

REINHOLD ENVIRONMENTAL Ltd.



## **2016 APC-Wastewater Round Table & Expo Presentation**

July 18 & 19, 2016 in Dearborn, MI / Hosted by DTE Energy

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# Wet FGD Operations and Lessons Learned

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July 18, 2016



# WFGD Operations and Lessons Learned – Monroe Station

Monroe Station Characteristics

WFGD System Performance

Equipment Opportunities for Improvement

Operations and Analysis

System Modifications

# System Characteristics



# WFGD System Characteristics

- **Limestone Force Oxidized**
- **Spray tower with trays**
- **Design Fuel 1.54% S (3 lb/Mbtu)**
- **Typical Fuel Blends**
  - PRB or Eastern Low Sulfur Coal
  - High Sulfur Fuel
- **Limestone Supply**
  - Local limestone supply
- **Make-up Water Sources**
  - River water, lake water
- **Gypsum Production**
  - Salable Gypsum



# WFGD System Performance

Limestone Slurry %TSS	28% – 30%
Absorber Slurry %TSS	19% – 21%
pH	4.5 – 5.5
Chlorides	9,000 – 12,000 ppm
Oxidation Air	13,500 – 15,000 scfm
SO <sub>2</sub> Removal	97%
Gypsum Purity	95%
Gypsum Moisture	8% – 10%

# AR Pump Challenges



**Warman 800 TY-GSL**  
**4 x 33%**

# AR Pump Impeller Wear



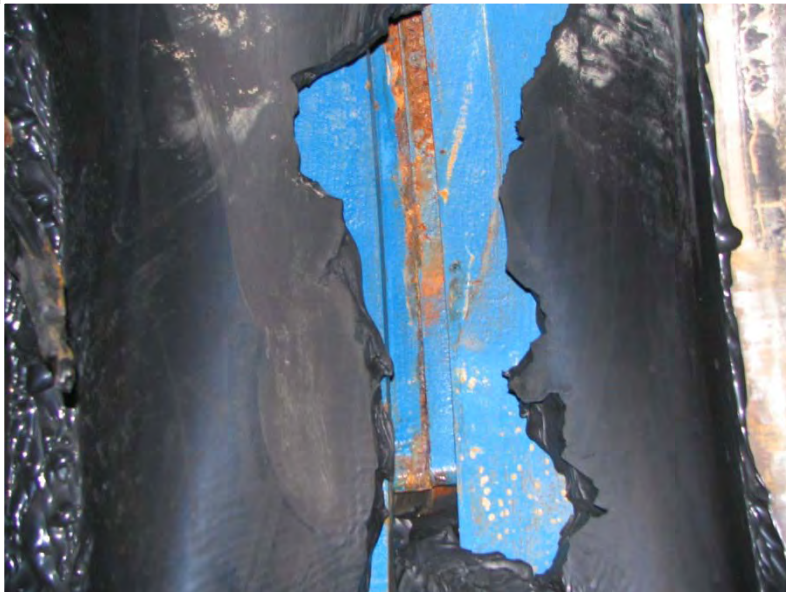
# AR Pump Rubber Liner Failure



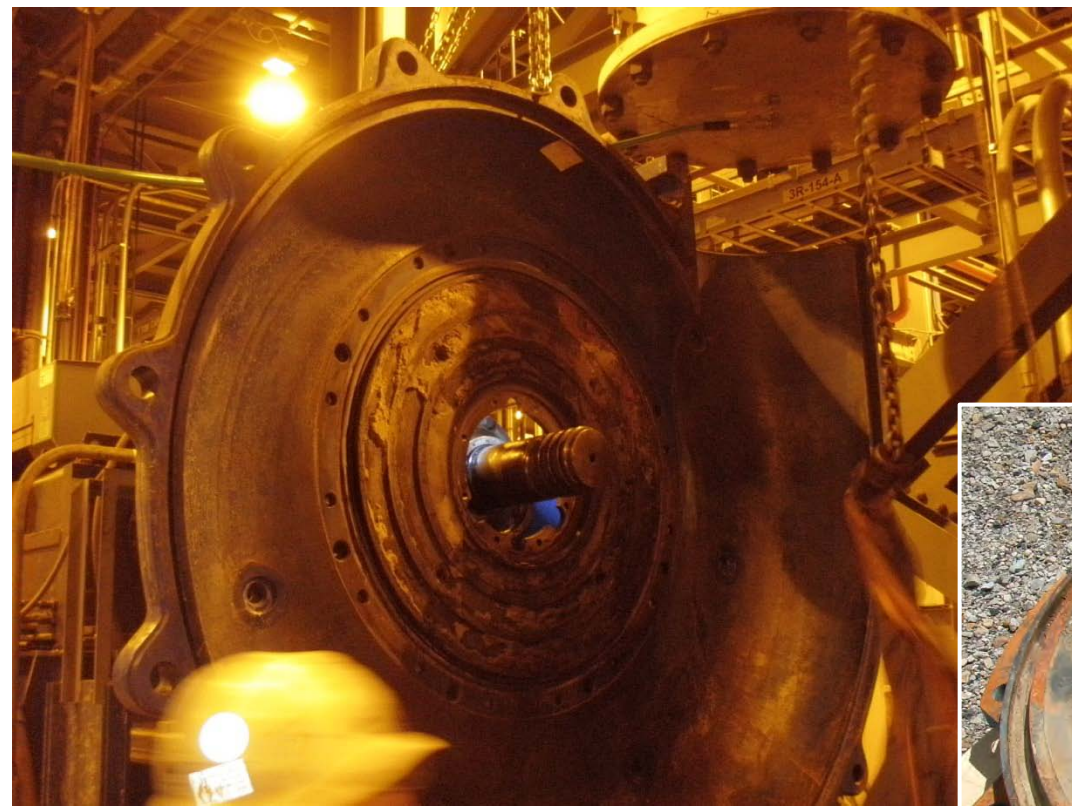
# AR Pump Rubber Liner Failure



# AR Pump Rubber Liner Failure



# AR Pump Rubber Liner Failure



# AR Pump Rubber Liner Failure

- ▶ Rubber plugging nozzle



# AR Pump Issues

- **Erosion of frame plate rubber liner insert**
- Severe enough to cause liner failure
- Slurry migrated behind liner
  - Corrosion of pump casing
- ▶ Original pump design used
  - Flush-less mechanical seal, Burgman 03-HR321/165-G1-E4
- **Rubber pieces from liner plugged AR spray nozzles**
- Reduction in SO<sub>2</sub> removal capability observed
- **Erosion/Corrosion of Impeller**

# AR Pump Issues

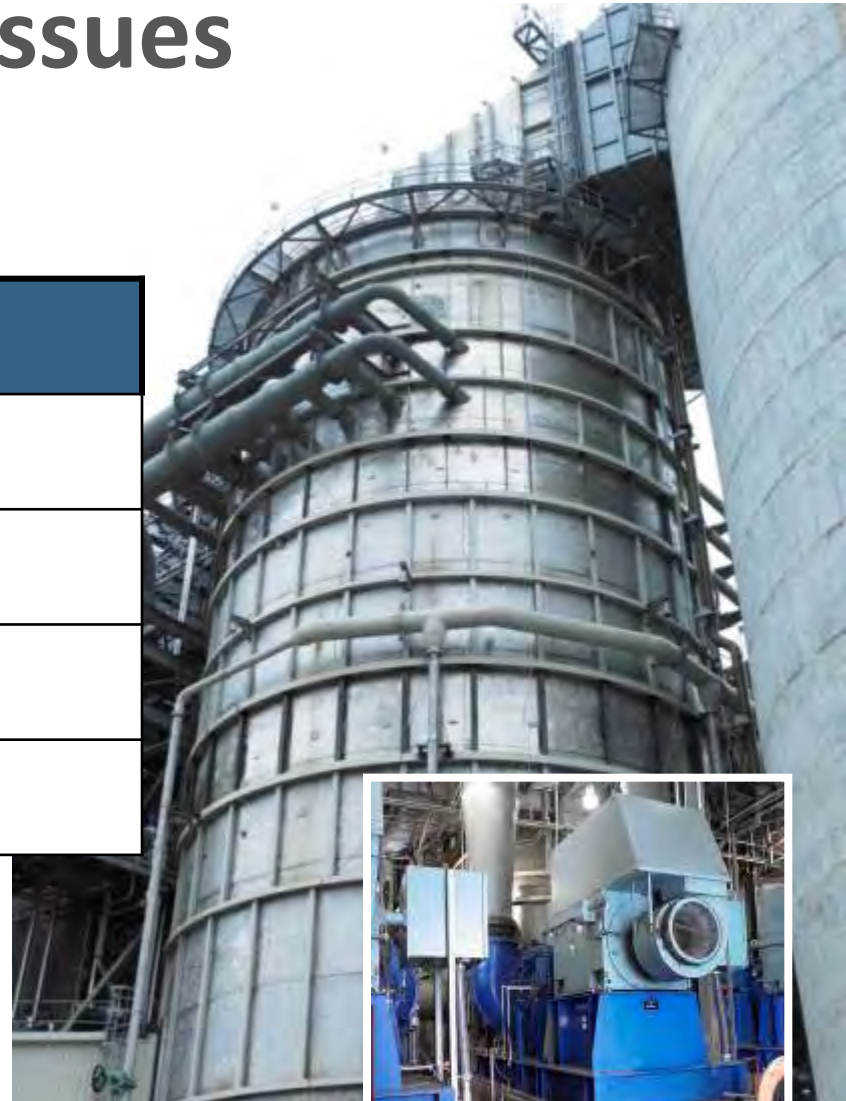
## *Performance Impacts*

**Decreased L/G – pump capacity**

**Impact to spray coverage/gas bypass**

**Decreased Nozzle dP**

**Operation of Spare Recycle Pump**



# AR Pump Modification

- **Replaced Impellers and Throatbush**
  - Cast alloy material
- **Added ceramic adapter plate behind impellers**
- **Added flush water to mechanical seals**
  - Approximately 10 gpm at 140 psig
  - Erosion rate decreased by pressurizing the area behind impeller
- **Achieved 3 year run time after modification**

# Inlet Buildup



# Inlet Buildup

## Inlet Buildup in LFSO WFGD System

- ▶ Observed in several WFGD installations across multiple Utilities
- ▶ Low load operation allows surface waves in tower to “lap” into the inlet
- ▶ Eddies in the flue gas flow are formed at the side edges of the inlet as the gas passes from the gas inlet to the interior of the WFGD tower



# Inlet Buildup

- **Buildup is several feet high**
- **Accumulates on handrail**



# Buildup on Inlet Handrail



# Inlet Buildup

- ▶ Deposits are mainly gypsum, gypsum hemi-hydrate, and anhydrite (dehydrated gypsum)
- ▶ The inlet deposits are not rehydrated in slurry, so large pieces break off and are drawn through the pumps
- ▶ Excessive buildup may shed due to thermal cycles (startup/shutdown and load cycling), or by gravity into absorber reaction tank at intervals
- ▶ Major source of hydroclone pluggage, excessive pump wear & header pluggage



# Inlet Buildup – Hydroclone Plugging



**Good Underflow Pattern**



**Roping – Potential Plugging**

# Inlet Buildup – Hydroclone Wear



**Wide Angle Indicates Worn Apex**



**Hard Inlet Scale May Prematurely Wear Apexes**



# Spray Header Plugging from Inlet Buildup



# Inlet Buildup

## *Performance Impacts*

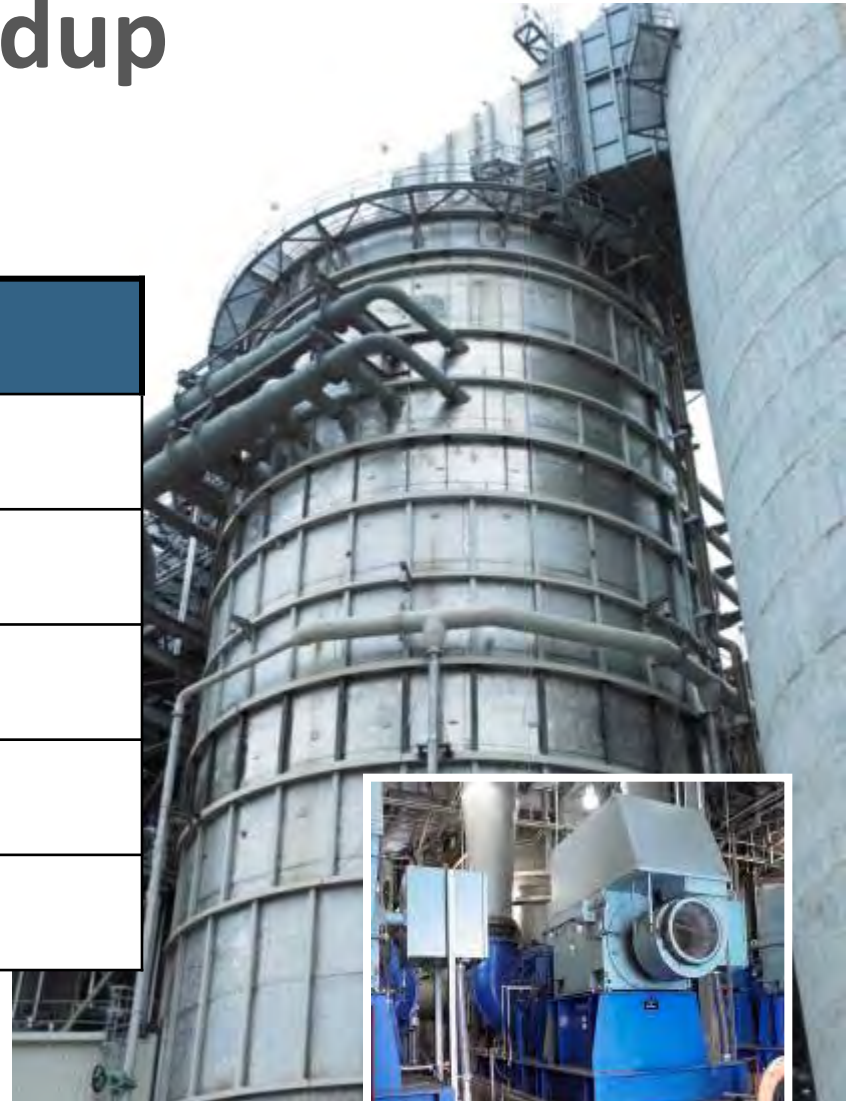
**Decreased L/G – header plugging**

**Impact to spray coverage/gas bypass**

**Decreased Nozzle dP**

**Operation of Spare Recycle Pump**

**Hydroclone Performance Impacts to Filter**



# Inlet Buildup - Remedies

- ▶ Inlet handrail removed at DTE Monroe
- ▶ Solids buildup has been greatly reduced since removal



# Inlet Buildup - Remedies

- ▶ **Installation of pump suction strainers**



# Inlet Buildup - Remedies

- ▶ Installation of dual basket strainers for hydroclone feed line



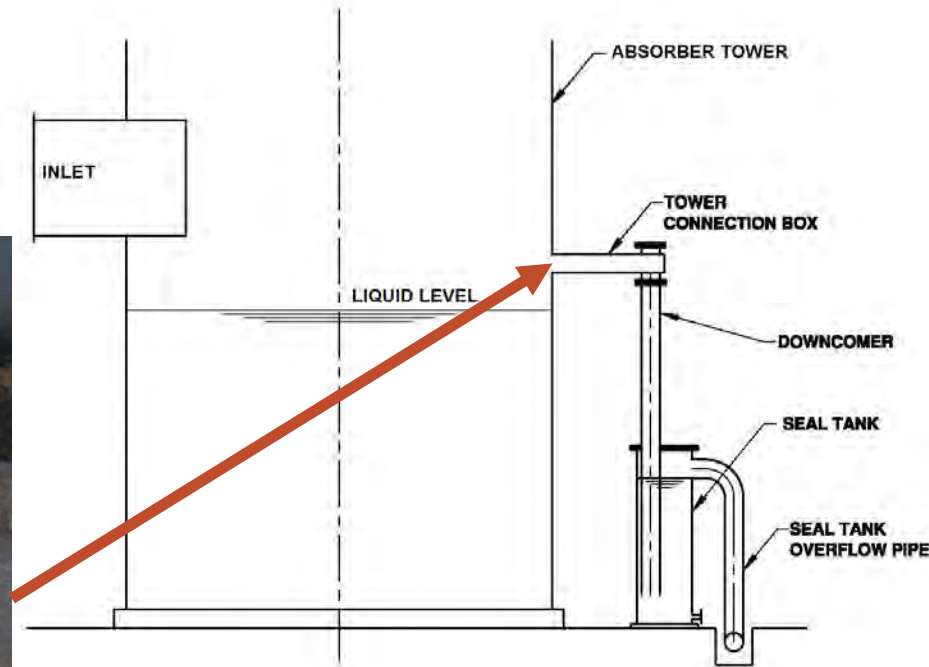
# Inlet Buildup - Remedies

- ▶ Installation of an inlet wash system



# Absorber Overflow Plugging

- Slurry solids accumulation in tower overflow connection box
- Did not allow overflow to drain out of tower



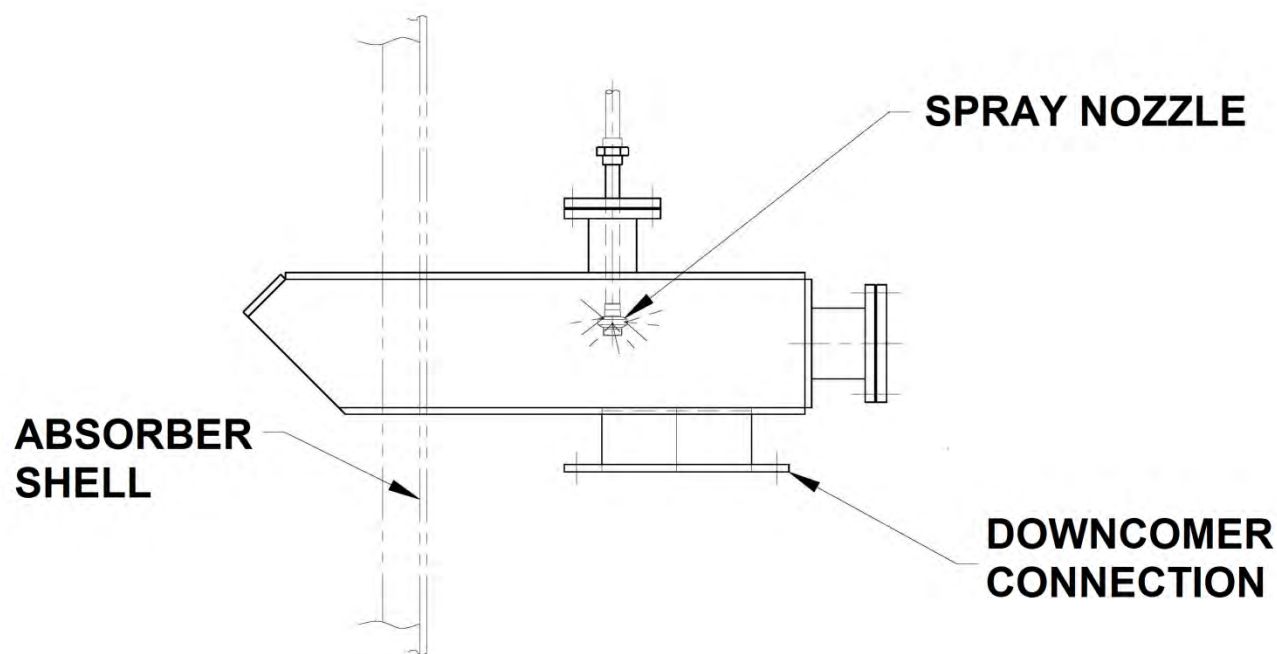
# Absorber Overflow Plugging

- **Blocked overflow caused slurry to flow into absorber inlet**
  - Inlet drain connections were plugged
  - Approximately 32" of material accumulated on floor of inlet



# Absorber Overflow Modification

- Spray nozzle installed in overflow connection box
- Periodically sprays water to wash-off solids deposits
- Overflow plugging not experiences since wash nozzle installed



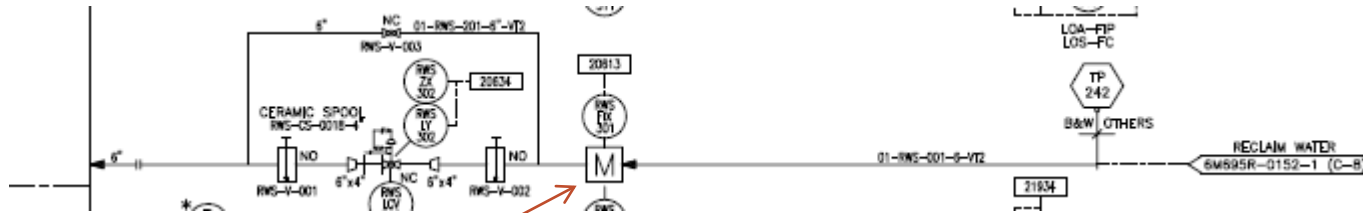
# Absorber Level Control Challenges

- ▶ Level measurement difficulty
  - Solids buildup on absorber floor
- ▶ Flush Connection Added
  - Flush water used to clear connection

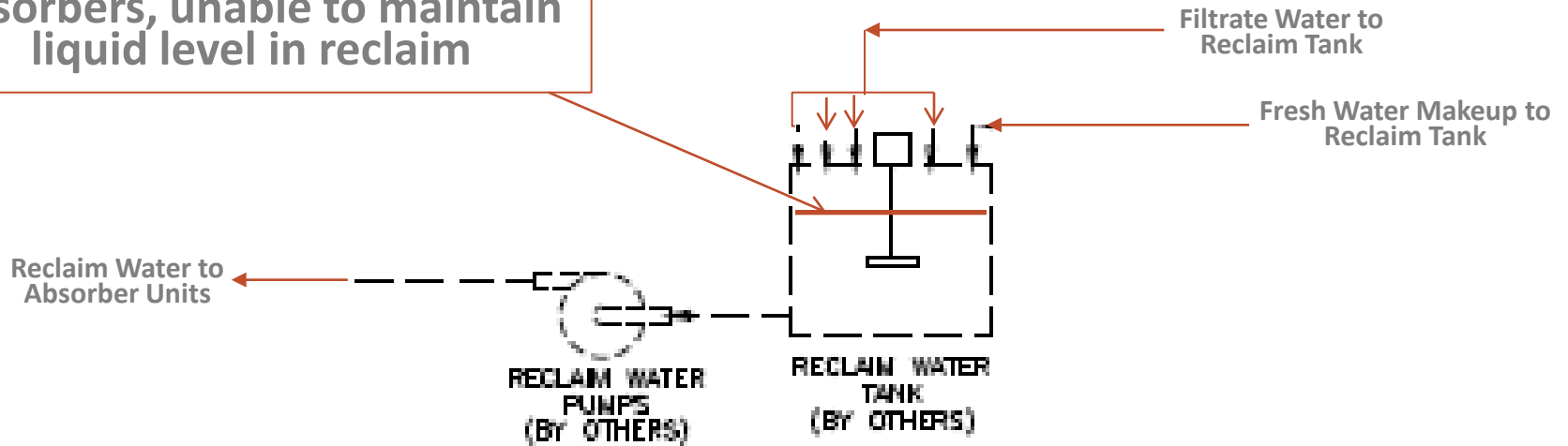


# Absorber Level Control Challenges

- ▶ Difficulty with level deadband control
- ▶ Switch from deadband level control to continuous level control



High demand for water to absorbers, unable to maintain liquid level in reclaim



# Absorber Bleed System

- **Density control difficulty with high S fuel**
- **Pump speed set too low to maintain %TSS setpoint**
  - Adjustable sheaves set to slowest speed
- **%TSS reached high set point and even with continuous bleed to the hydroclones did not decrease**
- **Pump sheaves replaced to increase pump speed with higher margin above maximum bleed required**



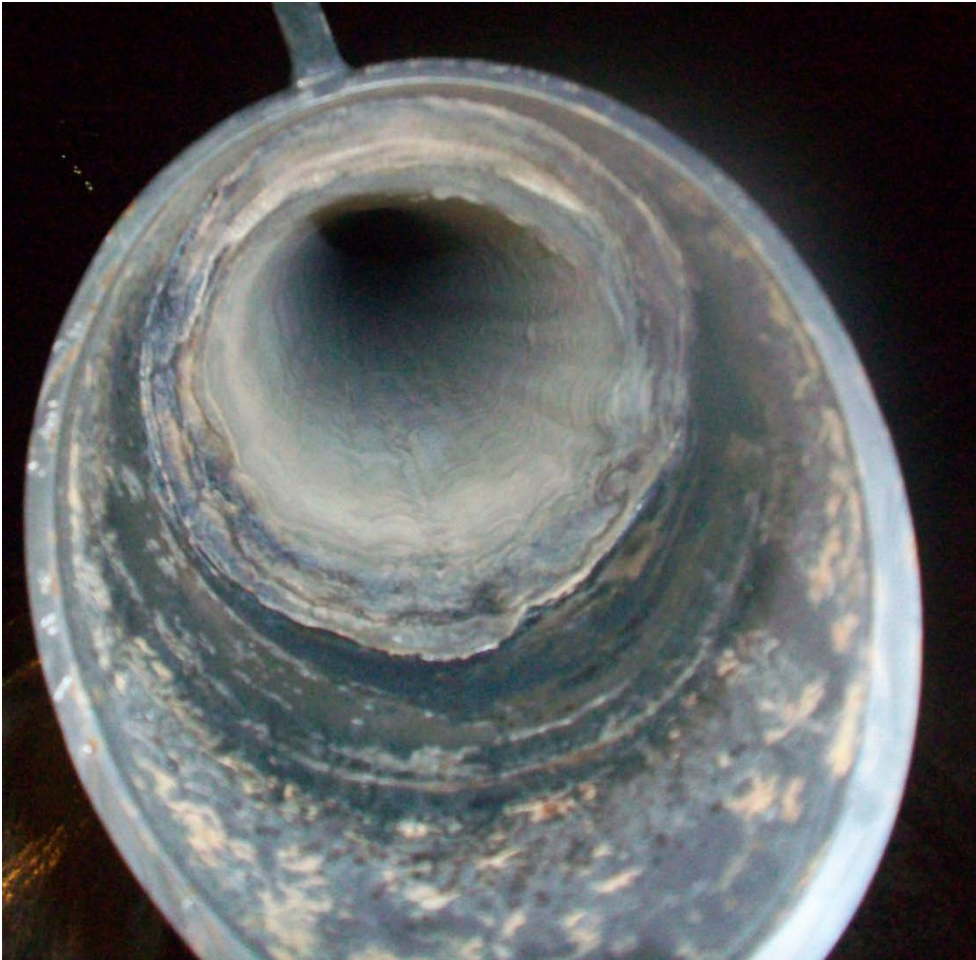
# Absorber Bleed System

- Possible that debris contributed to challenges
- Higher dP in hydroclone while plugged with solids



# Oxidation Air System Challenges

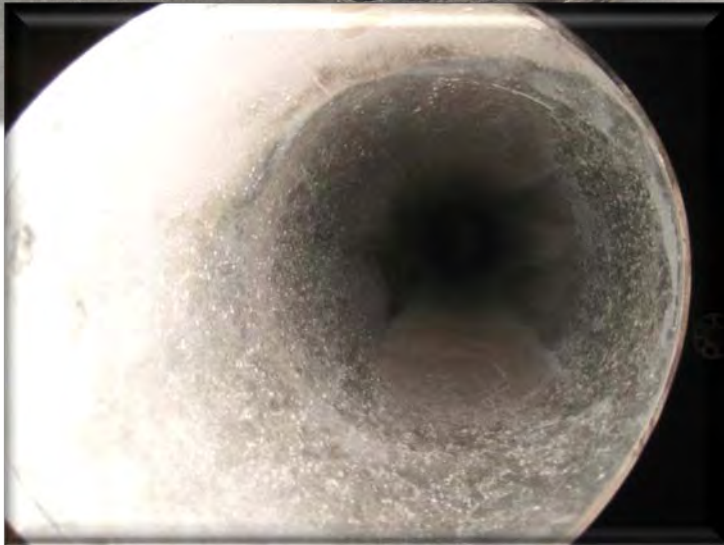
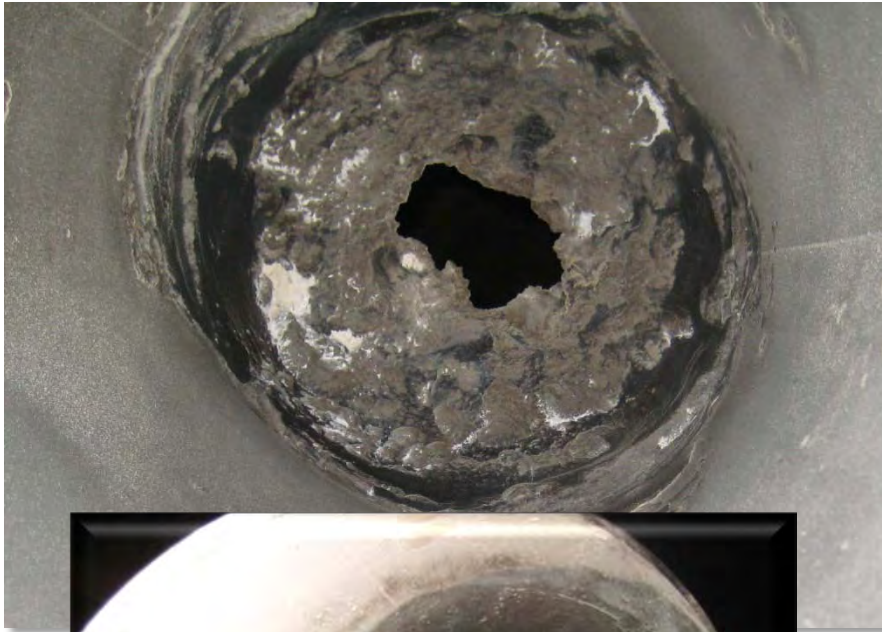
- ▶ Most oxidation air lances experience plugging



- ▶ Severe cases have 1" to 2" opening or completely plugged off
- ▶ Possibly due to:
  - Low lance air velocity when turning down air flow
  - Incomplete humidification
  - Impurities in humidification water
  - Chemistry upsets
  - Recirculation eddies in lance

# Oxidation Air System Challenges

- ▶ Possible solutions include:



- ▶ Individual lance airflow measurements
  - Detect plugged lances
- ▶ Humidification water to each lance:
  - Control water pressure
  - Spray nozzle for each lance
  - Strainer in humidification water piping

# Limestone Preparation System



# Limestone Weigh Feeder

## Chute plug detector

- Historically, system falsely trips w/ fine Limestone
  - Install Flush Line
    - Adds insignificant amount of water to Grinding Side (~2 gpm)
    - Activates only during cleaning cycle



# Charging Ball Mill

## ▶ Proper ball mill charge must be maintained

- Use the commissioning baseline ball mill motor amps as a reference point for adding new balls
- The continued addition of 2.5" or 3" balls is critical to keeping a proper ball charge. As balls wear down adding new large balls keeps the charge size distribution in spec.



# Charging Ball Mill



- ▶ **HIGH SOLIDS IS THE NAME OF THE GAME**
  - Operate with 70% design cyclones valved in @ min pump speed
    - Looking for max classifier pressure w/ proper underflow spray
- ▶ **Run grinding circuit for ~4 hours with ~35% design limestone TPH**
  - Monitor driveline temps
  - Record BM motor horsepower

# Tuning Grinding Circuit

- **To Increase TSS:**

- Decrease total water
- Decrease NPSH (PT Level)
- Decrease pump speed
- Increase pressure against pump
  - Close Classifiers – ensure no roping

- **Everything happens at the classifier**

- **Sample & Record:**

- Classifier overflow
- Classifier underflow
- Classifier feed

- **Get system to design specs then sample TSS**

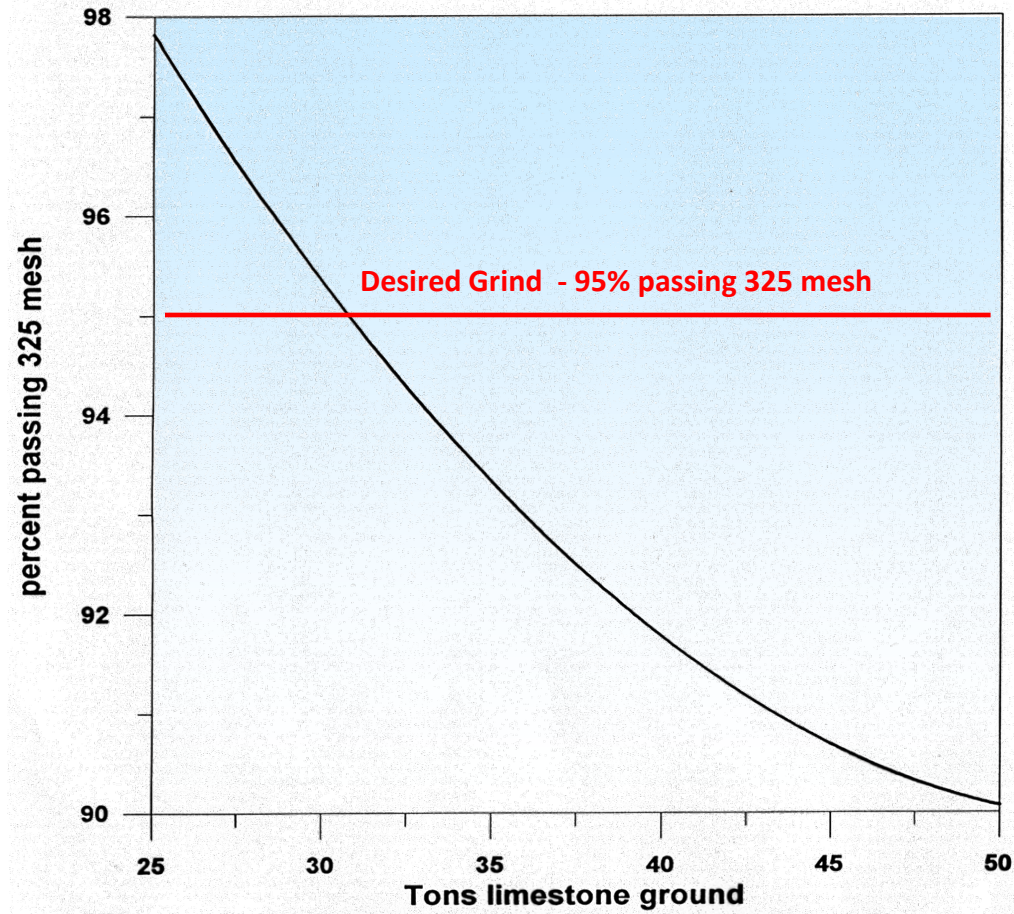
- **Adjust the above variables to get correct TSS**

- **If % passing (325 mesh) or rejects unacceptable at these settings, then consult vendor for design changes**

- **Important to maintain design grind for absorber performance**



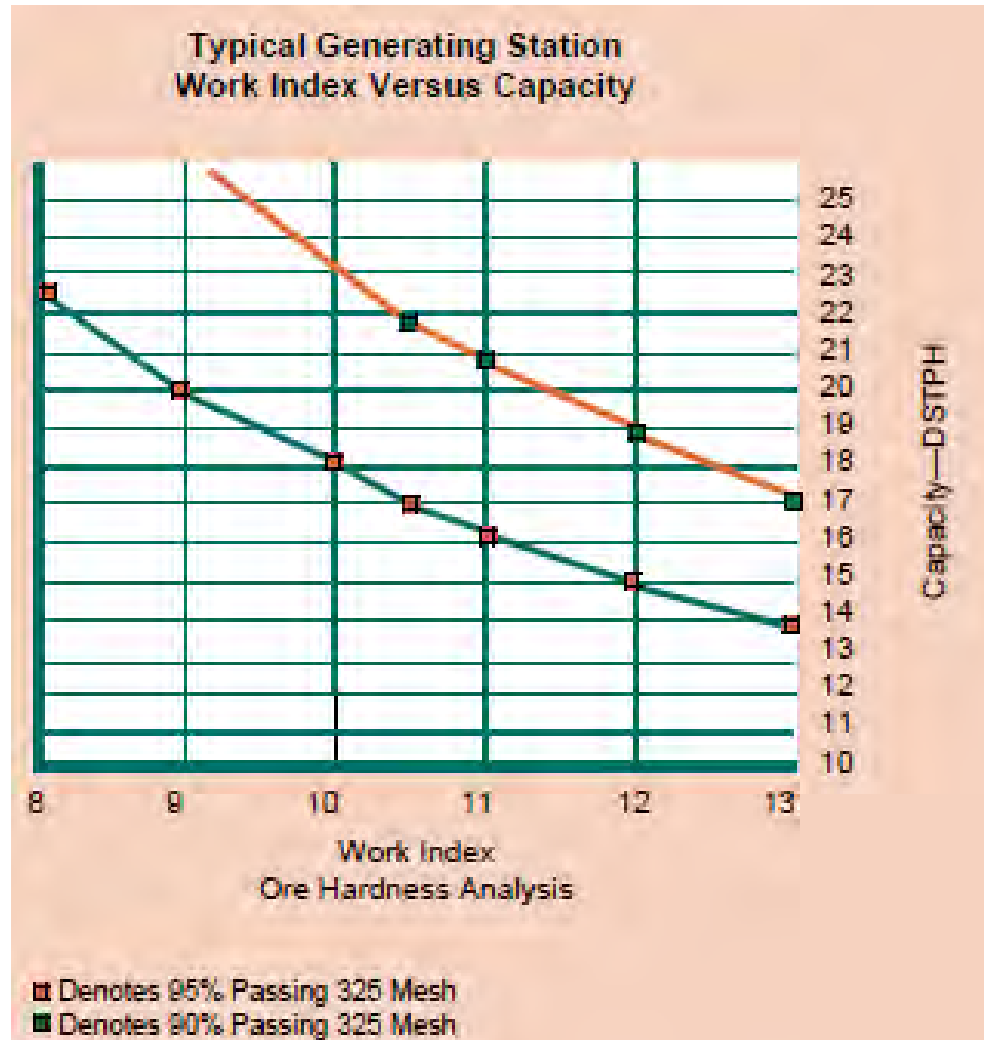
# Typical Ball Mill Performance (Theoretical)



For Illustration Only – Not for Design



# Typical Ball Mill Performance (Theoretical)

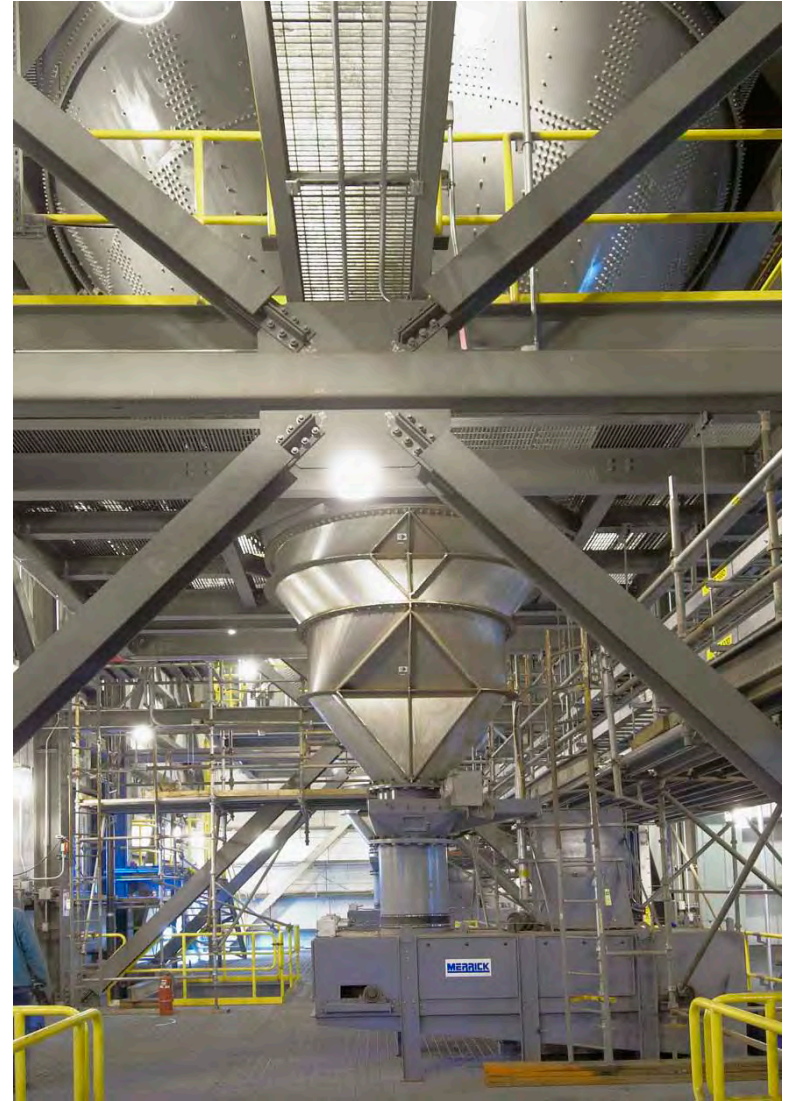


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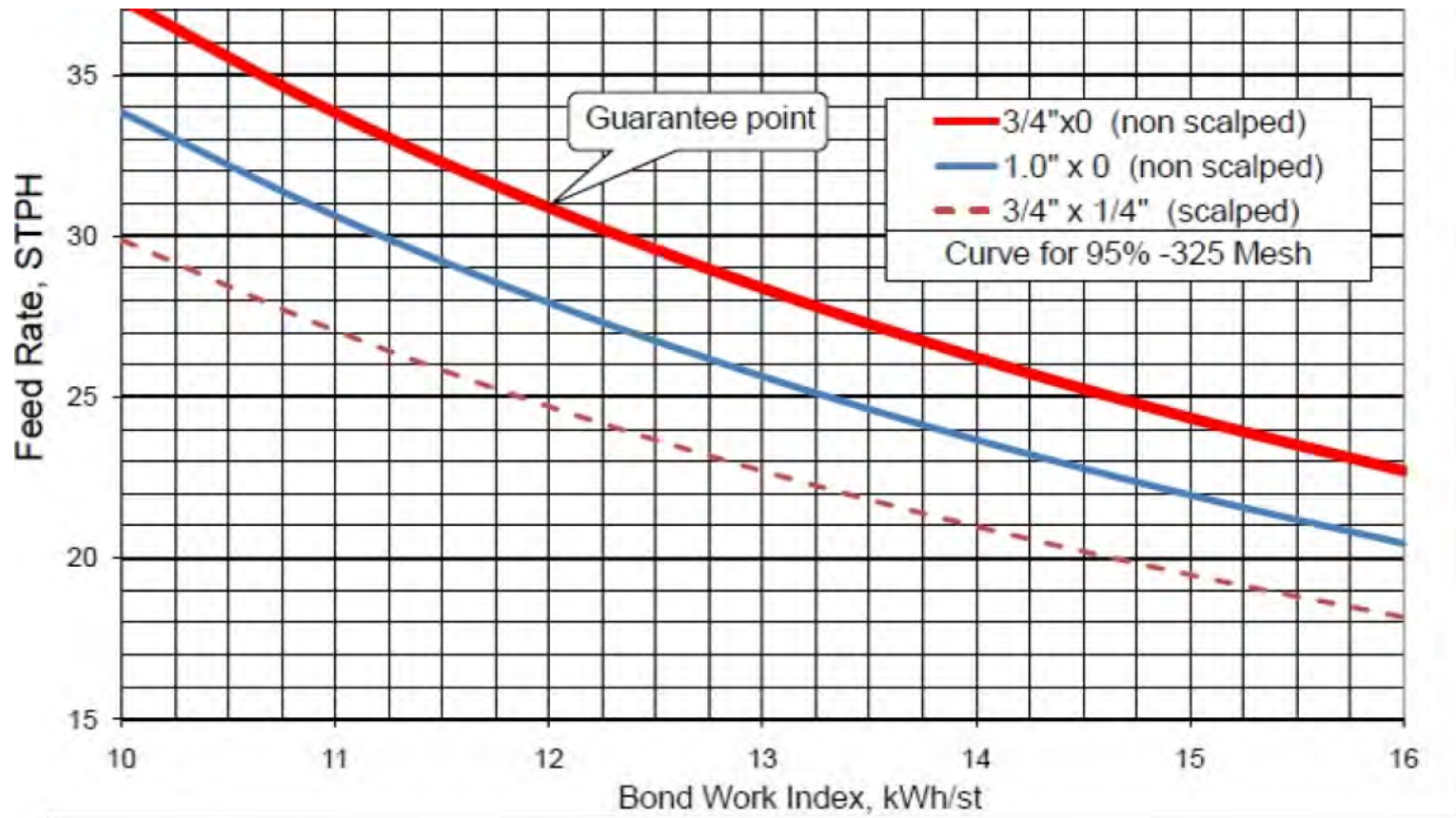
# Limestone Preparation System Challenges

- **Limestone freezing in storage piles or in rail cars**
- **Heaters installed to prevent freezing**
- **Avoid anti-freeze**
  - Potential to cause foaming
  - Chemistry upsets
- **Scalped limestone can be used periodically (not preferred)**
  - Very little fines
  - More resistant to freezing
  - Can cause issues will ball mill grind being too coarse due to impact on ball mill capacity



# Limestone Preparation System Challenges

Impact of scalped stone:



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# Gypsum Dewatering System



- **Saleable gypsum**
- **Moisture typically in acceptable range**
  - Influenced by ESP performance, excess inerts, limestone stoich
- **Crystal morphology can be an issue**

# Vacuum Belts

## Proper operations:

- ▶ **Setup trends for cake thickness, inerts, and vacuum level**
- ▶ **If system starts to behave outside of range, investigate**
- ▶ **Clean Cloth, ESP operation, hydroclone pluggage**



# Vacuum Belt Blinding

## Symptoms

- High vacuum – possible vacuum pump trip
- High % moisture gypsum

## Cause

- Excessive fly ash present in the absorber slurry
- Inerts in the limestone are higher than design
- Hydroclones need tuning
- Absorber bleed flow rate too low

## Operational Solution

- Verify inlet flue gas opacity to ensure amount is below design limits
- Check limestone composition to verify the inerts
- Verify hydroclone performance
- Increase absorber bleed flow rate

# Vacuum Belt Blinding

## Vacuum Belt Filter Cloth Cleaning

- Pressure washing of cloth
- Best to clean underside but can be washed on either side
- Spray from 8"-10" away
- Cleaning can be done spraying the feed end or discharge end
- Can run the filter belt in manual w/ NO PRODUCT for 12hrs. ENSURE lubrication and wash water (40 psi) are on



# Poor Water Quality

- ▶ Poor chemical properties such as high TDS and High hardness can cause scaling problems on the ME blades, in the Oxidation Air piping and in the belt filter system vacuum pump.
- ▶ High solids content can leave deposits on the ME blades, in the oxidation air piping and in the vacuum pumps. Additionally, high suspended solids can cause plugging of the ME wash nozzles and plugging of any water cooled heat exchangers.

# Oxidation Air Pipe Scaling at Humidification Spray Nozzle



# Wash Nozzle Plugging – ME plugging



# System and Trend Analysis – What to look for

**While operating the WFGD absorber, review of historic trends is essential so that system upsets can be identified and mitigation strategies implemented**

- ▶ **SO<sub>2</sub> Removal/Gas Phase Performance**
- ▶ **Reagent Usage**
- ▶ **Gypsum Product Formation**
- ▶ **System Feeds**
- ▶ **Slurry Solids Concentration (Absorber & Limestone)**
- ▶ **Operating pH**
- ▶ **ORP Measurements**

# **System and Trend Analysis**

## **Gas Phase Performance**

### **Has your SO<sub>2</sub> removal changed?**

- ▶ **Is your system operating in SO<sub>2</sub> removal, pH, or manual control mode?**
- ▶ **Plugged headers?**
- ▶ **Are your AR pumps performing per design?**
- ▶ **Have pump Amps changed?**
- ▶ **Are there changes in discharge pressure?**
- ▶ **Changes in inlet pressure or tower dP?**

# System and Trend Analysis

## Reagent Usage

**If your limestone stoichiometry has increased**

- ▶ **Has your limestone quality decreased? Higher BWI, lower reactivity, scalped stone?**
- ▶ **Is your ball mill tuned? Amps trend? Ball charge?**
- ▶ **Has limestone grind changed?**

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

# **System and Trend Analysis 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?**

# System and Trend Analysis

## System Feeds

**If your system is not performing as anticipated, feeds to the system may have changed.**

- ▶ Has the limestone supplier changed?
- ▶ Has the fuel composition changed?
- ▶ Is the make-up water shared from another system?
- ▶ Has the system been purging enough, or are fines being fed back into the absorber tower?

# Thank You Questions

