Reinhold Environmental Ltd.

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Effect of Key Process Variables on FGD Operation and Performance

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2007 APC/PCUG Conference

Key Factors in FGD Operation and Performance

Learning Objectives:

1. Understand which performance variables need to be controlled to achieve optimum performance and reliability
2. Understand that both chemical and mechanical factors affect performance and reliability

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Key Factors in FGD Operation and Performance (cont.)

Learning Objectives:

3. **Understand how FGD system performance and reliability are affected by process and operating conditions**
4. **Understand how various factors controlled or not controlled by operators affect FGD performance and reliability**

Session Topics:

- **SO_2 removal efficiency**
- **Reagent utilization**
- **Scaling**
- **Factors that affect FGD performance and reliability:**
  - pH
  - Slurry Density
  - Solution Chemistry
  - Limestone Properties
  - Liquid-to-Gas Ratio (L/G)
  - Mechanical Factors
  - Boiler Load

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Performance Variables That Require Control

- SO_2 removal efficiency
- Reagent utilization
- Scaling potential

SO_2 Removal Efficiency

Key Chemical Factors

- pH or alkalinity
- Excess limestone in recycle slurry (key for forced oxidized process)
- Solution chemistry
- Inlet SO_2 concentration

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SO_2 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

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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

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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

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pH

- Measure of acidity or alkalinity
- One of the most important process measurements
- Affects SO_2 removal efficiency and reagent utilization
- More limestone equals higher pH
- pH controlled by limestone addition rate
- Rate of corrosion increases at lower pH

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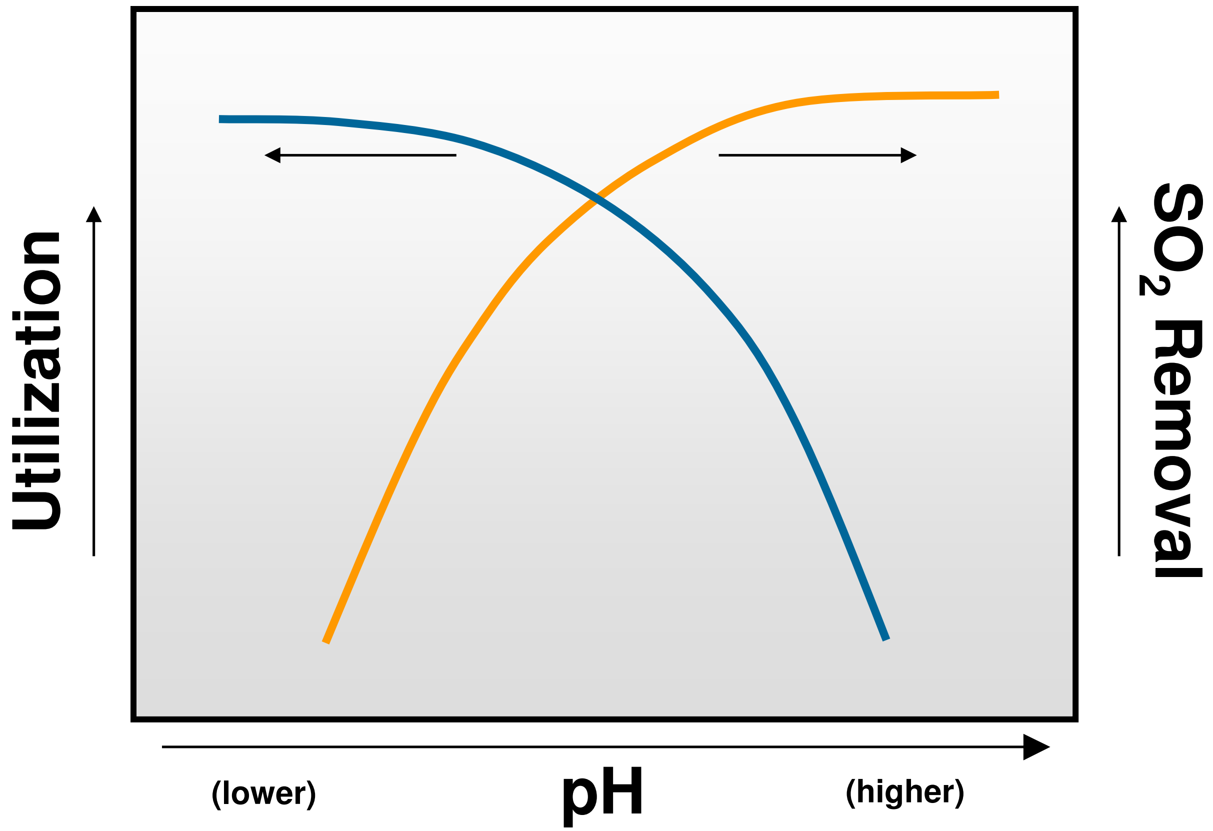
pH / Utilization / SO_2 Removal Relationships



Effects of Poor Reagent Utilization (pH too high)

- Increased reagent costs
- Increased waste disposal costs
- Increased scaling tendency
- Inability to produce acceptable gypsum byproduct

Rule-of-thumb: Poor utilization is any utilization lower than roughly 90% (or less than 95-97% for a system producing saleable gypsum)

pH Effects Summary

SO_2 Removal

- Increasing pH increases alkalinity and, as a result, SO_2 removal
- pH is one of the primary control variables for SO_2 removal efficiency
- Accurate pH control at an appropriate setpoint is critical to achieve design removal performance

pH Effects Summary (cont.)

Reagent Utilization

- Increasing pH can result in decreased reagent utilization
- pH is the primary control variable for reagent utilization
- Accurate pH control is necessary for maintaining good reagent utilization

pH Effects Summary (cont.)

Scaling Potential

- pH does not directly affect scaling potential
- Poor limestone utilization (less than 85%) can result in scaling

Corrosion

- Tendency for corrosion increases at lower pH

Slurry Density (Slurry Solids Concentration)

- 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_2 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.

Effects of Slurry Density Summary

SO_2 removal

- Density generally does not affect removal

Reagent Utilization

- Increased density improves reagent utilization (at a given pH)
- The effect on utilization is secondary to the effect of pH, but can be important when "fine tuning" scrubber performance

Effects of Slurry Density Summary (continued)

Scaling Potential

- Low density (less than ~4%) can result in scaling due to the limited seed solids surface area for precipitation to occur

Solution Chemistry

- **Dissolved Cl^- (Ca^{++}) Concentration**
  - Inhibits dissolution due to common ion effect
- **Forced oxidation vs. natural oxidation**
  - Stripping of 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**

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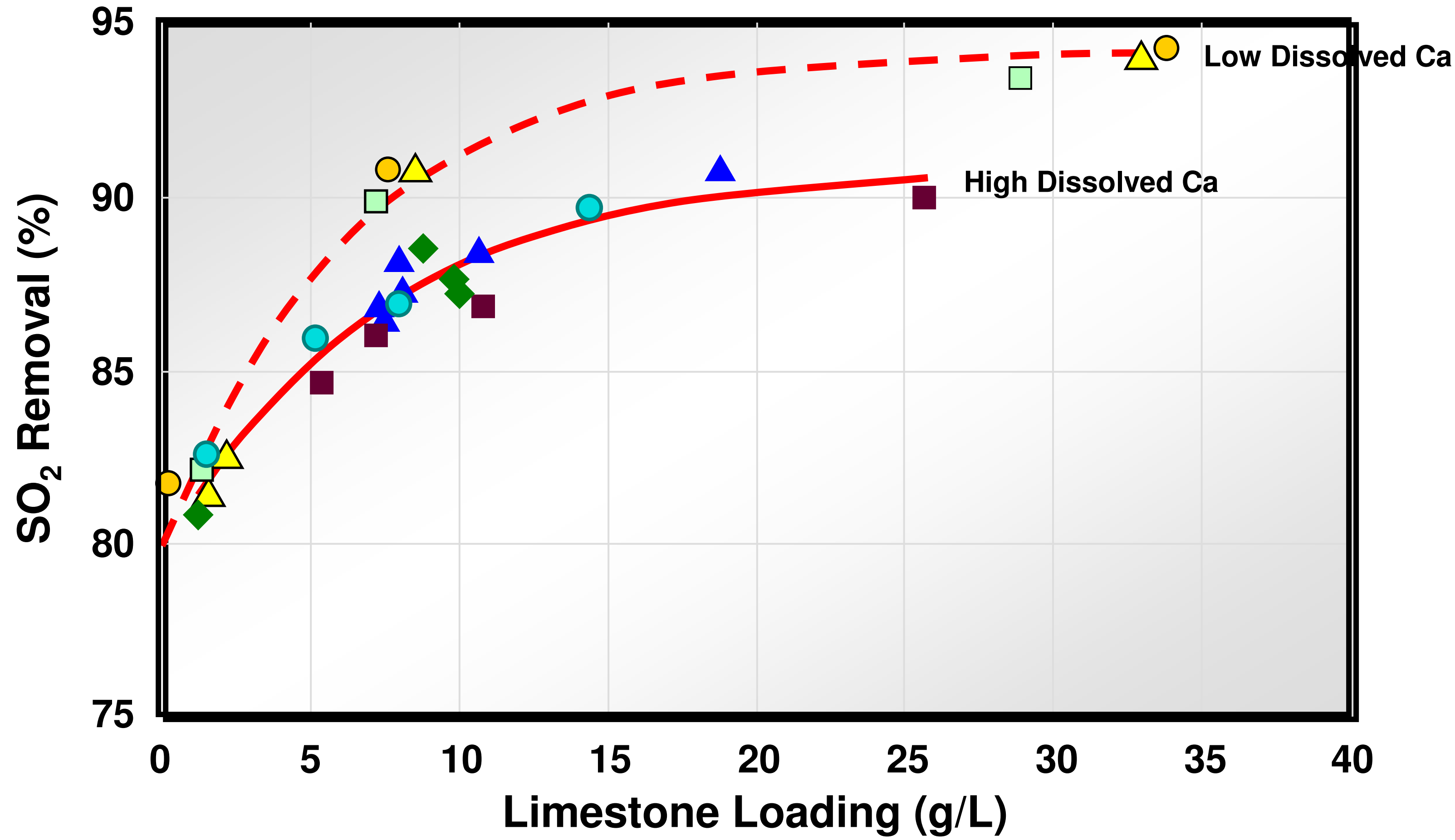
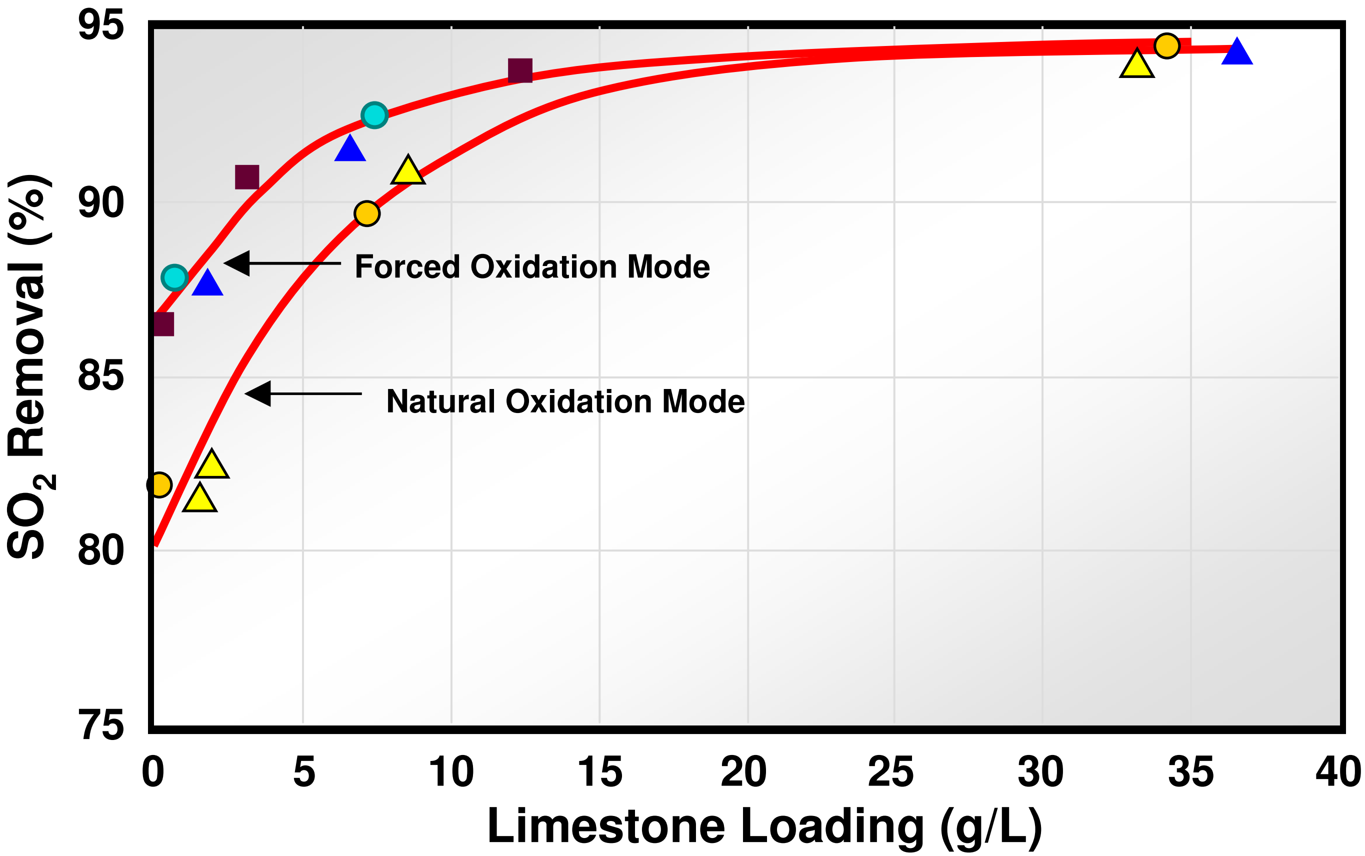
Effect of Dissolved Calcium Concentration

(Different Shaped Symbols Represent Different Limestone Tested)

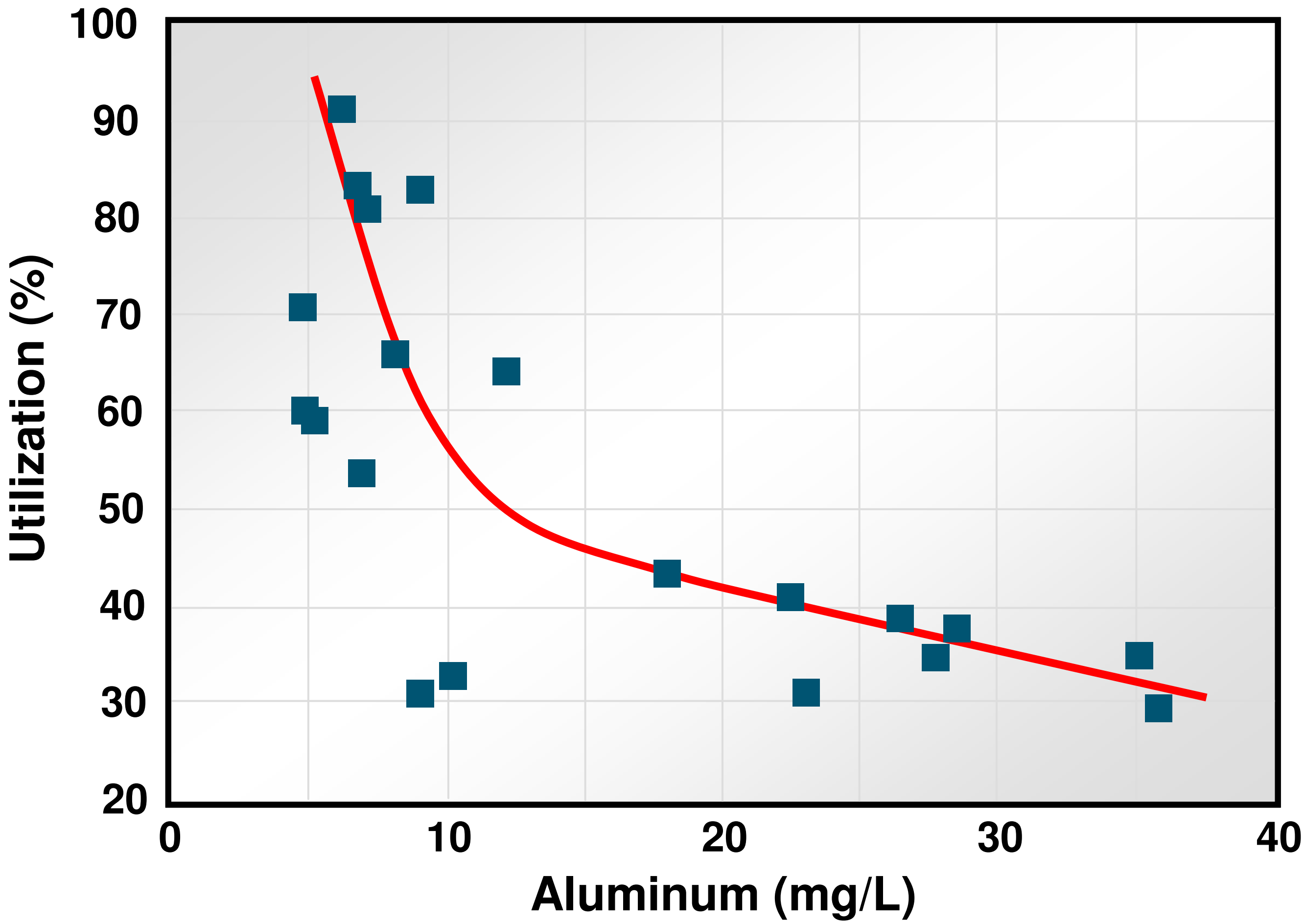


Effect of Oxidation Mode

(Different Shaped Symbols Represent Different Limestone Tested)



Effect of Soluble Aluminum on Limestone Utilization



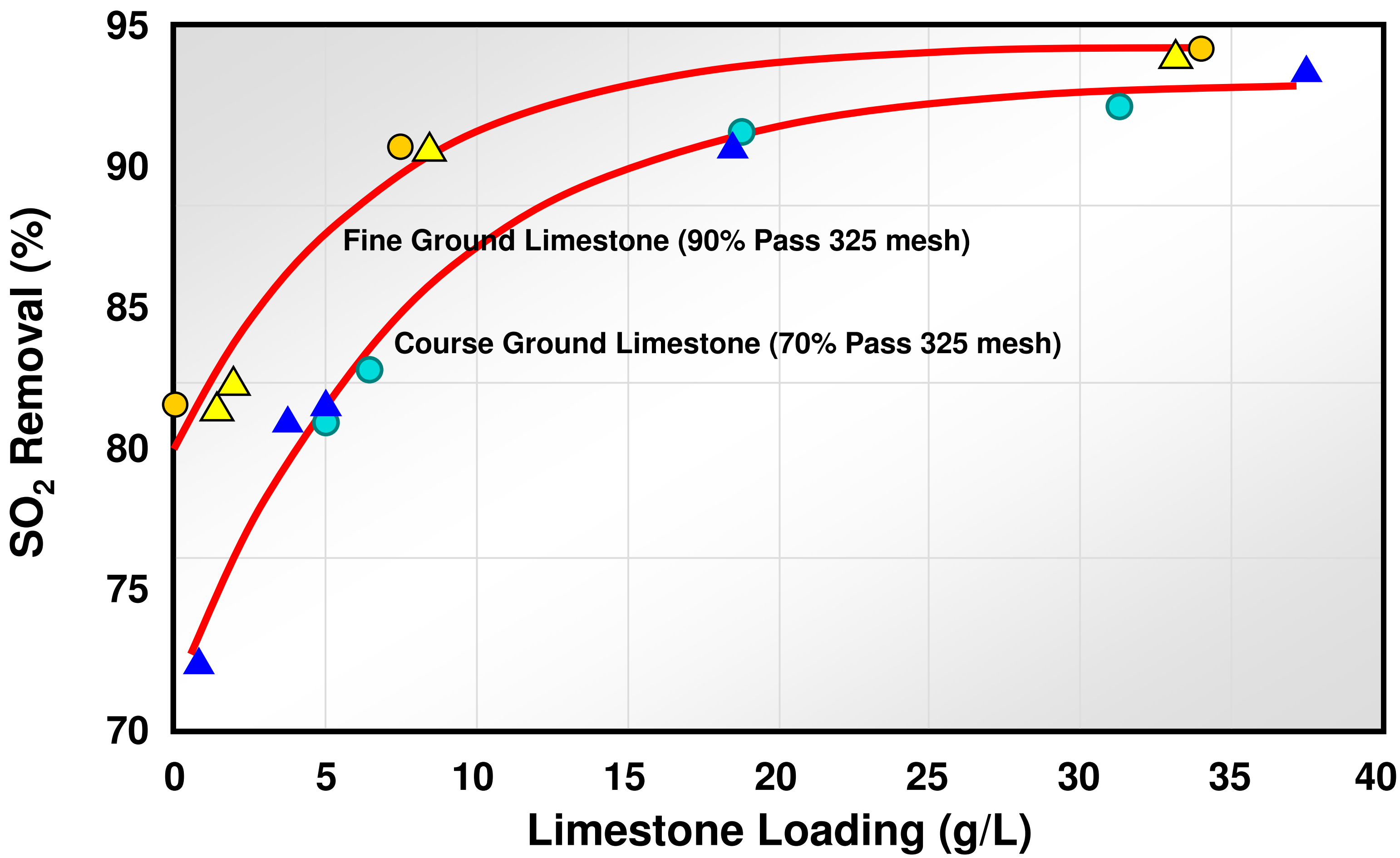
Limestone Properties Affecting Scrubber Performance

Properties will affect pH-Utilization-Removal relationship

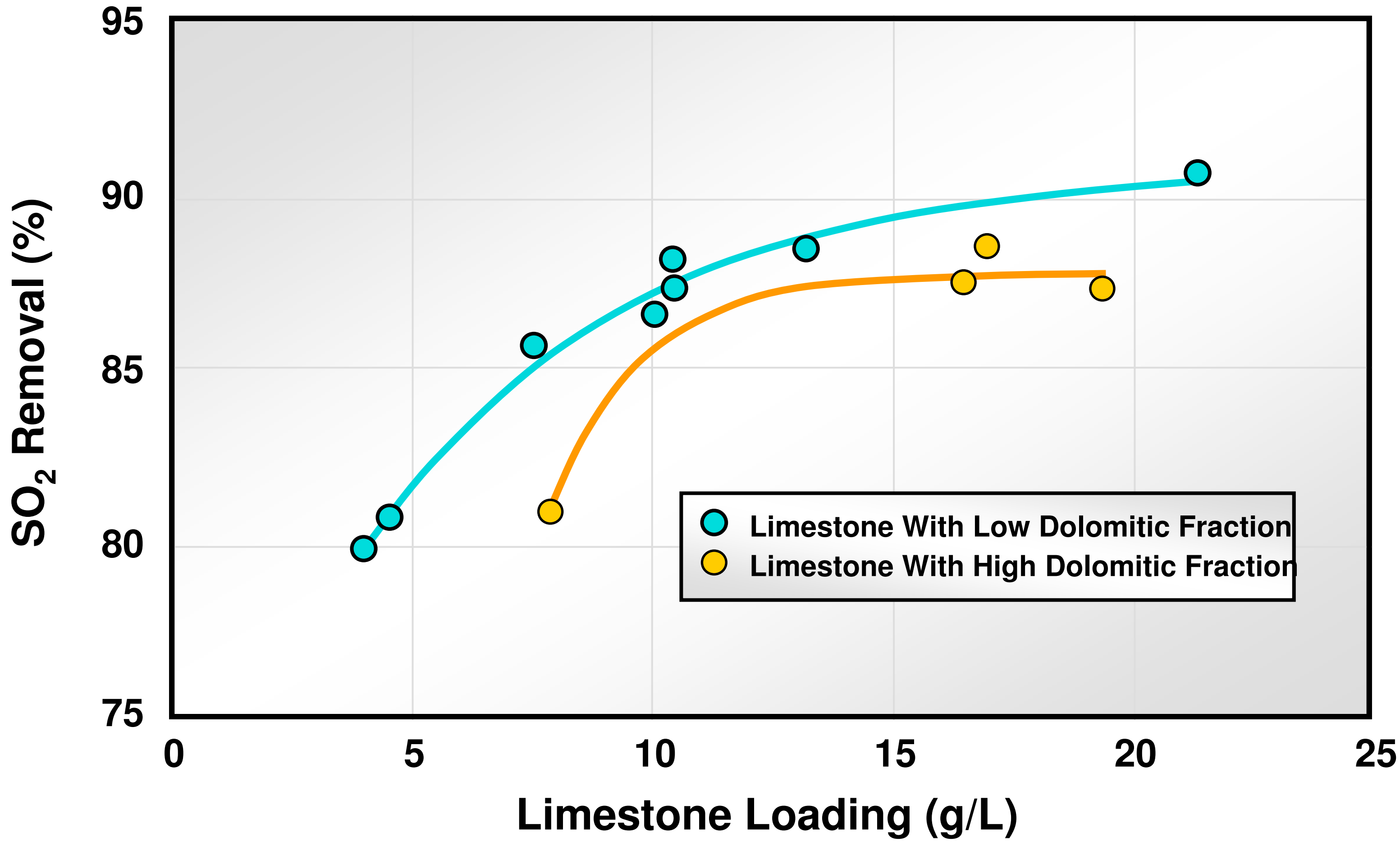
- **Grind**
- **Composition**
- **Reactivity (dolomitic fraction)**

Effect of Limestone Grind

(Different Shaped Symbols Represent Different Limestone Tested)



Effect of Limestone Dolomitic Fraction



Effects of Limestone Properties Summary

- Primarily affect the relationship between limestone loading and SO_2 removal
- Affect the limestone loading level required to achieve a specific SO_2 removal level
- Typically not controlled (although improving the grind may be possible)
- The cost of limestone has a significant impact on the total FGD operating costs. As a result, the selection of the limestone is very important.

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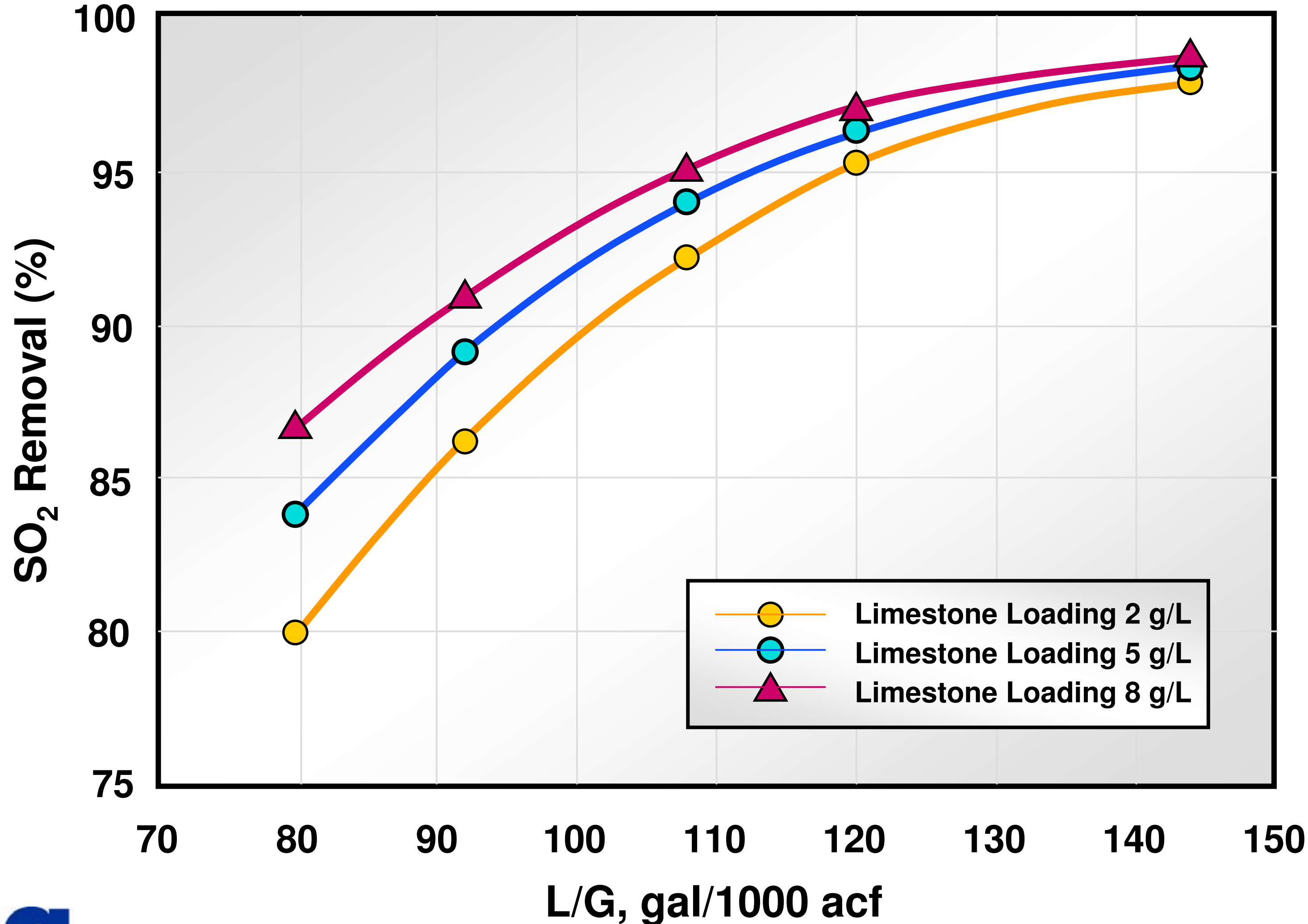
Liquid-to-Gas (L/G) Ratio

- **Determined from liquid flow (# of operating pumps) and gas flow (boiler load)**
- **Affects SO_2 removal efficiency**
  - Mass transfer driving forces
  - Alkalinity level
- **Increasing L/G increases particulate removal in scrubber**

Effect of Liquid to Gas Ratio on SO_2 Removal



Effects of Liquid-to-Gas Ratio (L/G) Summary

- **SO_2 Removal**
  - Increased L/G increases SO_2 removal
- **Reagent Utilization**
  - L/G generally has little effect on reagent utilization
- **Sulfite Oxidation**
  - Increased L/G tends to increase oxidation
- **Scaling Potential**
  - L/G generally has little effect on scaling potential

Mechanical Factors That Affect Performance

- Module cleanliness and maintenance
- Module design

Typical Module Mechanical Problems That Affect Performance (Cleanliness and Maintenance)

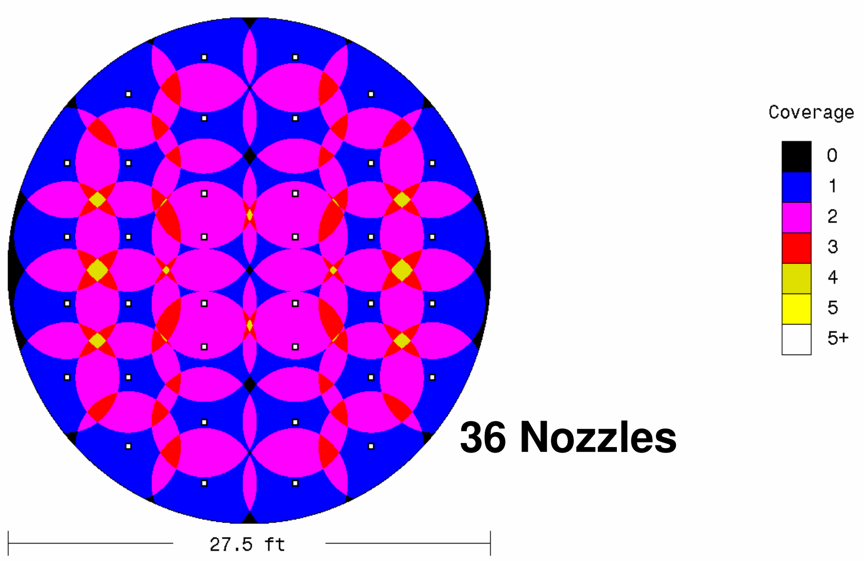
- Plugged nozzles
- Dirty / plugged mist eliminators
- Holes in headers
- All of these can dramatically affect SO_2 removal performance and scrubber reliability

Typical Problems with Module Design That Affect Performance

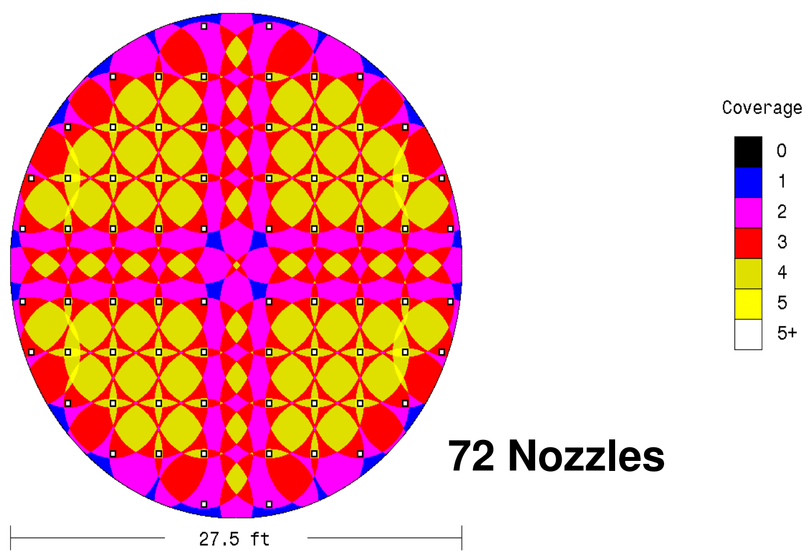
- Nozzle layout does not provide good slurry spray coverage
- Gas inlet / outlet orientation leads to gas maldistribution

Spray Coverage In Open Spray Tower

- ***Dense Spray Coverage Important For Good Removal Performance:***



Poor Spray Coverage



Good Spray Coverage

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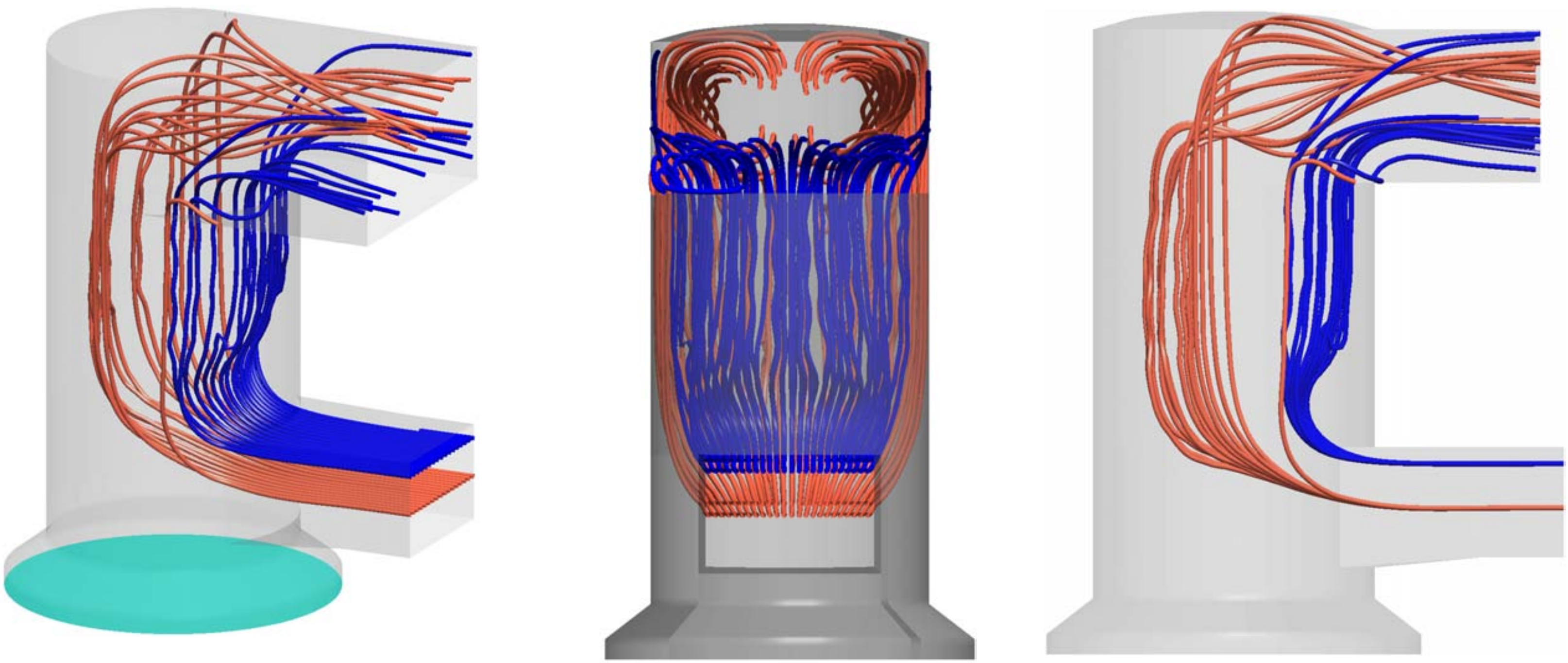
Example of Gas Maldistribution



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Effect of Boiler Load on Scrubber

Low Load

- Fewer recycle pumps needed to maintain constant L/G
- Water balance can be problem due to lower evaporation if water inputs are held constant

Effect of Boiler Load on Scrubber

High Load

- Higher inlet SO_2 loading, more difficult to achieve design performance (removal, gypsum quality, reagent utilization)
- Greater tendency for sulfite blinding in F.O. process
- High gas flow may increase droplet carryover through mist eliminator, especially if ME is fouled

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Effect of Boiler Load on Scrubber

Increasing Boiler Load

- **May upset particulate control increasing fly ash loading to scrubber**
- **Limestone feed response critical**
  - Low pH and reduced removal may result from inability to feed limestone fast enough
  - May overfeed limestone in attempt to correct
- **May initiate sulfite blinding or aluminum-fluoride blinding episode**
- **May require that additional recycle pumps be put into service to maintain L/G**

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Effect of Boiler Load on Scrubber (cont.)

Decreasing Boiler Load

- **Limestone feed response critical**
  - Tendency to overfeed limestone
  - Limestone utilization and gypsum quality may be poor until excess limestone is consumed
- **May be able to remove recycle pumps from service**


Questions?