

# **REINHOLD ENVIRONMENTAL Ltd.**



## **2011 APC Round Table & Expo Presentation**

July 11-12, 2011, in Cleveland, OH / Hosted by FirstEnergy

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.

# ***Wet Scrubber Operations Training Class***

**Greg Bielawski – Babcock & Wilcox**

**gtbielawski@babcock.com**

**Gordon Maller – URS Corporation**

**gordon\_maller@urscorp.com**

**APC Round Table**

**July 11, 2011**

# ***Agenda***

**Basic Process Overview**

**by Gordon Maller, URS**

**Chemical Factors Determining Performance  
& Reliability**

**by Gordon Maller, URS**

**WFGD Troubleshooting by System**

**by Greg Bielawski, B&W**

**WFGD Performance Optimization,  
Maintenance and Inspection**

**by Greg Bielawski, B&W**

# ***Agenda***



**Basic Process Overview**

**by Gordon Maller, URS**



**Chemical Factors Determining Performance  
& Reliability**

**by Gordon Maller, URS**



**WFGD Troubleshooting by System**

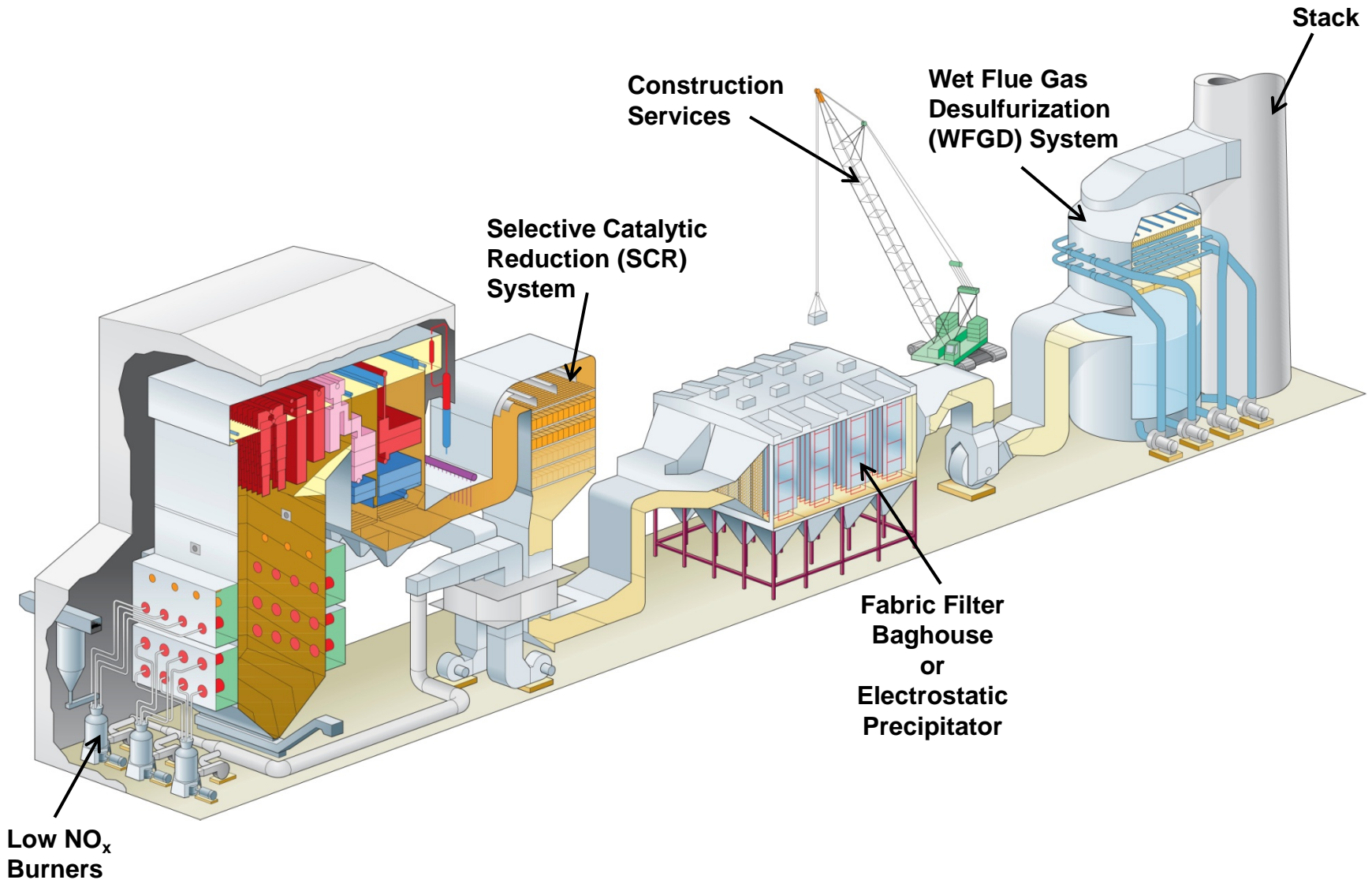
**by Greg Bielawski, B&W**



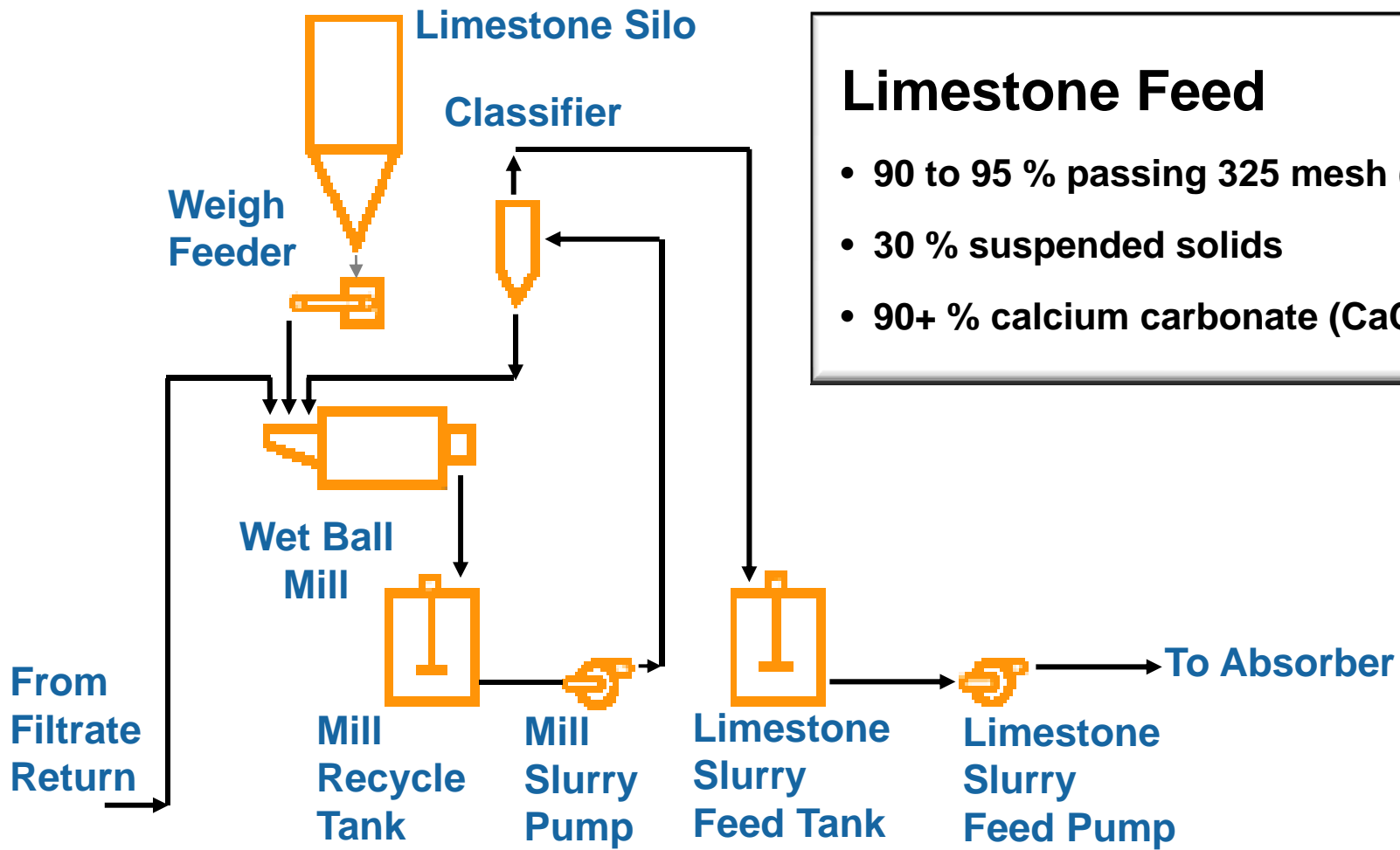
**WFGD Performance Optimization,  
Maintenance and Inspection**

**by Greg Bielawski, B&W**

# Basic Process Review



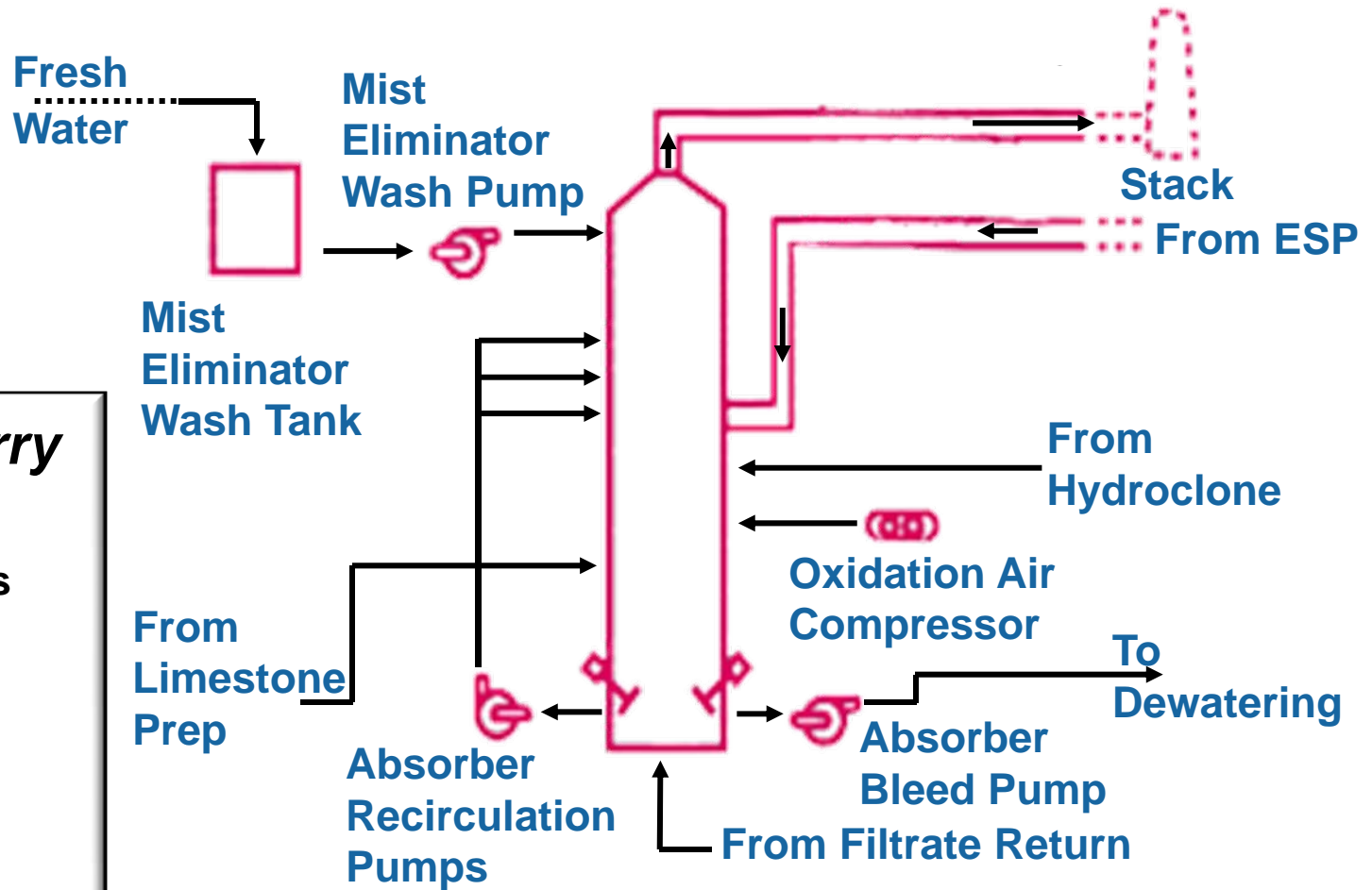
# Limestone Preparation System



## Limestone Feed

- 90 to 95 % passing 325 mesh (44 microns)
- 30 % suspended solids
- 90+ % calcium carbonate ( $\text{CaCO}_3$ )

# Absorber System

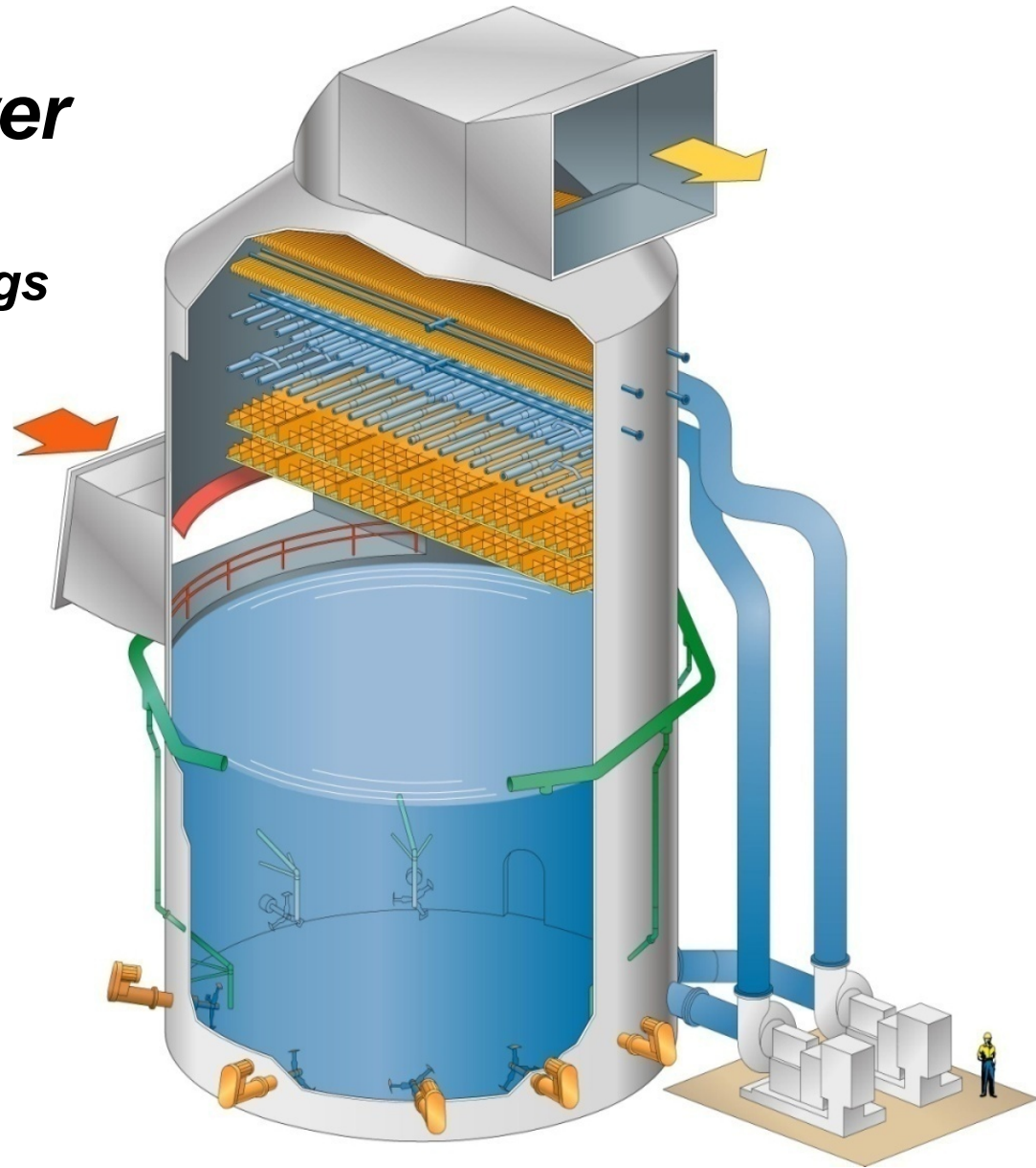


## Absorber Slurry

- 15 - 20 % suspended solids
- 92%+ gypsum (calcium sulfate,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ )
- Residual calcium carbonate, inerts and flyash

# Typical Spray Tower

- with or without tray
- with or without wall rings



# Dewatering System

## Absorber Bleed

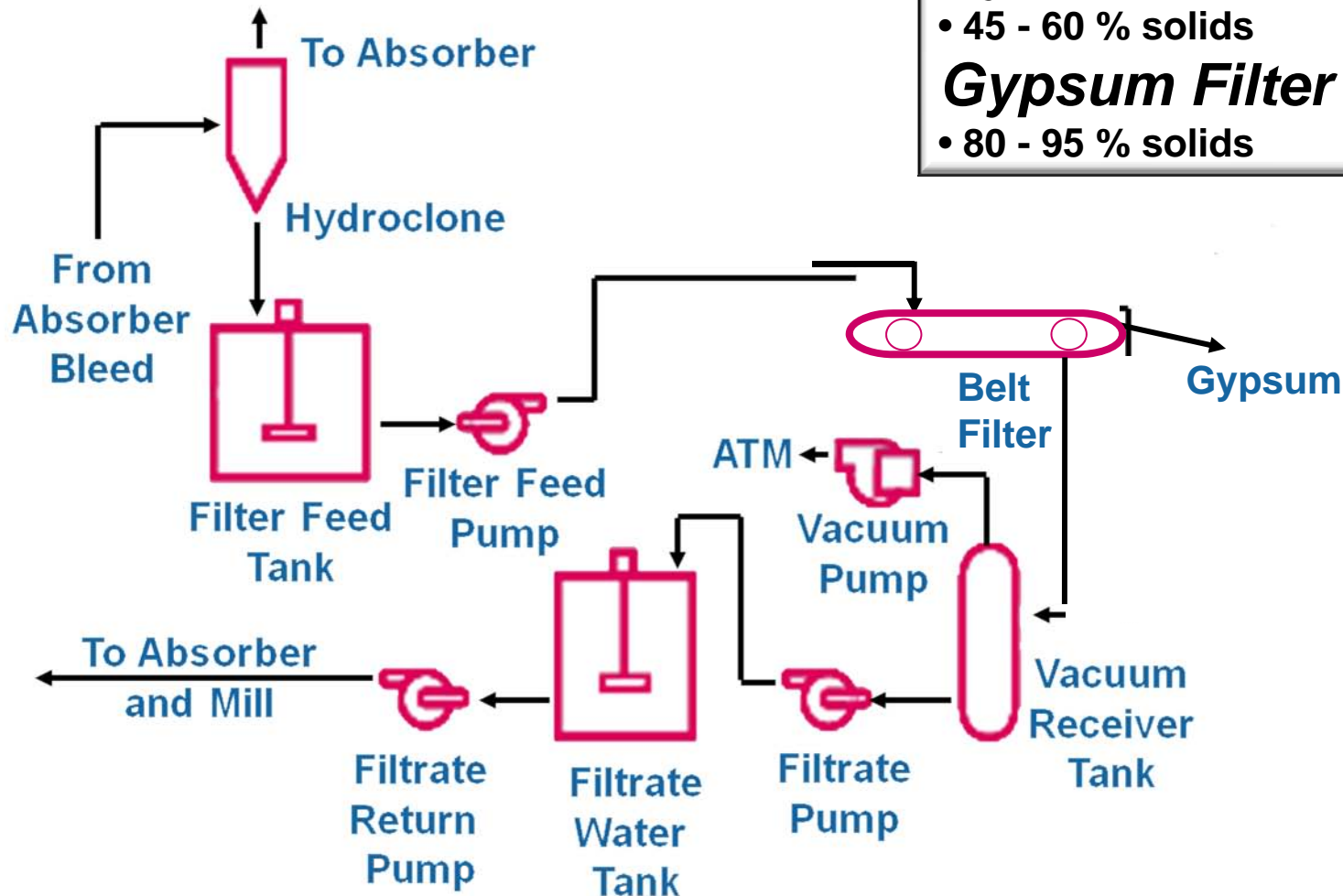
- 15-20 % solids

## Hydroclone Underflow

- 45 - 60 % solids

## Gypsum Filter Cake

- 80 - 95 % solids



# ***Agenda***

**Basic Process Overview**

**by Gordon Maller, URS**

**Chemical Factors Determining Performance  
& Reliability**

**by Gordon Maller, URS**

**WFGD Troubleshooting by System**

**by Greg Bielawski, B&W**

**WFGD Performance Optimization,  
Maintenance and Inspection**

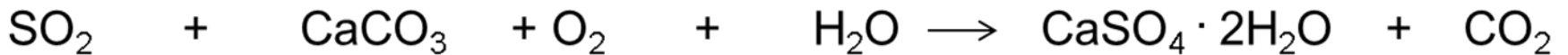
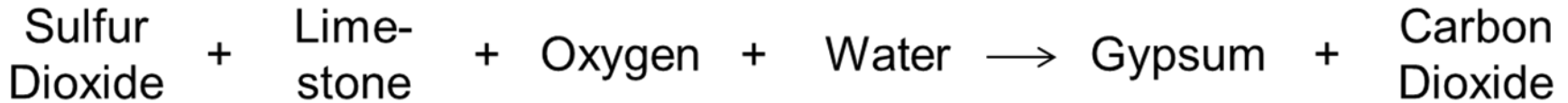
**by Greg Bielawski, B&W**

# Introduction to Chemical Factors Discussion

---

- Key Takeaways:
  - FGD is a chemical process
  - An understanding of the fundamental chemistry that controls the process is critical for maintaining good performance and reliability and for troubleshooting process problems and upsets (discussed later)

# Overall Chemistry for Wet LSFO FGD



*Gas*                      *Solid*                      *Gas*                      *Liquid*                      *Solid*                      *Gas*

**Reactions involve gas, liquid, and solid phases**

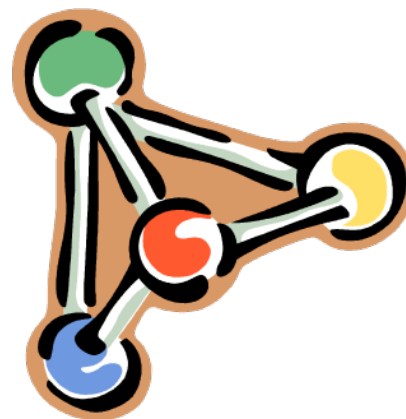
# Chemical Reaction Steps in FGD Process

---

1. Absorption of  $\text{SO}_2$  and other acidic gases (e.g., HCl) in absorber
2. Neutralization of the absorbed acid gases to keep the vapor pressure low so that more acidic gases can be absorbed
3. Dissolution of the limestone or lime reagent to provide alkalinity for neutralization and calcium ion for precipitation
4. Oxidation of absorbed  $\text{SO}_2$  to form sulfate ( $\text{SO}_4$ )
5. Precipitation of calcium and sulfate or sulfite to form byproduct

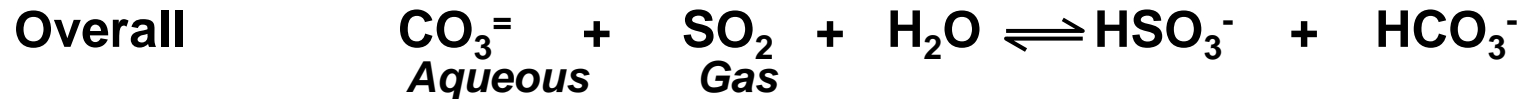
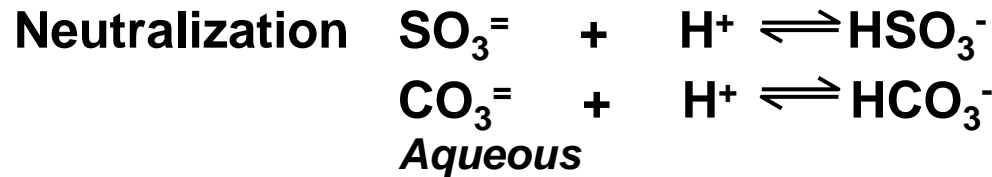
# Liquid-Phase Alkalinity

- Required to neutralize the acidic gases that are absorbed
- Concentration of liquid species that are alkaline with respect to  $\text{SO}_2$  absorption
- Main source of alkalinity for inhibited-oxidation FGD process



# Liquid-Phase Alkalinity (cont.)

## *Examples:*



# Solid-Phase Alkalinity

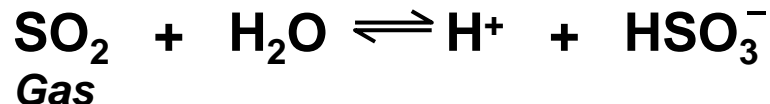
- Dissolution of limestone in absorber replenishes alkalinity and allows scrubbing to continue
- Main source of alkalinity for forced-oxidation FGD process



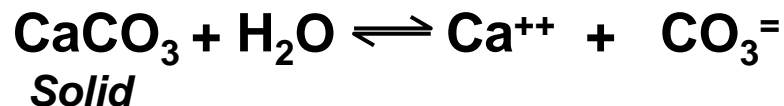
# Solid-Phase Alkalinity

## *Examples:*

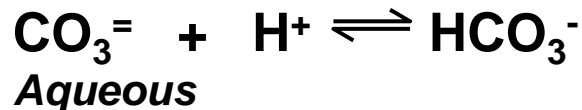
**Absorption**



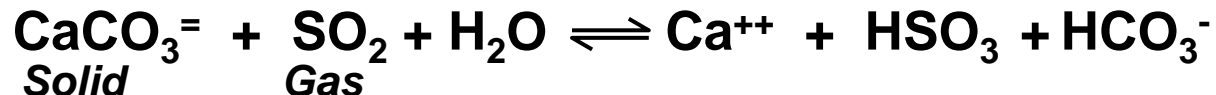
**Dissolution**



**Neutralization**



**Overall**



-

# Sulfite Oxidation

---

- Need to consider both natural and forced oxidation
- Natural oxidation refers to oxidation level a system operates at without forced oxidation air or oxidation inhibitor additive (thiosulfate)
- Natural oxidation depends on:
  - Ratio of O<sub>2</sub>:SO<sub>2</sub> flue gas
  - Solution chemistry
    - pH
    - [SO<sub>3</sub>=]
    - Trace metals which are needed to catalyze the oxidation reactions
    - NO<sub>x</sub> (NO<sub>2</sub>) in flue gas
  - Temperature
- The natural oxidation will have an impact on requirements for forced oxidation

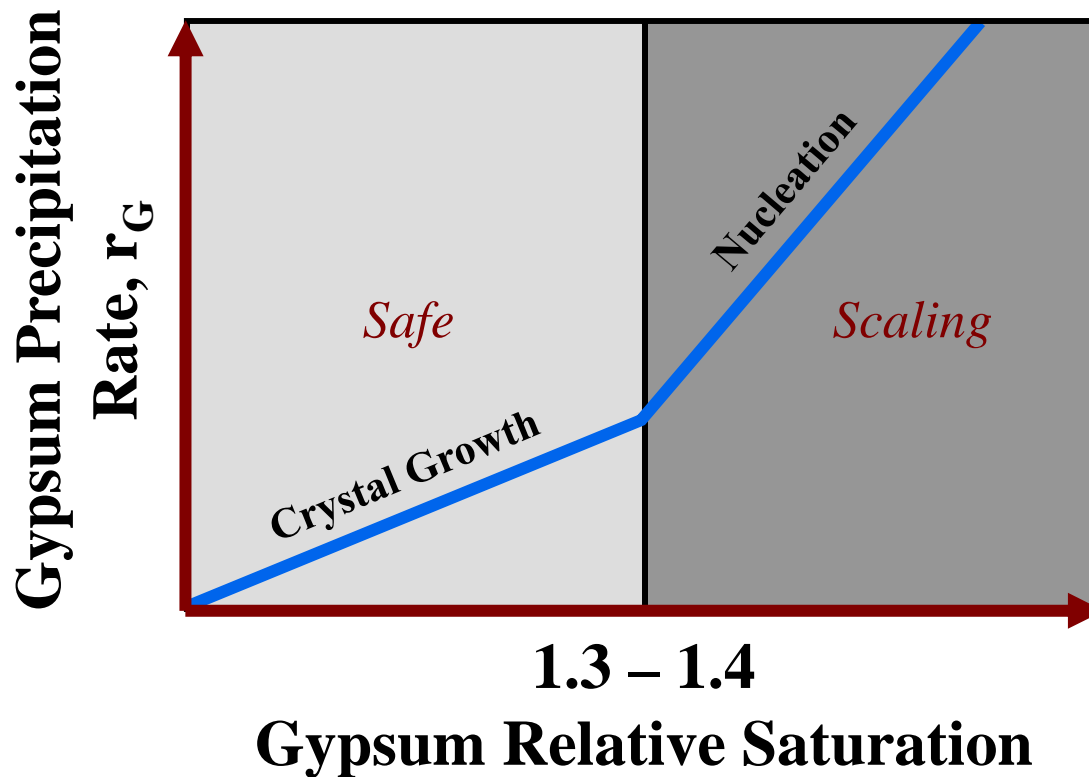
# Solid-Liquid Equilibrium

---

- Determines if limestone will dissolve
- Determines if gypsum will precipitate
- Dissolution refers to formation of ions in solution from a solid
- Precipitation refers to formation of solids from ions in solution
- Relative saturation (RS) is the parameter used to predict dissolution or precipitation
  - RS determined from *activities* of ions in solution plus other thermodynamic parameters like ionic strength and temperature
  - RS less than 1.0 indicates that a solid (e.g., limestone) will dissolve
  - RS greater than 1.0 indicates that a solid (e.g., gypsum) will precipitate

# Two Types of Gypsum Precipitation

- Nucleation (spontaneous)
- Crystal growth (controlled)



# Factors that Determine Type of Precipitation

---

- Relative saturation of the solution
- The presence of sufficient amount of seed solids
- The rate at which the gypsum precipitates

# Crystal Size, Shape, and Habit

---

- Affect dewatering and handling properties of solids
- Determined by:
  - FGD process or design
  - Type of crystal (gypsum or calcium sulfite)
  - Contaminants in the crystal
  - Crystal habit modifiers
  - Residence Time



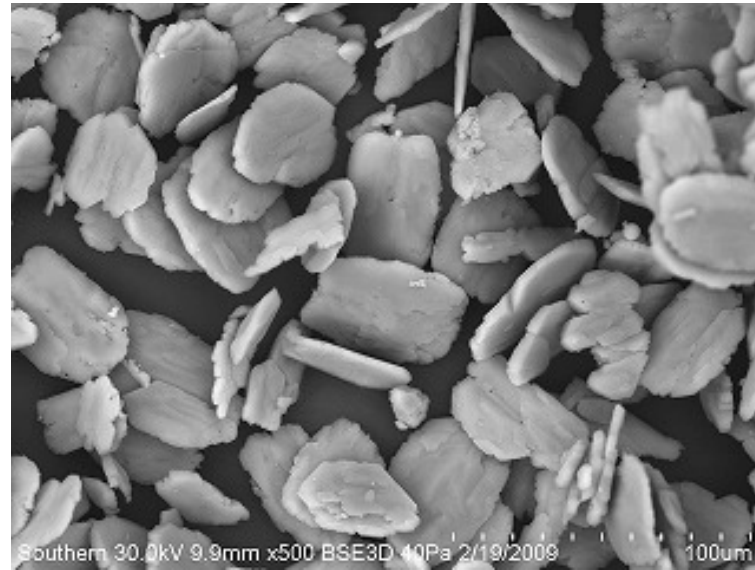
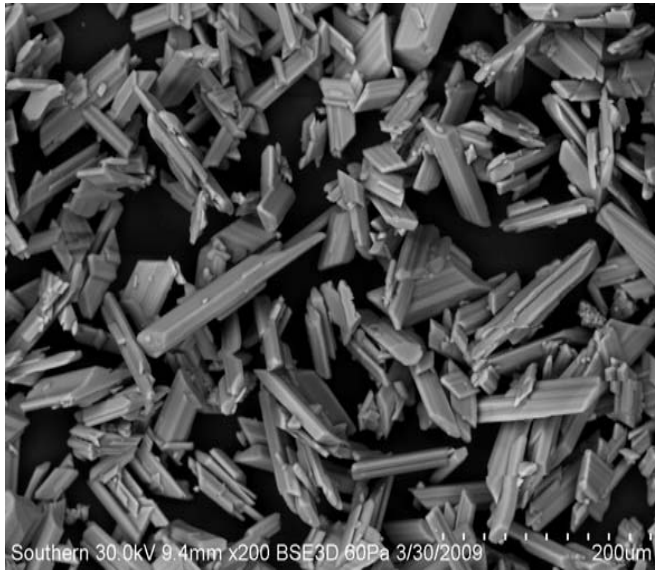
# Typical Gypsum Crystal



# Calcium Sulfite Crystal



# FGD Gypsum Crystals Precipitated in Presence of Crystal Modifier



# Performance Variables That Require Control

---

- SO<sub>2</sub> removal efficiency
- Reagent utilization
- Scaling potential

# SO<sub>2</sub> Removal Efficiency

---

## *Key Chemical Factors*

- pH or alkalinity
- Excess limestone in recycle slurry (key for forced oxidized process)
- Solution chemistry
- Inlet SO<sub>2</sub> loading (combination of concentration and load)

# SO<sub>2</sub> Removal Efficiency (cont.)

---

## *Key Mechanical Factors*

- Liquid-to-gas ratio (L/G)
- Mass transfer characteristics of absorber (e.g., trays, packing)
- Gas / liquid distribution
- Flue gas bypass (where applicable)

# Reagent Utilization

---

## *Key Factors*

- pH
- Solution chemistry
- Solids residence time
- Surface area (grind size)
- Limestone reactivity

# Causes of Scaling

---

## *Key Factors*

- Oxidation (not usually a factor in forced oxidation process)
- Limestone utilization
- Slurry density
- Reaction tank volume
- ME wash design or operation
- ME wash water quality

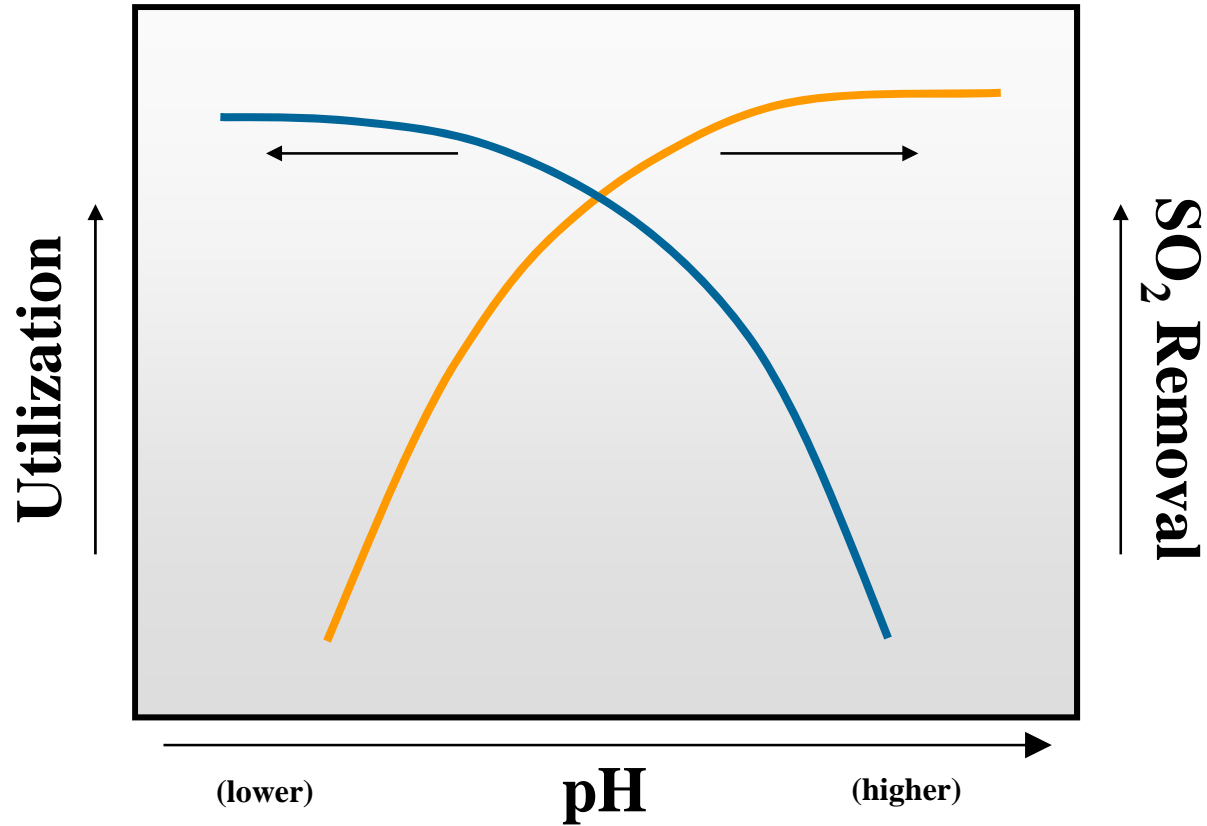
# Factors That Affect FGD Performance and Reliability

*Operators have direct, limited or no control of key parameters*

- Direct Control
  - pH
  - Slurry density
  - L/G
- Limited Control
  - Limestone properties
  - Solution chemistry
  - Mechanical factors
  - Water management
- No Control
  - Boiler load cycles
  - Coal S variations
  - Inlet flue gas properties

*All of these parameters will affect scrubber performance*

# pH / Utilization / SO<sub>2</sub> Removal Relationships



# Slurry Density

---

- Minimum slurry density ensures adequate crystal surface area for precipitation. This is important to prevent scaling
- Maintaining a higher slurry density can improve limestone utilization
- Slurry density affects solids residence time which, in turn, affects limestone utilization and scaling potential

# Explanation of Effect of Slurry Density on Limestone Utilization

---

- Maintaining pH and SO<sub>2</sub> removal requires a specific limestone loading (g-limestone/L-slurry) level for the system.
- At low density (low concentration of solids in the slurry), a higher concentration of the solids will be limestone. Therefore limestone utilization will be lower.

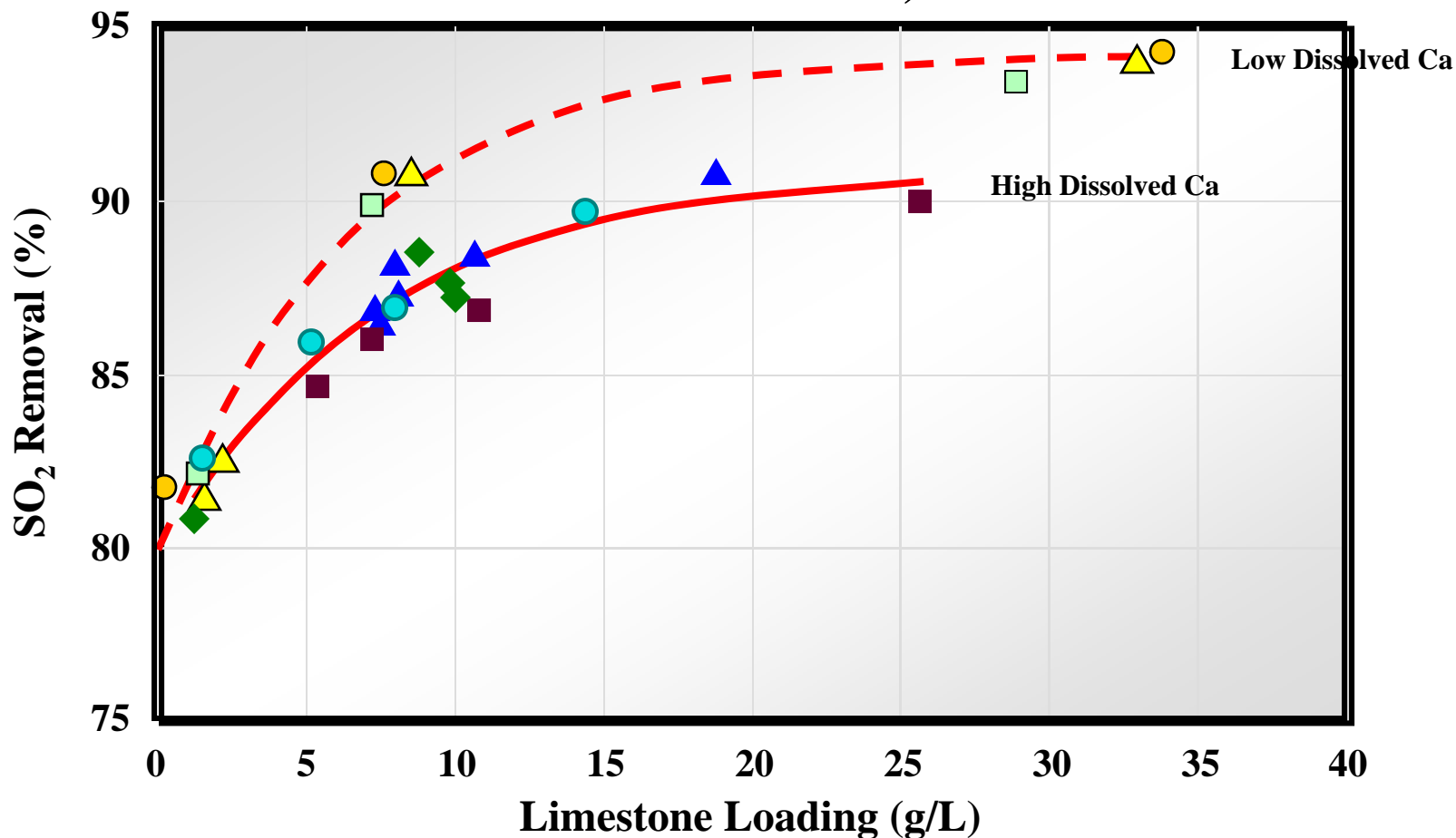
# Solution Chemistry

---

- Dissolved  $\text{Cl}^-$  ( $\text{Ca}^{++}$ ) Concentration
  - Inhibits dissolution due to common ion effect
- Forced oxidation vs. natural oxidation
  - Stripping of  $\text{CO}_2$  tends to enhance dissolution
- Aluminum fluoride blinding
- Sulfite blinding
  - Problem during periods of incomplete oxidation
- All can affect the ease with which reagent dissolves and removal performance of scrubber

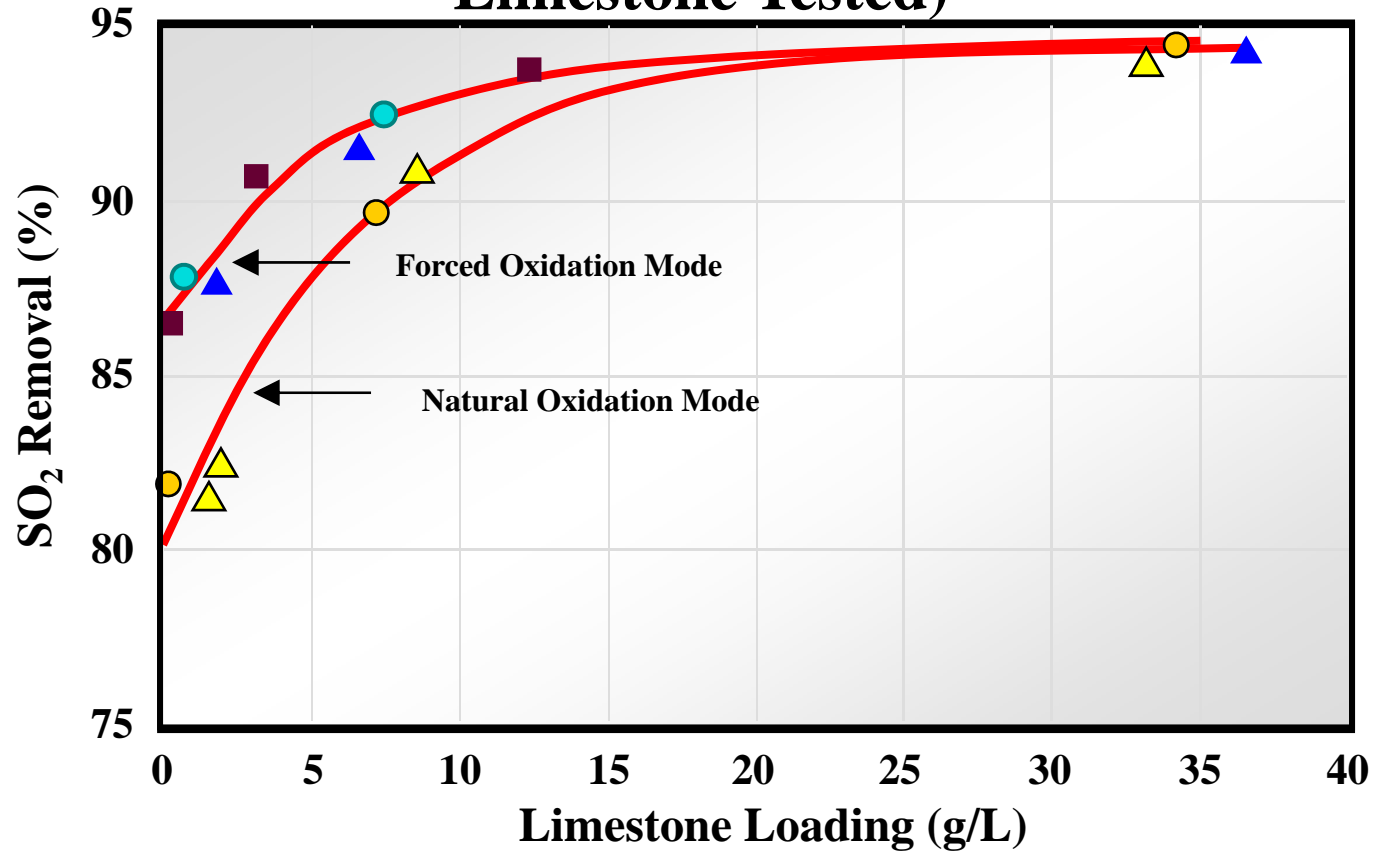
# Effect of Dissolved Calcium Concentration

(Different Shaped Symbols Represent Different Limestone Tested)



# Effect of Oxidation Mode

(Different Shaped Symbols Represent Different Limestone Tested)



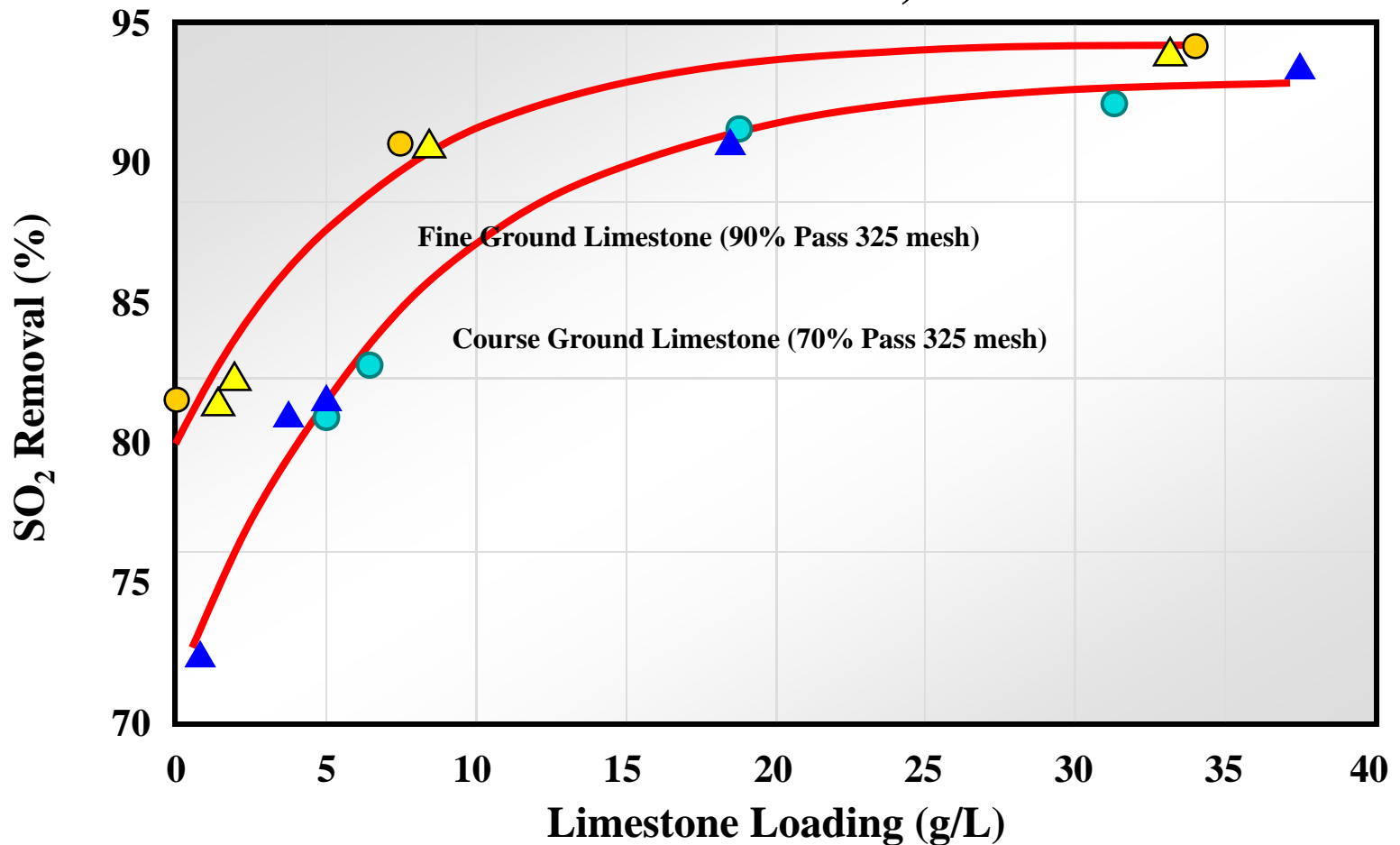
# Limestone Properties Affecting Scrubber Performance

*Properties will affect pH-Utilization-Removal relationship*

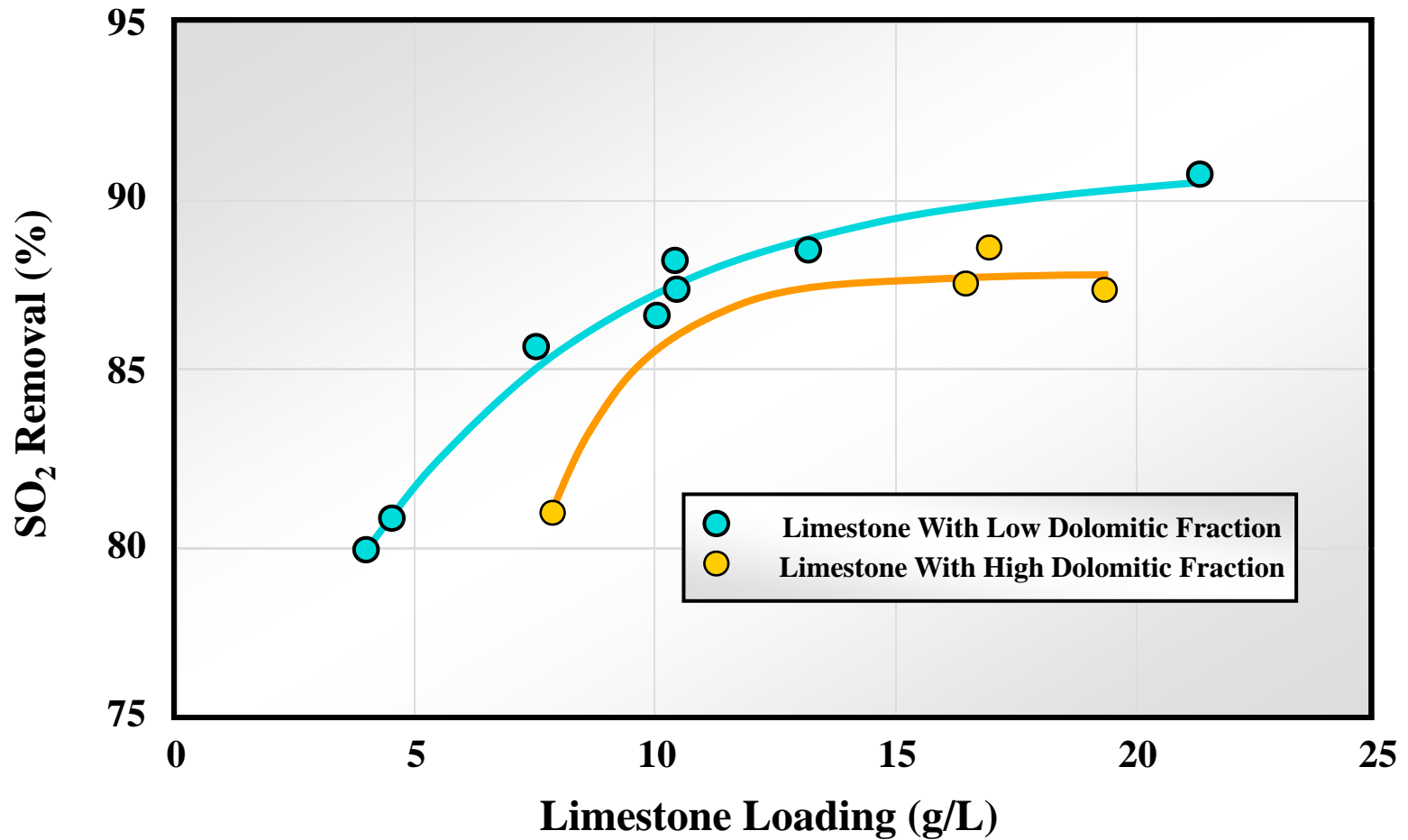
- Grind
- Composition
- Reactivity (dolomitic fraction)

# Effect of Limestone Grind

(Different Shaped Symbols Represent Different Limestone Tested)



# Effect of Limestone Dolomitic Fraction



# Inhibited Dissolution of Limestone

---

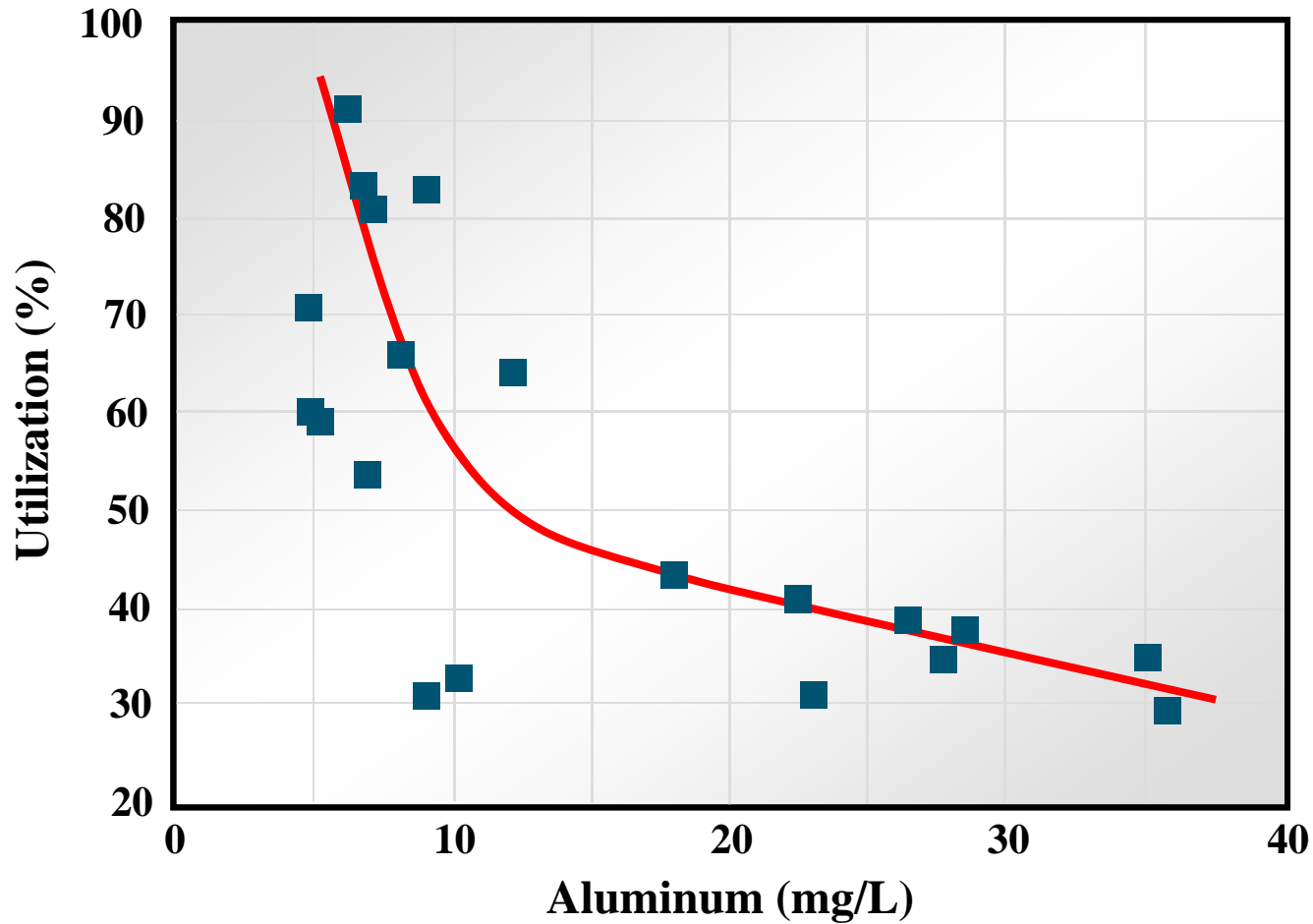
- Limestone must dissolve in scrubber to provide alkalinity
- Certain dissolved chemical species can significantly slow or stop the dissolution of limestone
- Inhibition - Slowing of dissolution
- Blinding - Significant slowing or stopping of dissolution
- High concentrations of dissolved chloride and magnesium will inhibit dissolution

# Limestone Blinding

---

- In forced oxidation process, limestone blinding can result from high concentrations of dissolved sulfite or aluminum-fluoride complex
- Either sulfite or aluminum-fluoride complex will react on surface of limestone particle to block dissolving site
- Aluminum-fluoride blinding often initiated by high concentration of inlet fly ash
- Sulfite blinding initiated by incomplete oxidation

# Effect of Soluble Aluminum on Limestone Utilization



# Poor SO<sub>2</sub> Removal as Result of Chemical Problem

<b>Cause</b>	<b>Analytical Indication</b>	<b>Corrective Action</b>
Insufficient Limestone In Scrubber	Low carbonate measured in scrubber solids	Increase pH set-point
Malfunctioning pH Monitor	Poor agreement during pH calibration check	Make repairs to pH monitor system
Sulfite Blinding	Poor reagent utilization along with elevated levels of soluble sulfite	Verify operation of oxidation air system. Correct as required
Aluminum Fluoride Blinding	Poor reagent utilization along with elevated levels of aluminum and fluoride	Improve particulate removal upstream of scrubber
Poor Limestone Quality or Off-Spec Grind Size	Sieve analysis, composition analysis	Modify grind circuit and/or obtain better limestone

# Poor Reagent Utilization

<b><i>Cause</i></b>	<b><i>Analytical Indication</i></b>	<b><i>Corrective Action</i></b>
Malfunctioning pH Monitor	Poor agreement during pH calibration check	Make repairs to pH monitor system
Sulfite Blinding	Poor reagent utilization along with elevated levels of soluble sulfite	Verify operation of oxidation air system. Correct as required
Aluminum Fluoride Blinding	Poor reagent utilization along with elevated levels of aluminum and fluoride	Improve particulate removal upstream of scrubber
Poor Limestone Quality or Off-Spec Grind Size	Sieve analysis, composition analysis	Modify grind circuit and/or obtain better limestone

# Agenda

**Basic Process Overview**

**by Gordon Maller, URS**

**Chemical Factors Determining Performance  
& Reliability**

**by Gordon Maller, URS**

**WFGD Troubleshooting by System**

**by Greg Bielawski**

**Reagent Preparation**

**Gypsum Dewatering**

**Absorber**

**WFGD Performance Optimization,  
Maintenance and Inspection**

**by Greg Bielawski**

# Reagent Prep

## *Symptom*

- ▶ High Volume of Ball Mill Rejects



## *Cause*

- ▶ Hardness of limestone

---

- ▶ Overfeeding

---

- ▶ Ball charge not per manufacture's rec.

---

- ▶ Ball charge needed

## *Solution*

- ▶ Verify hardness

---

- ▶ Verify TPH

---

- ▶ Verify size of balls used during last charge

---

- ▶ May be time for the addition of balls

# Reagent Prep

## Symptom

Limestone slurry is concentrated (%TSS\* is high)

\* TSS – Total Suspended Solids

## Cause

- › Improper inlet pressure to the classifier
- › Overfeeding the mill
- › Ball mill product pump variable sheave needs adjustment
- › Water addition valves malfunctioning

## Solution

- › Increase number of operating cyclones
- › Verify the TPH
- › Increase speed of pump. Verify that the recycle valve is completely closed.
- › Trend the water addition valves to verify performance and make the necessary adjustments to regain operation.
- › Add flush water to Limestone feed tank to dilute slurry, if necessary

# Reagent Prep

## Symptom

- › Limestone slurry is diluted (%TSS is low)

## Cause

- › Water addition valves malfunctioning

---

- › Check the inlet pressure to the classifier

---

- › Below the required ball charge

---

- › Flush valve not fully closing (leaking)

---

- › Ball mill product pump variable sheave needs adjustment

## Solution

- › Trend the water addition valves to verify performance and make the necessary adjustments to regain operation.

---

- › Decrease number of operating cyclones

---

- › Check amps. Add balls per manufacturer's recommendations

---

- › Valve seat / seal may need replaced

---

- › Verify that the recycle valve is completely closed

---

- › Decrease speed of pump

# Reagent Prep

## *Symptom*

- ▶ Increased pressure of classifier cluster



## *Cause*

- ▶ Plugged apex opening
  - ▶ Roping of one or more classifiers
- 
- ▶ Broken gauge or malfunctioning transmitter

## *Solution*

- ▶ Clear the pluggage
- 
- ▶ Replace gauge or troubleshoot transmitter

# Reagent Prep

## Symptom

- ▶ Decreased pressure of classifier cluster



## Cause

- ▶ Plugged apex opening
- ▶ Roping of one or more classifiers

---

- ▶ Classifier isolation valve leaking

---

- ▶ Wear in the classifier

---

- ▶ Broken gauge or malfunctioning transmitter

## Solution

- ▶ Clear the pluggage

---

- ▶ Valve seat/seal may need to be replaced

---

- ▶ Refer to manufacturer's manual for recommendation

---

- ▶ Replace gauge or troubleshoot transmitter

# Reagent Prep

## Symptom

- ▶ Ball mill amps high



## Cause

- ▶ Limestone Bond Work Index (BWI) is higher than design limit

---

- ▶ Overfeeding the mill

---

- ▶ Ball charge above the recommended limit

## Solution

- ▶ Verify limestone properties are per design limits

---

- ▶ Verify the TPH of limestone being sent to the mill

---

- ▶ Refer to manufacturer's recommended solutions

# Reagent Prep

## Symptom

- ▶ Ball mill amps low



## Cause

- ▶ Below the required ball charge
- 
- ▶ Underfeeding the mill

## Solution

- ▶ Add balls per manufacturer's recommendation
- 
- ▶ Verify the TPH of limestone being sent to the mill
  - ▶ Silo or chute may be plugged

# Dewatering

## *Symptom*

- ▶ Moisture content in the gypsum has increased



## *Cause*

- ▶ Vacuum filter cloth is blinded

---

- ▶ Cake thickness is not per design

---

- ▶ Vacuum pump may be scaled

## *Solution*

- ▶ Pressure wash to remove fines

---

- ▶ Set the speed of the belt to obtain the design cake thickness

---

- ▶ Verify the water quality is per specifications. Acid cleaning may be necessary.

# Dewatering

## *Symptom*

- Filter cloth blinding

## *Cause*

- Excessive fly ash present in the absorber slurry

---

- Inerts in the limestone are higher than design

---

- Hydroclones need to be tuned

---

- Absorber bleed flow rate too low

## *Solution*

- Verify inlet flue gas dust content / opacity to ensure amount is below design limits

---

- Check limestone composition to verify the inerts

---

- Verify hydroclone performance

---

- Increase absorber bleed flow rate

# Dewatering

## *Symptom*

- ▶ Gypsum properties are not meeting specifications

## *Cause*

- ▶ Hydroclone Tuning
- ▶ Limestone out of Spec
- ▶ Limestone Valve / Valve Tuning



# Dewatering

## Gypsum not per specifications

### *Hydroclone Causes*

- › Roping of one or more hydroclones

---

- › Wearing of the hydroclone apex

---

- › Wearing of Vortex finder

---

- › Improper inlet pressure to hydroclone cluster

### *Solution*

- › Clear the pluggage

---

- › Replace apex

---

- › Verify size and check for wear

---

- › Change number of operating hydroclones to meet the suggested inlet pressure

---

- › Adjust the variable sheaves to achieve the design inlet pressure

# Dewatering

## Gypsum not per specifications

### *Limestone Causes*

- ▶ Limestone does not meet specifications

---

- ▶ High limestone stoichiometry (as indicated by pH)

### *Solution*

- ▶ Verify limestone composition

---

- ▶ Limestone feed control valve may be worn out
- ▶ Limestone feed control valve may need to be tuned

# Dewatering

## Gypsum not per specifications

### *Limestone Valve / Valve Tuning Causes*

- › Limestone valve needs to be tuned; delayed valve response to demand signal
- 
- › Limestone feed valve is worn out; unable to maintain controllability

### *Solution*

- › Trend the demand and response signal of the valve. Both signals should trend right on top of each other or as close as possible without any delay.
- 
- › Trend the demand signal to the valve to compare demand vs. response
  - › Visual verification of the valve operation

# *Absorber*

**SO<sub>2</sub> Removal  
Efficiency**

```
graph TD; A[SO2 Removal Efficiency] --- B[Slow Loss]; A --- C[Sudden Loss]; A --- D[Loss and Drop in pH]
```

**Slow Loss**

**Sudden Loss**

**Loss and Drop  
in pH**

# Absorber

## *Symptom*

- ▶ Slow loss of % removal efficiency  
(degradation noticed over a period of weeks)



## *Cause*

- ▶ Low absorber slurry %TSS

---

- ▶ Inert accumulation

---

- ▶ Reactivity of the limestone is decreasing

---

- ▶ Slurry spray nozzle(s) plugging

## *Solution*

- ▶ Check density meter value against laboratory analysis and recal if deviation is greater than 1% TSS

---

- ▶ Verify limestone composition; inerts may be high

---

- ▶ Purge more to wastewater treatment

---

- ▶ Check limestone composition and reactivity

---

- ▶ Visually verify and clear pluggage

# Absorber

## *Symptom*

- Sudden loss of % removal efficiency

## *Cause*

- Deterioration of limestone slurry grind

---

- Amount of available  $\text{CaCO}_3$  has decreased

---

- High inlet  $\text{SO}_2$  loading
- Limestone slurry or absorber pump trip

---

- $\text{SO}_2$  removal or pH control loop in manual
- Rapid load increase

## *Solution*

- Recharge ball mill

---

- Verify source and supplier of limestone is unchanged

---

- Verify that all required AR pumps are in operation
- Verify that fresh limestone slurry is being added

---

- Put control loop back in auto

# Absorber

## *Symptom*

- › Loss of % removal efficiency and drop in pH

## *Cause*

- › Loss of limestone flow to absorber
- 
- › Excessive flow to recycle loop

## *Solution*

- › Verify that the flow path of the limestone into the absorber is free and flowing
- 
- › Check back pressure orifice plate for wear and replace if necessary

# Absorber

## *The Situation*

- › At low load and/or low sulfur loading, system pH increases above normal operating conditions and limestone valve operation is not continuous

## *Cause*

- › The amount of limestone being added is more than what is required to achieve removal causing higher than normal pH.
- 
- › The demand for limestone slurry is low which makes the valve operate in a batch mode.

## *Solution*

- › Reduce the number of operating AR pumps to maintain a continuous limestone flow and thus the pH.
- 
- › Dilute the limestone slurry if low sulfur loading and/or low load operation is expected to continue

# Absorber

## *The Situation*

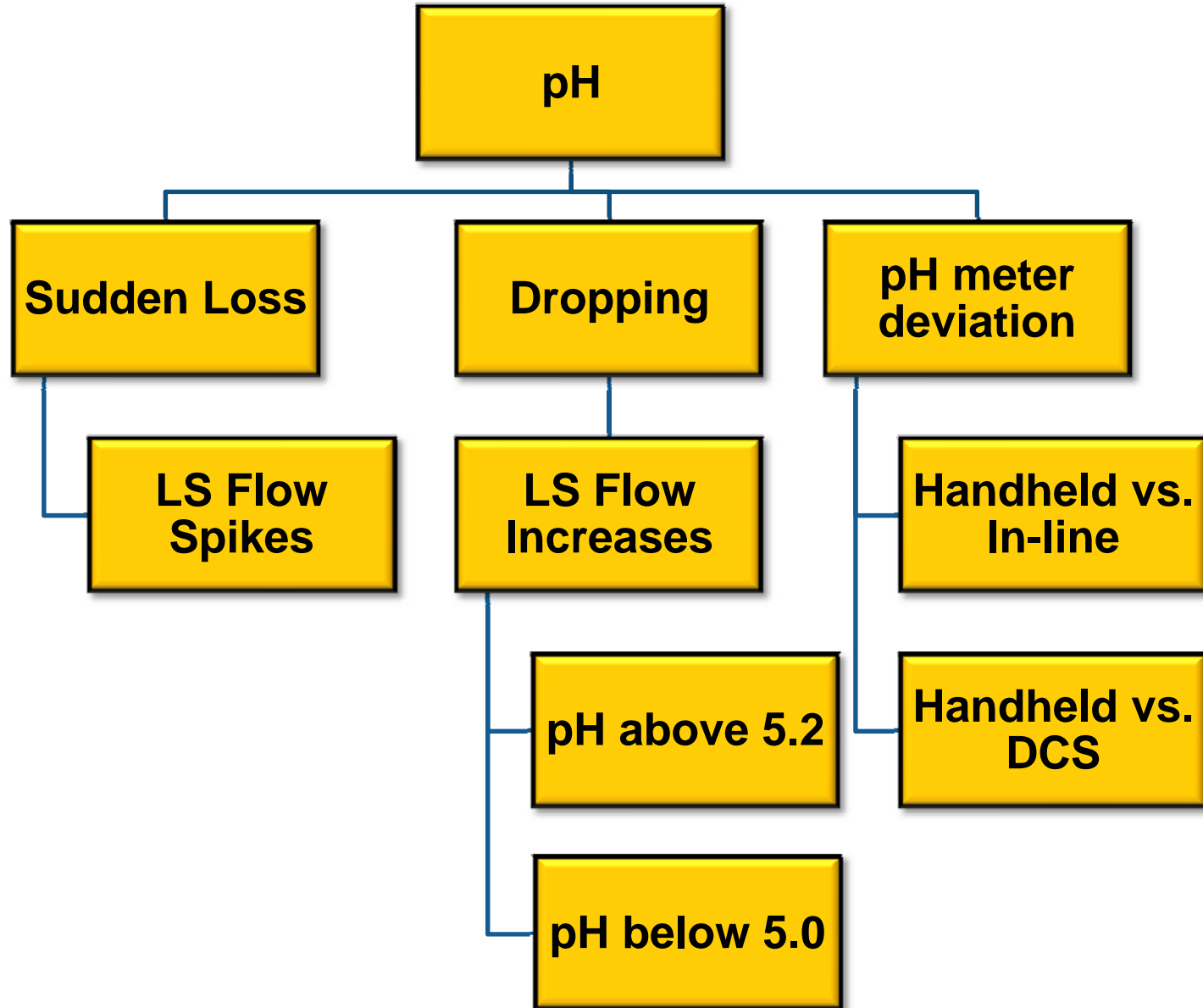
- ▶ When the CEMS goes into calibration, the limestone flow is erratic causing pH swings

## *Cause*

- ▶ The control logic is not operating as intended.

## *Solution*

- ▶ Verify that when the CEMS goes into calibration, the system control mode is switched from SO<sub>2</sub> removal efficiency to pH control and the last pH value becomes the operating set point.



# Absorber

## *The Situation*

- › Sudden loss of pH causing limestone flow to spike



## *Cause*

- › pH sampling system is plugged

## *Solution*

- › If in pH control, switch to % removal efficiency until plug is cleared
- › If pH sampling system is ex-situ, make sure sample lines are warm, indicating flow

# Absorber

## *The Situation*

- ▶ pH dropping while limestone flow is increasing.  
pH may be above 5.2 depending on starting pH.

## *Cause*

- ▶ Sulfite Blinding

## *Solution*

- ▶ Maximize the oxidation air flow
- ▶ Maximize the tank level (if not already there)
- ▶ Stop the limestone feed flow to the absorber completely
- ▶ A sudden drop in pH is a sign of recovery
- ▶ Let pH drop to around 3.8 before introducing limestone
- ▶ Operate in manual mode until pH reaches 5.0 or % of SO<sub>2</sub> removal efficiency is within 3% of set point

# Absorber

## *The Situation*

- › pH dropping while limestone slurry flow is increasing. pH drops below 5.0.

## *Cause*

- › Aluminum Fluoride Blinding

## *Solution*

- › Increase purge rate
- › Add sodium hydroxide
- › Dump the tank and start over

# Absorber

## *Symptom*

- ▶ pH handheld meter displays deviation greater than 0.05 from the in-line probe

## *Cause*

- ▶ Handheld probe is not temperature compensated

---

- ▶ In-line probes need to be calibrated

---

- ▶ One of the in-line probes may need replaced

## *Solution*

- ▶ Retake the measurement with a temperature compensated probe

---

- ▶ Calibrate the in-line probe using 4.0 and 7.0 standard buffers

---

- ▶ Replace probe

# Absorber

## *Symptom*

- ▶ pH handheld meter displays deviation greater than 0.05 from DCS reported pH

## *Cause*

- ▶ Control logic may be averaging the in-line probe values causing erroneous results

## *Solution*

- ▶ Change logic to use only one probe as the indication and the other as a back up

# Absorber

## *Symptom*

- ▶ Density meter no longer agrees with lab analysis

## *Cause*

- ▶ Specific gravity of the slurry has changed from the value that was originally set
- 
- ▶ Calibration is needed

## *Solution*

- ▶ Verify the specific gravity of the slurry and input the new value if necessary
- 
- ▶ Use lab's results when calibrating the meter

# *Absorber*

**High Absorber  
Reaction Tank Level**

```
graph TD; A[High Absorber Reaction Tank Level] --- B[Calibration Issue]; A --- C[Incoming Flow overwhelming Bleed Pump Flow]; A --- D[Control System];
```

**Calibration Issue**

**Incoming Flow  
overwhelming Bleed  
Pump Flow**

**Control System**

# Absorber

## *The Situation*

- ▶ The level is above the set point due to a calibration issue; however, it is still controllable.

## *Cause*

- ▶ Level transmitters are not calibrated properly

---

- ▶ Density compensation not working properly (% TSS high)

---

- ▶ Oxidation air flow is higher than design

---

- ▶ Air holdup is higher than predicted

## *Solution*

- ▶ Reduce absorber level set point

---

- ▶ Calibrate transmitters

---

- ▶ Check lab's results against density meter

---

- ▶ Verify the oxidation air flow entering the absorber

---

- ▶ Verify the air holdup and adjust the value that is used in the level calculation

# Absorber

## *The Situation*

- › The level can not be reduced using the control system indicating that the incoming flow is overloading the absorber bleed pump flow.

## *Cause*

- › Flows coming into the absorber are too high (reclaim water, mist eliminator wash water, limestone feed slurry)
- 
- › Absorber bleed pump flow is low
- 
- › A valve is not fully closed. (reclaim water, ME wash, flush water, etc.)

## *Solution*

- › Decrease the frequency of the ME wash cycles
  - › Lower the tank level set point
  - › Don't turn off or reduce the limestone slurry feed or else the SO<sub>2</sub> removal will decrease
- 
- › Check the hydroclone pressure and inspect for pluggage
  - › Verify pump flow if an in-line meter is available
  - › Switch to spare pump
- 
- › Visually verify that the valves are closed

# *Absorber*

**Low Absorber  
Reaction Tank  
Level**

**Calibration Issue**

**Incoming Flow  
is  
too Low**

**Control System**

# Absorber

## *The Situation*

The level is below the set point due to a calibration issue; however, it is still controllable.

## *Cause*

- ▶ Level transmitters are not calibrated properly

---

- ▶ Density compensation not working properly (% TSS low)

---

- ▶ Oxidation air flow is lower than design

---

- ▶ Air holdup is lower than predicted

## *Solution*

- ▶ Calibrate transmitters

---

- ▶ Check lab's results against density meter

---

- ▶ Verify the oxidation air flow entering the absorber

---

- ▶ Verify the air holdup and adjust the value that is used in the level calculation

# Absorber

## *The Situation*

The level can not be increased using the control system indicating that the incoming flow is too low.

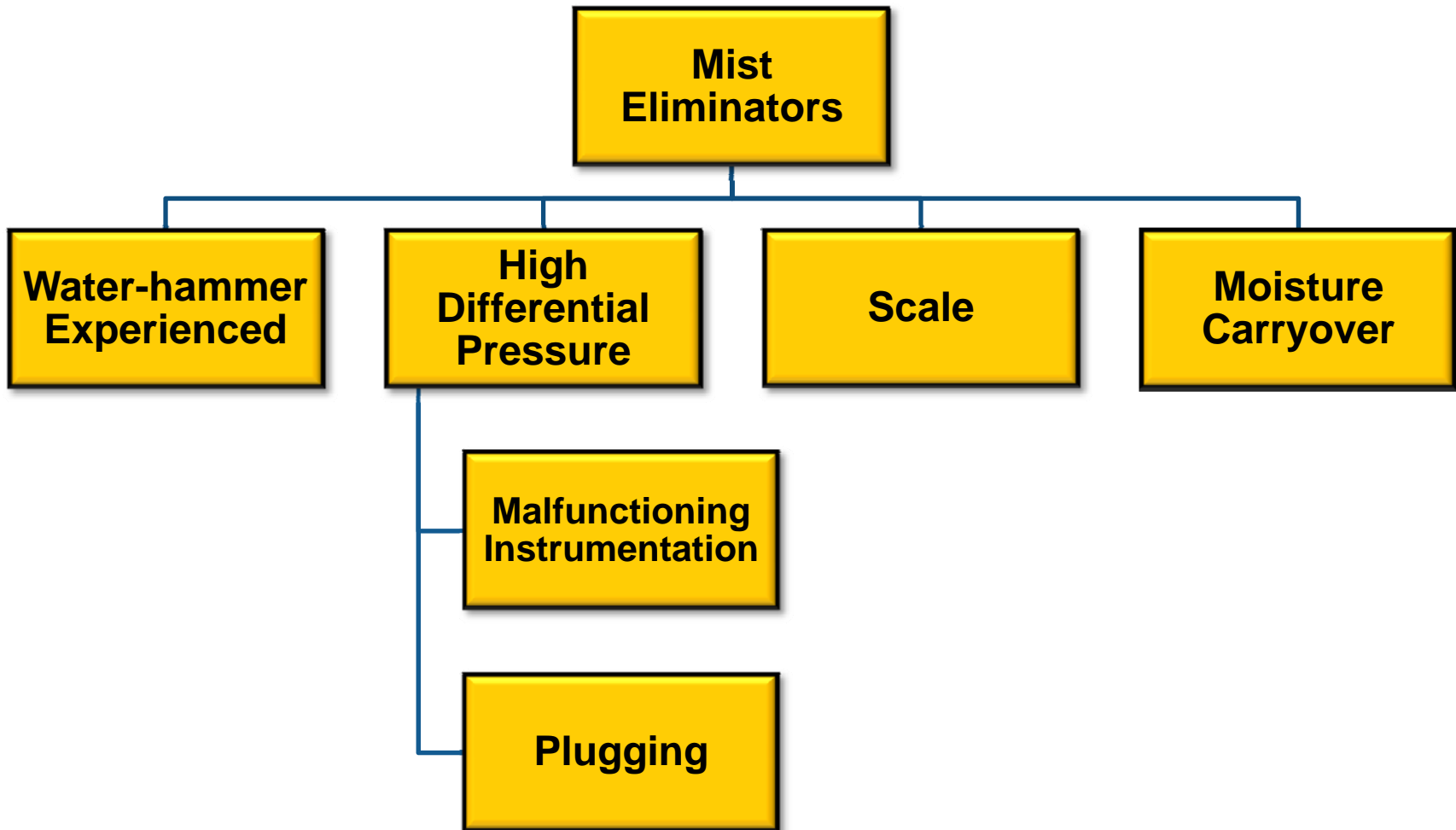
## *Cause*

- › Flows coming into the absorber are too low (reclaim water, mist eliminator wash water, limestone feed slurry)
- 
- › Absorber bleed pump flow is high
- 
- › A valve is not fully open. (reclaim water, ME wash, flush water, etc.)

## *Solution*

- › Increase the frequency of the ME wash cycles or switch to manual operation and wash continuously while investigating further
  - › If the tank level control is a modulating valve, open it manually to verify operation and increase level
  - › Do not increase the limestone slurry feed unless absolutely necessary
  - › Verify that the flush valve is fully closed
  - › Verify hydroclone operation
  - › Verify pump flow if an in line meter is available
- 
- › Visually verify that the functionality of valves

# Absorber



# Absorber

## *The Situation*

**Water-hammer when switching from one quadrant to the next**



## *Cause*

- ▶ **Valve transition from the open to close position is not in sequence with the next valve to open.**

## *Solution*

- ▶ **Verify that as one valve closes the next valve is opened in a simultaneous motion to reduce the potential for water-hammer.**

# Absorber

## *Symptom*

- ▶ High ME differential pressure due to plugging



## *Cause*

- ▶ Insufficient washing of the ME blades
- 
- ▶ Blockage or debris of the mist eliminator blades
- 
- ▶ Gas flow higher than design

## *Solution*

- ▶ Verify that the ME wash sequence is being followed per B&W O&M Manual
- 
- ▶ Verify that the valves are sequencing properly
- 
- ▶ Shutdown and secure absorber, if necessary, to clean the blades. Check for plugged wash nozzles
- 
- ▶ Verify gas flow; correct sources of in-leakage upstream of ID fan

# Absorber

## *Symptom*

- ▶ **Scale on Mist Eliminator blades  
(Check down between the blades)**



## *Cause*

- ▶ **Insufficient mist eliminator wash**

## *Solution*

- ▶ **Verify that the mist eliminator wash sequence is being followed per B&W SRS**
- ▶ **Verify that the valves are sequencing properly**
- ▶ **Check for plugged wash nozzles at next shutdown**

# Absorber

## *The Situation*

- ▶ **Excessive Moisture Carryover; Solids Carryover**

## *Cause*

- ▶ **Gas flow higher than design**

---

- ▶ **Mist eliminator plugging**

---

- ▶ **Mist eliminator sections missing and/or out of position (check stack drain TSS)**

## *Solution*

- ▶ **Verify gas flow; correct in-leakage upstream of ID fan**

---

- ▶ **Verify that the ME wash sequence is being followed per B&W SRS**
- ▶ **Verify ME wash water flow and pressure**

---

- ▶ **Replace and/or reposition damaged mist eliminator sections**

# Absorber

## *Symptom*

- High oxidation air flow



## *Cause*

- Flow transmitter not properly calibrated

---

- Broken oxidation air injection piping/lance

---

- Low absorber reaction tank level

## *Solution*

- Recalibrate flow transmitter

---

- Shutdown and secure the absorber, if necessary, to fix the piping

---

- Correct the level to normal operating conditions

# Absorber

## *Symptom*

- › Low oxidation air flow



## *Cause*

- › Flow transmitter not properly calibrated
- 
- › Plugged oxidation air lance

- 
- › Oxidation air compressor trouble

## *Solution*

- › Recalibrate flow transmitter.
- 
- › If isolation valves are installed, close then open the valves to verify that flow is regained; otherwise, shutdown and secure the absorber, if necessary, to clean the lance/piping.
- 
- › Verify that the compressor is operating and that the inlet guide vanes are opening. Measure flow with pitot tube and compare with annubar reading.

# ***Agenda***



**Basic Process Overview**

**by Gordon Maller, URS**



**Chemical Factors Determining Performance  
& Reliability**

**by Gordon Maller, URS**



**WFGD Troubleshooting by System**

**by Greg Bielawski, B&W**



**WFGD Performance Optimization,  
Maintenance and Inspection**

**by Greg Bielawski, B&W**

# ***WFGD Performance Optimization***

## ***Reagent Preparation***

- **Monitor limestone slurry quality**
- **Maintain mill tuning**

# Reagent Preparation Optimization

Limestone slurry quality should be monitored frequently for density and fineness. Do not rely on Marcy scale for tuning.

- **Density: >25%, <35% TSS**
- **Fineness: >95% passing 325 mesh sieve**

\*Follow OEM recommendations



# Reagent Preparation Optimization

## Adjustments

- Limestone feed rate
- Mill ball charge
- Mill product pump speed
- Number of classifiers in service

Adjust these parameters to optimize overflow (product) TSS and grind

## System Variables

- Overflow (product) TSS
- Overflow (product) grind
- Classifier Pressure
- Underflow TSS

Do not exceed OEM recommendations

# *Limestone Feed Rate*

Change to compensate for changes  
in limestone grindability  
(BWI, Bond Work Index)



## *Increase Feed Rate*

- **Increases TSS of product**
- **Decreases grind**

## *Decrease Feed Rate*

- **Decreases TSS of product**
- **Increases grind**

# ***Mill Ball Charge***

**Monitor mill motor amps to determine when additional ball charge is required.**



- ▶ **Mill motor amps and slurry grind will drop over time as balls wear**
- ▶ **Add additional charge according to OEM recommendations**
- ▶ **A “mill motor low amp” or “mill run time” alarm can help identify when additional ball charge is required**
- ▶ **Add a few balls a day after experience gained**

# ***Mill Product Pump Speed***

- ▶ **Changing the mill product pump speed changes the amount of dilution water required to maintain mill product tank level.**
- ▶ **A change in classifier inlet pressure will result in a change in slurry “cut” (lower inlet pressure = larger particles in overflow-product); higher inlet pressure = smaller particles in overflow-product)**

## ***Increase Speed***

- **Increases Classifier Pressure**
- **Decreases TSS of product**
- **Smaller particles in overflow product**
- **Increases grind**

## ***Decrease Speed***

- **Decreases Classifier Pressure**
- **Increases TSS of product**
- **Larger particles in overflow product**
- **Decreases grind**

# Number of Classifiers in Service

- ▶ **Similar effect as changing pump speed**
- ▶ **Number of spare classifiers should not be reduced from OEM recommendations**



## **More Classifiers**

- **Decreases Classifier Pressure**
- **Decreases TSS of product**
- **Smaller particles in overflow product**
- **Increases grind**

## **Less Classifiers**

- **Increases Classifier Pressure**
- **Increases TSS of product**
- **Larger particles in overflow product**
- **Decreases grind**

# ***WFGD Performance Optimization***

## ***Absorber***

- **Tune limestone slurry feed valve**
- **Verify online density measurements**
- **Set oxidation air flow**

# *Absorber Optimization*

## *Implement Efficiency Mode Control*

- Removal efficiency mode allows for most efficient use of limestone slurry. Reagent feed is controlled directly by the current SO<sub>2</sub> removal rate, rather than by the pH.

## *Verify Online Density Measurement*

- Ensures optimal slurry residence time
- Maintain gypsum quality

## *Set Oxidation Air Flow*

- Prevent excessive sulfite levels
- Maintain gypsum quality

# *Efficiency Mode Control*

## *Parameters Used for Feed Calculation*

- **SO<sub>2</sub> removal (lb/MBtu)**
- **Boiler coal flow**
- **Limestone slurry density (TSS)**

## *Tuning*

- **Slurry control valve should respond without delay to its demand signal (do not use derivative gain)**
- **Adjust proportional and integral gain on controller until a satisfactory response time is achieved**
- **A 1% step change in removal efficiency should reach steady state in less than 1 hour**

# ***Absorber Density Measurements***

**Accurate density measurements are crucial for proper absorber performance**

- ▶ **Compare Marcy scale density reading with in-line meter once per day**
- ▶ **Verify online density meter with lab processed sample at least once a week**
- ▶ **Marcy scales should be used as a spot check only, not for calibrating the in-line meter**

# *Oxidation Air Flow Rate*



**The oxidation air flow rate should be optimized to minimize sulfite levels**

- ▶ **If gypsum sulfite levels are high, increase oxidation air flow rate**
- ▶ **Do not go higher than required to maintain low sulfite levels, as selenate levels may be affected**
- ▶ **Ensure adequate humidification water is being added**

# ***Routine Performance Monitoring***

<i><b>Monitor</b></i>	<i><b>Initial Action / Remedy</b></i>
<b>SO<sub>2</sub> concentrations and removal</b>	<b>Calibration</b>
<b>pH</b>	<b>Calibration Acid flush</b>
<b>Slurry Density</b>	<b>Calibration Gravimetric check</b>
<b>DBA concentration (if used)</b>	<b>Analysis</b>
<b>Limestone grind</b>	<b>Sieve analysis</b>
<b>Stoichiometry (pH / gypsum quality)</b>	<b>Analysis</b> <ul style="list-style-type: none"> <li>• Wallboard – more frequent</li> <li>• Disposal – less frequent</li> </ul>
<b>Gypsum moisture content</b>	<b>Analysis (wallboard)</b>

# ***Routine Maintenance of Instrumentation***

## **Gas-side taps**

- **Rod out monthly**

## **Flowmeters**

- **Calibrate bi-monthly**
- **Clean process piping and repair as necessary**

## **Local controls**

- **Inspect and repair as required**

## **Level detectors**

- **Clean probes weekly and repair as necessary**

## **Pressure gauges and switches**

- **Calibrate annually and repair as necessary**

# ***Periodic Equipment Inspection***

## **Pumps**

- **Check oil level**
- **Check for excessive seal leakage**
- **Check for vibration**
- **Check belt tension (if belt drive)**
- **Check gear box (if used) oil temperature and coolers**
- **Check pump bearing and motor temperatures**
- **Trend amps in DCS to detect wear / spray nozzle pluggage**

## **Agitators**

- **Check oil level**
- **Check for high vibration**
- **Check blades for wear or damage (outage)**
- **Check for gland seal water leakage**
- **Trend amps in DCS to detect wear**

## **Strainers**

- **Check differential pressures each shift**
- **Clean when differential is high and/or alarm sounds**

# ***Periodic Equipment Inspection***

## **Motors**

- **Perform temperature check on bearings and casing**
- **Check shaft alignment and couplings**
- **Check motor heater current**
- **Measure insulation resistance**
- **Check bearings**
- **Check brush wear and slip-ring face roughness**
- **Clean all parts contaminated with carbon dust**

## **Electrical**

- **Annual inspection unless manufacturer advises higher frequency**

## **Relays**

- **Confirm target reset**
- **Check rotating points and lubricate**
- **Check contact points**

# ***Scheduled Outage Inspections***

## **Absorber Entry Safety Precautions**

- **Observe confined space safety procedures**
- **Before entering any absorber access door, be aware that there may be large deposits, debris, or loose internals above the door that could fall and cause injury or worse (use mirror prior to entry)**
- **Carefully install temporary lighting for outage work and do not leave unattended (ME's and FRP headers burn!)**

## **Absorber Reaction Tank**

- **Document on the inspection sheet the location of scale or deposits, or any signs of corrosion. Removal of loose material, e.g., sludge deposits, scale, tramp materials and debris, will help decrease the possibility of nozzle plugging and nozzle and pipe wear.**

## ***Scheduled Outage Inspections – Cont'd***

### **Absorber Spray Headers**

- **Check the spray nozzles for plugging. These nozzles may be inspected from the absorber tray or separate maintenance platform (open spray tower).**
- **Note the nozzles in need of repair on the inspection sheets. Plugged nozzles may result in lower SO<sub>2</sub> removal and may increase the wear rate of the other nozzles in the header.**
- **Replace or clean nozzles as necessary. Planking, scaffolding, or a ladder can be used for access to the nozzles as may be permitted by specific safety instructions.**
- **Check headers for erosion due to unusual gas flow patterns or direct spray impingement on the header.**

## ***Scheduled Outage Inspections***

### **Mist Eliminator Sprays**

- **Check the spray headers by running water through the headers. Note the locations of plugged nozzles on the inspection sheet. If plugged nozzles are found, the cause should be determined and remedied (e.g., a missing or broken mist eliminator wash water basket strainer). Poor spray flow may lead to mist eliminator plugging.**
- **Replace or clean nozzles as required. Under sprays may be accessed from planking across the spray headers. Over sprays may be accessed from planking carefully placed on the mist eliminator blades after specific safety measures are taken.**

### **Reagent Preparation and Dewatering Equipment**

- **Inspect and repair in accordance with manufacturers' instructions.**



## ***WPCA Illinois Regional Seminar***

***September 13-15, 2011***

***Marriott Bloomington-Normal Hotel***

***Bloomington-Normal, IL***

**The power generation end user is facing a challenge in the upcoming years with Utility MACT, CATR, state specific mercury regulations, and more. This seminar will help them identify upcoming O&M problems and find solutions.**

***Thank You!***

