Wet Flue Gas Desulphurization Systems

Babcock Power ENVIRONMENTAL
a Babcock Power Inc. company

SOx NOx 2018

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ISGEC
ISGEC Heavy Engineering Ltd.

Agenda

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Introduction

WFGD SO_2 Control Systems of BPE

- Single Loop Open Spray Tower Design
- Efficient use of reagents
- High chlorine designs
- Bidirectional nozzles installed
  - Wider-angle spray cone ensures efficient spray pattern in spray zone
  - Increase gas - liquid collisions
  - Dual direction allows for complete coverage
- Over 12 GWs in operation
- Industry leading removal efficiency
  - Greater than 99%

- >20 units: ~12,000 MW
- Open spray tower
- Dual spray nozzles and wall rings technology
- High (>99%) SO2 removal producing wallboard grade gypsum
- High Reliability: >99%

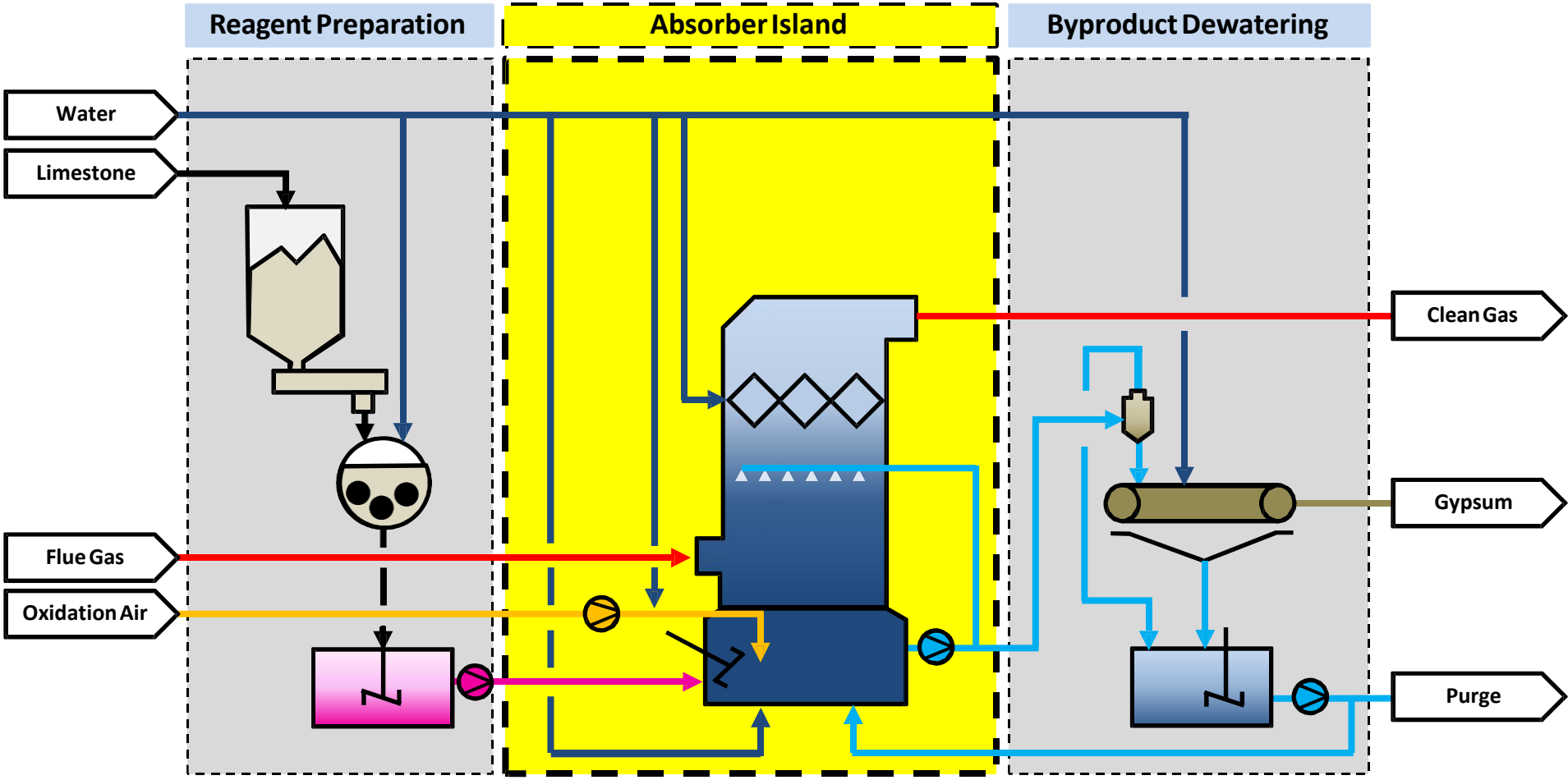
Limestone Forced Oxidation WFGD Chemistry

- Overall Chemistry

$$SO_2(g) + CaCO_3(s) + O_2(g) + H_2O(l) \rightarrow CaSO_4 \cdot 2H_2O(s) + CO_2(g)$$

Major Equipment

Major Equipment – Absorber Island



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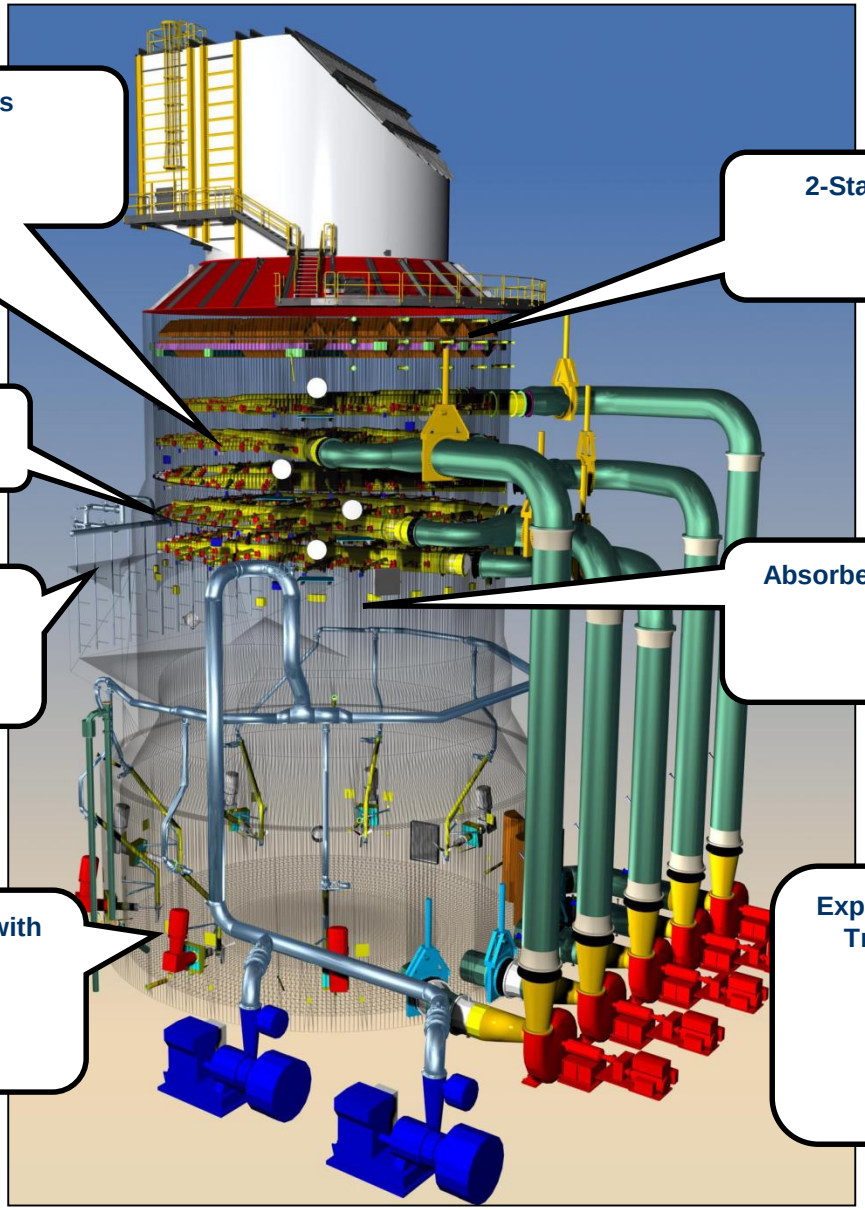

Bi-Directional Spray Nozzles

2-Stage Internal Mist Eliminator

Wall Ring

Absorber Inlet and Inlet Awning

Absorber Design Greater Than 500 MW

Reaction Tank forced oxidation with agitator

Experience with Designing Systems to Treat Flue Gas from Multiple Units

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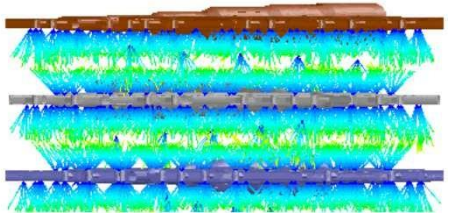
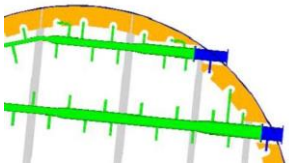
Absorber Island Components

Bi-Directional Spray Nozzles

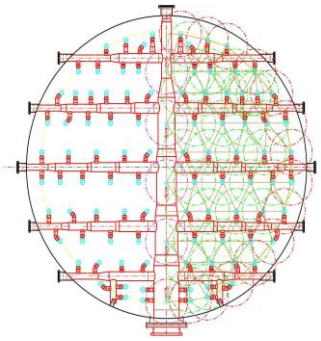


Staggered spray pattern

Inlet Flow Distribution



Absorber Baffles

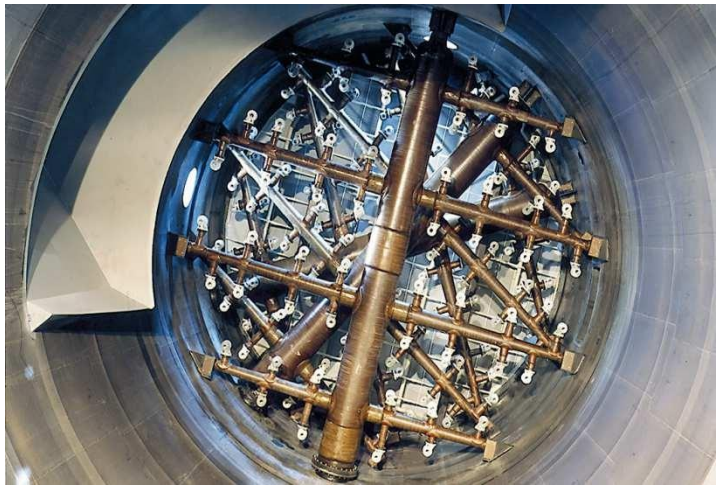


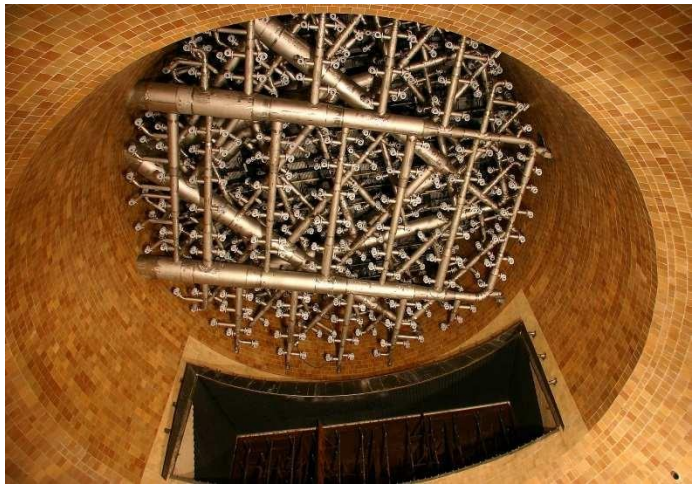
Tower Flow Distribution

Absorber Island Components – Absorber Tower

Wet/Dry Interface

Spray Headers (Single vs. Multiple Header Penetrations)

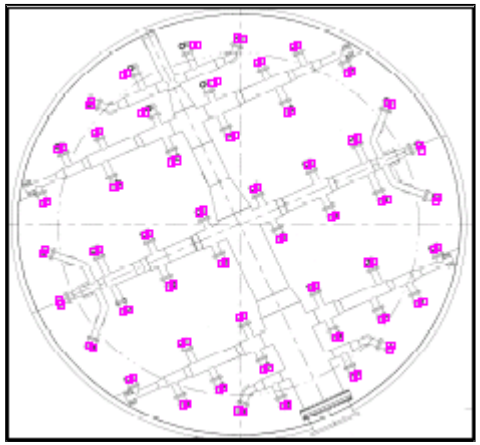




Absorber Island Components – Absorber Tower

Spray Headers – Staggered Spray Pattern

Spray Level 1



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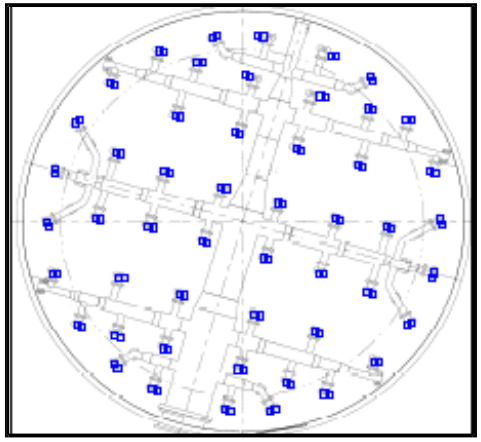
Spray Level 2



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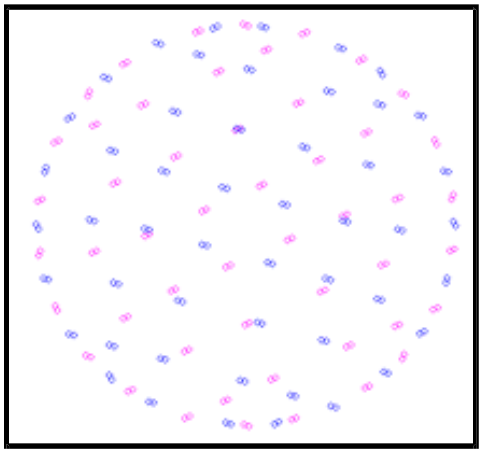
Spray Levels 1 & 2

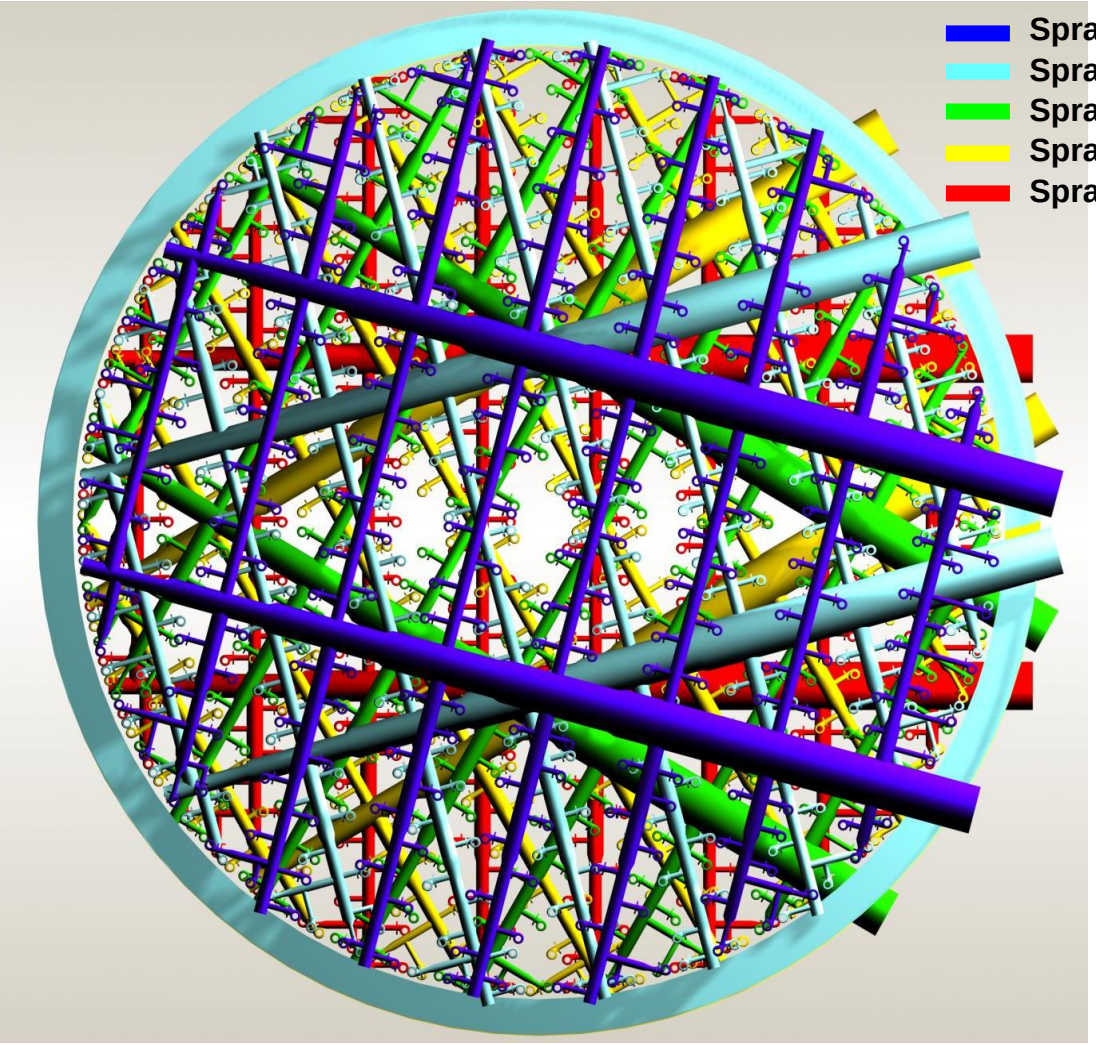


Adjacent levels are offset from one another to provide complete coverage, prevent channeling, and minimize wall sneakage.

Absorber Island Components – Absorber Tower

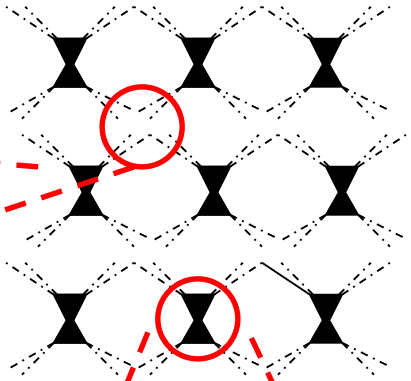
Spray Headers – Staggered Spray Pattern

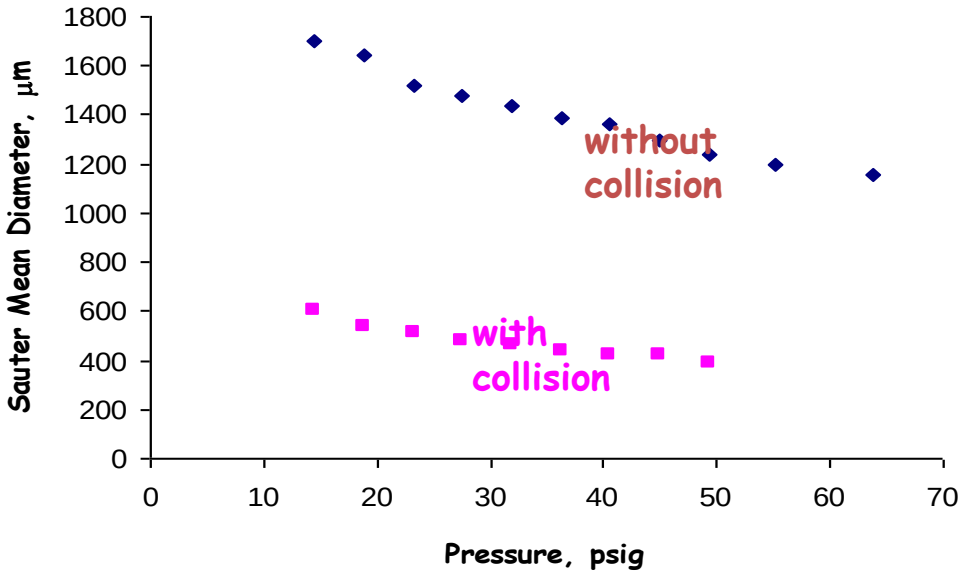
- Spray nozzles and piping arranged to minimize vertical alignment of nozzles and maximize spray pattern coverage

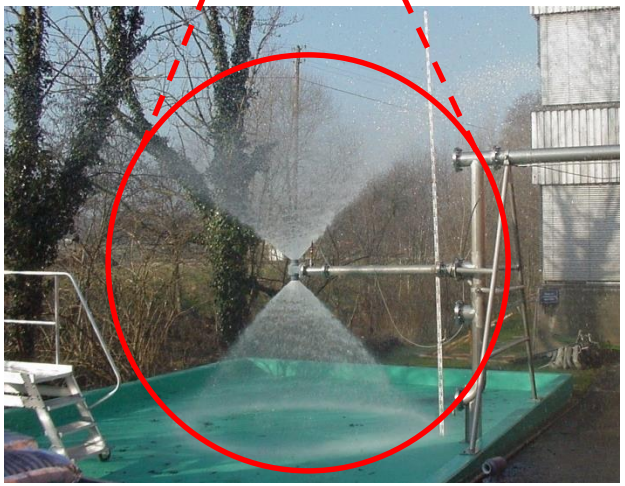


Absorber Island Components – Absorber Tower

Spray Nozzles

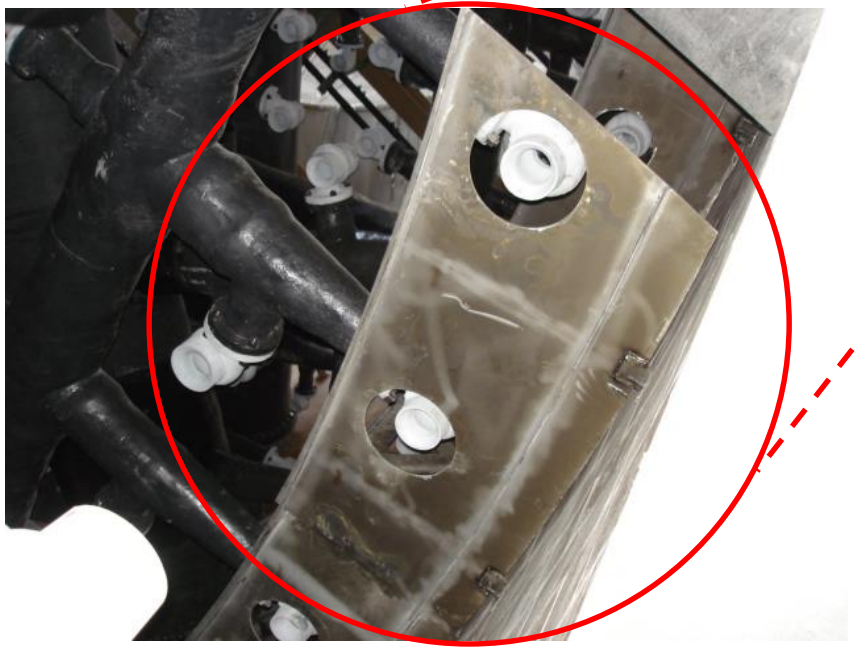


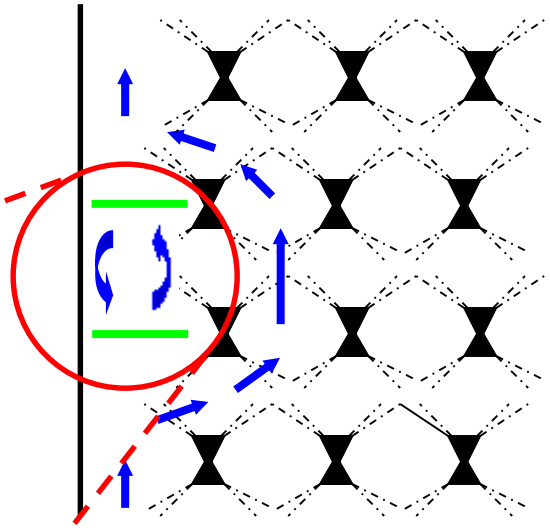




Absorber Island Components – Absorber Tower

- Absorber Baffles
  - Increase SO_2 removal efficiency by up to 3%
  - Reduce L/G by greater than 20%
  - Negligible increase in gas-side pressure drop





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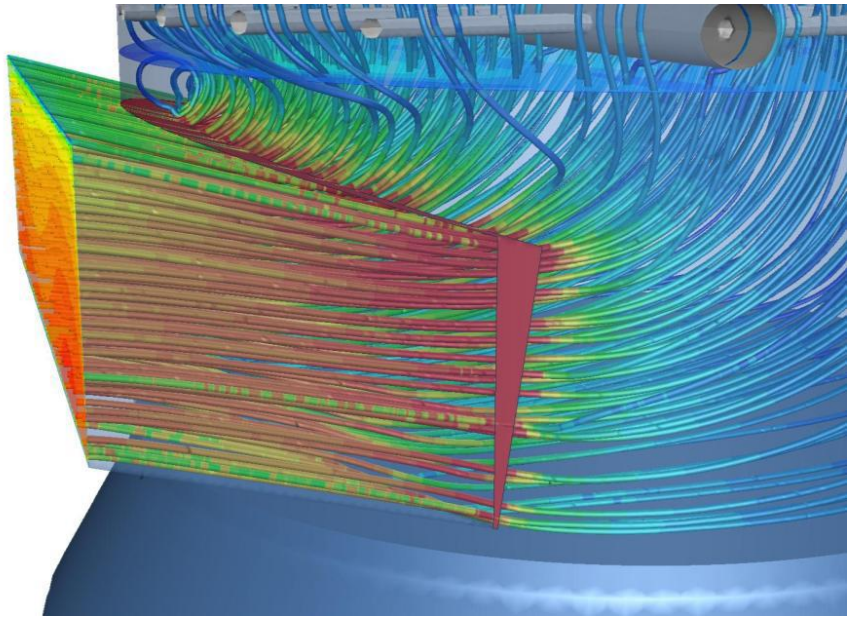
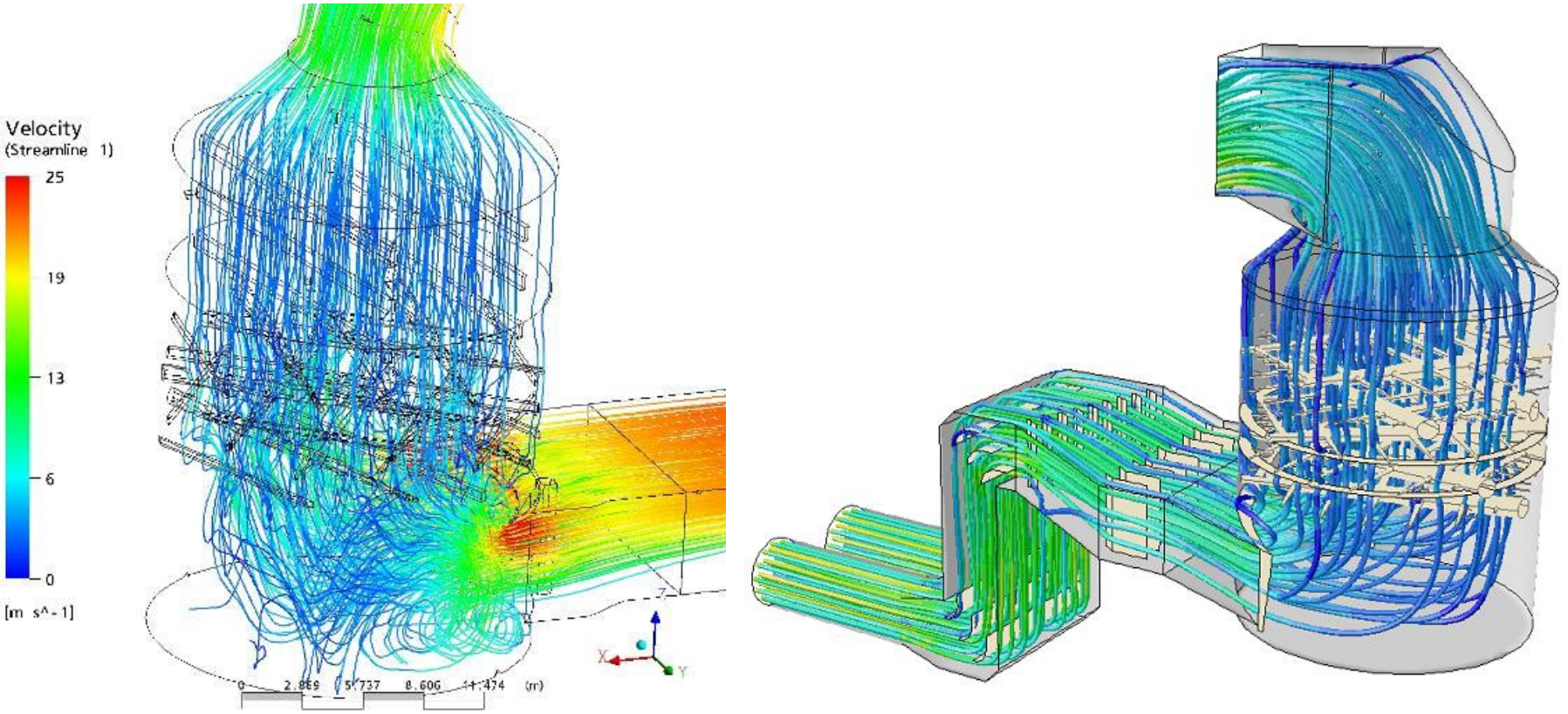
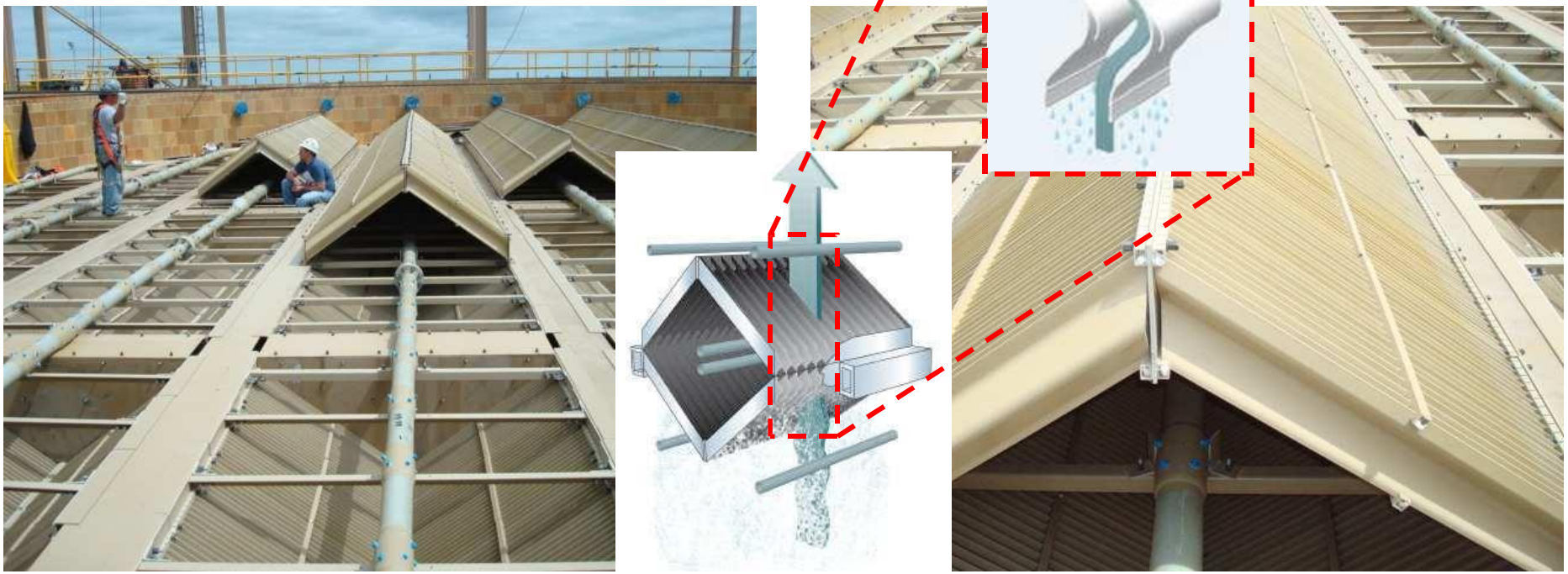


- **Extensive physical and computational flow modeling at all operating conditions to ensure no reverse flow**
- **Modeling especial important on WFGD designs treating flue gas from larger units with 4 ID fans or multiple units**



Inlet duct design and spray pattern, spray nozzle placement and wall ring prevents channeling and distributes gas over the entire cross section while delivering even slurry spray.

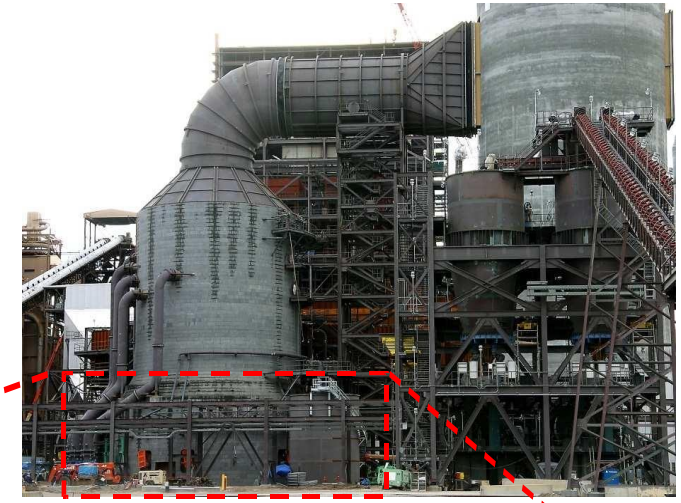
Absorber Island Components – Mist Eliminators

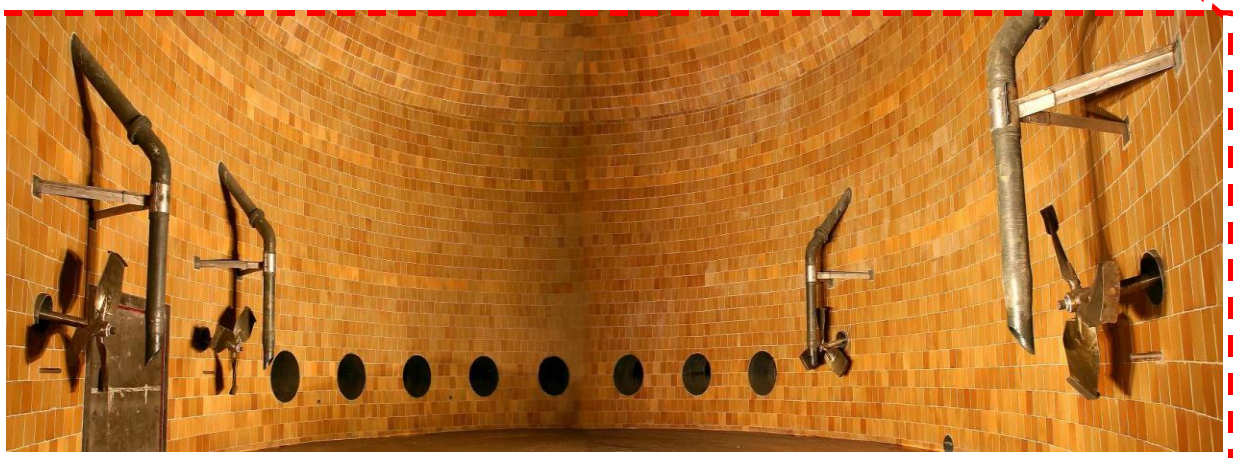


Absorber Island Components – Reaction Tank & Agitators

Agitators

- Solids Suspension
- Oxidation Air Dispersion





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Absorber Island - Components

- Recycle Pumps

- External Spray Headers

- Mist Eliminator Wash Pumps

- Oxidation Air Blower

- Oxidation Air Distribution Piping

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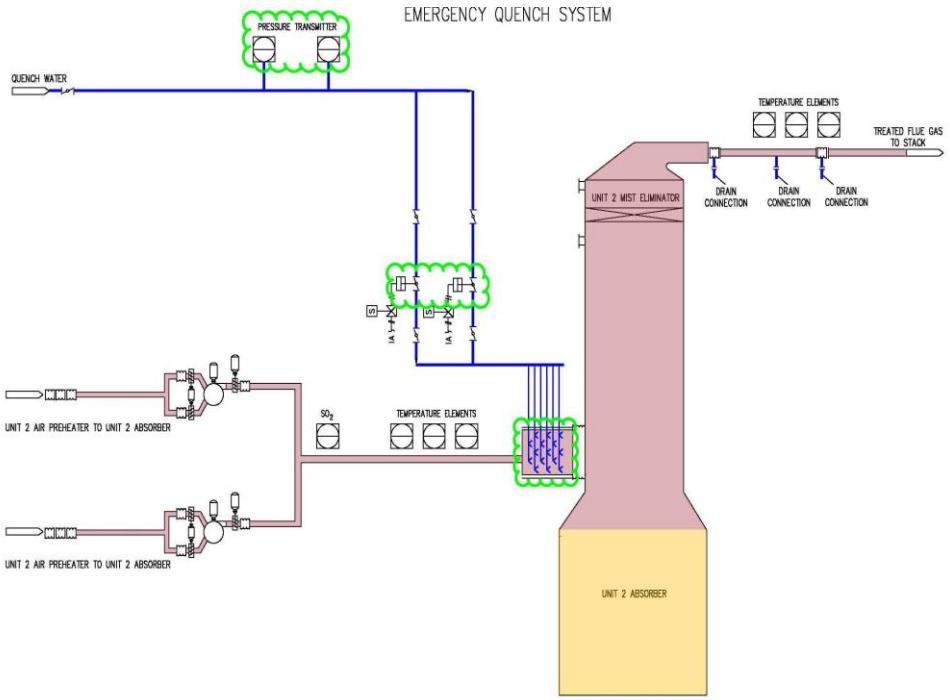
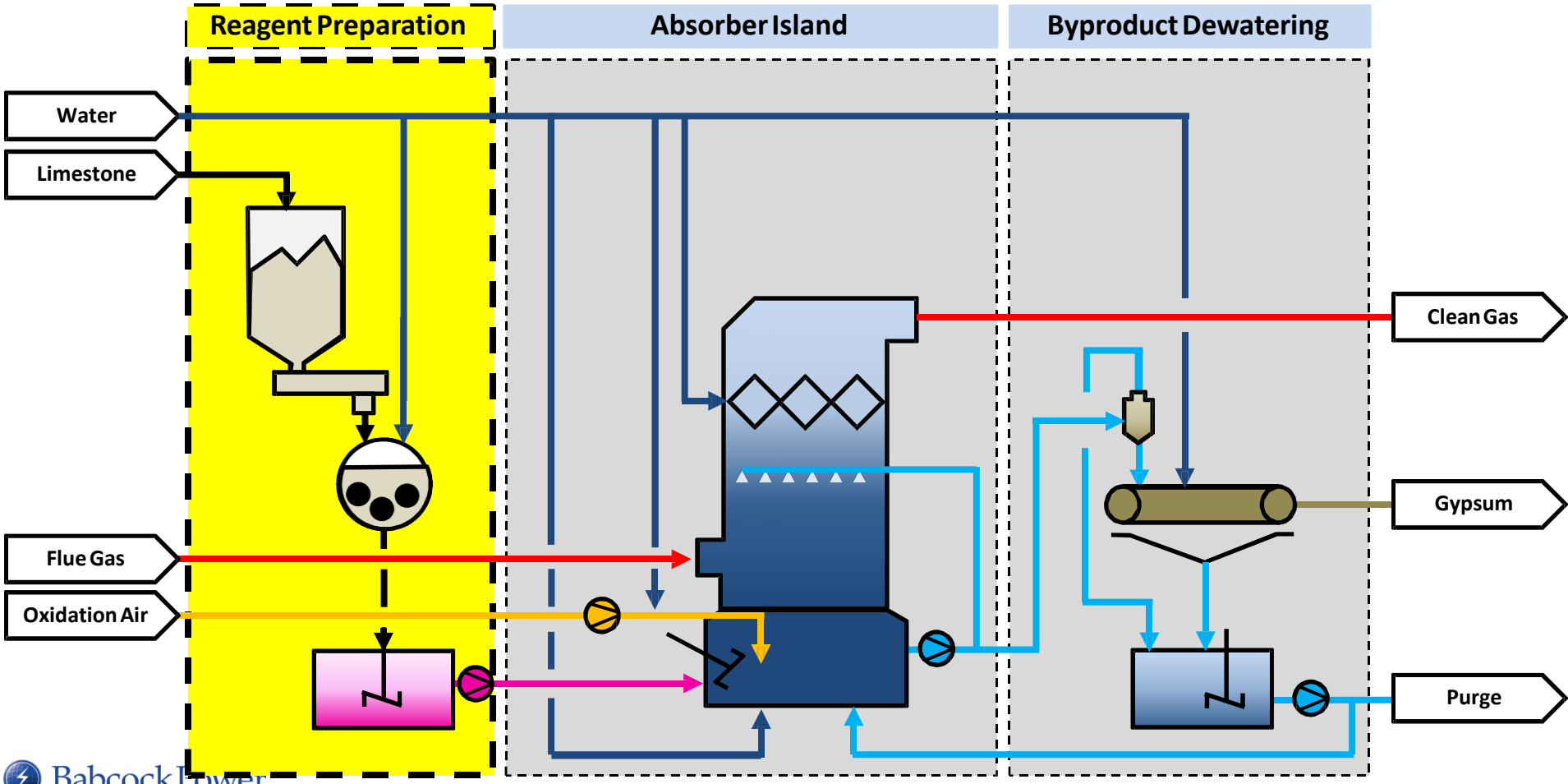
Absorber Island - Components

- Mist Eliminator Wash Headers

- Emergency Quench Headers



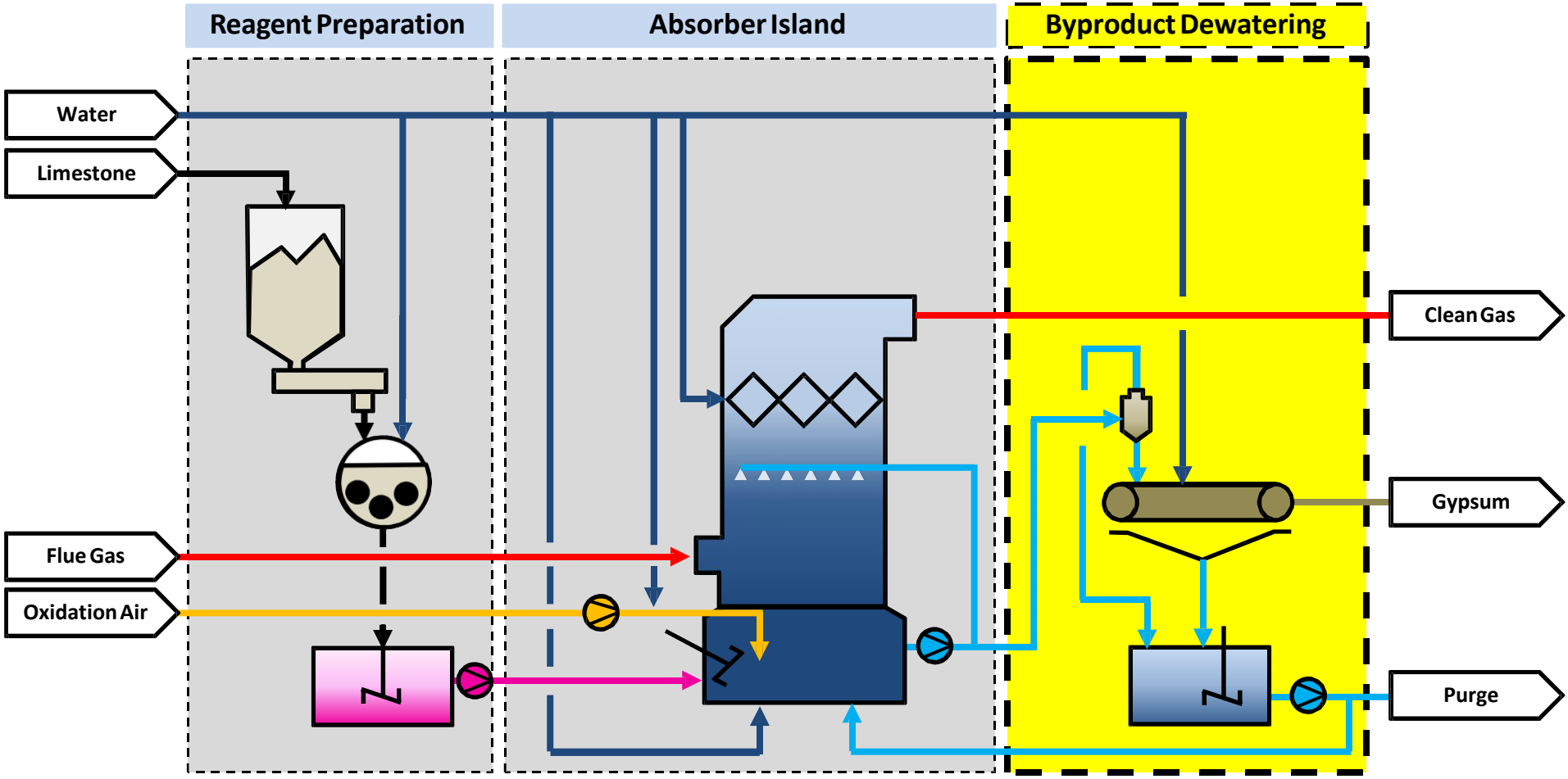
Reagent Preparation



Reagent Preparation

- Limestone Silo System
  - Limestone Storage Silo
  - Bin Vent Filter
  - Isolation Valve
  - Weigh Feeder
- Limestone Slurry Preparation
  - Horizontal or Vertical Ball Mill
  - Mill Slurry Tank, Agitator, and Pump
  - Mill Classifier
- Limestone Slurry Storage and Feed
  - Limestone Slurry Tank and Agitator
  - Limestone Slurry Pumps

Dewatering


Reagent Preparation
Absorber Island
Byproduct Dewatering
Water
Limestone
Flue Gas
Oxidation Air
Clean Gas
Gypsum
Purge

Dewatering Components

- Hydrocyclone Feed Tanks and Agitators
- Hydrocyclone Feed Pumps
- Primary Dewatering Hydrocyclones
- Secondary Dewatering Hydrocyclones
- Vacuum Belt or Rotary Drum Filters
- Reclaim Water Tanks and Agitators
- Reclaim Water Pumps
- Wastewater Tanks and Agitators
- Wastewater Pumps
- Transfer Conveyors

Typical Guarantees – Wet FGD

Typical Guarantees Provided

- SO_2 reduction
- Reagent consumption
- Gypsum oxidation and quality
- Pressure drop
- Water consumption
- Turndown
- Power consumption
- Availability

Multiple Unit Wet FGD Solution

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Multiple Unit Wet FGD Solution

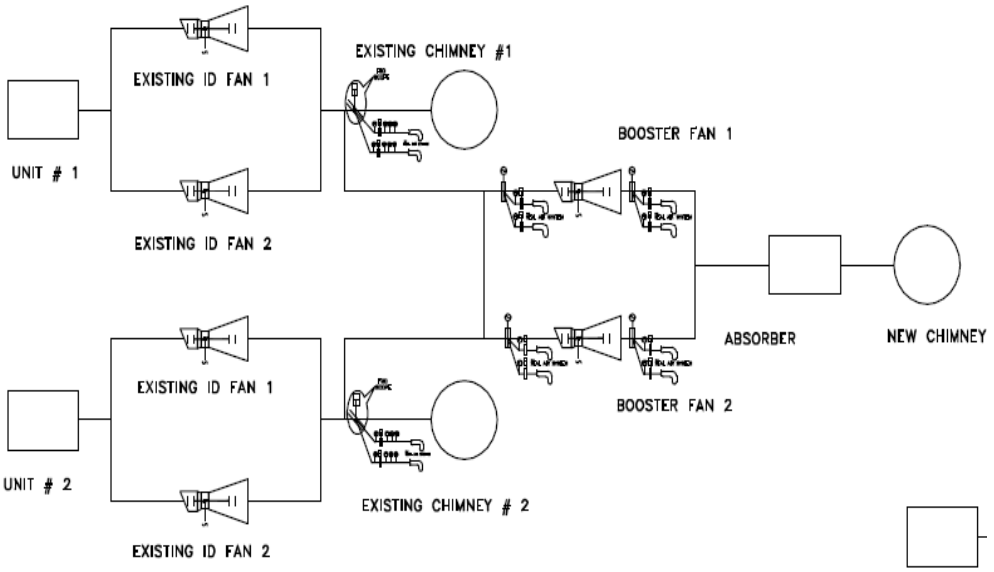
- Flue Gas from 2-3 Boiler Units ranging up to 250 MW each can be combined and treated in a single absorber.

Advantages:

- Lower Capex Solution
- Lower OPEX
- Minimizes Space Constraint

Constraints:

- Availability
- Operational Flexibility



Babcock Power References

FGD Project Reference – SCE&G Wateree U1&2

SCE&G Wateree Units 1 & 2 Eastover, SC	
SIZE OF UNIT(S), MW	700
NUMBER OF ABSORBERS	1
FUEL TYPE	Bituminous
FUEL SULFUR CONTENT, %	2.00
FLUE GAS FLOW, SCFM	1,735,568
REAGENT	Limestone
OXIDATION	Forced
END PRODUCT	Gypsum
SO_2 REMOVAL	98.0
DATE OF START-UP	2010

FGD Project Reference – LG&E-KU Brown U1,2&3

LG&E-KU Brown Units 1, 2, & 3 Harrodsburg, KY	
SIZE OF UNIT(S), MW	750
NUMBER OF ABSORBERS	1
FUEL TYPE	Bituminous
FUEL SULFUR CONTENT, %	3.80
FLUE GAS FLOW, SCFM	1,971,997
REAGENT	Limestone
OXIDATION	Forced
END PRODUCT	Gypsum
SO_2 REMOVAL*	98.0
DATE OF START-UP	2010

FGD Project Reference – LG&E-KU Mill Creek U1&2

LG&E-KU Mill Creek 1&2 Louisville, KY	
SIZE OF UNIT, MW	660
NUMBER OF ABSORBERS	1
FUEL TYPE	Bituminous
FUEL SULFUR CONTENT, %	3.5
FLUE GAS FLOW, SCFM	1,671,590
REAGENT	Limestone
OXIDATION	Forced
END PRODUCT	Gypsum
SO_2 REMOVAL*	98.5
DATE OF START-UP	2015

FGD Project Reference – Luminant Oak Grove U1

Luminant Oak Grove Unit 1 Robertson County, TX	
SIZE OF UNIT(S), MW	850
NUMBER OF ABSORBERS	1
FUEL TYPE	Lignite
FUEL SULFUR CONTENT, %	1.34
FLUE GAS FLOW, SCFM	2,284,454
REAGENT	Limestone
OXIDATION	Forced
END PRODUCT	Gypsum
SO_2 REMOVAL	98.0
DATE OF START-UP	2010

FGD Project Reference – Luminant Oak Grove U2

Luminant Oak Grove Unit 2 Robertson County, TX	
SIZE OF UNIT(S), MW	850
NUMBER OF ABSORBERS	1
FUEL TYPE	Lignite
FUEL SULFUR CONTENT, %	1.34
FLUE GAS FLOW, SCFM	2,284,454
REAGENT	Limestone
OXIDATION	Forced
END PRODUCT	Gypsum
SO_2 REMOVAL	98.0
DATE OF START-UP	2010

WFGD SO_2 Control Systems - References

Plant	Client	MW	Date Completed	Notice to Proceed	Guarantee SO2 Removal Efficiency
Ghent Station Unit 1	E. On	550	2009	2006	98.5%
Warrick Station Unit 4	ALCOA	320	2008	2005	98%
Cholla Unit 4	PacifiCorp/APS	380	2008	2006	96.5%
Warrick Station Units 1	ALCOA	150	2008	2005	98%
Warrick Station Units 2	ALCOA	150	2008	2005	98%
Warrick Station Units 3	ALCOA	150	2008	2005	98%
Ghent Station Unit 4	E. On	551	2008	2006	98.5%
Ghent Station Unit 3	E. On	550	2007	2006	98.5%
Cross Unit 4	Santee Cooper	599	2007	2006	97%
Huntington Station Unit 2	PacifiCorp	455	2006	2005	95.6%
Cross Unit 3	Santee Cooper	600	2006	2003	97%
F. B. Culley Units 2 & 3	Vectran	370	1994	1991	98%

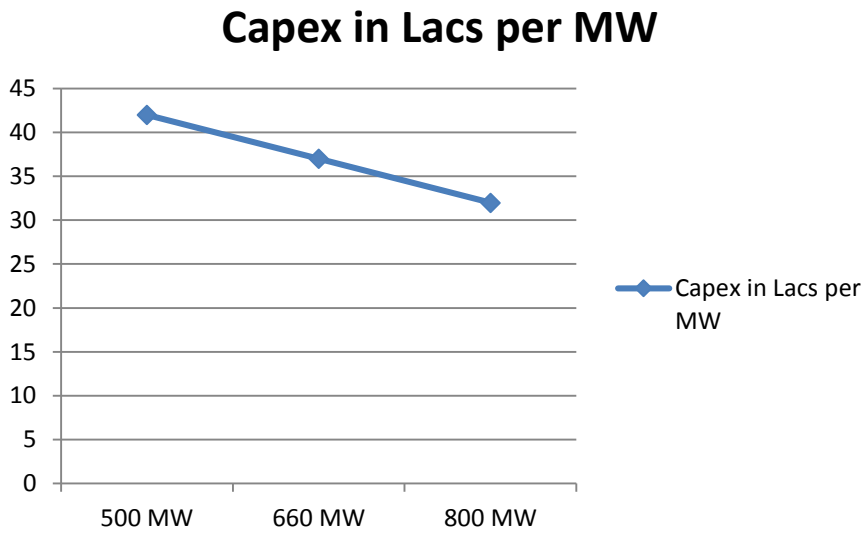
WFGD SO_2 Control Systems - References

Plant	Client	MW	Estimated Start-up	Guarantee
Leland Olds Unit 2	Basin Electric Power Cooperative	440	May-11	98%
Leland Olds Unit 1	Basin Electric Power Cooperative	220	May-10	98%
Williams Unit 1	South Carolina Electric & Gas	630	Dec-09	97.5%
Wateree Units 1 & 2	South Carolina Electric & Gas	700	Sep-09	98%
Oak Grove Units 1	Luminat	800	Oct-09	98%
Oak Grove Units 2	Luminat	800	Feb-10	98%
Brown Station Units 1, 2 & 3	E.ONUS	750	May-10	98%
Cholla Unit 3	APS	260	Jun-09	96.5%
Mill Creek Station Unit 3	LG&E/KU	425	Jul-16	98.5%
Mill Creek Station Unit 1&2	LG&E/KU	660	Jul-15	98.5%
Mill Creek Unit 4	LG&E/KU	525	Apr-15	98.5%

Current CAPEX Trends in Indian Market

Current CAPEX Trends in Indian Market:

Sr. No.	Unit Size (in MW)	Capex in Lacs per MW (Range)
1	500	40-45
2	660	35-40
3	800	30-35



Above CAPEX includes Broad Scope as mentioned below:

Absorber Spray System (including C276 Cladded Absorber), Limestone Preparation System, Gypsum Dewatering System, Flue Gas Ducting and Booster Fans, Electrical & C&I Package, HVAC, ECW System, Fire Detection and Protection, Compressor System, Limestone and Gypsum Handling, Wet Stack (with Borosilicate/titanium lining), Civil and Structural Works, Erection and Commissioning.

Projects under Execution

Projects under execution by Isgec in collaboration with BPE:

Sr. No.	Client Name	Project Name	Capacity	Effective Date of Contract
1.	NTPC Limited	Kudgi STPP	3x800 MW	31.07.2018
2.	NTPC Limited	Gadarwara STPP	2x800 MW	18.09.2018

Above projects include Broad Scope as mentioned below:

Absorber Spray System (including C276 Cladded Absorber), Limestone Preparation System, Gypsum Dewatering System, Flue Gas Ducting and Booster Fans, Electrical & C&I Package, HVAC, ECW System, Fire Detection and Protection, Compressor System, Limestone and Gypsum Handling, Wet Stack (with Borosilicate/titanium lining), Civil and Structural Works, Erection and Commissioning.

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Thank You!!!

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