REINHOLD ENVIRONMENTAL Ltd.

2010 APC Round Table
& Expo Presentation

July 18-20, 2010, in Concord, NC / Hosted by Duke Energy

Dry Flue Gas Desulfurization SDA and NID Technology

Comparison, Operations, and Maintenance

Larry Gatton

2010 APC/PCUG Conference
July 19 - 23

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Agenda

Introduction

DFGD Process Overview

SDA Technology

NID Technology

Operations and Maintenance

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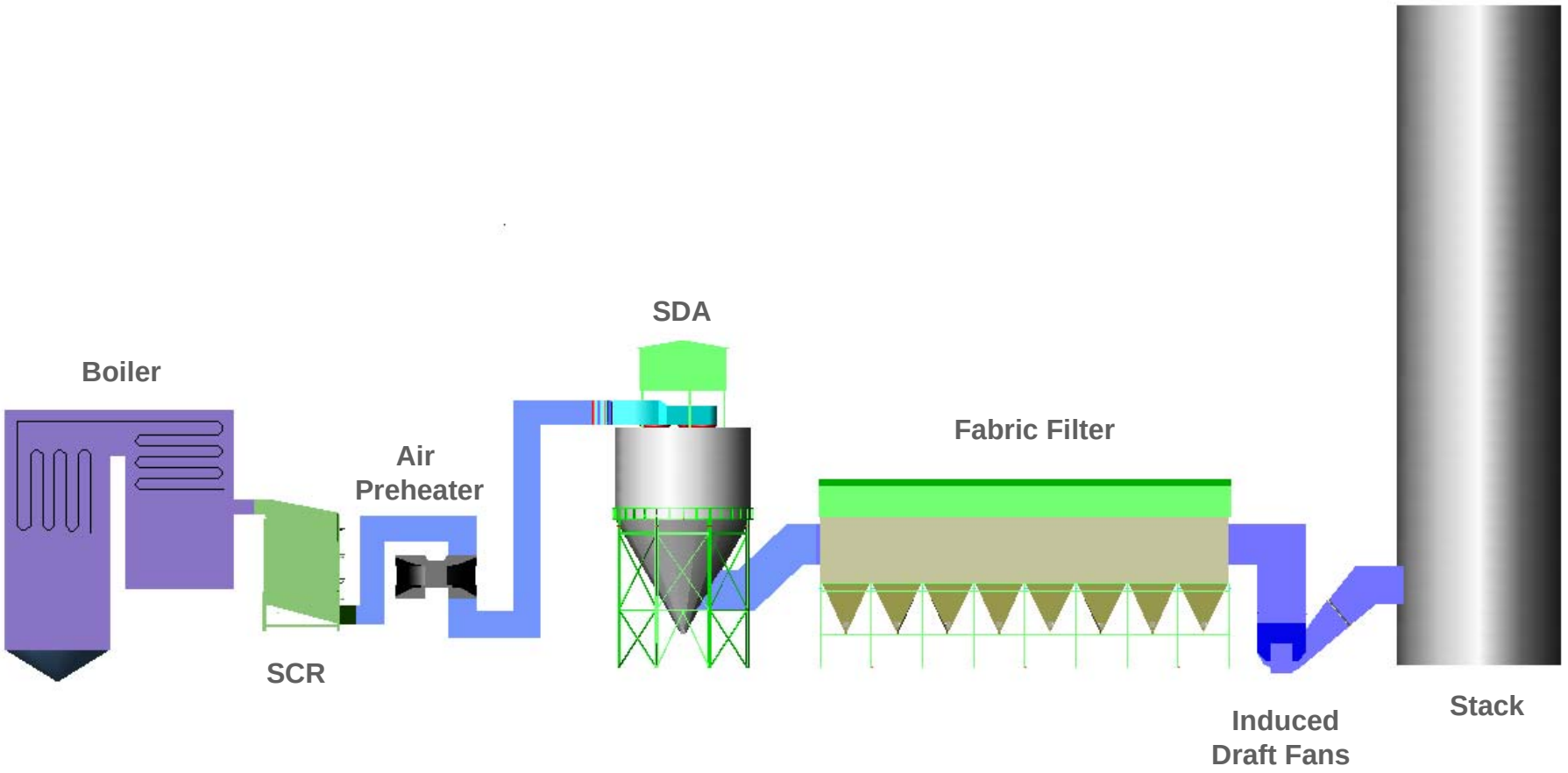
Typical DFGD Installation



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Typical DFGD Installation

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DFGD Reactions & Products

Lime Slaking

- $CaO + H_2O \rightarrow \mathbf{Ca(OH)_{2(s)}}$

Acid Gas Scrubbing

- $SO_2 + Ca(OH)_2 \rightarrow \mathbf{CaSO_3\text{-}½H_2O_{(s)}} + ½H_2O_{(g)}$
- $SO_2 + Ca(OH)_2 + H_2O + ½O_2 \rightarrow \mathbf{CaSO_4\text{-}2H_2O_{(s)}}$
- $SO_3 + Ca(OH)_2 + H_2O \rightarrow \mathbf{CaSO_4\text{-}2H_2O_{(s)}}$
- $CO_2 + Ca(OH)_2 \rightarrow \mathbf{CaCO_{3(s)}} + H_2O_{(g)}$
- $2HCl + Ca(OH)_2 \rightarrow \mathbf{CaCl_2\text{-}2H_2O_{(s)}}$
- $2HF + Ca(OH)_2 \rightarrow \mathbf{CaF_{2(s)}} + 2H_2O_{(g)}$

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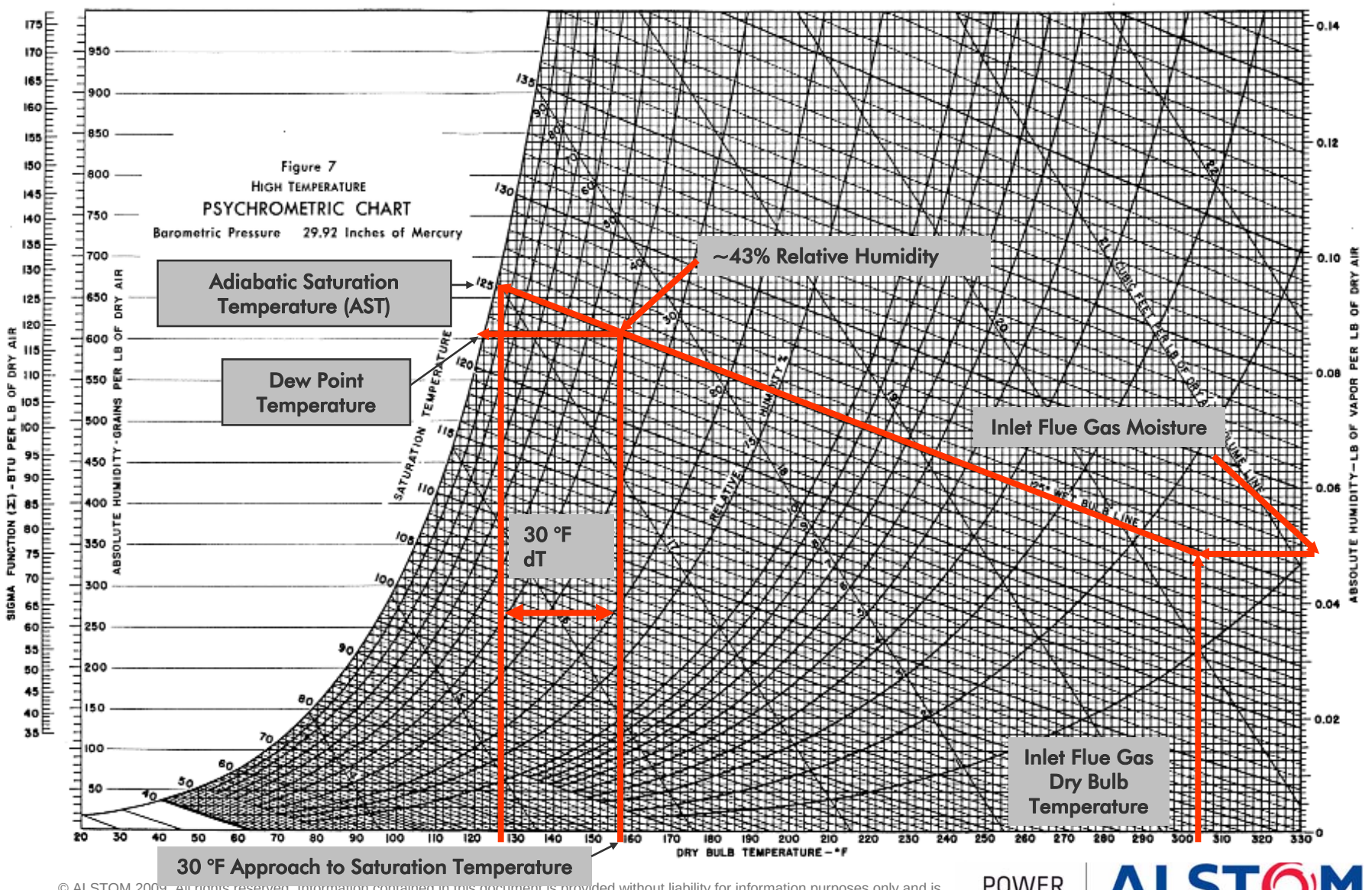
Temperature Control

- Dry Bulb Temperature
- Dew Point Temperature
- Approach to Adiabatic Saturation Temperature (AST)

Psychrometric Chart



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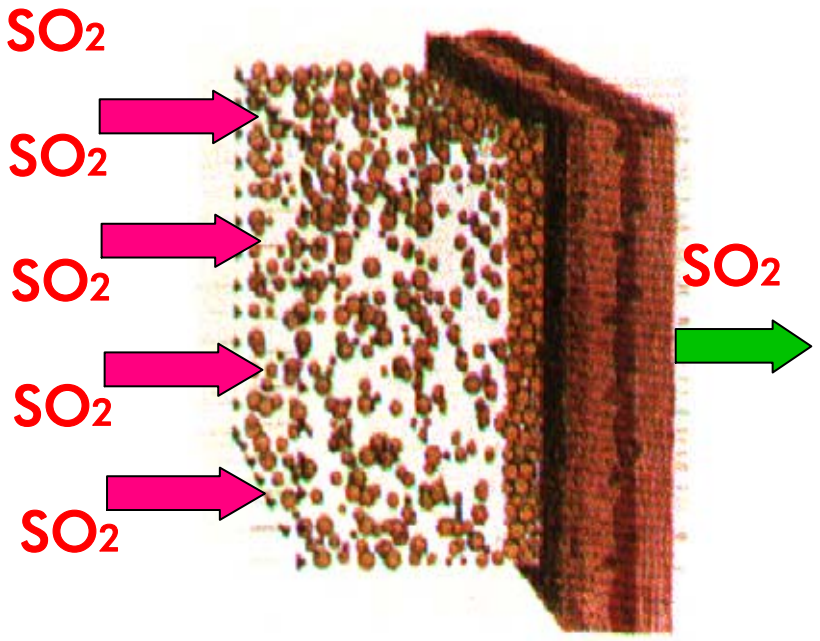
Fabric Filter

- Important part of DFGD

- Reaction
  - Second Stage SO_2 Removal

- Collection
  - Fly ash
  - Reaction Products



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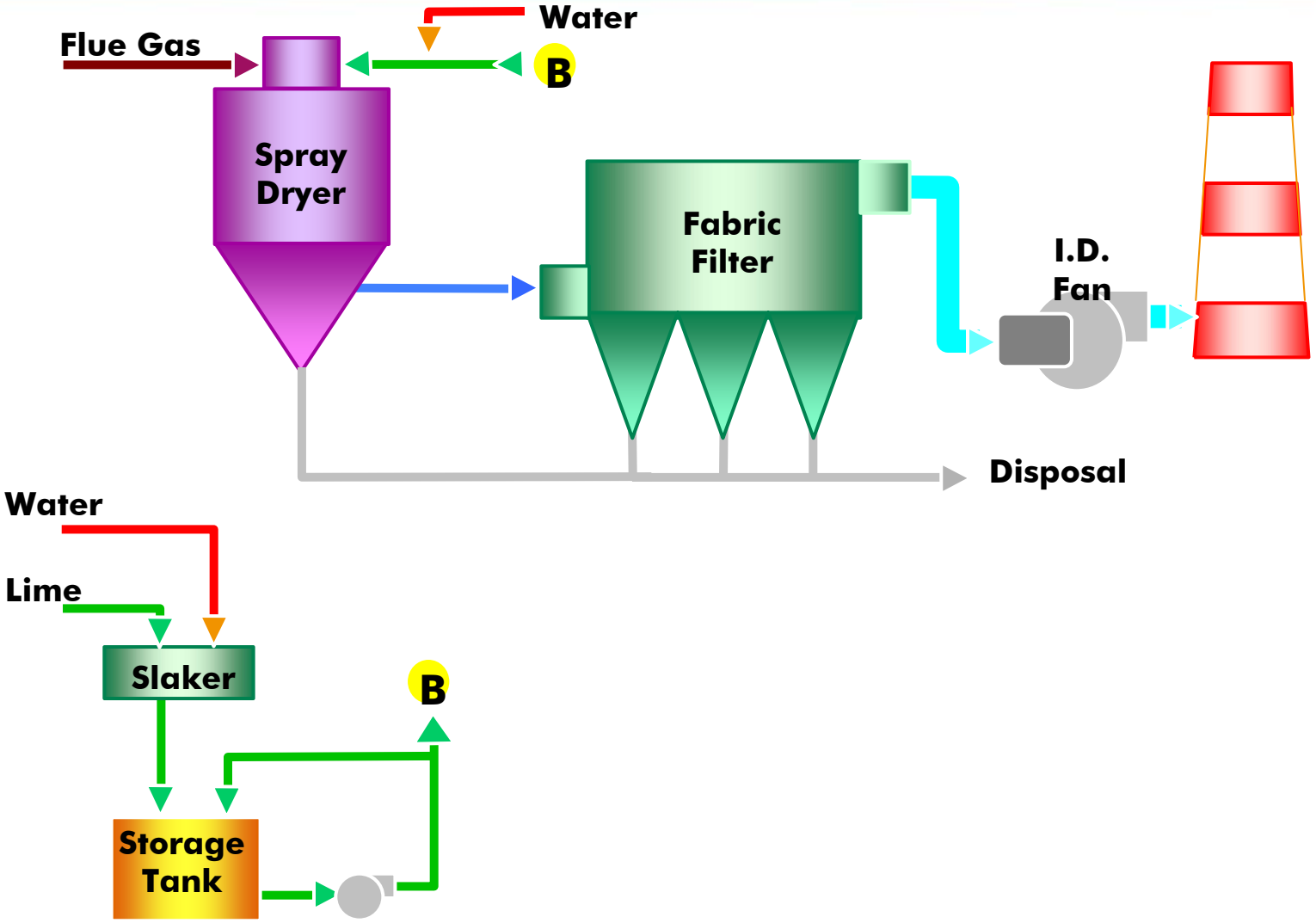
SDA Process Flow - Lime Only



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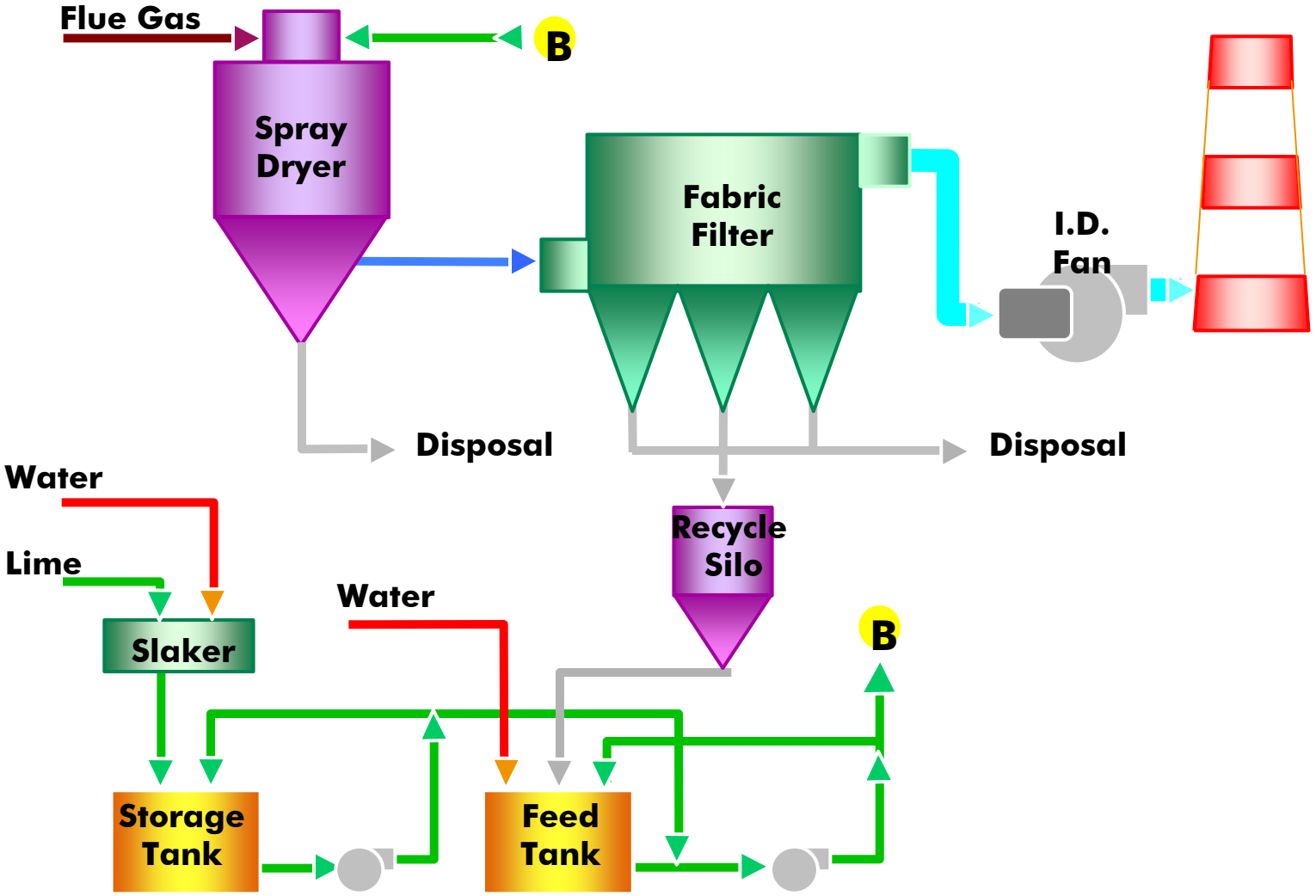
SDA Process Flow - Recycle



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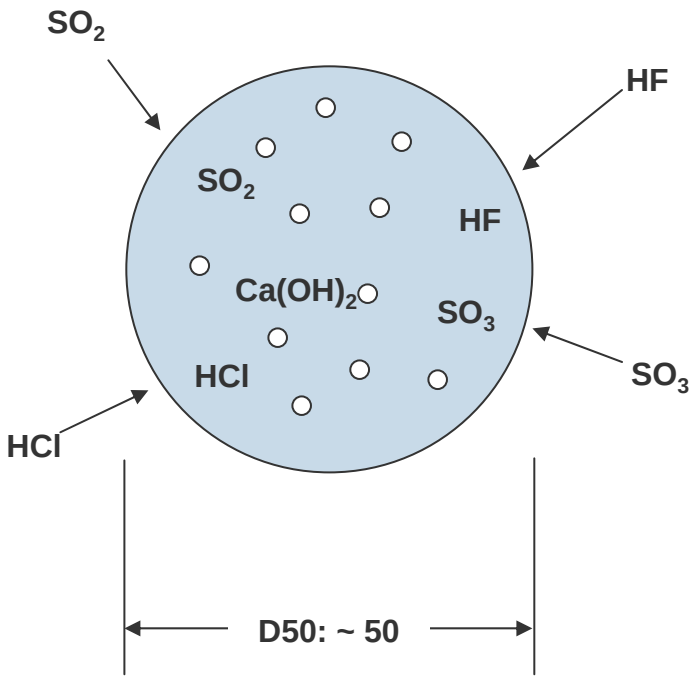
Dry Flue Gas Desulfurization - SDA

SDA - Atomization



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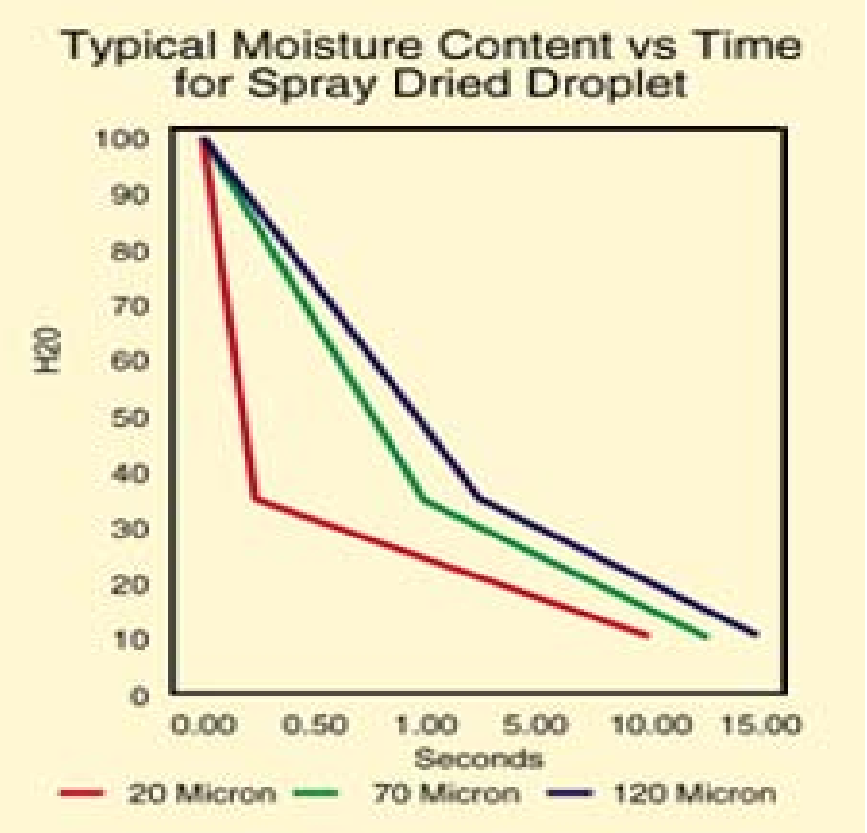
Atomizing Key to the Process

- Fine/Uniform Droplet Size
- Controlled Cloud Shape
  - Optimum Gas/Liquid Mixing
- Stable and Controlled Temperatures



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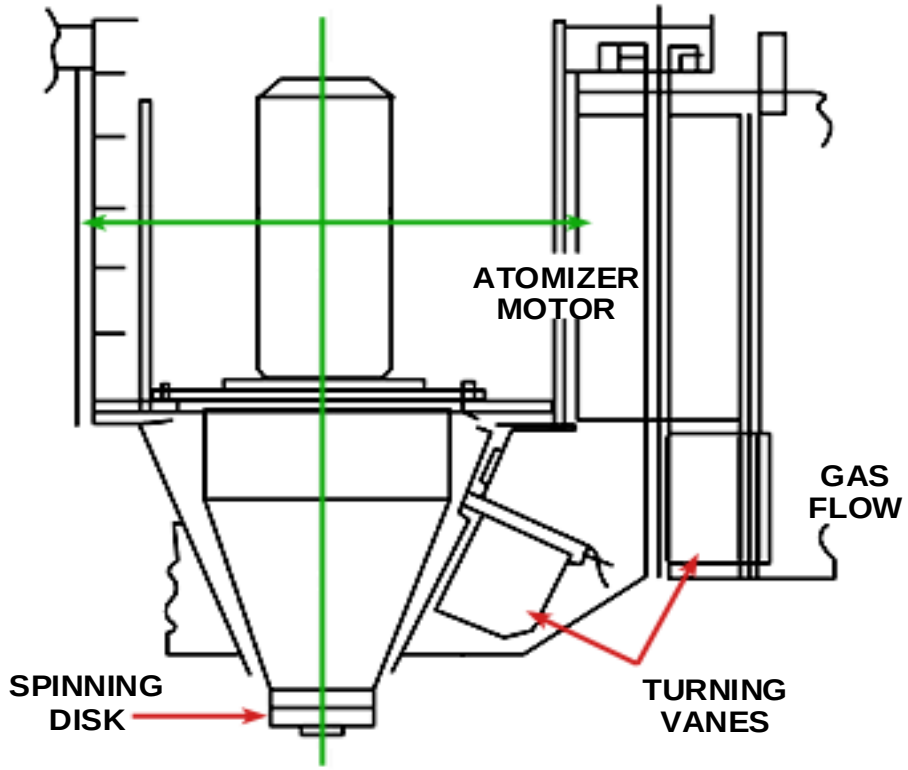
Rotary Atomizer

Inlet Gas Distributor and Atomizer

- Disk Rotates 8,000 to 13,000 rpm
- <50 Micron Droplets Created by Centrifugal and Shear Forces
- Each Atomizer Unit Operates Independently



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Rotary Atomizer

400 hp Atomizer and Oil Cooler

Atomizer Assembly

Oil Cooler

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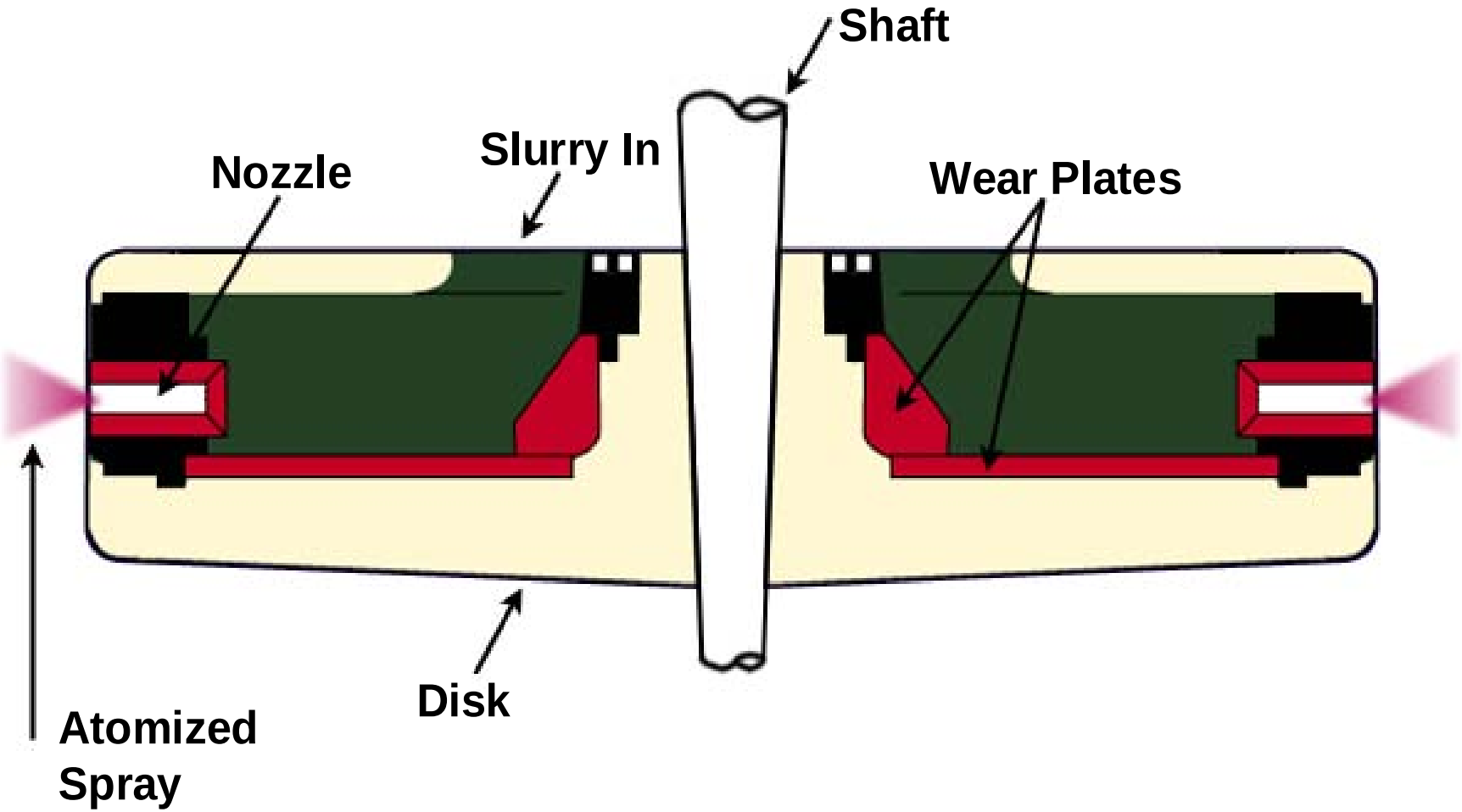
Rotary Atomizer

Rotary Atomizer Disk—Cut Away Graphic



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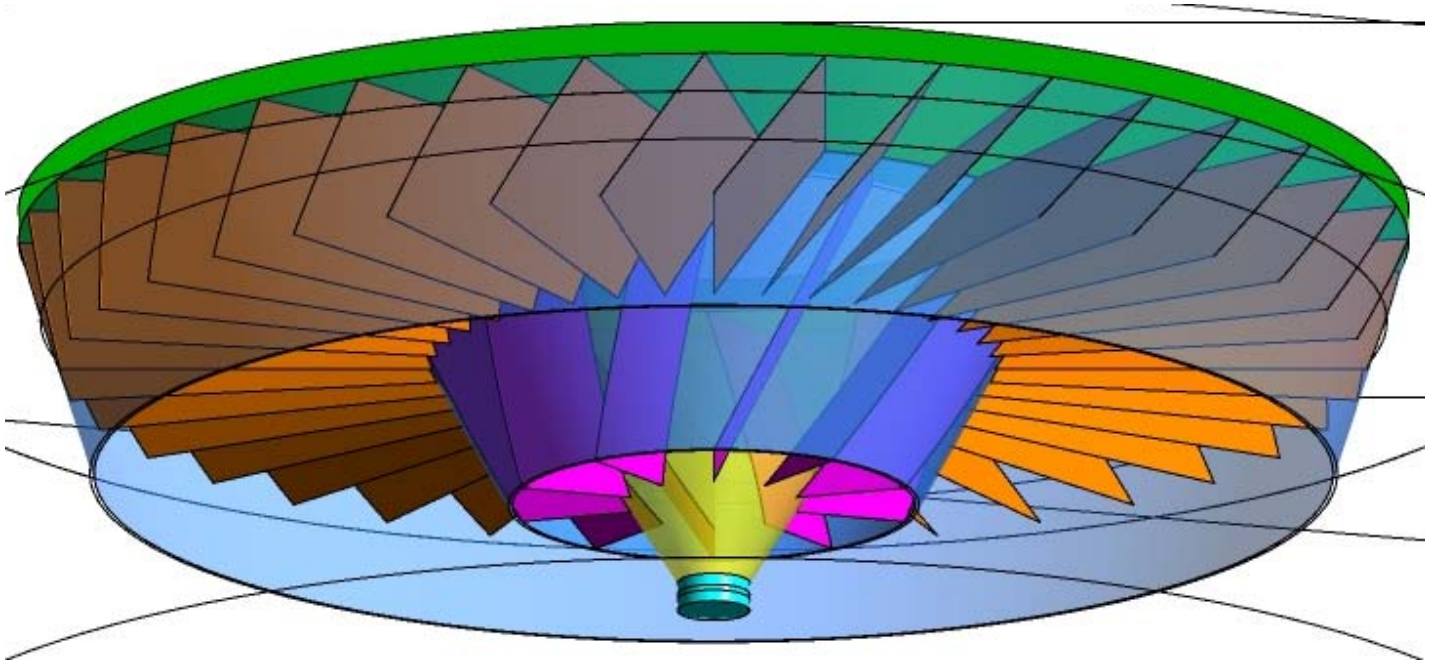
Dry Flue Gas Desulfurization - SDA

Rotary Atomizer Gas Disperser



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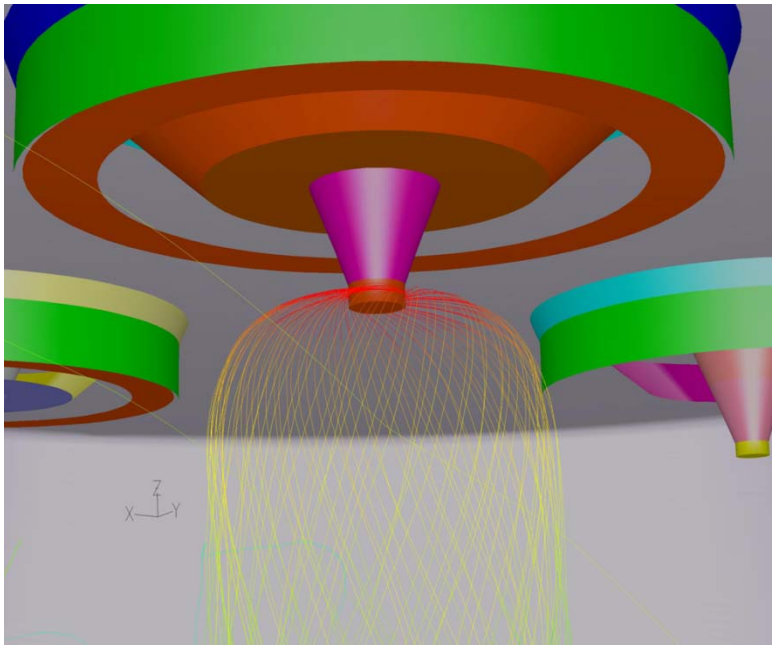
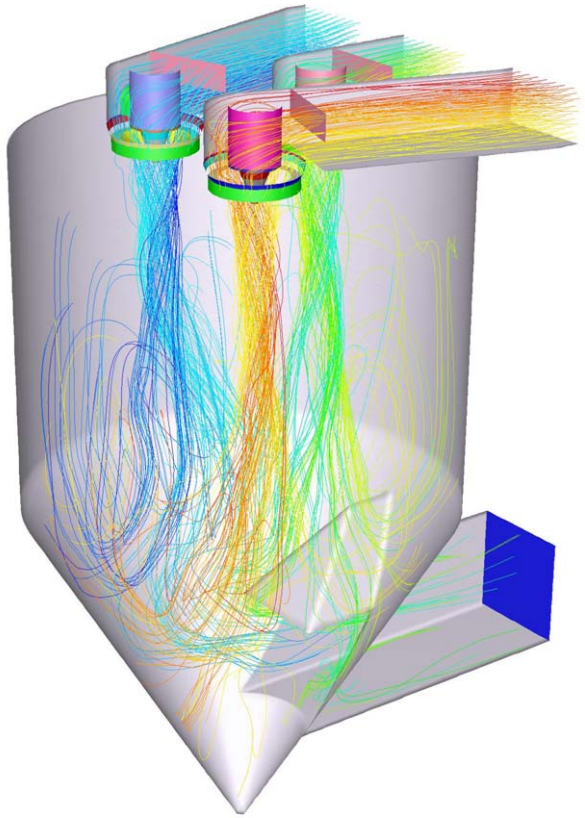
Dry Flue Gas Desulfurization - SDA

Rotary Atomizer—CFD Model



Evaporating droplet trajectories—colored by water content



Gas flow lines colored by starting location

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Dry Flue Gas Desulfurization - SDA

Rotary Atomizer

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Dry Flue Gas Desulfurization - SDA

Rotary Atomizer – Top Enclosure Area

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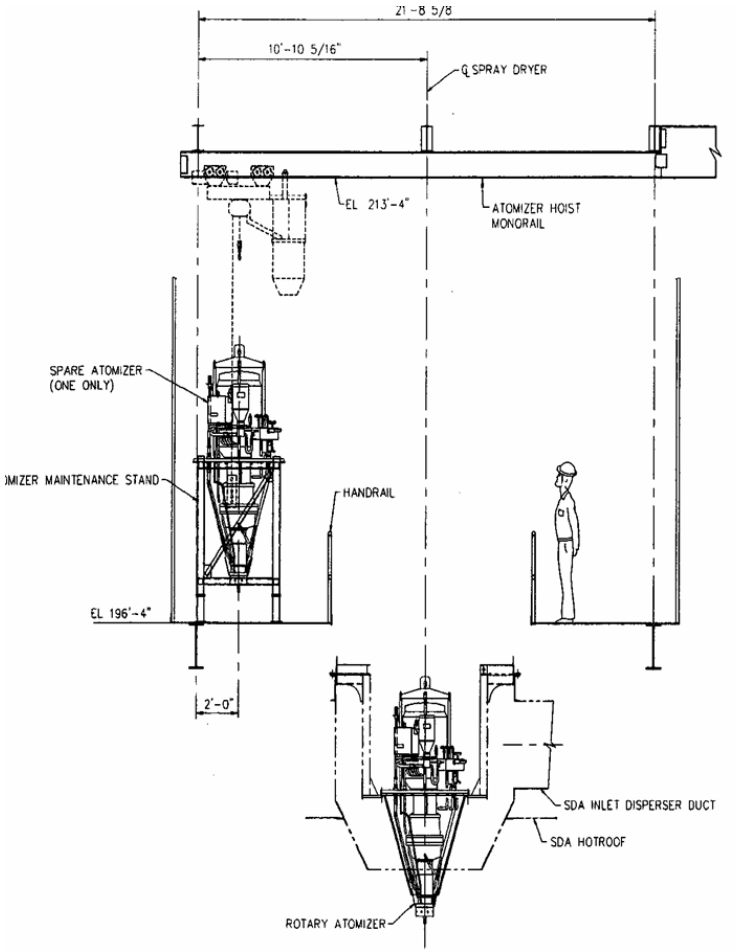
Dry Flue Gas Desulfurization - SDA

Rotary Atomizer Assembly - Removal Operations



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Dry Flue Gas Desulfurization - SDA

Alstom SDA

B&W SDA

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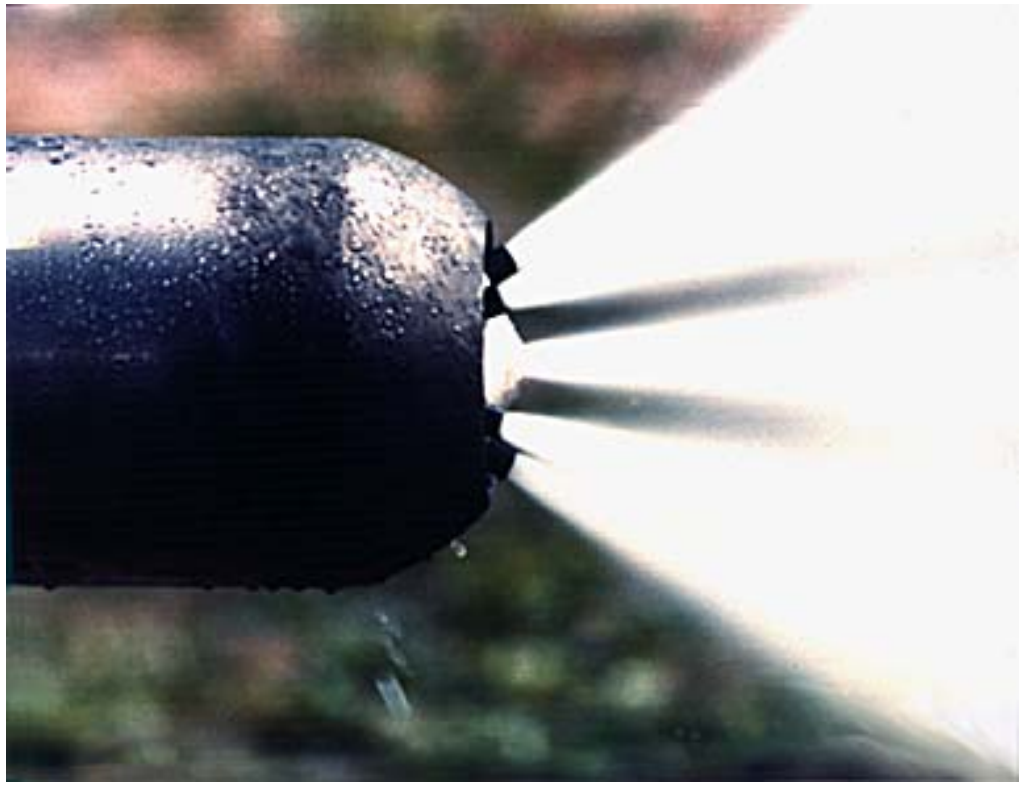
Dual Fluid Nozzle Atomization

- Air is Used to Atomize the Slurry to Fine Droplets
- Droplet Distribution 20 to 60 Microns
- Abrasion Resistant Nozzle Tips Ensure Long Life



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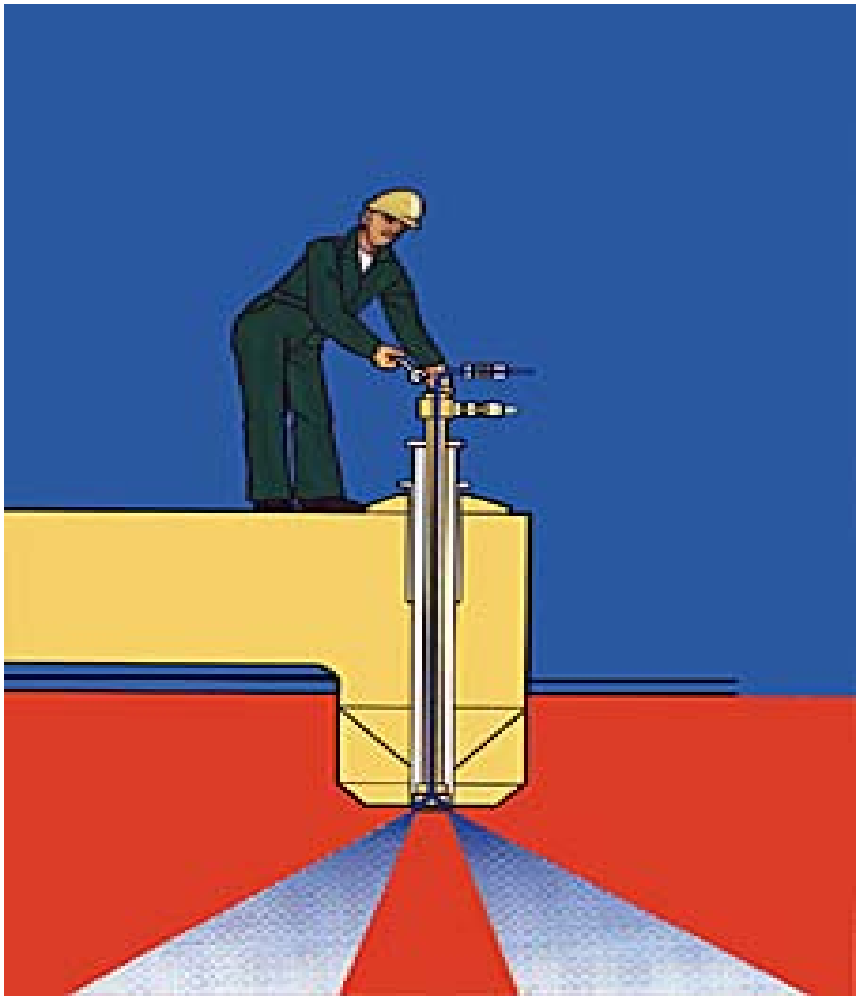
Dual Fluid Nozzle Gas Disperser

- Individual Nozzles Can Be Removed While the Spray Dryer is On-Line
- Spray Pattern is Tailored to the Spray Dryer Vessel Configuration



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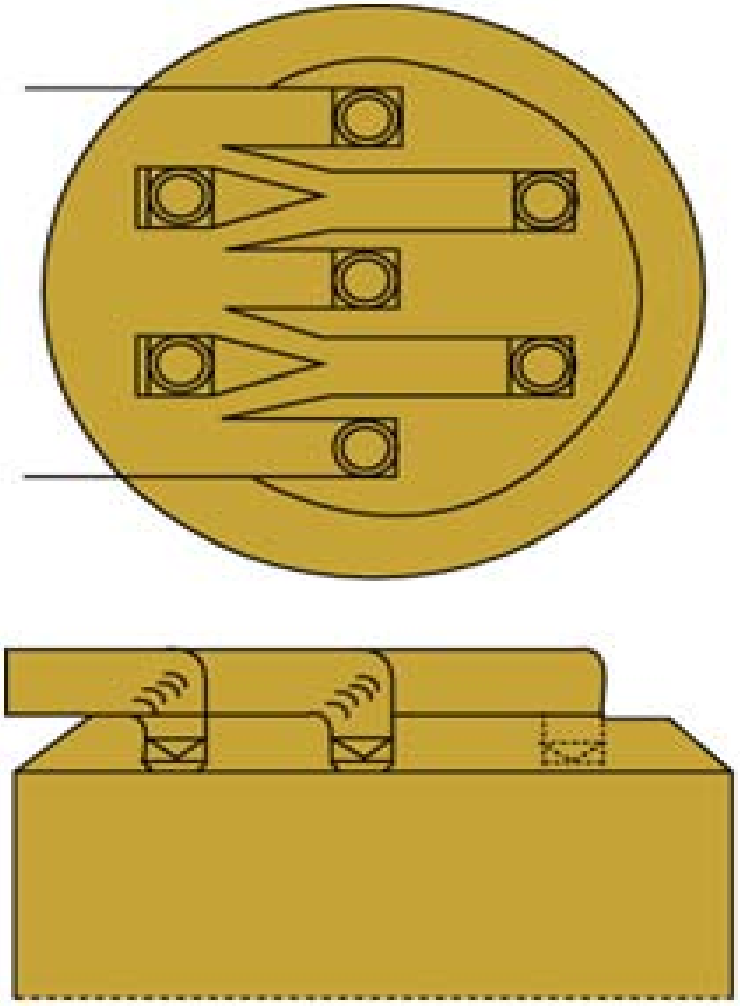
Nozzle Spray Dryer Gas Inlet

- Flue Gas is Balanced and Directed to Individual Nozzle Assemblies
- Turning Vanes Ensure Equal Gas Distribution at the Nozzle Tips



Dry Flue Gas Desulfurization – Lime Prep

Lime Unloading and Storage

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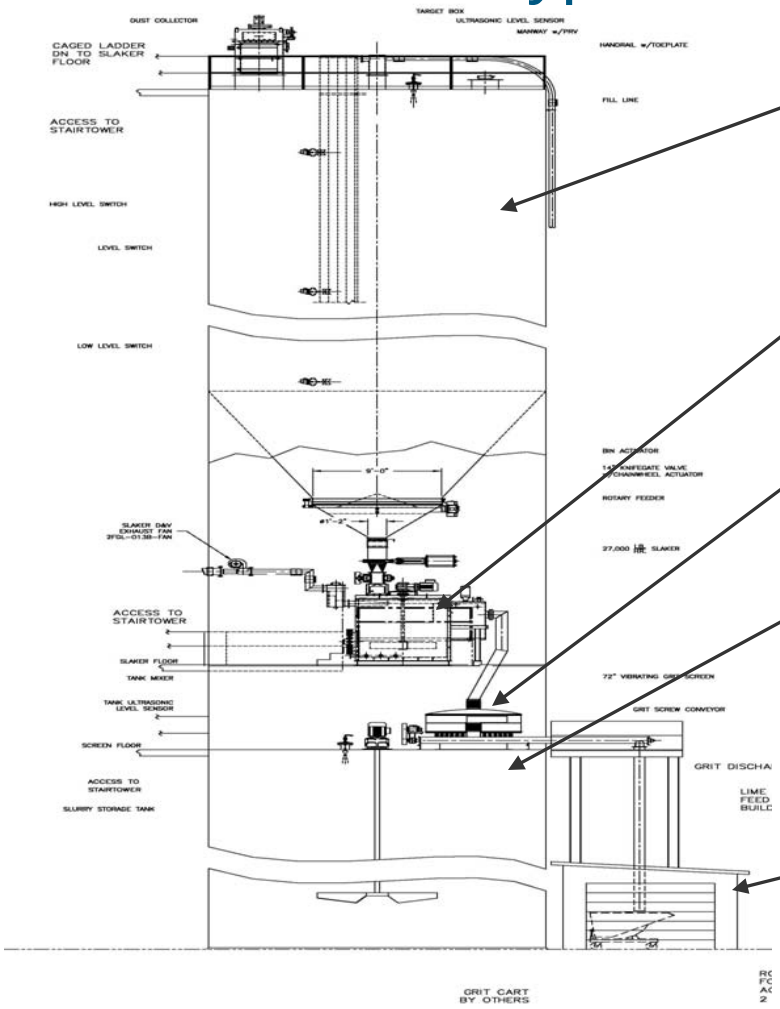
Dry Flue Gas Desulfurization – Lime Prep

Typical Lime Slaking System



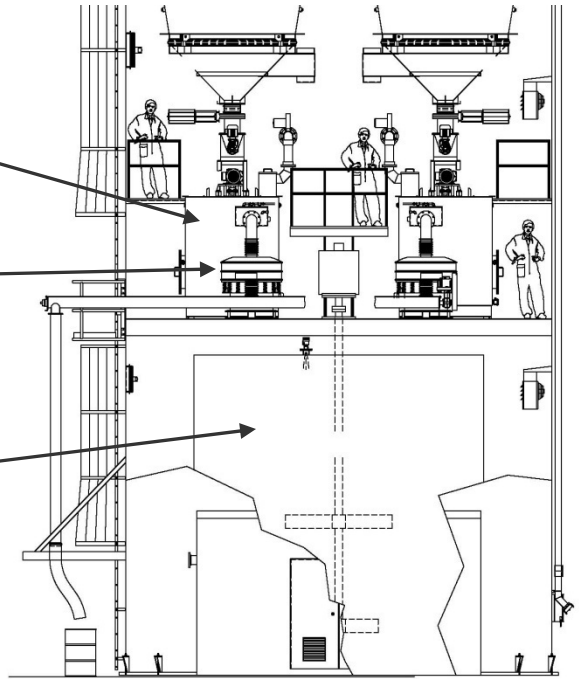
Lime Day Silo

Lime Slaker

Grit Screen

Slurry Storage Tank

Lime Slurry Pump Bldg.



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Lime Slaking Guidelines

- Slaking Temperature - 175°F +/-
- Diluted to 20% solids
- Filtered to 20 mesh or less

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Lime Quality

Particle Size:	3/4” x 0” with no more than 50% less than 10 mesh.
Availability:	90 % CaO or greater as measured by ASTM Method C25.
Reactivity:	Greater than 40 °C temperature rise at three minutes as measured by ASTM Method C110.

Dry Flue Gas Desulfurization - SDA

Detention Slaker

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Dry Flue Gas Desulfurization - SDA

Ball Mill Slaker

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Dry Flue Gas Desulfurization – Recycle System

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DFGD Process Overview

SDA Technology

NID Technology

Operations and Maintenance

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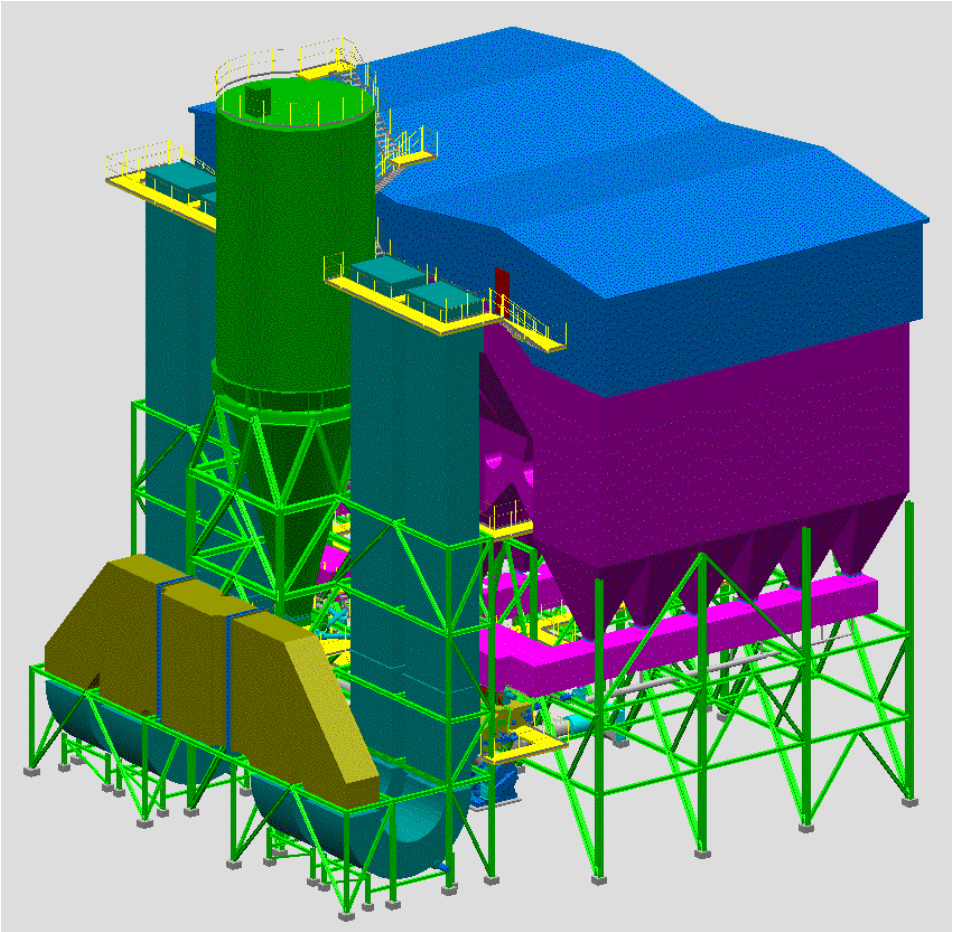
Dry Flue Gas Desulfurization - NID

- Dry lime feed is fed for SO_2 reduction
- Lime is dry slaked in a hydrator attached to the mixer.
- No slurry handling
- No separate grit stream
- Compact design
- High SO_2 removal – to 98%
- High S fuels



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Typical DFGD NID Installation

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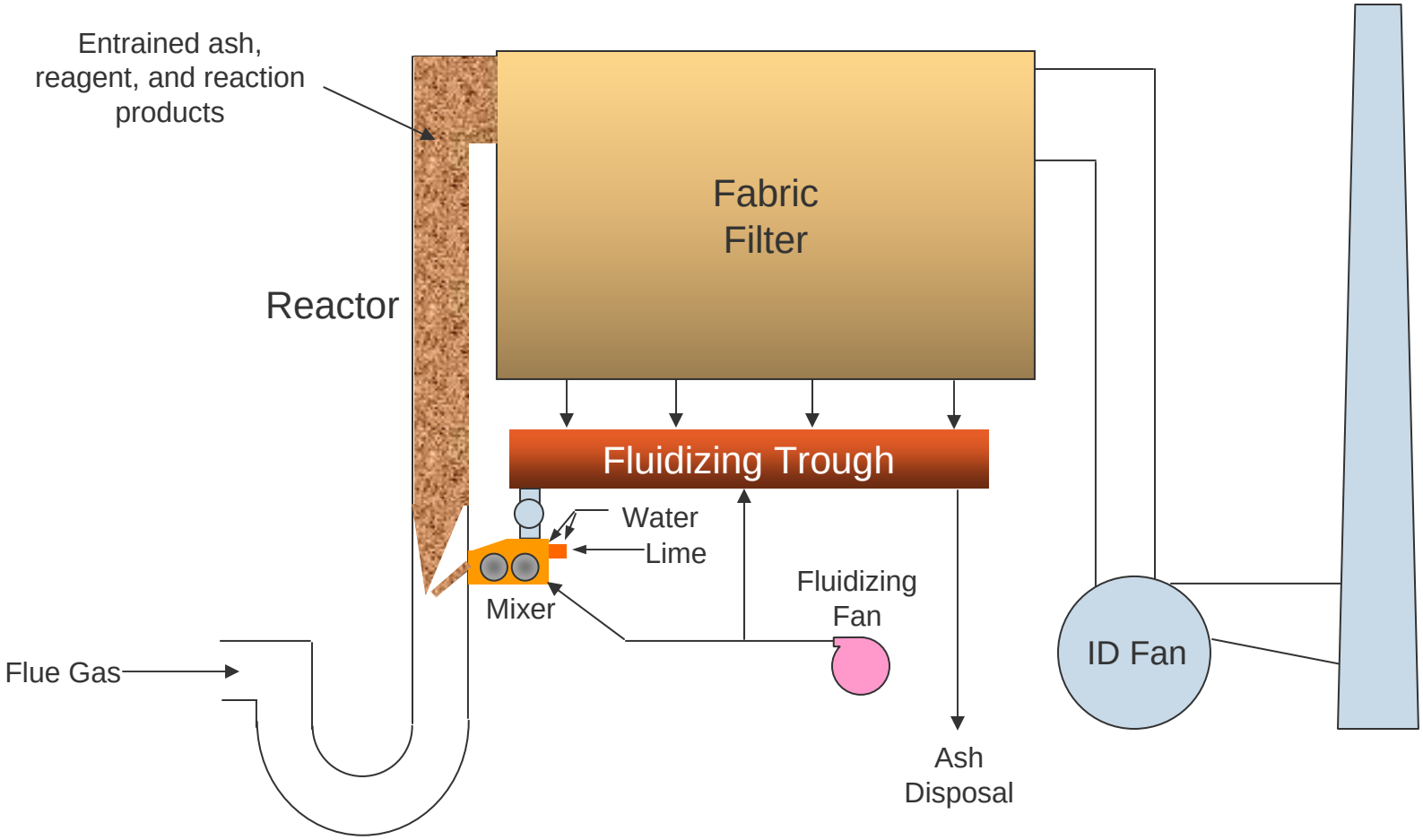
Dry Flue Gas Desulfurization - NID

NID Schematic



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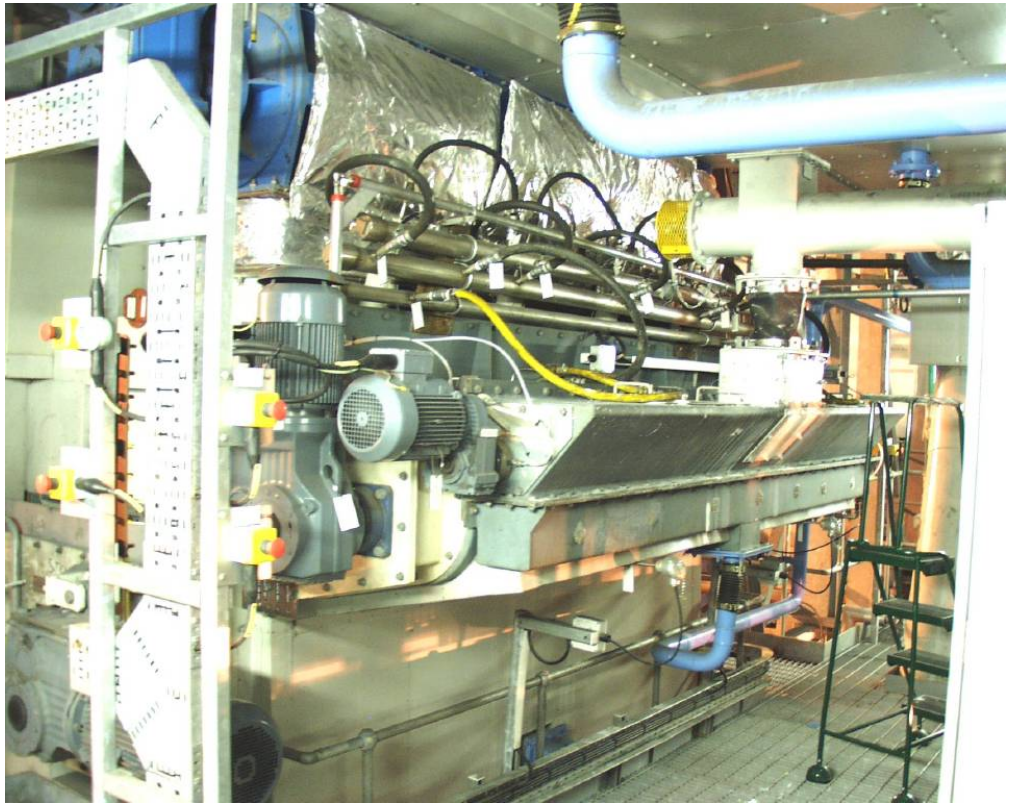
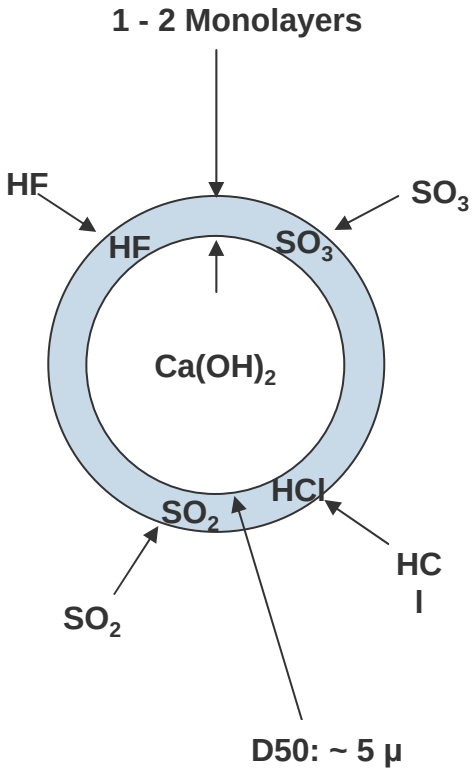
Dry Flue Gas Desulfurization - NID

NID – Mixer/Hydrator





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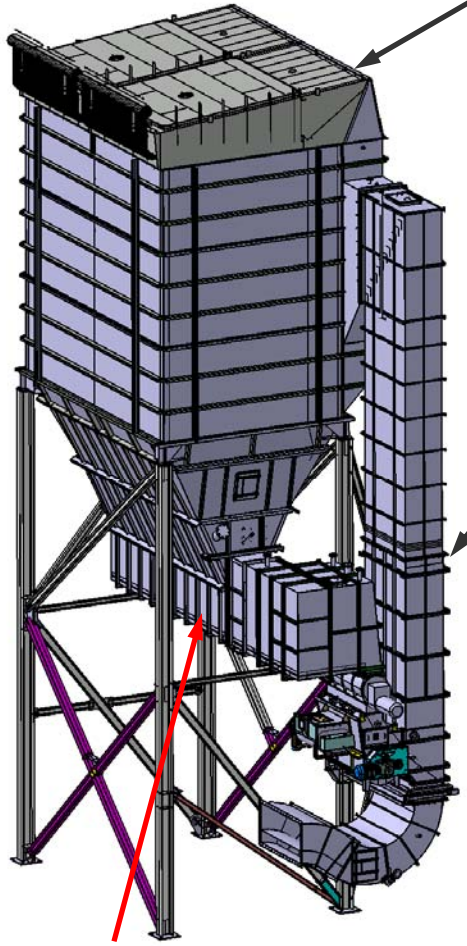
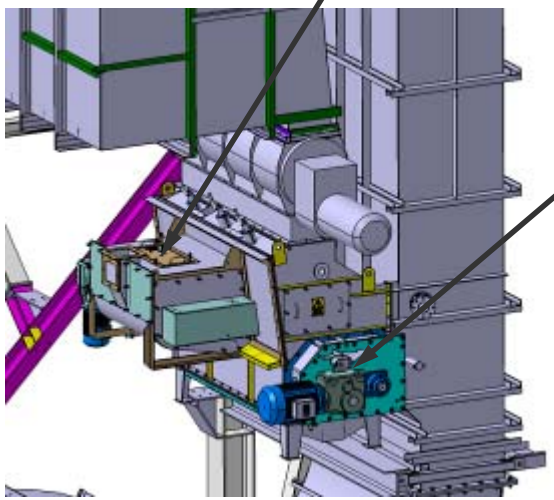
Dry Flue Gas Desulfurization - NID



Key Components

- Fabric filter
- Reactor
- Mixer
- Hydrator
- Fluid bottom



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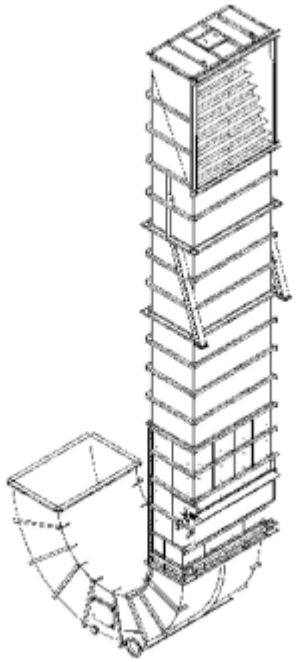
Dry Flue Gas Desulfurization - NID

“J” Duct Reactor



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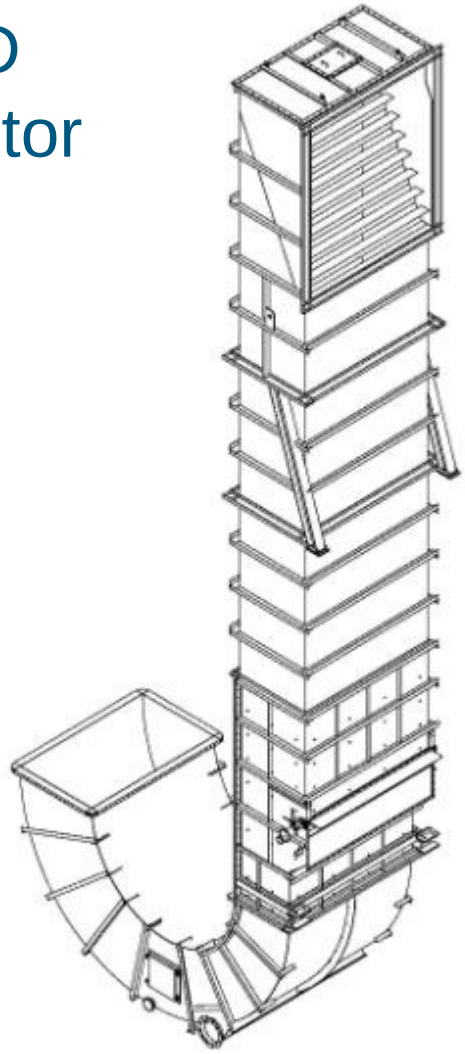
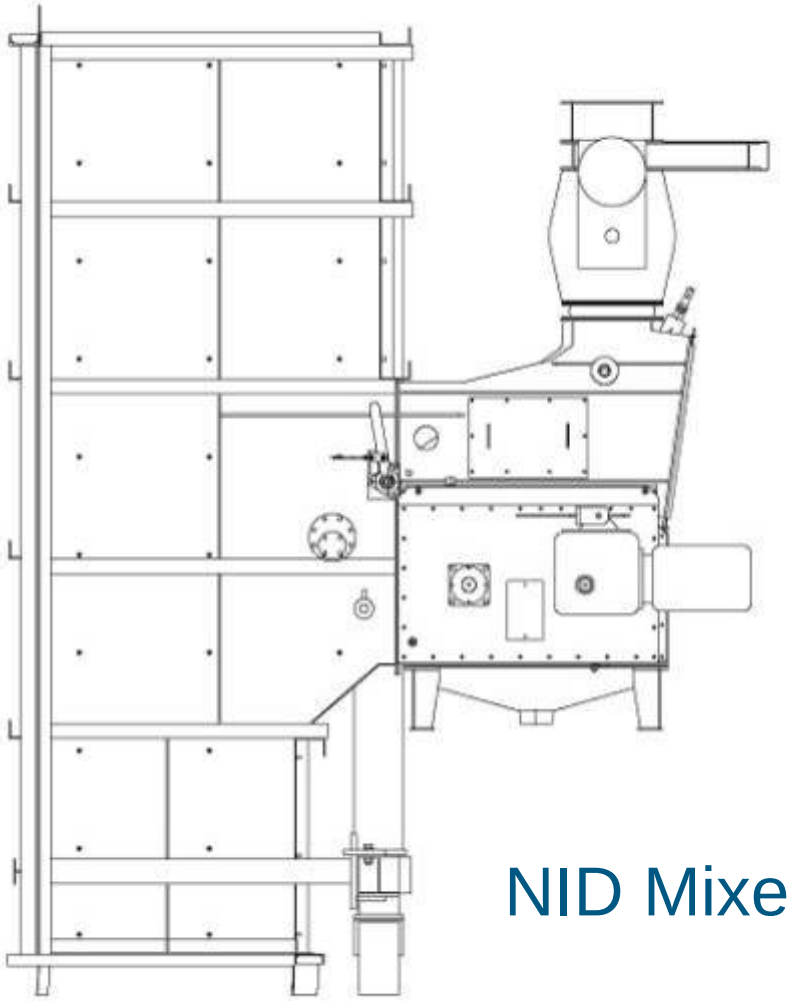
Dry Flue Gas Desulfurization - NID

NID
Reactor





NID Mixer

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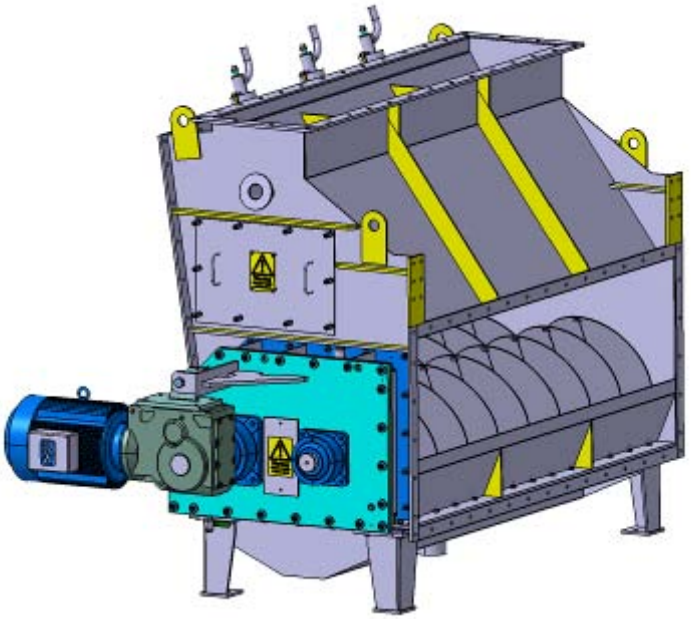
Dry Flue Gas Desulfurization - NID

NID Mixer

- Function
  - Humidifying re-circulated end product
  - Mixing humidified recirculation end product and hydrated lime
  - Located underneath fluid trough/recycle rotary feeder, connected to reactor



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Dry Flue Gas Desulfurization - NID

NID Recycle Mixer

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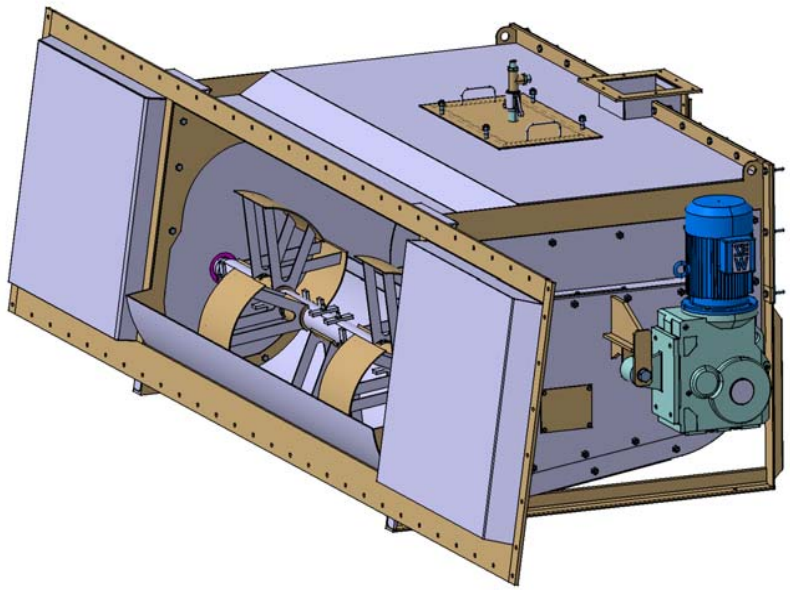
Dry Flue Gas Desulfurization - NID

Lime Hydrator

- Function
  - Hydrating lime (CaO)
- Location in plant
  - “Backpack” to Mixer



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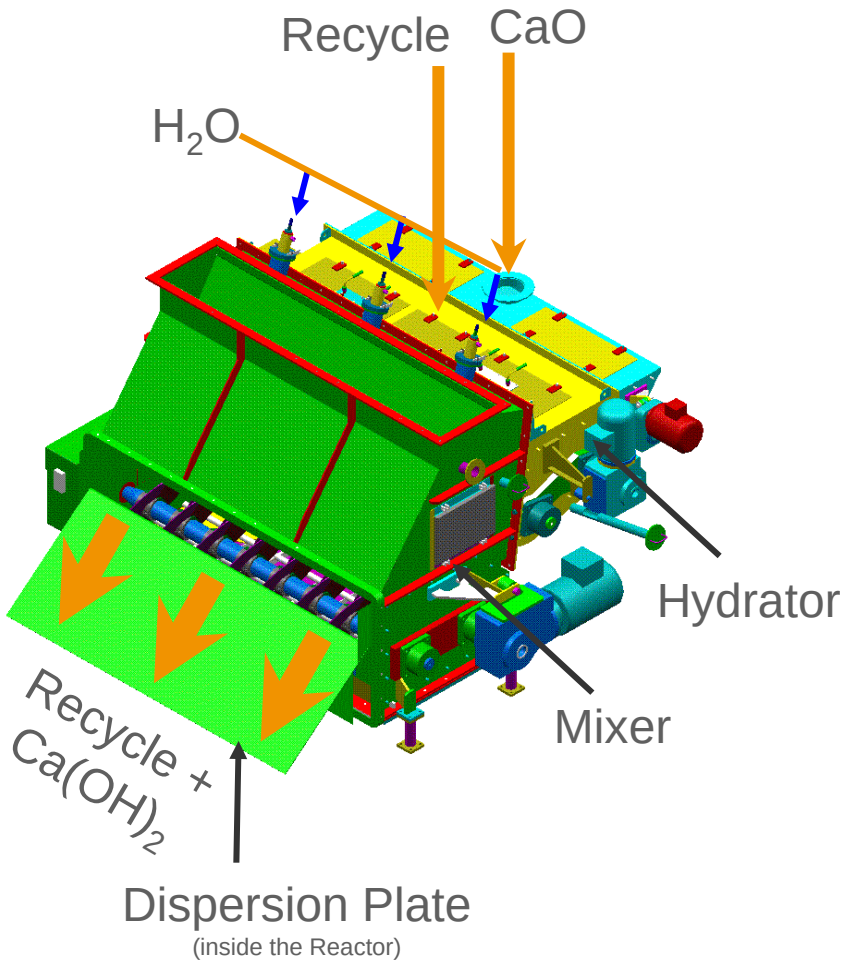
Dry Flue Gas Desulfurization - NID

Mixer & Lime Hydrator



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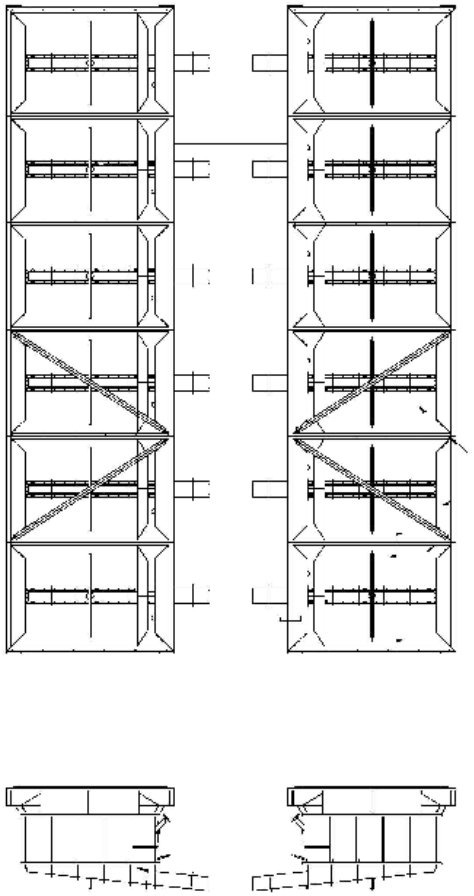
Dry Flue Gas Desulfurization - NID

Compartment Hopper Slides



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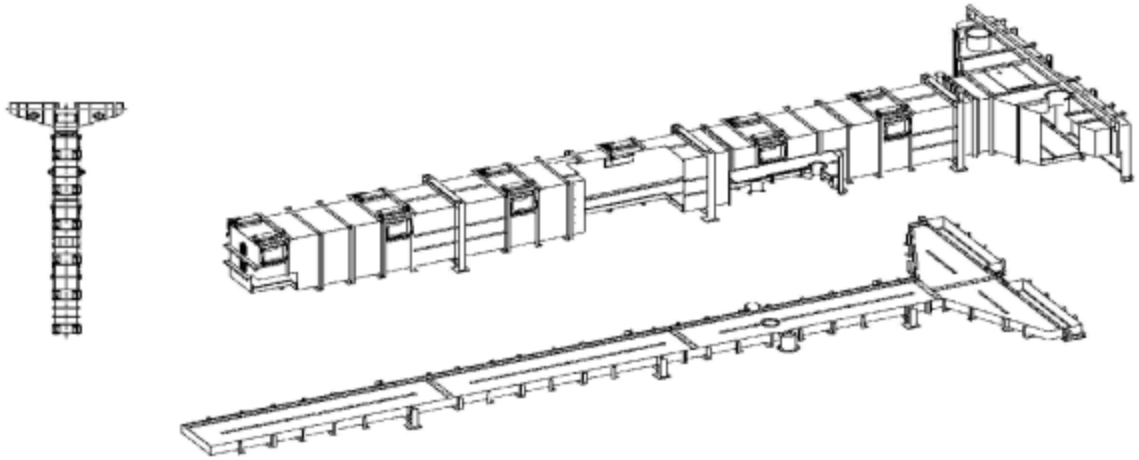
Dry Flue Gas Desulfurization - NID

Fluid Trough and Media with Ash Overflow



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Dry Flue Gas Desulfurization - NID

Fabric Filter

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Dry Flue Gas Desulfurization – CFB/NID

CFB/NID – No Separate Lime Feed

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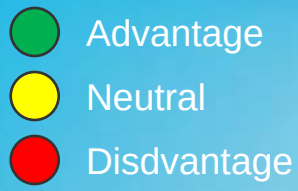
Dry Flue Gas Desulfurization



Technology Comparison	SDA	NID
Plant area required	Neutral	Advantage
Lime consumption	Neutral	Neutral
Fuel flexibility	Neutral	Advantage
System maintenance	Neutral	Advantage
Pulverized coal installed base	Advantage	Neutral
Field installation costs	Neutral	Advantage
Lime preparation system complexity	Neutral	Advantage
Retrofit to existing fabric filter	Neutral	Disdvantage
Applicability for units 400 MW and less	Neutral	Neutral
Applicability for units 400 MW and larger	Neutral	Neutral
Turndown	Neutral	Neutral

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Agenda

Introduction

DFGD Process Overview

SDA Technology

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Operations and Maintenance

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Operations and Maintenance

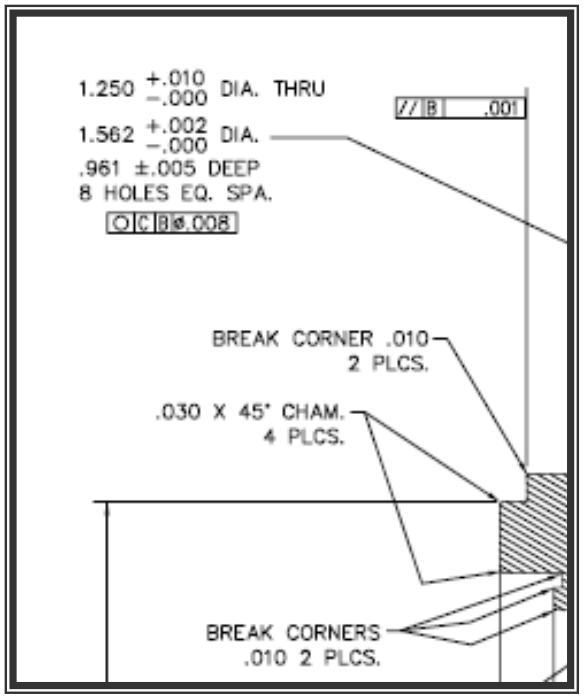
Atomizer Maintenance

- Cleaning
  - Follow Supplier cleaning requirements as a minimum
  - Maintain Cleaning Records
  - Each plant is different, and should develop individual schedules
  - Note any abnormalities and photos help

Operations and Maintenance

Atomizer Maintenance

- Replacement Parts
  - Use high quality parts
  - Use Supplier recommended materials at a minimum
  - Parts should meet strict supplier tolerances and balance



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Atomizer Maintenance

- Lubrication
  - Visually check lubricant levels daily
  - Use supplier recommended lubricants
  - Follow supplier recommended lubrication change schedule

Operations and Maintenance

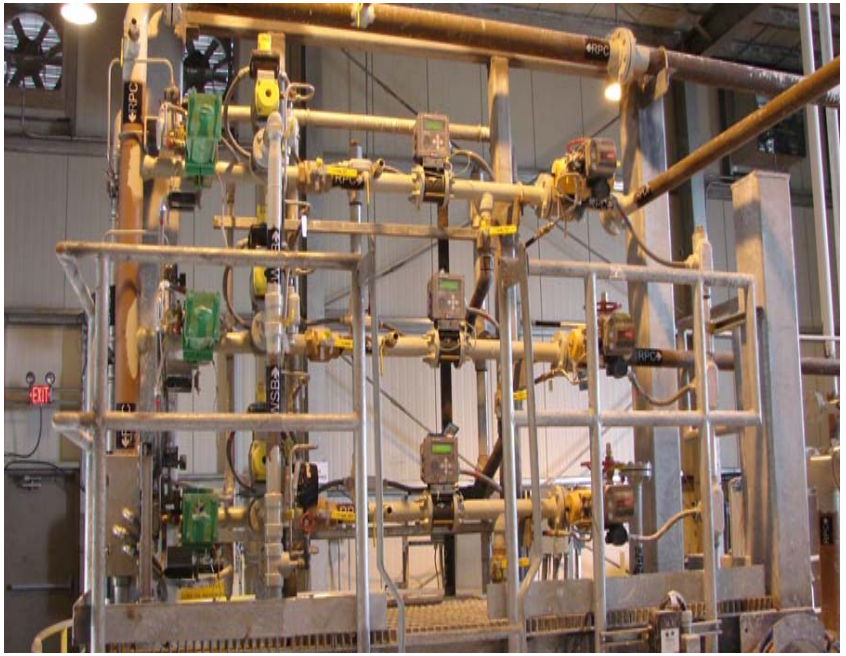
Automated Slurry Strainers

- All are not equal
- Remember “strainer” not “filter”
- Not a “turn it on and leave it” fix

Operations and Maintenance

Slurry Piping and Handling

- Arrangement
  - Flush and drain connections are your friend
  - Flushing should be planned not an afterthought
- Valving
  - Air assist-to-close
  - Actuate Valves to Avoid Sticking
- Handling
  - Recycle Slurry is not Lime Slurry
  - Flyash Impact Slurry Characteristics



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Operations and Maintenance

Lime Slaking

- Lime Quality
  - Impacts SO_2 Removal
  - Effects Slaker Efficiency
  - Excess Inerts Increase Downtime
- Water Quality
  - Sulphate effect

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Operations and Maintenance

Baghouse

- Pre-Coat
  - Pre-coat Material Selection
    - Diatomacious Earth (DE)
    - Hydrated Lime (Not Quick Lime)
    - DFGD Byproduct
    - Flyash
  - Verify Pre-coat Loading with Supplier (~1 lb / yd^2)

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Operations and Maintenance

Blinded Filter Bag

Operations and Maintenance

Corrosion

- Moisture acts as the host
  - SO_2 absorbs into residual moisture
  - The pH drops as residual $Ca(OH)_2$ is consumed
  - Acid attacks the mild steel surfaces
- Residual Moisture is created by:
  - Cold surface condensation
    - Poor insulation
    - Air inleakage
    - Hopper heater failure
  - Hygroscopic effect of $CaCl_2$

Operations and Maintenance

Corrosion Prevention

- Reduce Relative Humidity / Raise Operating Flue Gas Temperature
- Hopper Heaters
- Minimize ambient air in leakage
- Protective Coating on clean side of tube sheet
- Maintain seals and gaskets

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