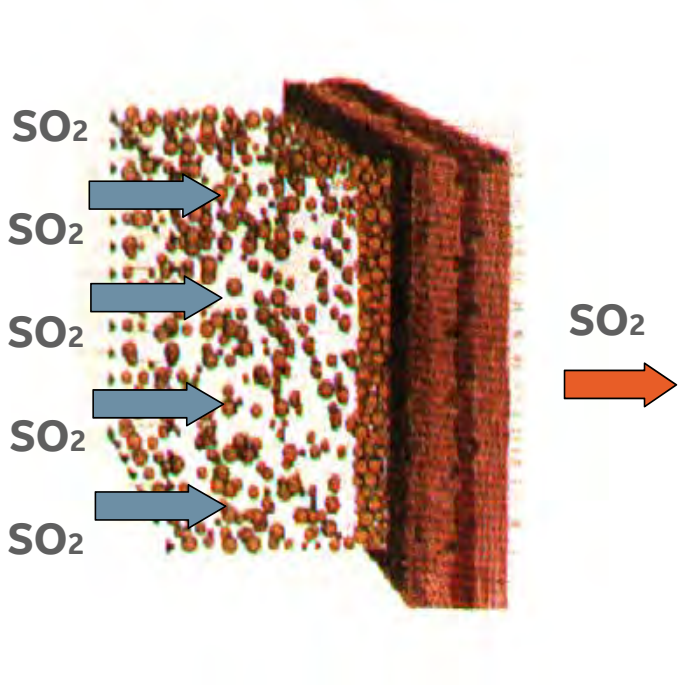
Rotary Atomizer

Dual-Fluid Nozzle

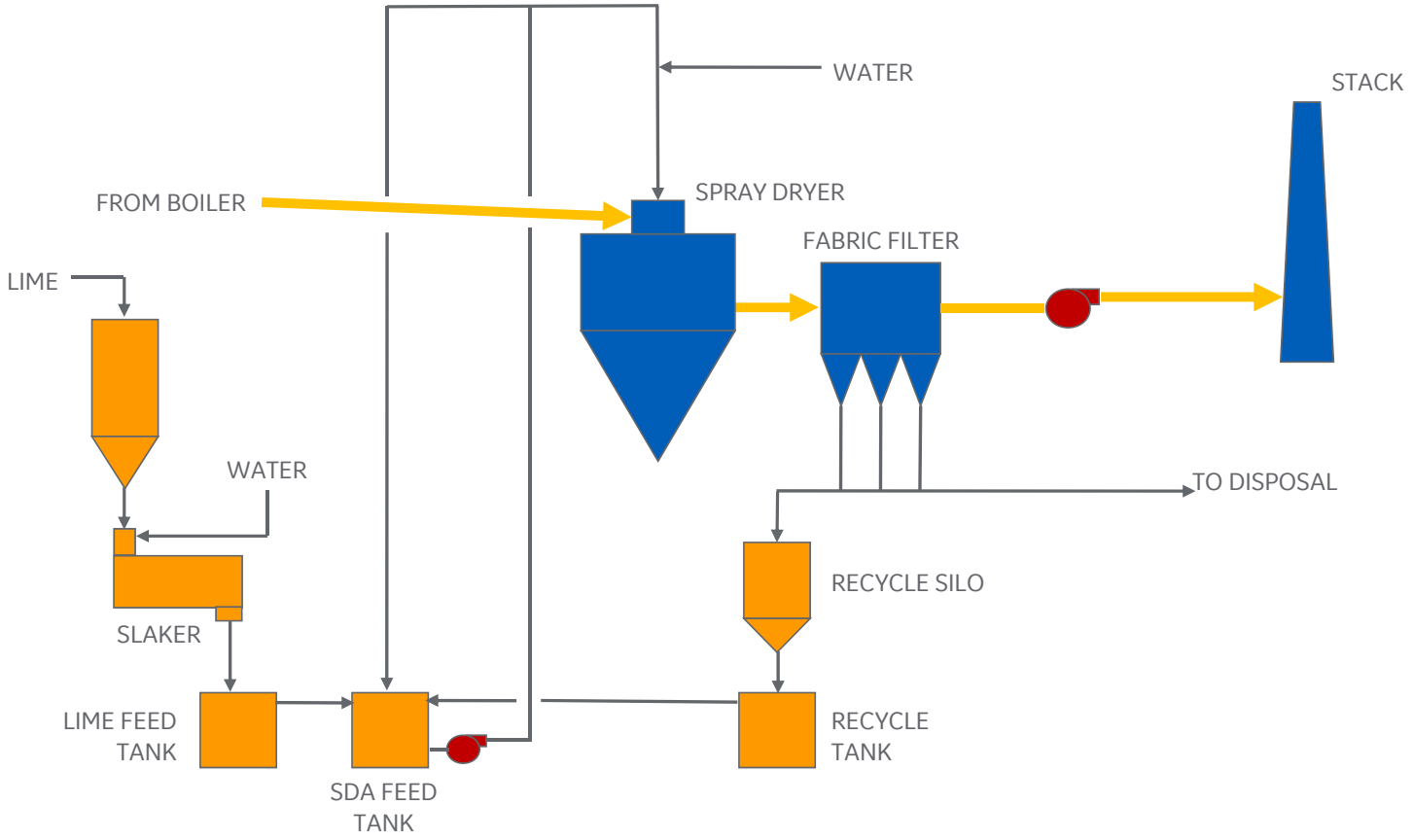


# Role of Fabric Filter

- Second Stage Reaction
  - $SO_2$
  - $SO_3$
  - HCl / HF
  - Hg
  - Other trace elements
- Collection
  - Fly ash
  - Carbon



# DFGD Process Flow Diagram



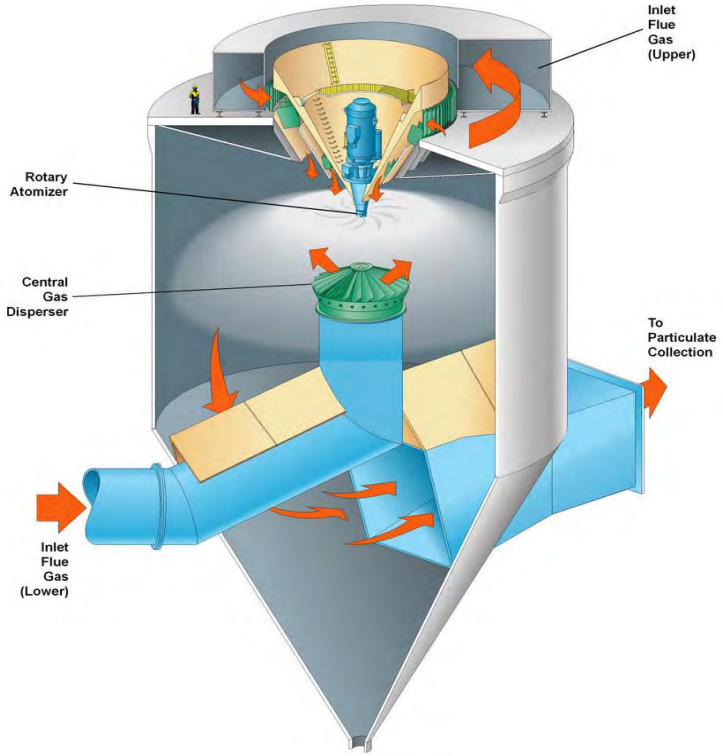
# SDA FAQ

Q. Can SDA achieve high $SO_2$ removal efficiencies?

A. $SO_2$ removal efficiency in spray dryer absorbers is a function of stoichiometric ratio, gas temperature, and inlet $SO_2$ concentration. Typical removal efficiencies are in the range of 92-95%, but >98% is possible in some circumstances.

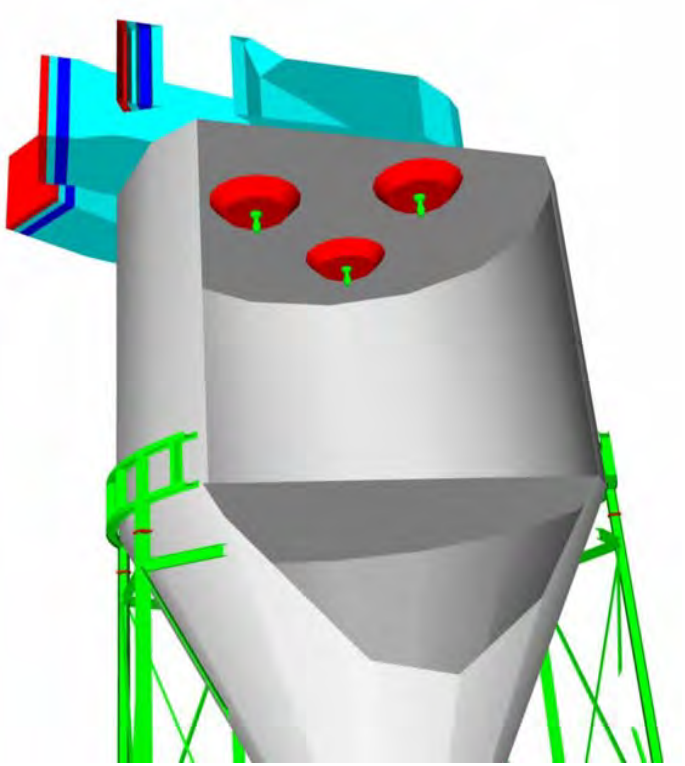
# Single Rotary Atomizer SDA Design

- Single large atomizer (up to 1000 hp)
- Large applications use 2 gas inlets to obtain required gas/liquid contact
  - Tangential spiral top inlet
  - Center inlet with disperser vanes



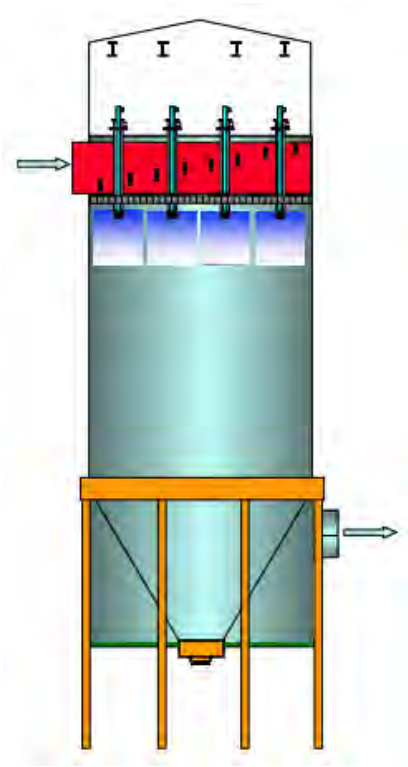
# Multiple Rotary Atomizer SDA Design

- Multiple atomizers (up to 400 hp)
- Each atomizer acts independently
- Typically designed to allow compliance at full-load with one atomizer out of service
- Top inlet with gas disperser to promote good gas/liquid contact
- No internals inside of Spray Dryer Absorber (SDA)



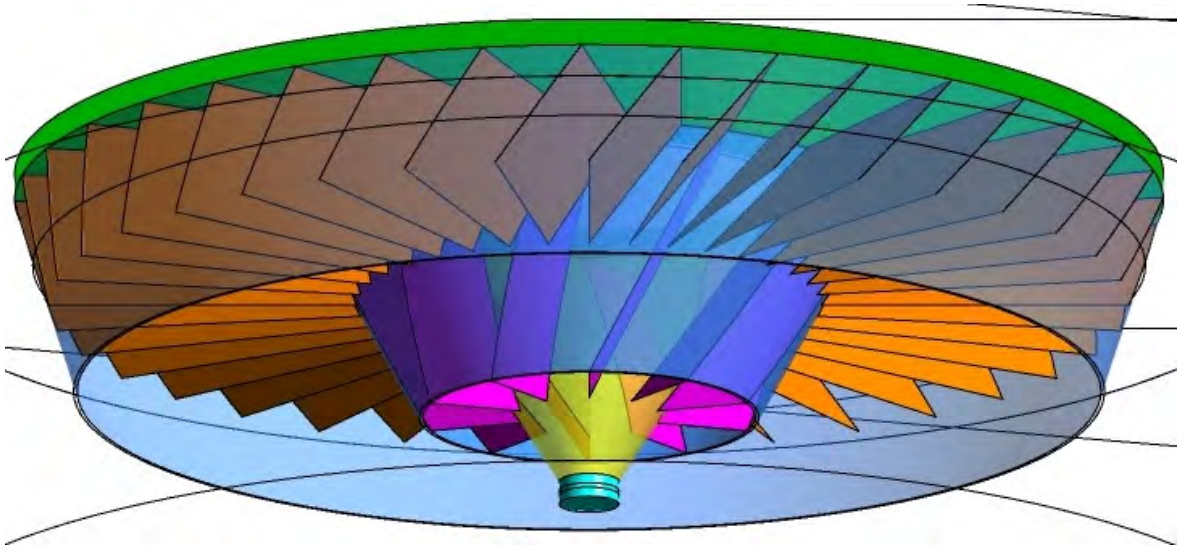
# Dual-Fluid Nozzle SDA Design

- Multiple dual-fluid nozzle assemblies
- Each atomizer acts independently
- Large number of nozzles minimizes impact of maintenance activities
- Side inlet with ladder vanes and egg crate to promote good gas/liquid contact
- No internals inside of Spray Dryer Absorber (SDA)

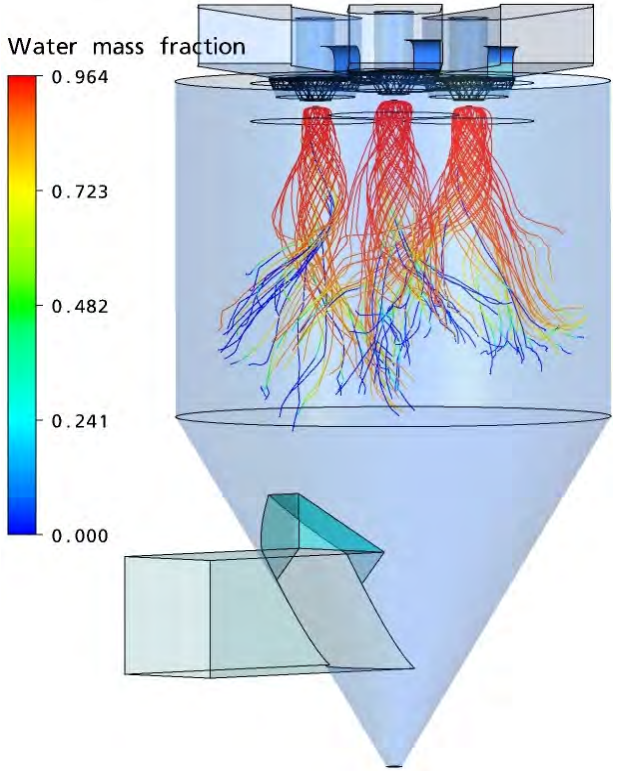


# Gas Disperser

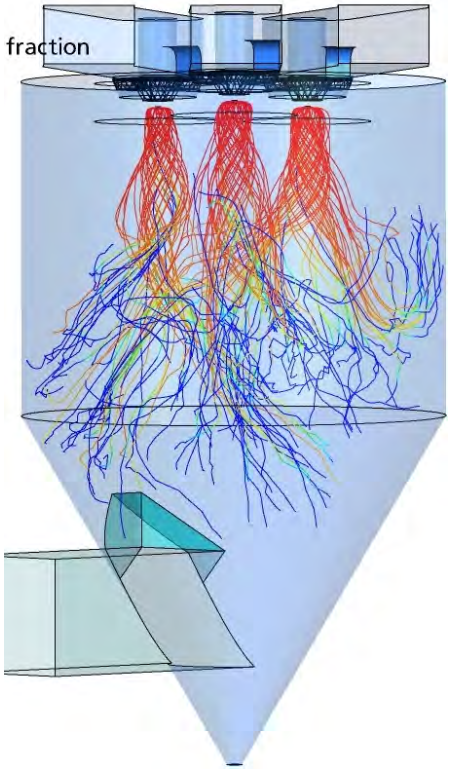
**Rotary Atomizer Gas Disperser**



# Rotary Atomizer CFD Model

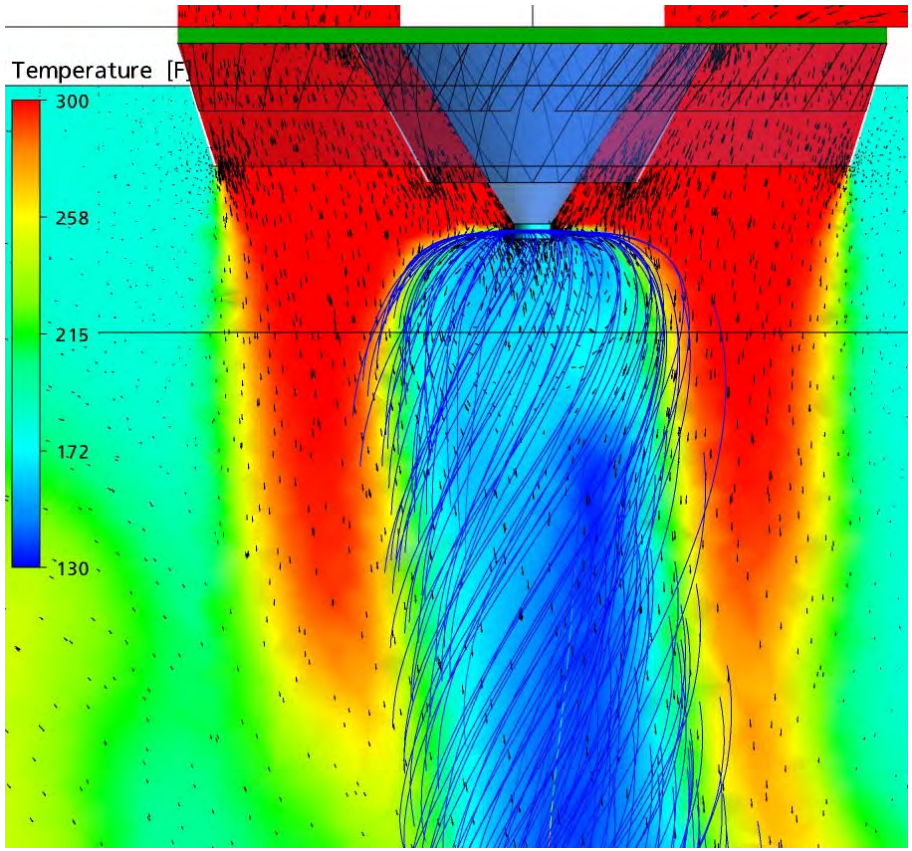



Droplets, 1st second of travel



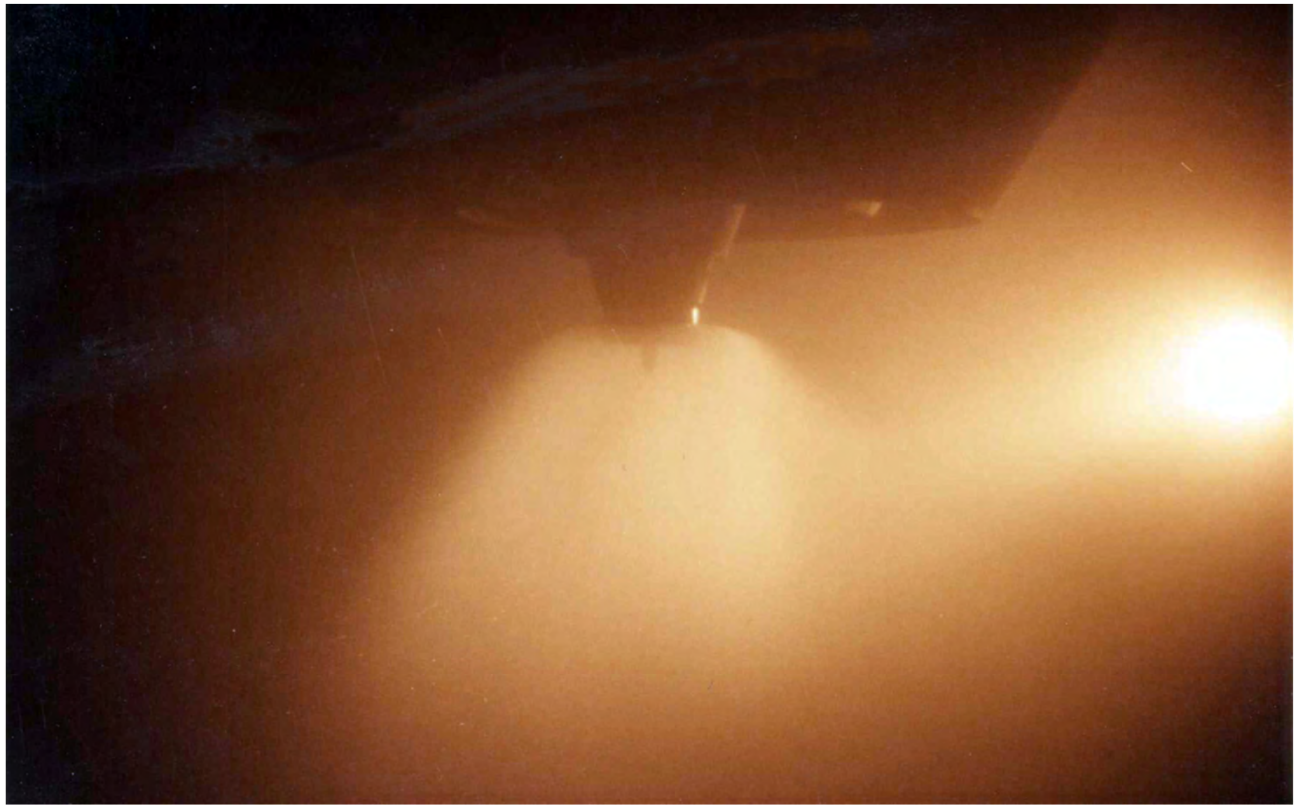

Droplets, 2nd second of travel

# Rotary Atomizer CFD Model

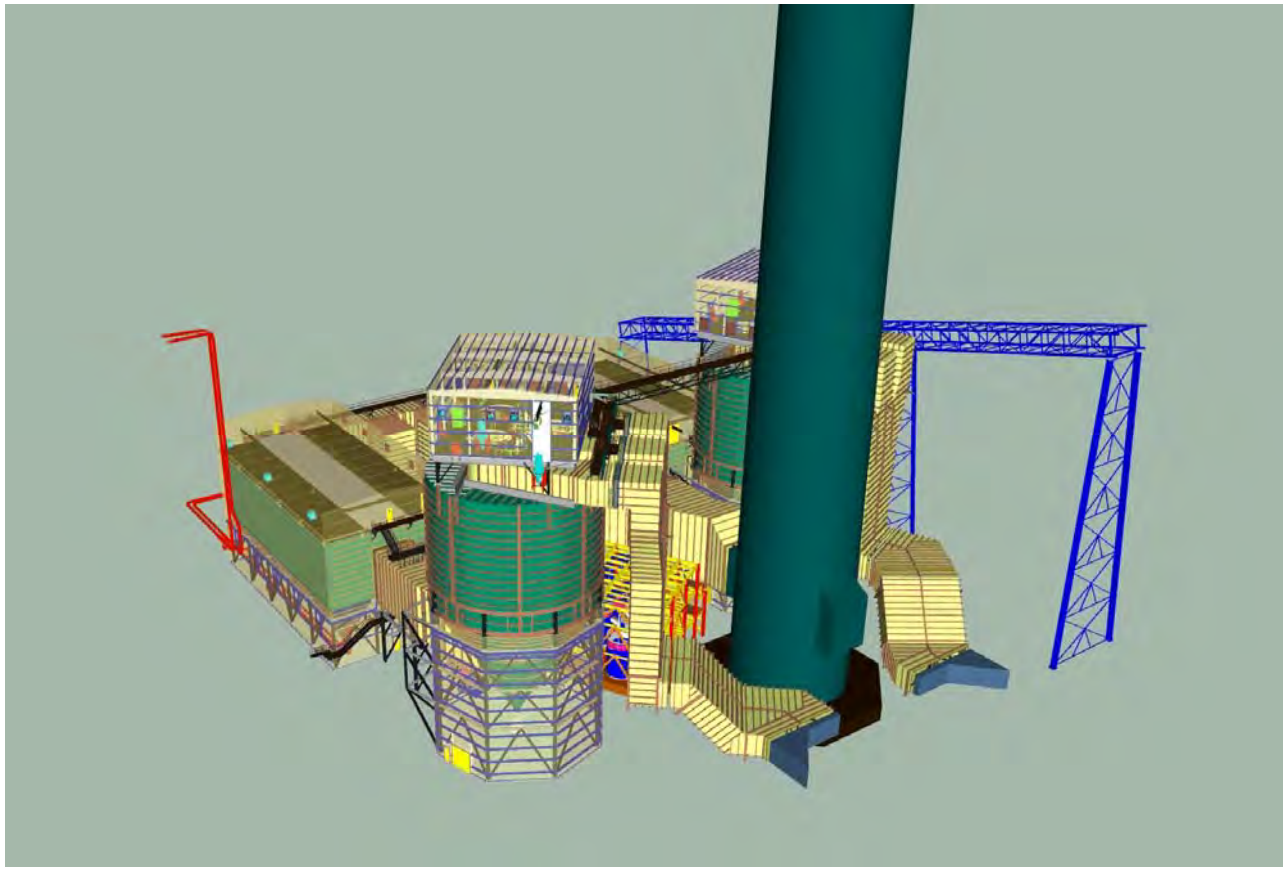



**Zoom in on atomizer**

# Rotary Atomizer



# SDA/FF Arrangement



# Atomizer Designs

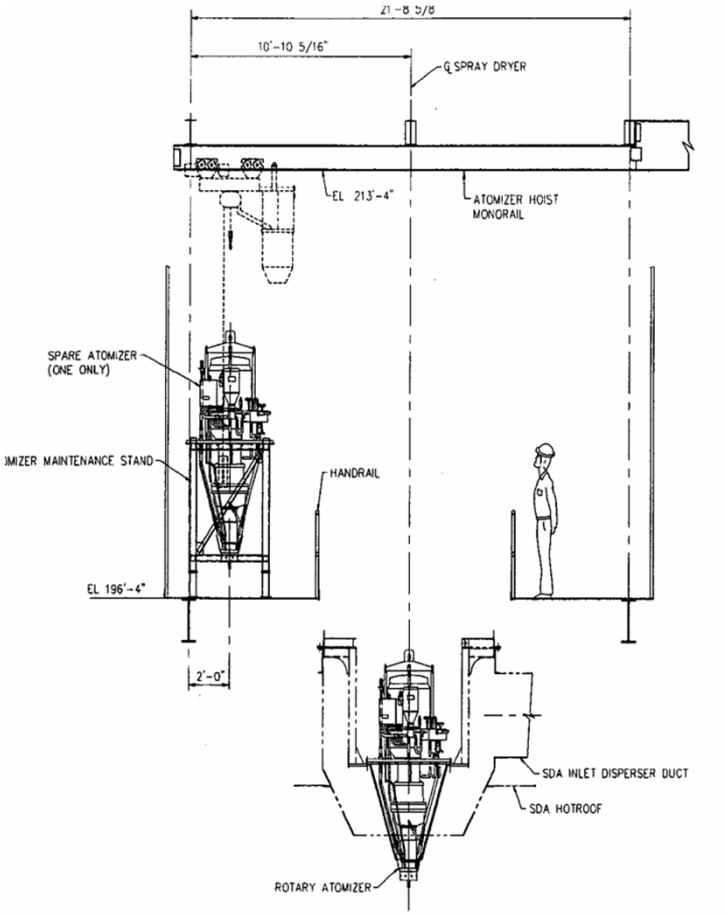
## Rotary Atomizer

- Major sub-components:
  - Vertical shaft motor
  - Gear drive / flex-shaft
  - Liquid disperser
  - Disc
  - Lubrication rack
- Titanium disc with metallic or ceramic wear parts
- 1-3 per SDA vessel

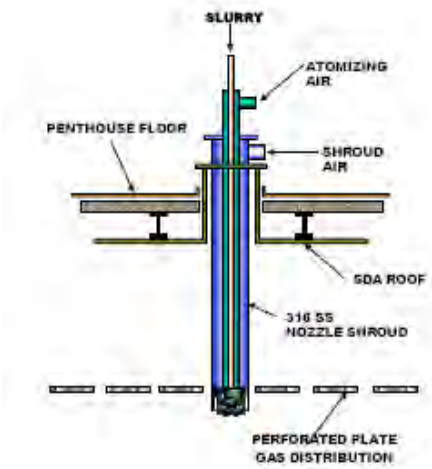
## Dual-Fluid Atomizer

- Major sub-components:
  - Compressor
  - Nozzle shroud
  - Feed lance
- Stainless steel lance with ceramic nozzle inserts
- 16-18 per SDA vessel

# Rotary Atomizer Maintenance




# Dual-Fluid Nozzle Atomizer Maintenance




# SDA FAQ

Q. How often do rotary atomizers have to be maintained?

A. Run time on atomizers varies widely depending on operating conditions such as water quality and ash quantity. Run times can range from 6-20 weeks.

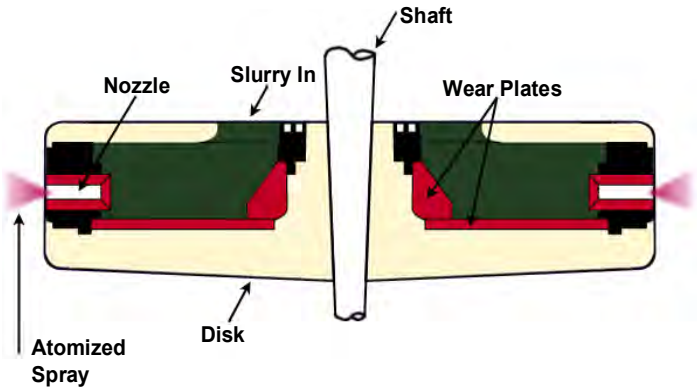
# SDA FAQ

Q. How long does it take to change out a rotary atomizer?

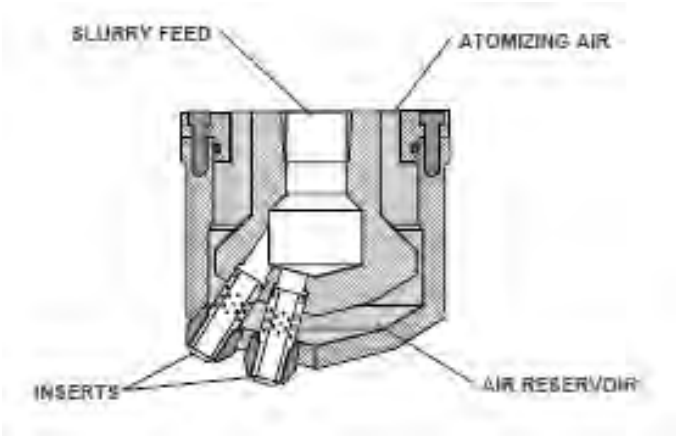
A. An experienced team of two individuals can accomplish the following activities in 30-60 minutes:

- Shut down operating atomizer
- Disconnect reagent, lube oil, and electrical leads
- Remove Atomizer A; transfer to stand
- Transfer Atomizer B to atomizer well
- Reconnect reagent, lube oil, and electrical leads
- Restart atomizer

# Atomizer Details

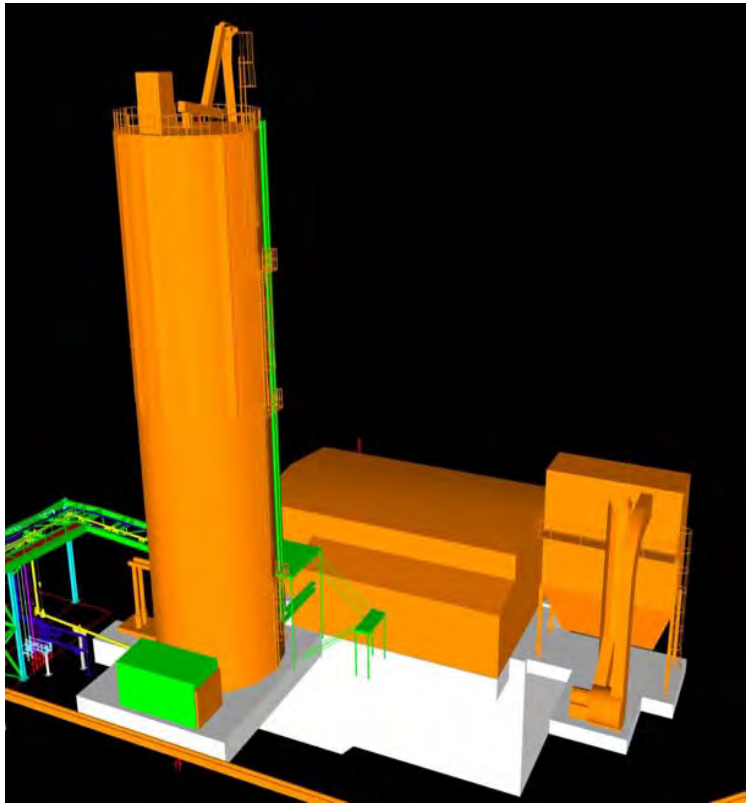



Rotary Atomizer Disc



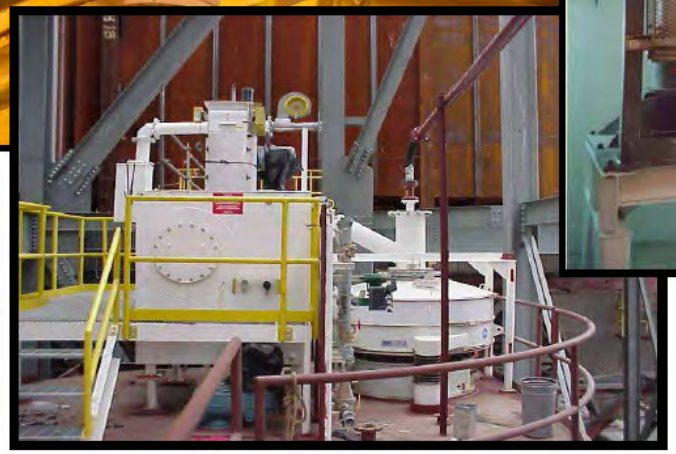

Dual-Fluid Atomizer Head

# Lime Preparation



# Slaking Alternatives

Horizontal Ball Mill

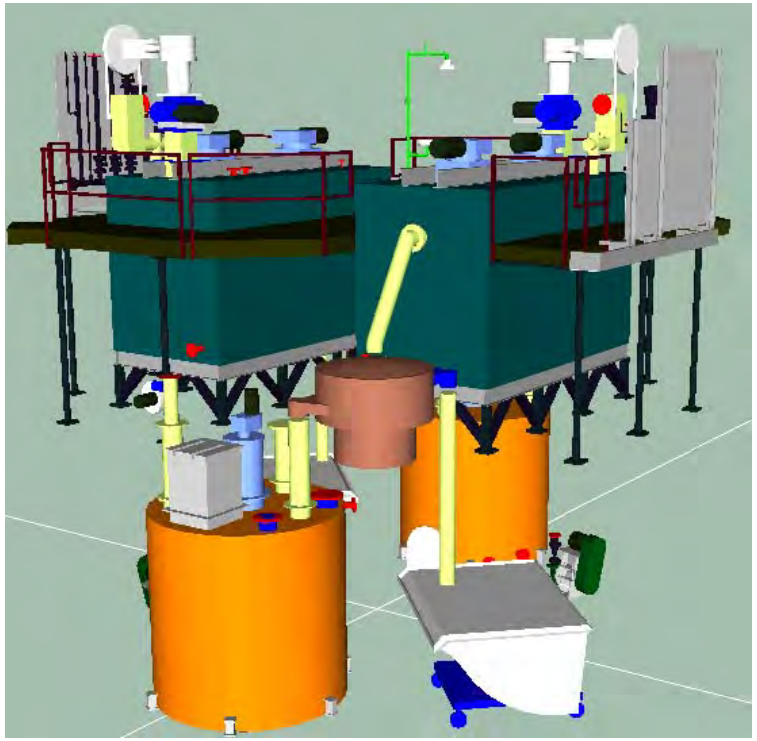


Detention Slaker

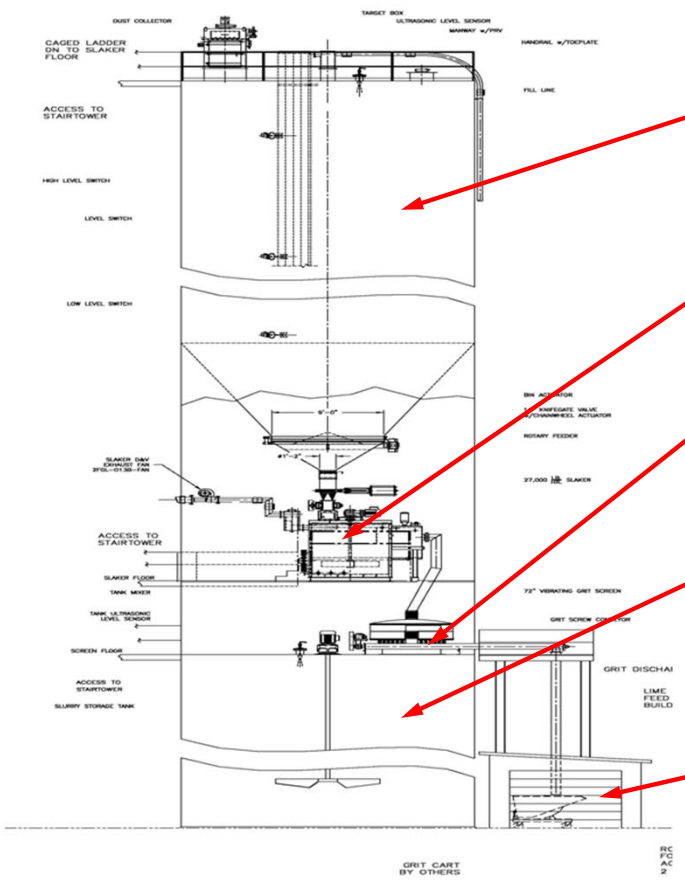
Vertical Ball Mill

# Typical Lime Slaking System

- Temperature 175°F +/- 5°F
- Diluted to 20% solids (Sp. Gr. 1.15 +/- 0.02)
- Settled Volume after 24 hrs >50 ml @ 10% solids
- Filtered to 20 Mesh or less



# Typical Lime Slaking System



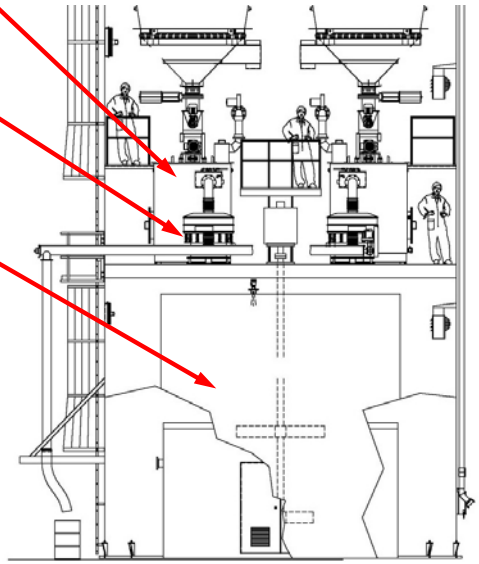

**Lime Day Silo**

**Lime Slaker**

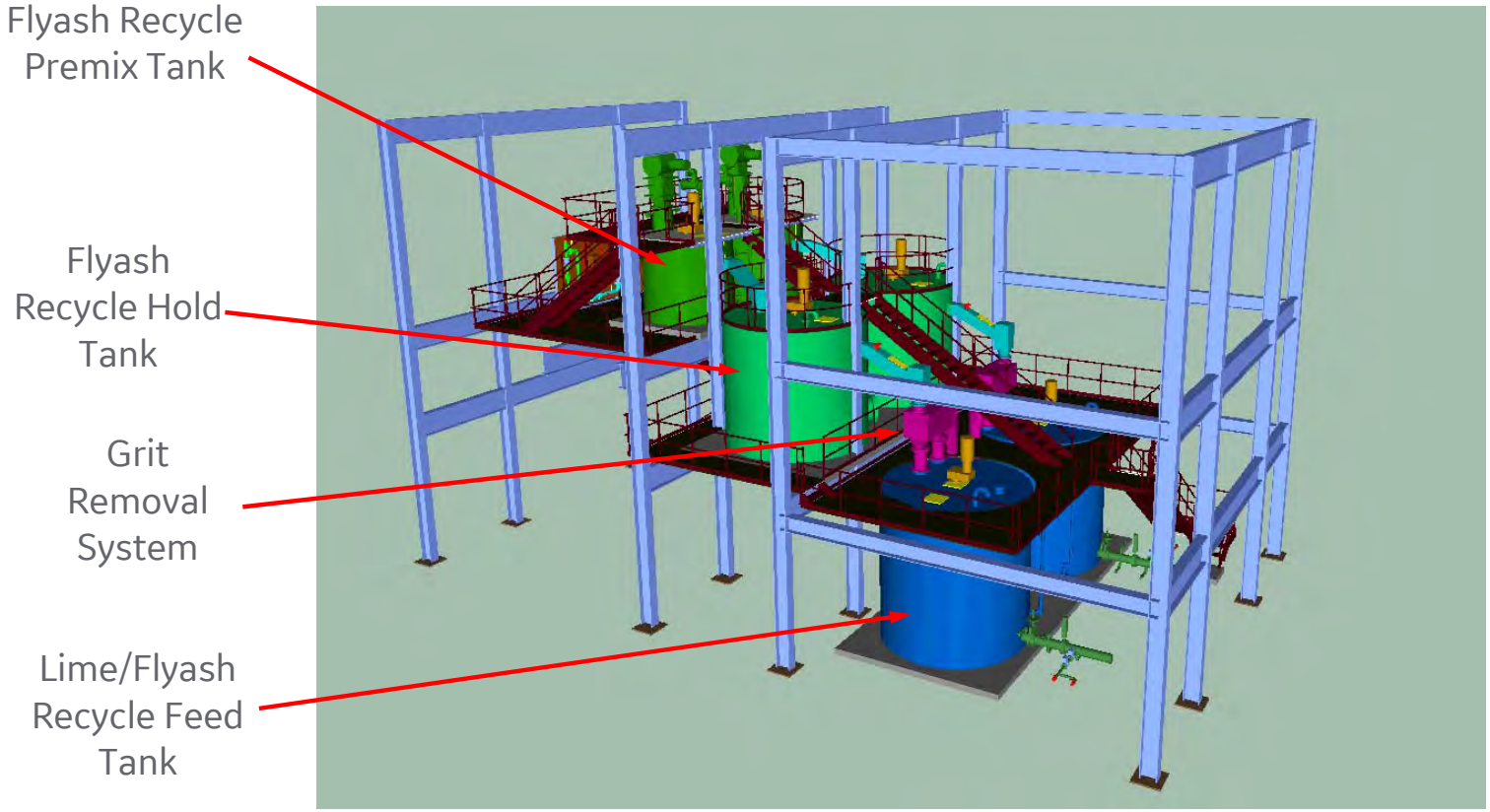
**Grit Screen**

**Slurry Storage Tank**

**Lime Slurry Pump Bldg.**



# Typical Recycle Preparation System

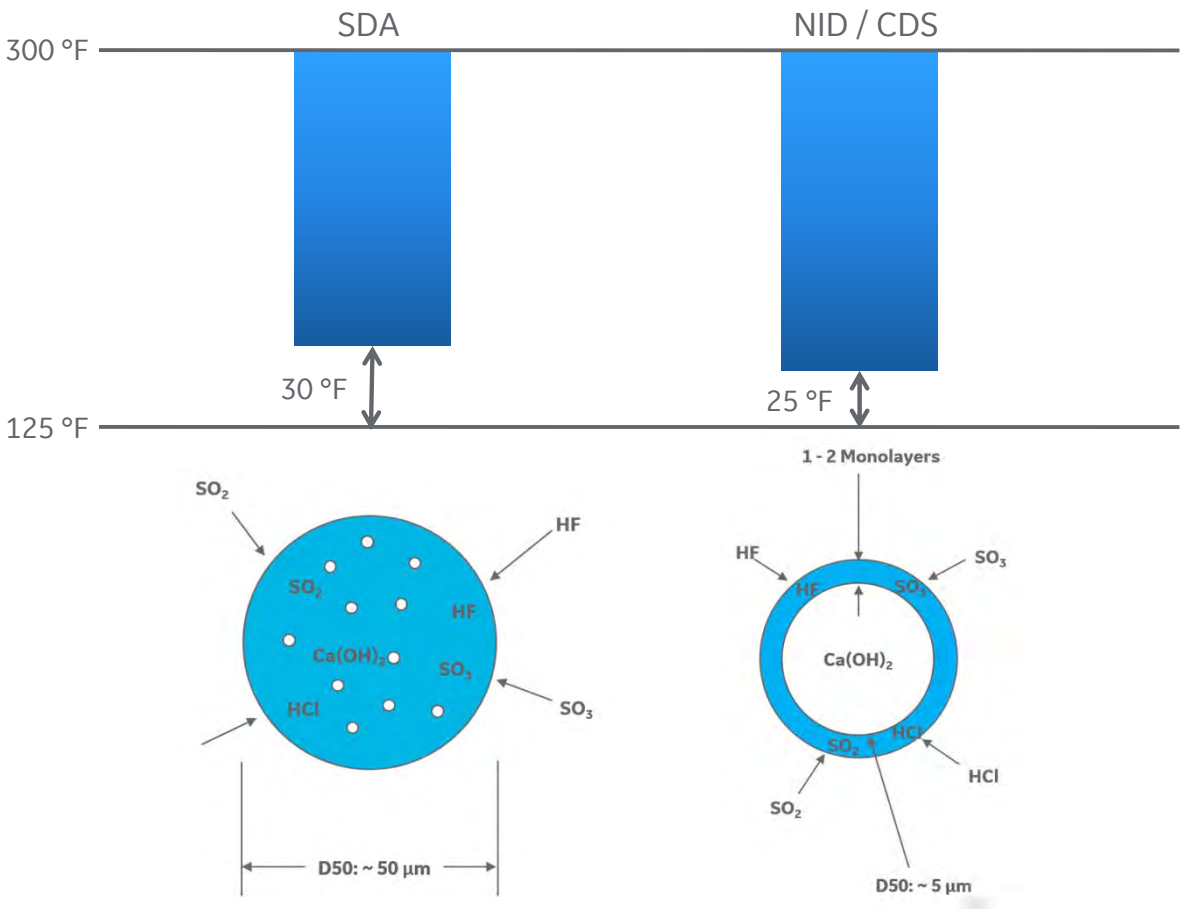


# NID / CDS Technology

# Key Benefits of NID / CDS

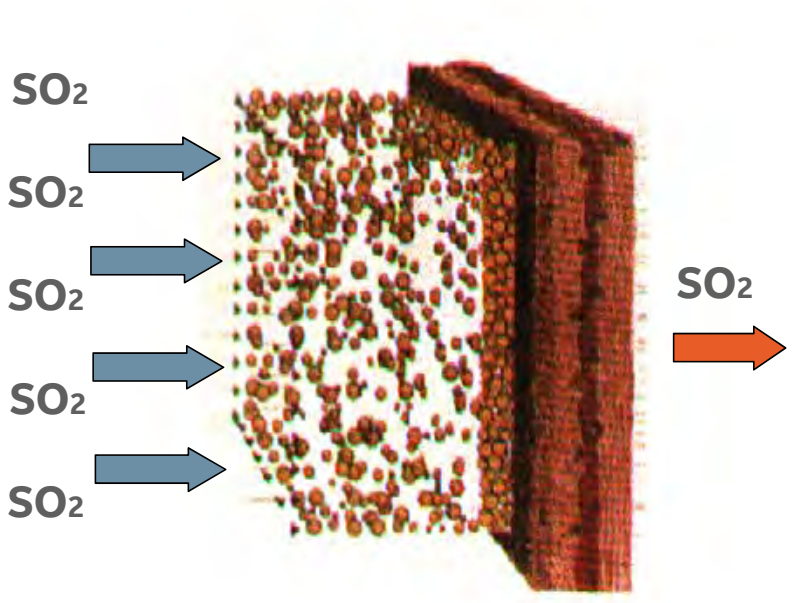
- Multi-pollutant control: High efficiency removal of $SO_2$, $SO_3$, PM, HCl, and HF
  - $SO_2$ removal: ≤ 98%
  - $SO_3$ emissions: < 1 ppm
  - PM (filterable): < 0.012 lb/MBtu
- Lime-based semi-dry FGD technology
  - Patented, integrated hydrator/mixer – no slurry handling (NID only)
  - Zero liquid discharge
  - Low water consumption; ability to use low quality water: CTB, WFGD purge
- Simple, compact design
  - Small footprint offers retrofit advantage
  - Low capital cost
  - Low BOP/construction cost
  - Low O&M cost
- Modular design (NID only)
  - High reliability
  - Excellent turndown
  - No scale up issues
- Fuel flexibility of up to 2.5% sulphur coal or higher

# DFGD Technology Comparison

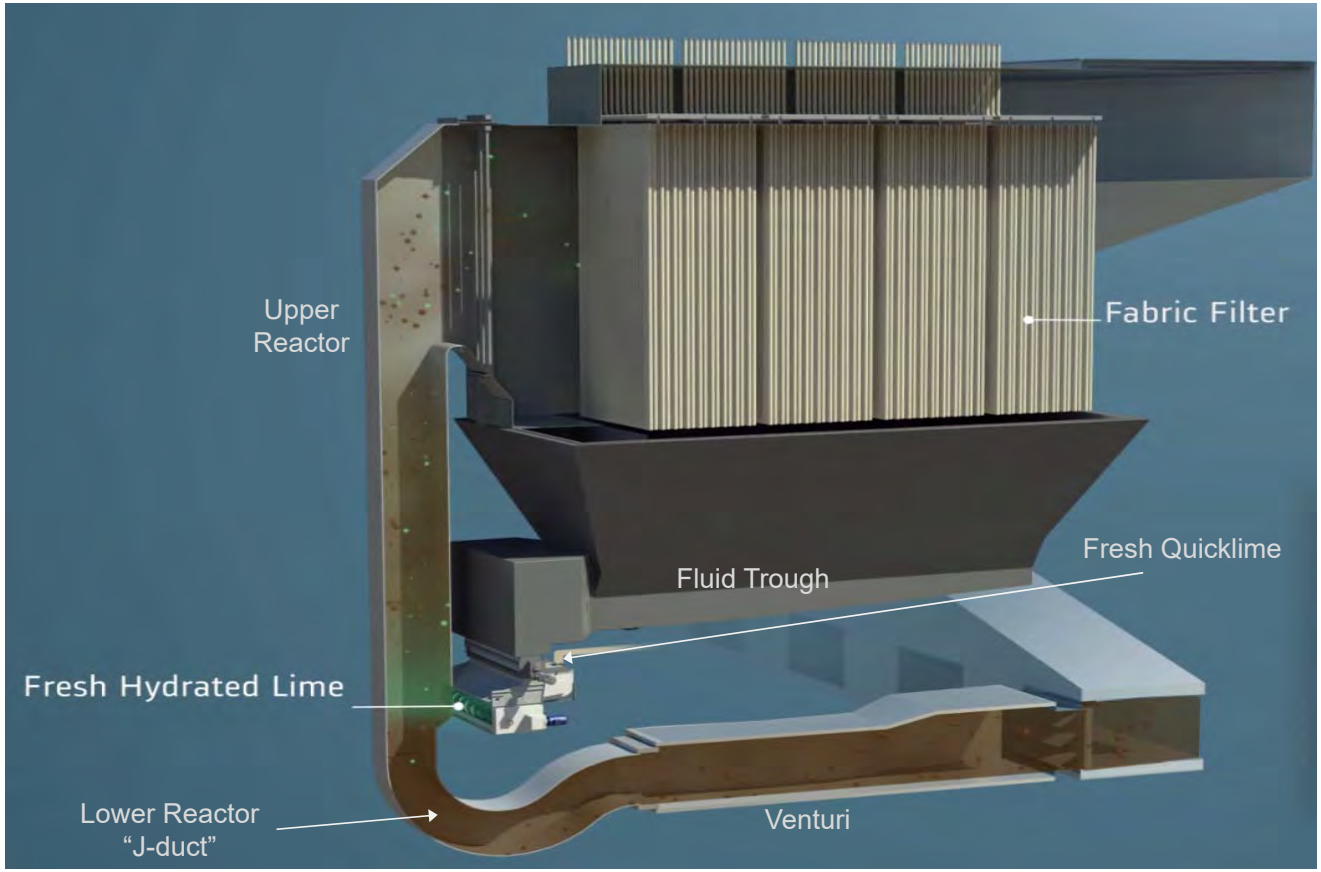


# Role of Fabric Filter

- Second Stage Reaction
  - $SO_2$
  - $SO_3$
  - HCl / HF
  - Hg
  - Other trace elements
- Collection
  - Fly ash
  - Carbon

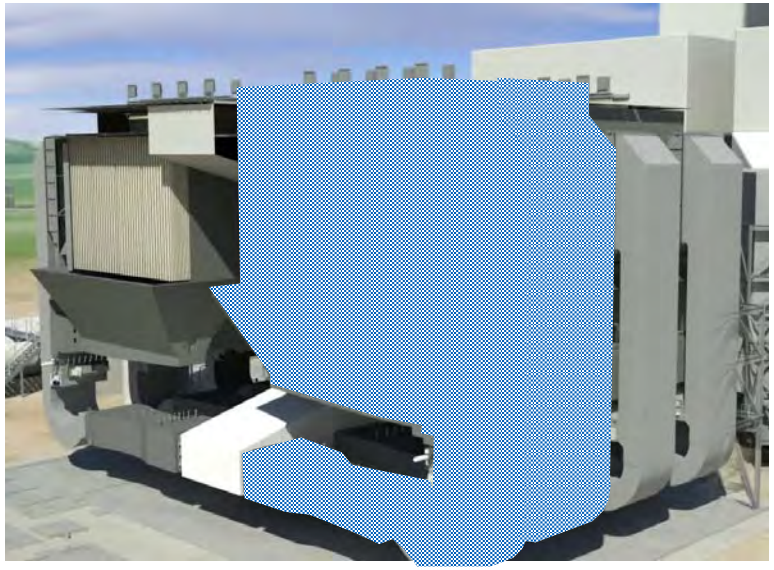


# NID Overview

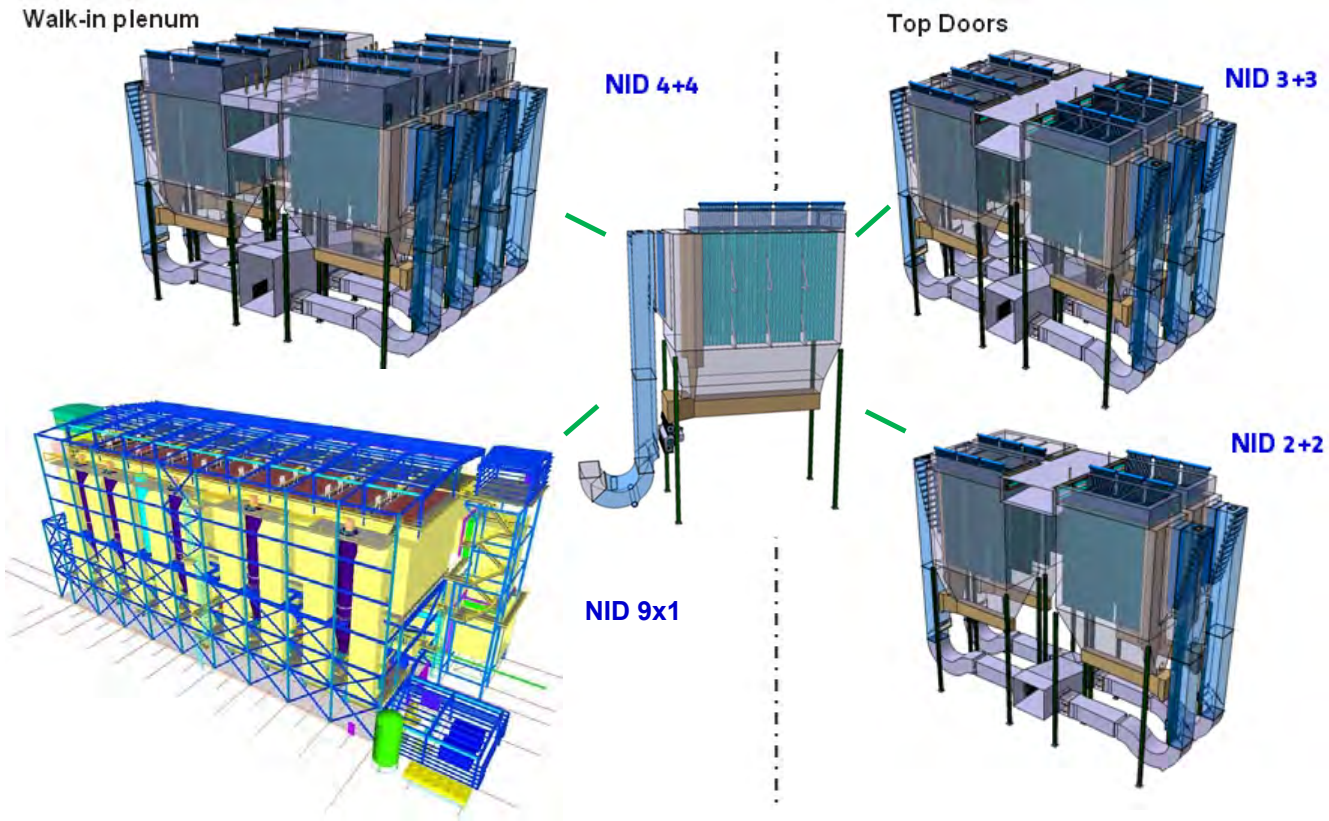


# Modular NID Concept

- Multiple, independently isolatable modules
- Capable of full-load operation with one module out of service
  On-line maintenance of key mechanical components
  On-line bag replacement
- Turndown managed by matching the number of modules to actual boiler gas flow
  40% to 100% MCR
- Dampers
  - Upstream of reactor
  - Downstream of FF compartment



# Modular Design



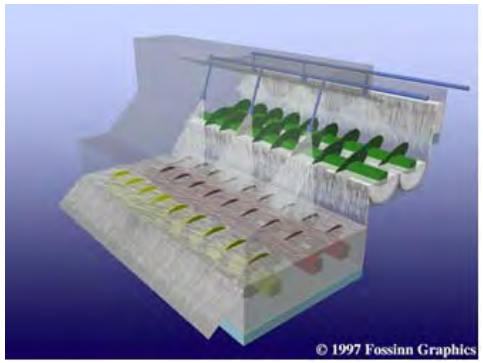

Modularization Offers Design Flexibility

# Key Components

- Concept
  - Mixing humidified recirculation end product and hydrated lime
  - Hydration in separate compartment integrated with the NID Mixer
  - CaO feed controlled directly, based on $SO_2$ emission
  - Hydrated lime added to mixer by displacement of CaO addition; overflow directly into mixer section

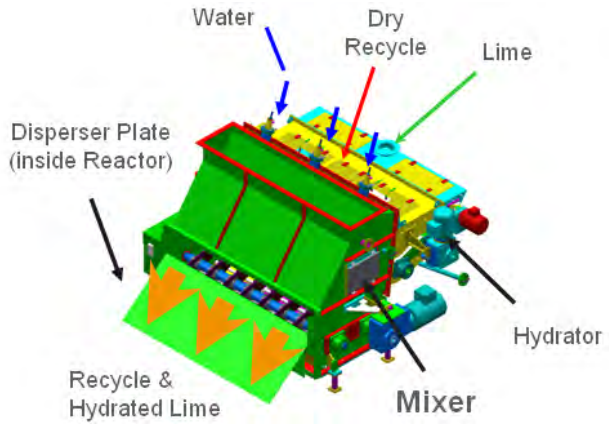
- Advantages
  - No intermediate silo
  - No separate filter - venting through NID FF
  - No transport of hydrated lime - direct overflow into the NID Mixer

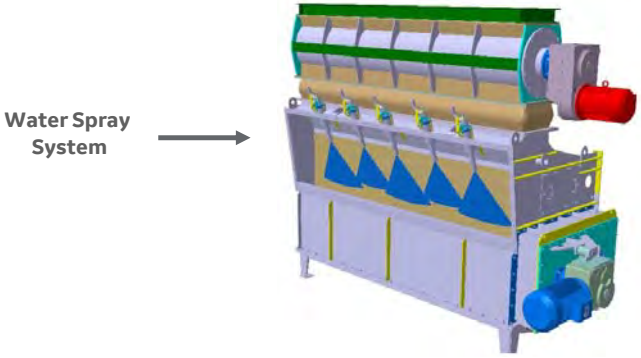
**Mixer / Hydrator**




NID Mixer / Hydrator

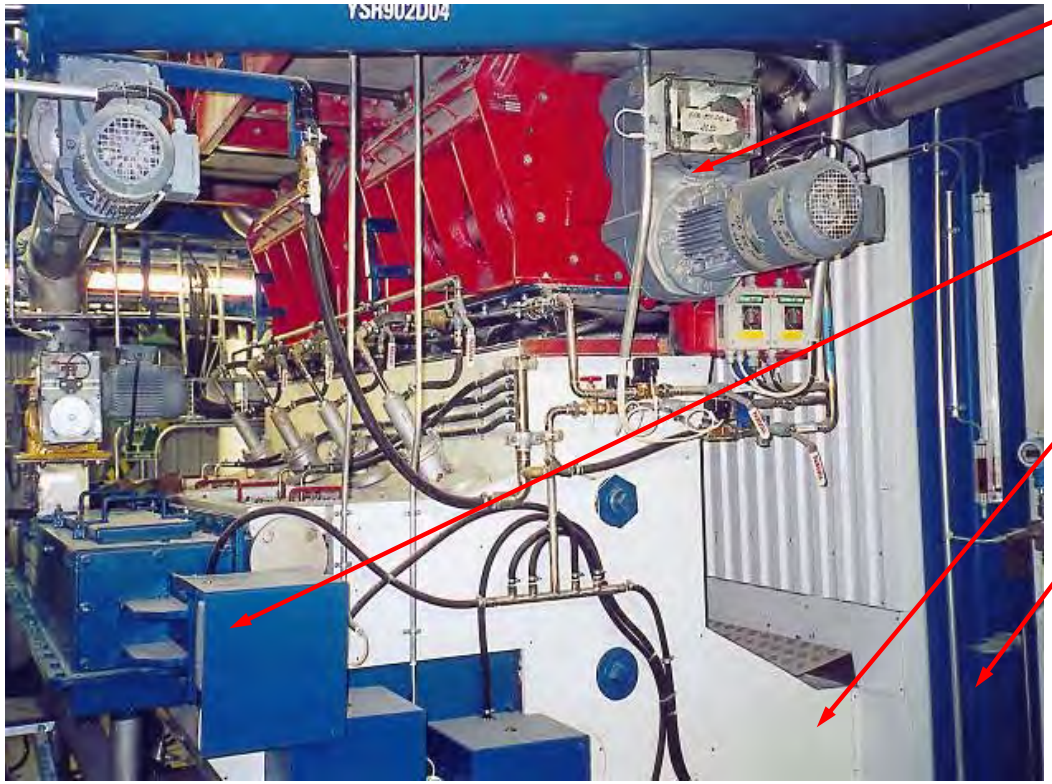
# Key Components



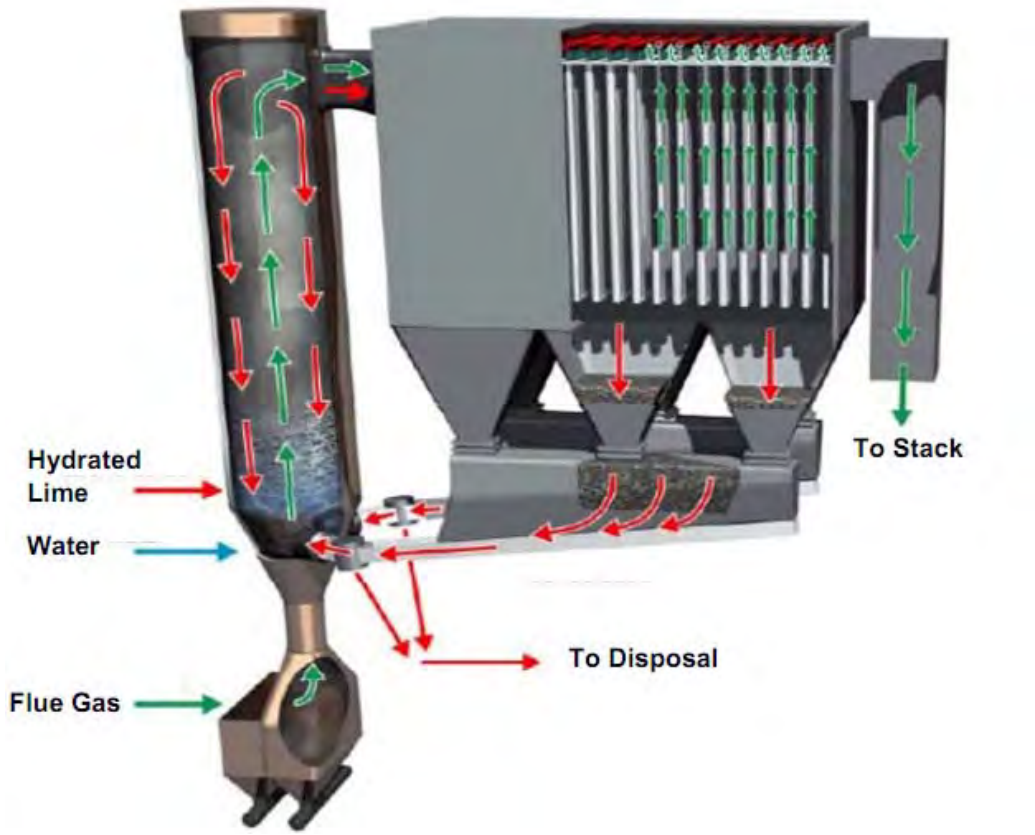




NID Mixer / Hydrator

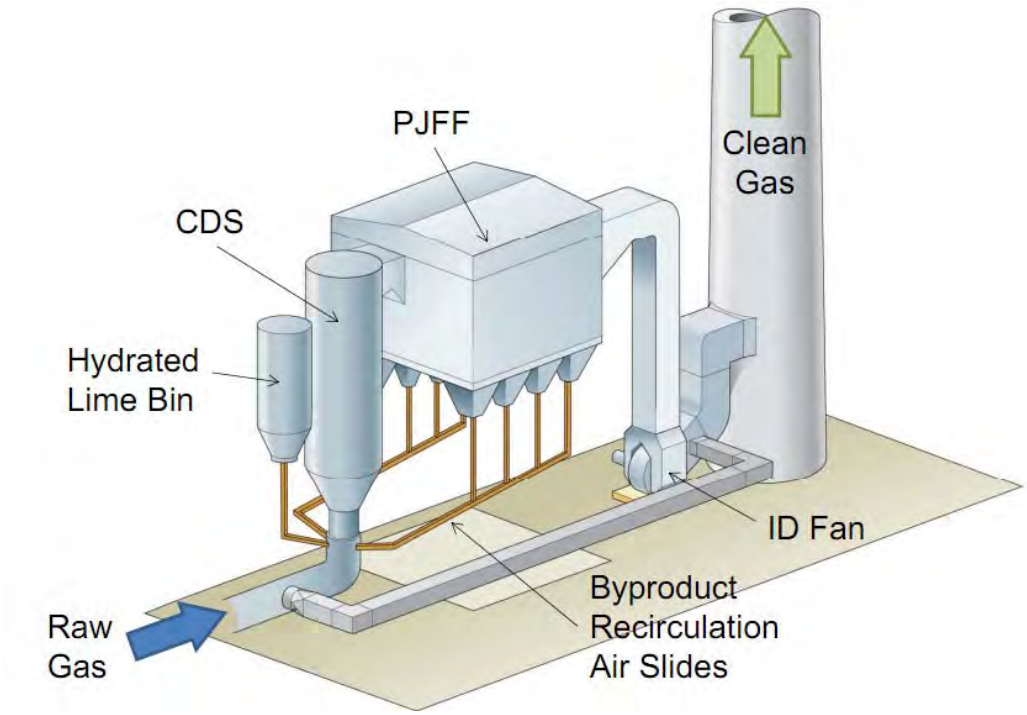
# Rotary Air Lock and Mixer/Hydrator (NID)

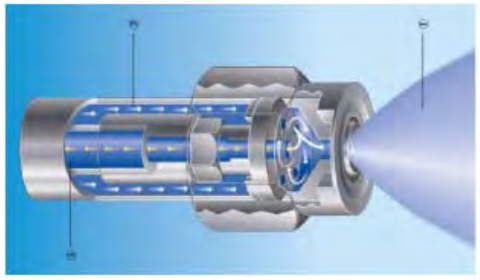


# CDS Flow Diagram



# CDS Arrangement

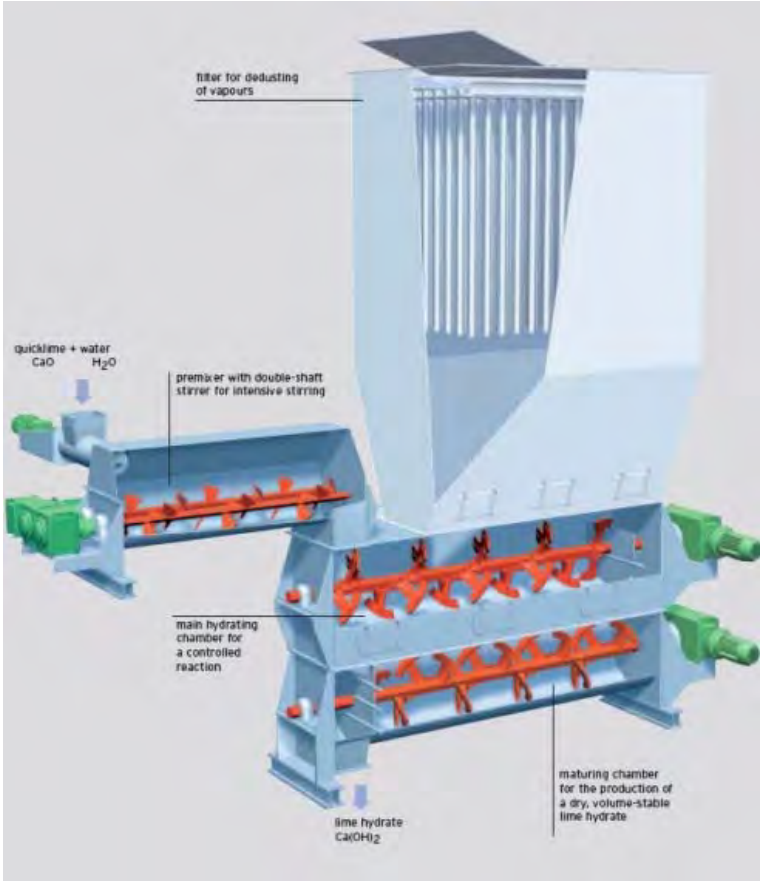


Water Injection Nozzle

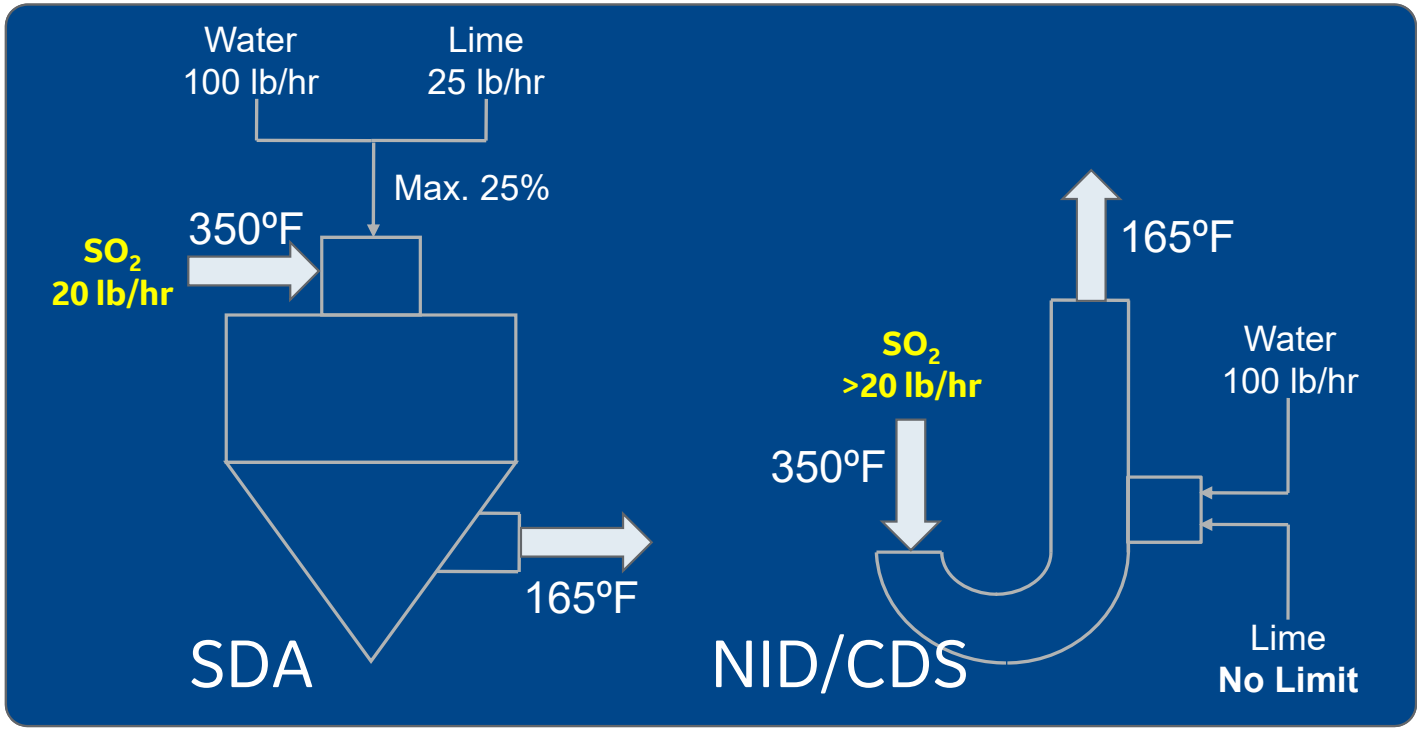
High Pressure Pumps

# Lime Hydrator



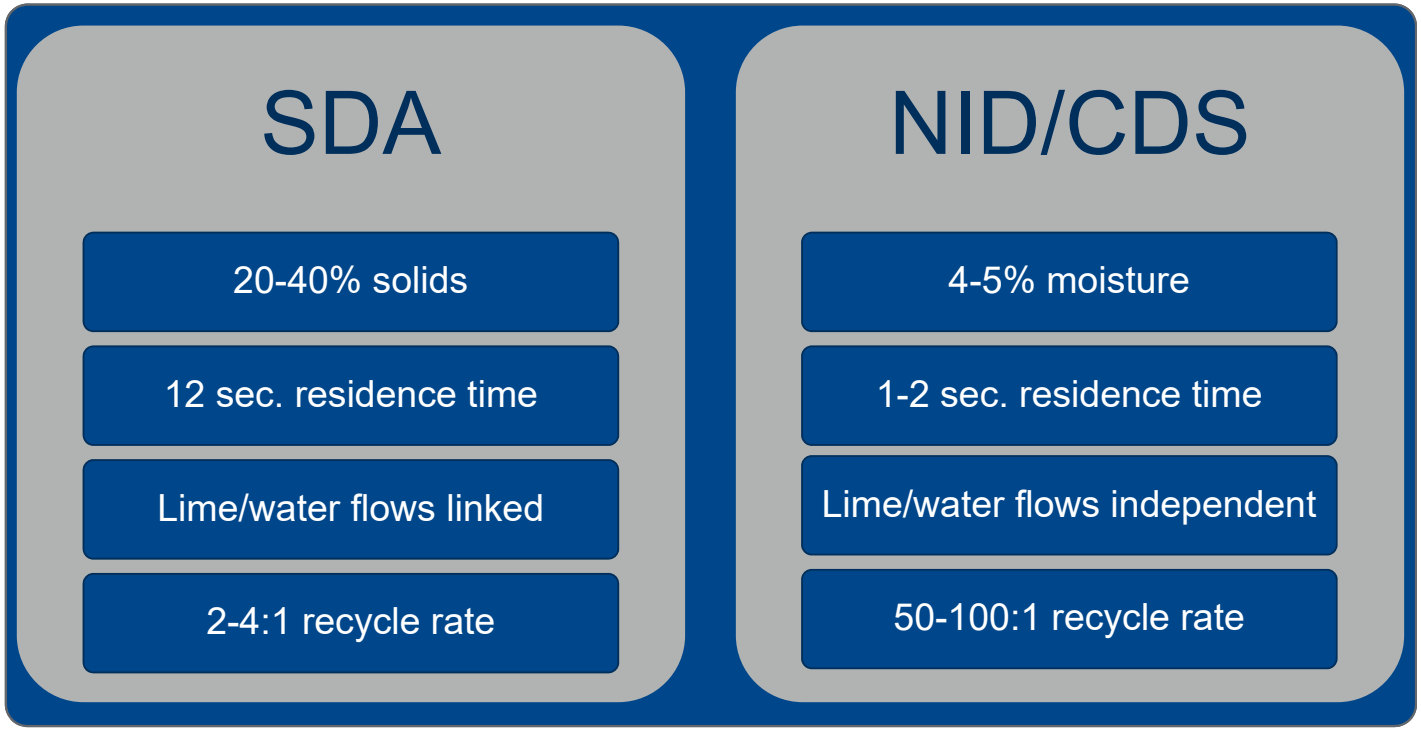
# NID/CDS FAQ

Q. Why can NID/CDS achieve higher removal than SDA?



# NID/CDS FAQ

Q. What is the difference betw. NID/CDS and SDA systems?

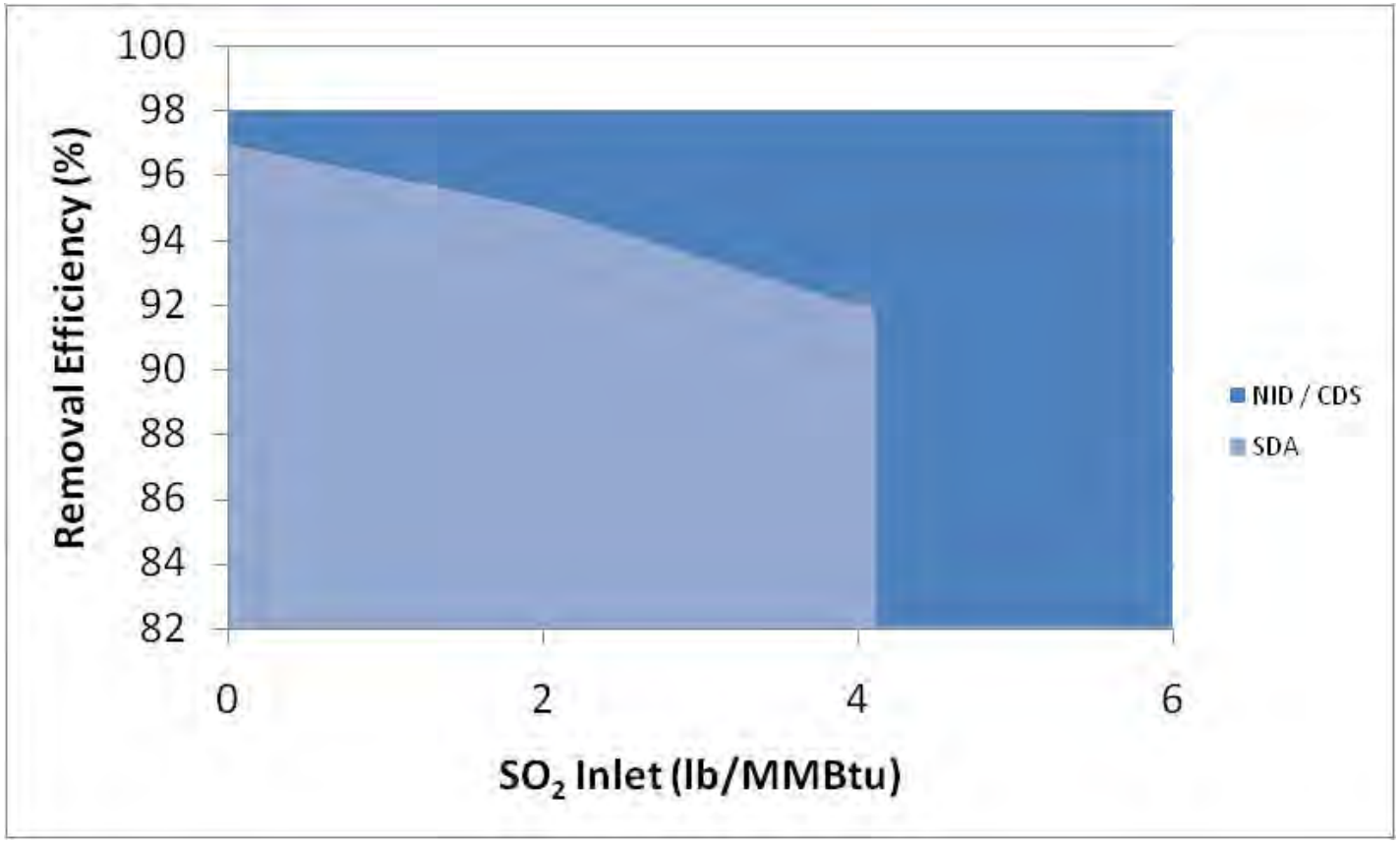


# Summary

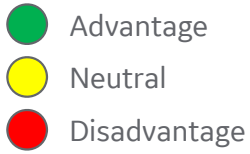
# FGD Technology Comparison

| Technology | SDA | NID / CDS |
|---|---|---|
| **Design** | | |
| Absorber | Spray Dryer | J-Reactor / Fluidized Bed |
| Reagent | Lime | Lime |
| Reagent Preparation | Slaker | Hydrator |
| Byproduct | CaSO3/CaSO4/Ash | $CaSO_3/CaSO_4$/Ash |
| **Performance** | | |
| Stoichiometric Ratio | 1.2-1.8 | 1.2-1.8 |
| Approach Temperature | 30-35 ºF | 25-30 ºF |
| L/G | 0.03 gal/kacf | 0.03 gal/kacf |
| Pressure Drop | 11-13 in. w.g. | 14-16 in. w.g. |
| $SO_2$ Removal Eff. | 95% | 98+% |
| $SO_2$ Inlet (max) | 2-3 lb/MBtu | >5-6 lb/MBtu |

# NID / CDS Fuel Flexibility



# DFGD Technology Comparison




| Technology Comparison | SDA | NID/CDS |
|---|---|---|
| Footprint | Neutral | Advantage |
| Fuel Flexibility | Neutral | Advantage |
| Lime Consumption | Advantage | Advantage |
| System Maintenance | Neutral | Neutral |
| Retrofit to existing fabric filter | Neutral | Disadvantage |
| Turndown | Advantage | Neutral |
| HAPS emissions | Advantage | Advantage |

Imagination at work

# Fabric Filter Technology