

REINHOLD ENVIRONMENTAL Ltd.



**2014 Wastewater-Ash Round Table
& Expo Presentation**

September 22, 2014, in Birmingham, AL / Hosted by Southern Company

All presentations posted on this website are copyrighted by Reinhold Environmental, Ltd (RE). Any unauthorized downloading, attempts to modify or to incorporate into other presentations, link to other websites, or obtain copies for any other uses than the training of attendees to RE's Conferences is expressly prohibited, unless approved in writing by RE or the original presenter. RE does not assume any liability for the accuracy or contents of any materials contained in this library which were presented and/or created by persons who were not employees of RE.



power generation group

Wet FGD Operations and Waste Water Impacts

September 22, 2014

Daniel B. Johnson, P.E.,
Field Service Engineer

Overview

Introduction and System Overview

Swinging Load

Integration and Tuning

Environmental Optimization

Summary & Conclusion

Overview

Introduction and System Overview

Swinging Load

Integration and Tuning

Environmental Optimization

Summary & Conclusion

Introduction

- ▶ **ELG, MACTs and Impending Greenhouse gas rules drive new operation strategies**
- ▶ **New operational guidelines impact boiler operations, and AQCS train equipment**
- ▶ **Wet FGD effluent, with both quantity and composition, drive design basis and control of the wastewater treatment**
- ▶ **New regulations require**
 - Understanding system(s) interaction
 - Controls able to handle upstream upsets



Wet FGD Control

Basics of wet FGD Control

- ▶ Reagent Feed
- ▶ SO_2 to CaSO_4^- conversion
- ▶ Oxidation Air
- ▶ Bleed/Blow Down System

Effluent Stream

- ▶ TSS and TDS
- ▶ pH and ORP levels
- ▶ Flow Rates



Reagent Feed System

Why is Reagent Feed Control is Important

- ▶ Control of excess carbonates and gypsum purity
- ▶ Proper control of SO₂ removal and pH operating band
- ▶ Smoother operation prevents batch feeding of reagent
- ▶ The dissolved alkalinity sets how much SO₂ can be absorbed in the absorption zone

Control Parameters for Optimization of Reagent Feed

- ▶ Limestone Reactivity – B&W Design Standard
- ▶ Limestone Grind – 95% passing 325 mesh typical
- ▶ Limestone Slurry Density – 28% typical
- ▶ Limestone Purity – control fines in dewatering and inerts entry into system

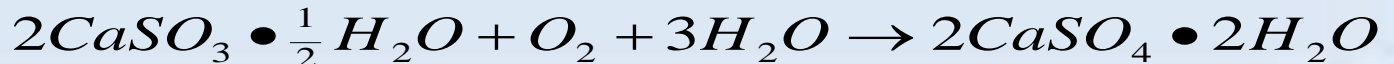
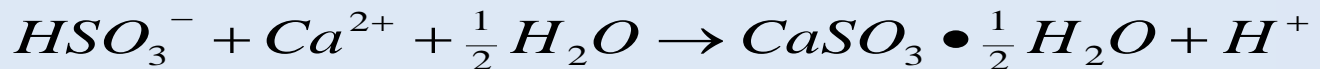
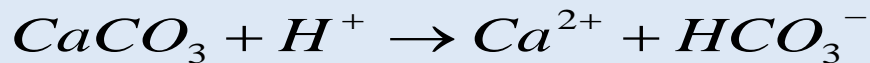
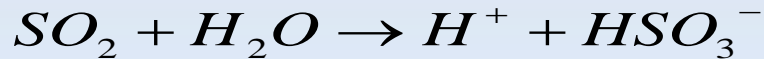


SO₂ to CaSO₄ Conversion Basic Equations

Basics of conversion

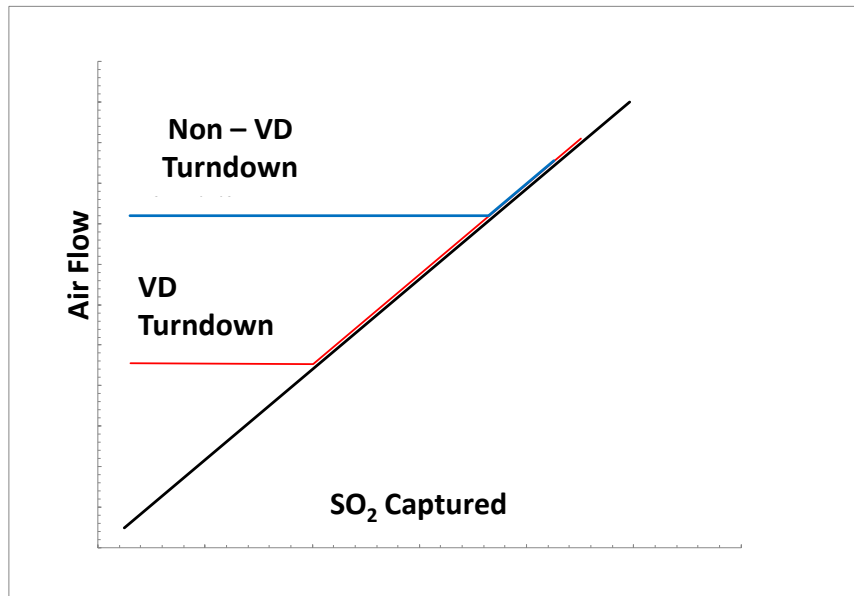
- › The conversion from SO₂(g) to CaSO₃- (aq) occurs in the spray zone of the tower
- › The conversion causes the slurry to become acidic, which is the cause for the drop in pH
- › The acidic slurry causes the limestone slurry, CaCO₃, to disassociate. This allows for the formation of the calcium sulfite, CaSO₃
- › Oxidation to CaSO₄ in ART

Equations:



Oxidation Air

Example Oxidation Air Flow Control Curve



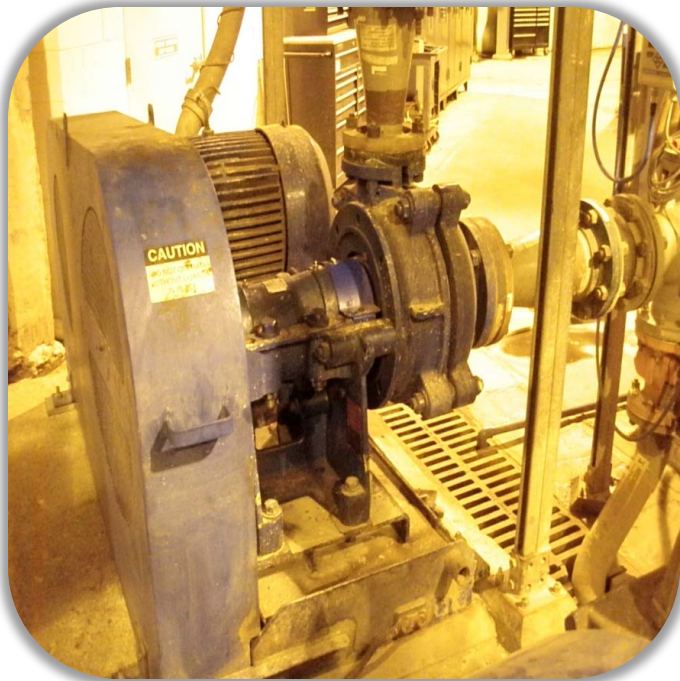
- ▶ Stoichiometry ratios based upon a contract
- ▶ Based upon design sulfur coal and full load boiler operation
- ▶ Integrated variable diffuser vane allowing for a lower turndown of 45% of full load capacity
- ▶ Low sulfur coal operations require less



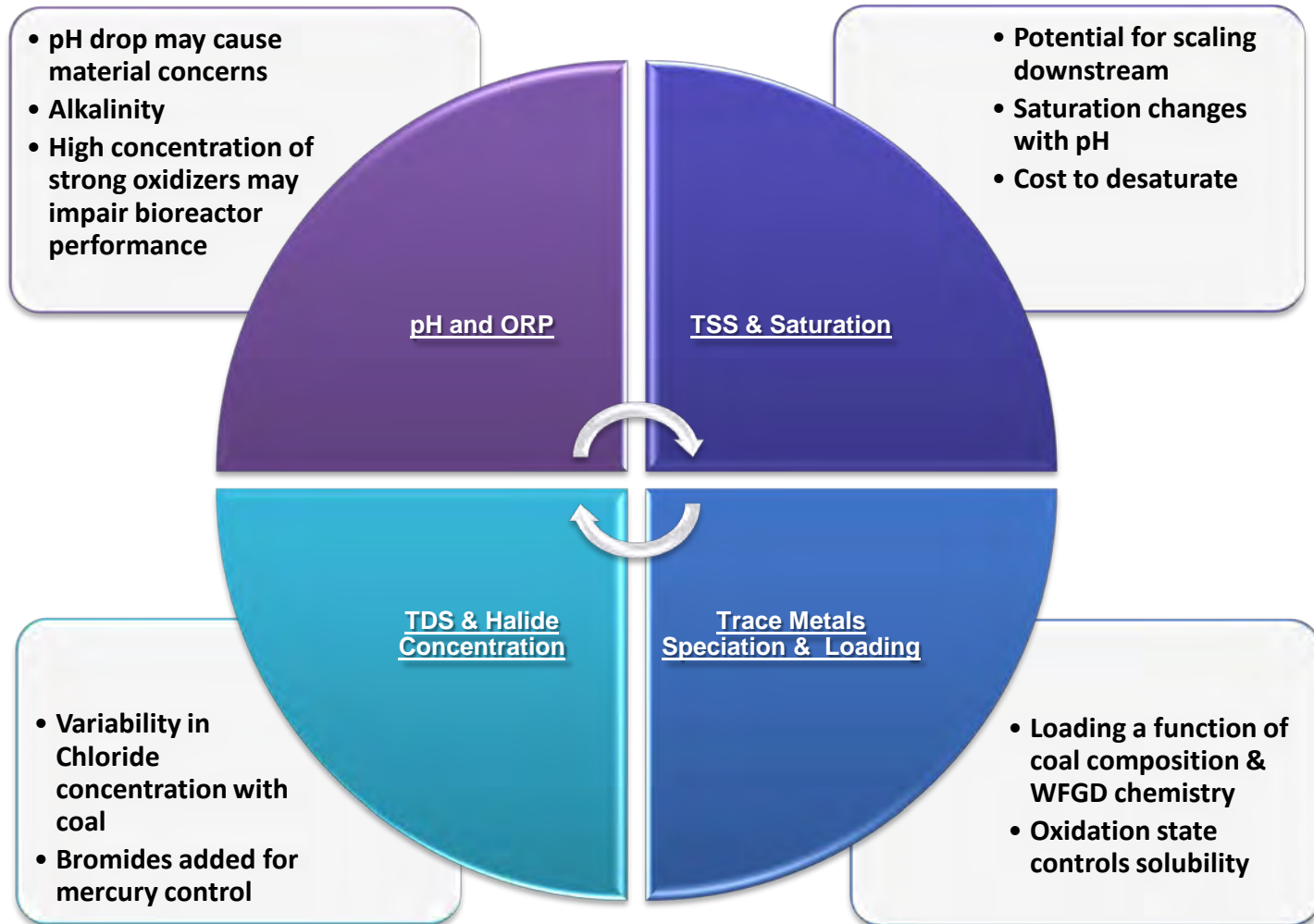
Bleed System

Function

- ▶ **Control Total Suspended Solids, TSS**
 - Gypsum Production
- ▶ **Control Chloride Concentration in the absorber tower, TDS**
 - Secondary Dewatering System Overflow



Effluent Stream Overview



Overview

Introduction and System Overview

Swinging Load

Integration and Tuning

Environmental Optimization

Summary & Conclusion

Swing Load Operation

- ▶ **Due to economics, deregulation and environmental concerns, swing load operation of coal fired power plants is becoming more common**
- ▶ **To increase BTU/\$, industry is trending toward more variance in fuel composition**
- ▶ **Swing load and variable load operation alter the flue gas flux and composition through the Air Quality Control System (AQCS) train**



Impacts on Effluent and Flue Gas Chemistry

Some variances in WFGD chemistry and gas composition at the stack have been correlated with swing and low load operation

- ▶ Selenium speciation in wastewater
- ▶ Mercury emission and speciation in wastewater
- ▶ Oxidative content of the bleed stream
- ▶ Gypsum crystallization
- ▶ Reagent utilization
- ▶ Manganese precipitation



B&W Field Test Results

Slurry ORP

- ▶ Changed in relation to ESP performance factors
 - These factors correlated to changes in the gas flux through the AQCS train
- ▶ Is *not* controlled by Oxidation Air once the slurry is saturated with dissolved oxygen
- ▶ Is *not* a function of fly ash loading to the WFGD absorber

System Purge can be approximated as a CSTR

- ▶ ORP often changes in a sigmoidal function, as if an equivalence point has been reached
- ▶ ORP decreases often take an extended time period and close coupled units can impact each other's chemistry through a shared recycle



Overview

Introduction and System Overview

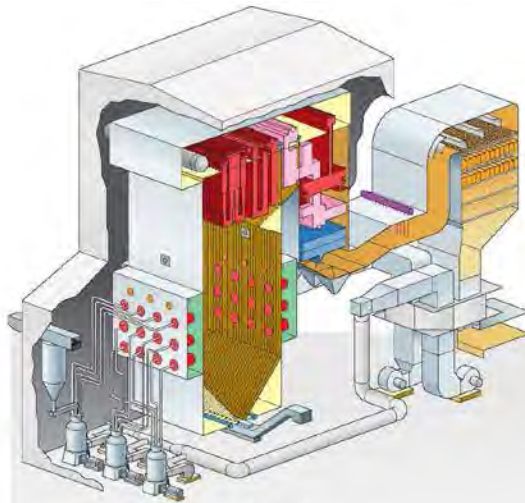
Swinging Load

Integration and Tuning

Environmental Optimization

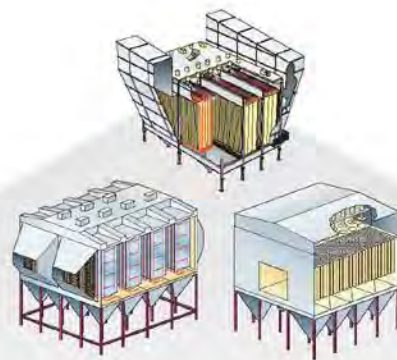
Summary & Conclusion

Chute to Stack System Overview



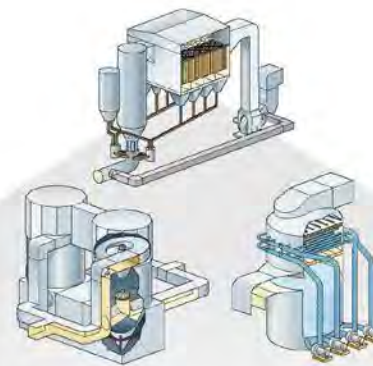
Boiler

- Pulverizers and Components
- Burners and Ignitors (including FPS™ ignitors)
- Pressure Parts and Attemperators
- Coal Piping and Airheaters
- Selective Catalytic Reduction Systems



Particulate Control

- Fabric Filter (including cages)
- Electrostatic Precipitator (wet and dry)
- Multiclone® Dust Collector
- Turbulaire™ Scrubber



Flue Gas Desulfurization
Including all auxiliary systems

- Spray Dry Absorber (including Niro® atomizers)
- Circulating Dry Scrubber
- Seawater Scrubber
- Wet FGD (limestone and lime)



Emissions

- Complete Portfolio of KVB-Enertec™ Products and Solutions for Continuous Emissions Monitoring Systems

AQCS System Interactions

Major Equipment Interactions

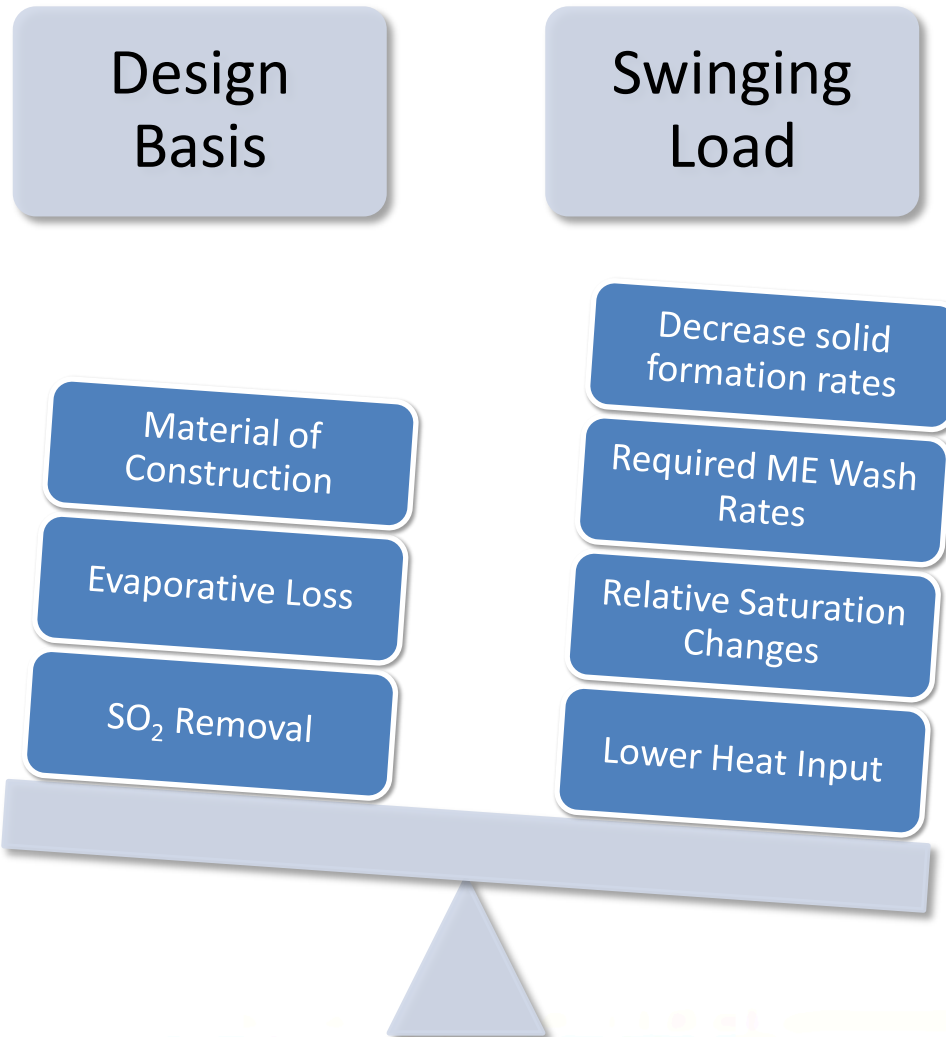
- ▶ SCR and ESP Performance
 - Formation of SO₃ across catalyst impacts ash resistivity and collection efficiency
- ▶ ESP and Wet FGD Performance
 - Increase in ash loading into the wet FGD system impacts absorber chemistry through gypsum crystal sizing problems, and shape as well as possible depression of limestone dissolution
- ▶ ORP levels in absorber
 - Major factor is load variation through upstream equipment
 - Source such as ESP Performance, and sulfur-nitrogen chemistry need to be considered
- ▶ System and Mercury
 - SCR and ESP help to catalyze and capture mercury in the flue gas
 - ORP level swings, without the presence of additives, are showing to be a potential driver for mercury emission from stack

Water Usage

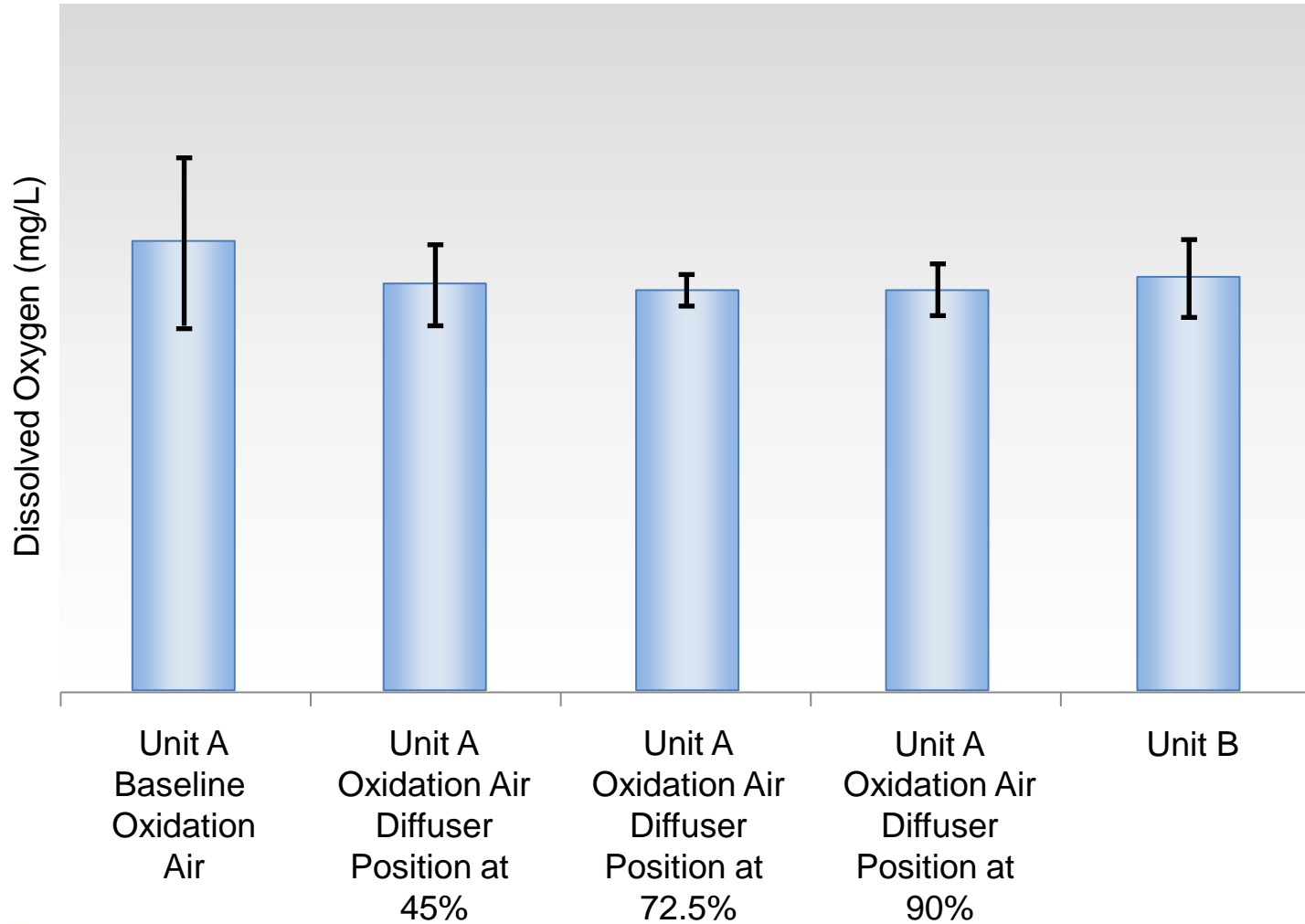
Mist Eliminator Wash Water	Balance between cleaning and evaporation loss
Limestone Slurry Water	Transport of limestone to absorber
Seal Water	Addition of water to system
Reclaim Water	Level control
TSS control	<ul style="list-style-type: none"> • Addition of water for dilution of solids, but increase blow down rates • Concentration utilizes less fresh water but control of system can be unstable and increases risk of pluggage and erosion may result
TDS and Halide Control	<ul style="list-style-type: none"> • Control of relative saturation for gypsum crystal formation • Control of limestone dissolution • Control of halide concentration for material of construction concerns



Water Balance



Oxidation Air Turndown – Parametric Test Results



Dewatering

Hydroclone Tuning for swinging load

- ▶ Low loading on tower builds up TDS and Fines
- ▶ At high concentrations, fines separate as piping tee
- ▶ Excess fines in gypsum increase difficulty of dewatering and degrade gypsum purity
- ▶ Increased fines circulation lead to gypsum crystal issues
- ▶ At low loads, it is possible for fines to build faster than chlorides

Operational Strategy for tank management

- ▶ Switch from batch to continuous
- ▶ Constant flow rates to WWT
- ▶ Ease of tank level management
- ▶ Constant dilution water to absorber



Controls Tuning for Swinging Load

- ▶ **Swinging load causes controls concerns since units are sized for steady state, full load**
- ▶ **Prevent slug feeding of reagent at low loads with integrated controls logic and low velocity feed rates**
- ▶ **Turndown of oxidation air and possible turn off of absorber recycle pumps**
- ▶ **Improved response to load swings**
- ▶ **Improves wastewater treatment unit operation performance, ensuring compliance**

Condition Assessment of System

- ▶ **Reagent Prep System**
 - Ball Mill Amps/Grind Dropping
 - Classifier Pressure Dropping
- ▶ **Dewatering Systems**
 - High Vacuum or vacuum trend upwards
 - High Moisture on cake
 - Gypsum Purity
- ▶ **Absorber Systems**
 - Reagent Feed and SO₂ control
 - Pressure Drop
 - Carryover from Stack



Reagent Usage

If your limestone stoichiometry has increased

- ▶ **Has your limestone quality decreased?**
- ▶ **Is your ball mill tuned?**
- ▶ **Is your limestone feed tuned for changes in tower load?**

$$\text{Stoichiometry} = 1 + \left(\frac{\text{Moles of } CO_3 - 2 * \text{Moles of } Mg}{\text{Moles of Sulfur}} \right)$$

Gypsum Product Formation

If your gypsum purity decreased by over 1%

- **Does your system have more inerts**
 - **Fly ash, change in limestone, recycled inerts**
- **Is your limestone feed rate tuned to the load?**

If your gypsum average particle size has changed

- **Is their adequate oxidation?**
- **Does the system have significant fines buildup?**
- **Has the Ca/S ratio changed?**

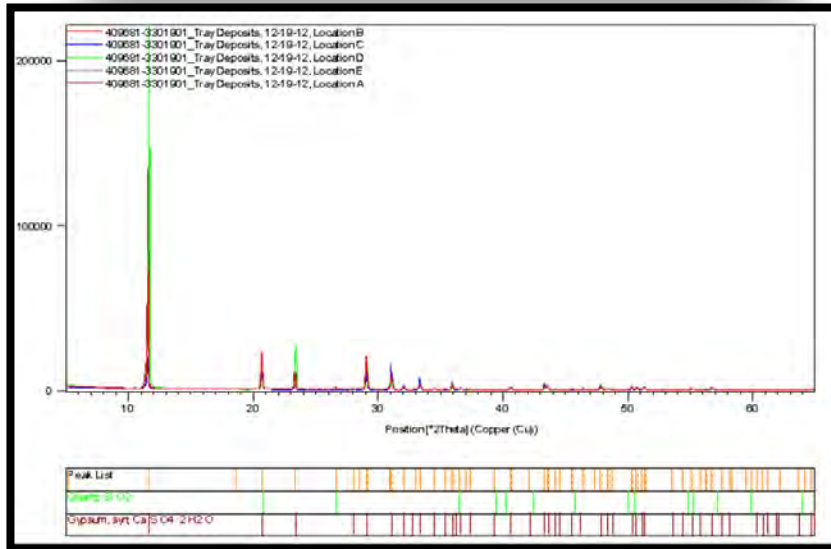
Deposit Analysis



Client's Sample ID:	Tray Deposits	Deposit not adhered in agitator
12/19/2012	3301901	3301902
Material type:	Gypsum	Gypsum
CTL Sample ID:	3301901	3301902
Analyte	Weight %	Weight %
SiO ₂	3.10	1.02
Al ₂ O ₃	0.99	0.21
Fe ₂ O ₃	1.84	0.42
CaO	30.57	34.97
MgO	0.98	0.78
SO ₃	42.47	49.72
Na ₂ O	0.04	0.09
K ₂ O	0.14	0.09
TiO ₂	0.18	0.13
P ₂ O ₅	0.03	0.02
Mn ₂ O ₃	0.15	0.18
SiO	0.02	0.02
Cl ₂ O ₃	<0.01	<0.01
ZnO	0.02	<0.01
BaO	<0.01	<0.01
L.O.I. (950°C) ^a	21.58	12.53
Total	100.57	100.17

Calculated per ASTM C 471
 Gypsum % purity
 SO₃ combined as Gypsum excess SO₃
 % Anhydrite, CaSO₄
 %CaO combined as Gypsum
 %CaO combined as Anhydrite
 %CaCO₃
 % MgCO₃

Thermogravimetric Analysis
 L.O.I. (ambient-45 °C)
 L.O.I. (45-220 °C)
 L.O.I. (220-550 °C)
 L.O.I. (550-950 °C)



Overview

Introduction and System Overview

Swinging Load

Integration and Tuning

Environmental Optimization

Summary & Conclusion

Impact of Oxidation Reduction Potential (ORP) on Wet FGD and Waste Water

- ▶ **ORP is a measure of the tendency of a chemical species either to release (oxidize) or acquire (reduce) electrons**
- ▶ **ELG and MACT compliance may be very difficult, if not impossible, without ORP control**
- ▶ **Impacts of variation in coal type, and boiler load swings, may cause fluctuations in ORP levels in WFGD and WWT systems**

ORP Impacts

- 1. Emissions**
- 2. Alloy Vessel Corrosion**
- 3. Waste Water Treatment (WWT)**
- 4. WWT Materials**
- 5. Additive usage**
- 6. For biological treatment – bug health**

Potential Mitigation Strategies

System Impact

- Integrated control & tuning of AQCS chain

Fine Adjustment

- Optimization of WFGD Chemistry & Control
- Reduced Oxidation Air

Additives

- Injection of Reducing Agents

?

- Other

Sulfide Addition for Mercury Control

- ▶ **Oxidized Mercury**
 - Mercury bound as HgS cannot be reduced by the slurry
- ▶ **Elemental Mercury**
 - Some possible removal correlated with injection during field trials
- ▶ **Co-Benefits**
 - Other possible co-benefits of this additive are currently under research by B&W
 - It may work as a reducing agent
 - Possible impacts on other trace metals of concern is being evaluated



Mitagent™

- ▶ **Several years ago, a B&W project experienced rapid SCR catalyst deactivation**
- ▶ **Gas-phase P might be poisoning catalyst (PRB Fuel ~1% P in ash)**
- ▶ **Evaluation of additive (Mitagent™) impact on boiler performance**
- ▶ **Technical feasibility of injection**
- ▶ **Short term testing /Long term testing**
- ▶ **Multiple foreign & domestic patents pending**

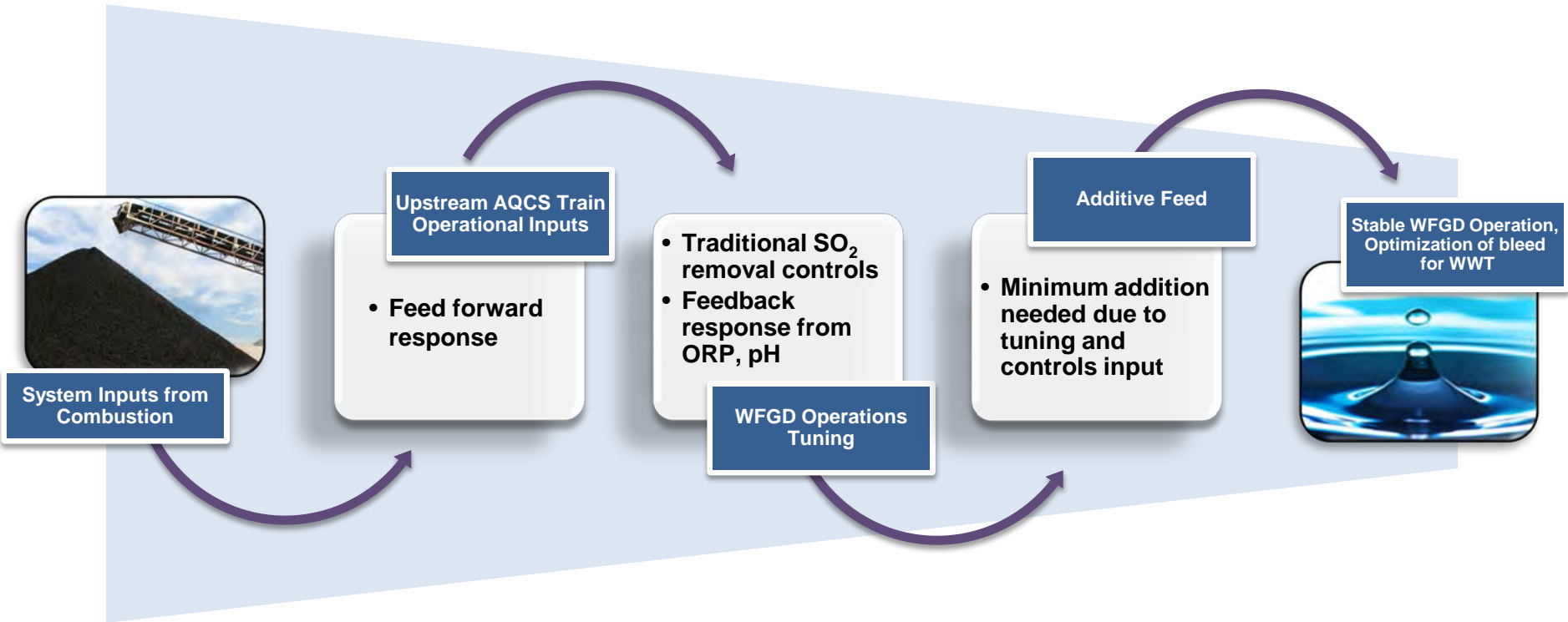


Mitagent Benefits for Br Injection

- ▶ Testing at full scale unit burning PRB coal and only ESP

Br Injection Rate ppm to coal	Mitagent Rate lb/hr to coal	% Oxidized Hg @ Stack (Method 30B)
0	0	38.0
70	0	46.5
100	0	62.5
40	25	56.0

Process Controls Tuning



B&W Environmental Optimization

- ▶ **Development of an optimizer that will link data communication of systems within the plant and provide ability for WFGD chemistry control in progress (B&W patent-pending)**
- ▶ **Potential for ORP Control**
- ▶ **Possible reduction of O&M Costs by reduction of parasitic power load and reagent use**



B&W Environmental Optimization

- ▶ **Anticipated function is to allow variability of coal and load while maintaining performance of AQCS equipment**
- ▶ **Developing online diagnostic software for health of system**
- ▶ **Possible reduction in power loss by turning down system components**
- ▶ **Overall goal is to respond to boiler changes and operate system through bias controls**



Overview

Introduction and System Overview

Swinging Load

Integration and Tuning

Environmental Optimization

Summary & Conclusion

Wastewater and Wet FGD

Major Areas of Concern

- ▶ **Bleed Stream Composition**
- ▶ **Water Balance**
 - TSS and TDS
- ▶ **Economics**
 - Controls vs. Chemicals
- ▶ **EPA MACTs and Effluent Regulations**
 - Phys-Chem Systems
 - Biological Systems
 - ZLD and Near-ZLD permitting



Tuning Parameters

- ▶ **Integrated AQCS Controls**
- ▶ **WFGD Performance Tuning for both steady state and variable loading**
- ▶ **Pre-Bleed Mitigation**
 - Additives
- ▶ **Post-Bleed Mitigation**
 - Additives

Optimization with Varying Load

- ▶ **Tuning for a steady state ORP number**
 - Possible (Re)Emission control of Hg
 - Control of phase-partitioning of metals
 - WWT
 - Corrosion control
- ▶ **Optimization of effluent stream for future ZLD or Near-ZLD Permitting**



- ▶ **ORP Control**
 - Additives for trim or feedback control
 - PAPs systems
 - B&W Patent Pending Optimization Control System
- ▶ **TDS Control**
 - Adjustment of blow down rates
 - Variation in dilution rates
 - Batch to continuous mode
- ▶ **Near ZLD and ZLD Permitting**
 - Effluent System may be tuned for specific parameter requirements of system
 - Ability to maintain parameters with system variation

Conclusions

- **Absorber System can be controlled for better results on variation of loads**
- **WFGD Bleed Streams can be tuned for optimal bleed stream composition and flow rate**
- **By tuning the Bleed Stream, performance of WWT unit operations is consistent or enhanced**
 - **Oxidation state and phase partitioning of metals (Se, Hg, etc...)**
 - **pH, ORP, Dissolved halogen content (F-, Cl-, Br-, I-)**
- **Optimization can accomplished by:**
 - **Integrated control of the AQCS chain**
 - **Optimizing the WFGD (tuning)**
 - **Chemical Additives (as needed)**
- **Industry thought process change**



Questions?



Thank you