

Worldwide Pollution Control Association

IL Regional Technical Seminar
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MARSULEX

ENVIRONMENTAL TECHNOLOGIES



Wet FGD Upgrades | Needs and Strategies

David Murphy, Chief Technology Principal

SOLUTIONS. PERFORMANCE. RELATIONSHIPS.

Points of Discussion

- Historical Practice
- Upgrade Drivers
- Gas Side Considerations
- Liquid Side Considerations
- Case Studies



Wet FGDs of the 1970's – 1980's did not reflect today's design approaches:

- Lower SO₂ removal performance
- Spare towers
- Bypass
- Packing
- Double-Loop and other unique process designs



Today's Requirements or Preferences Drive Upgrades:

- Boost SO₂ removal / reduce other emissions
- Fully scrub (eliminate bypass)
- Reduce maintenance and operation costs
- Fuel switching
- By-product and / or reagent changes

Upgrade Considerations

Gas Side Considerations

Liquid Side Considerations

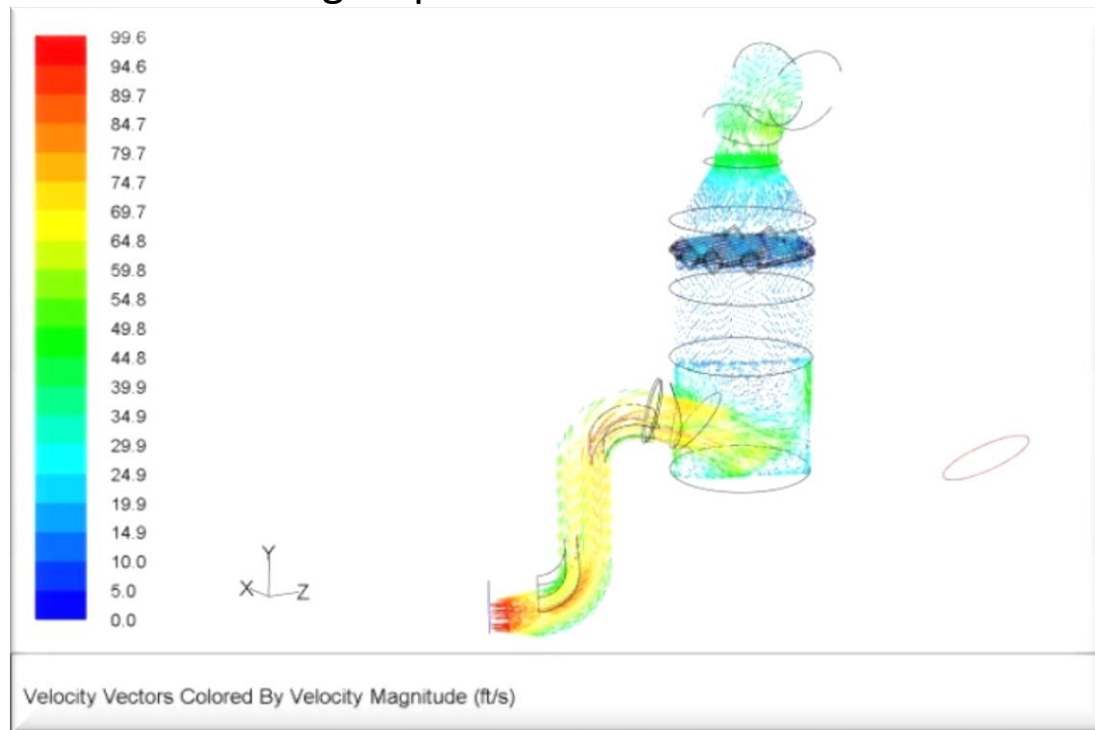
Gas Side Considerations

- Ductwork
- Bypass
- Reheat
- Booster Fan
- Mist eliminator Performance

Assessment via Computation Fluid Dynamics

Perform Computation Fluid Dynamic (CFD) Model

- A. Assess Current System condition
- B. Assess Impact of System Upgrades
- C. Perform Design Optimization Studies



Gas Side Considerations

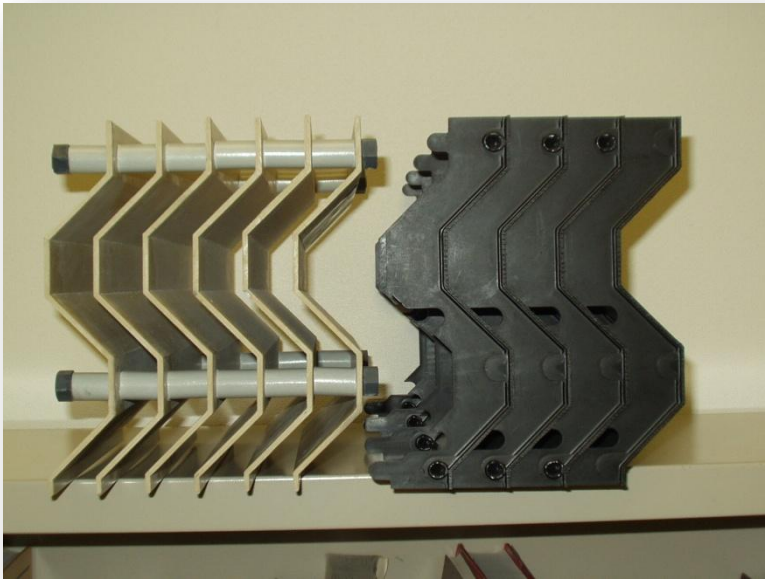
Mist Eliminator Performance

- Absorber gas velocities are generally limited by mist eliminator performance
- Supersaturated liquid film on mist eliminators will cause precipitation of solids and scaling
- Water quality, spray coverage and optimized sequencing act together to minimize build-ups while keeping emissions low



Gas Side Considerations

Mist Eliminator Performance



Mist Eliminator



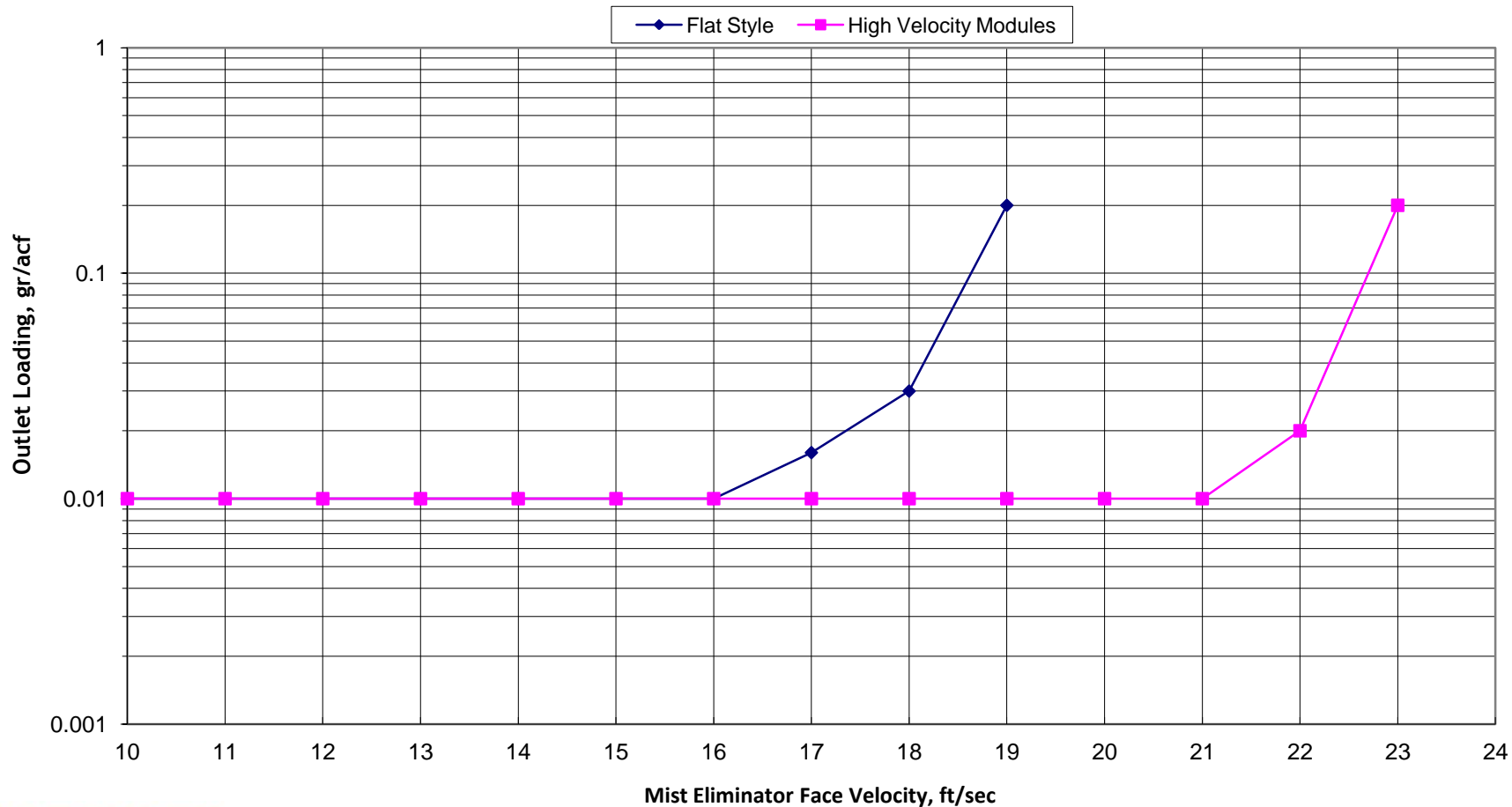
Mist Eliminator Wash System

Gas Side Considerations

Velocity vs. emissions mist eliminators graph

Potential Performance Enhancement

Mist Eliminator Outlet Loading Vs. Mist Eliminator Face Velocity



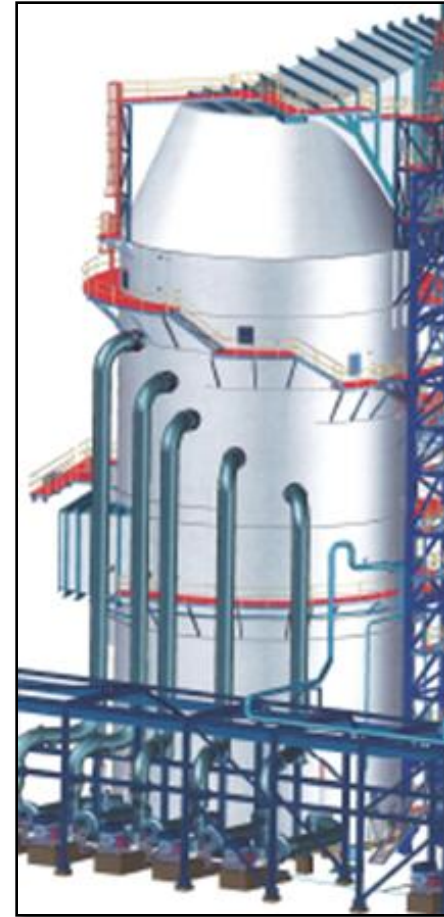
Upgrade Considerations

Gas Side Considerations

Liquid Side Considerations

Liquid Side Considerations

- Absorber Recycle Sprays
- Modify Spray Towers
- Recycle Pumps / Line Sizes
- Reaction Tank Issues
- Bleed Loop / Waste Stream
- Reagent System



Liquid Side Considerations

Absorber Recycle Sprays

Re-Design / Replacement of Absorber Recycle Sprays:

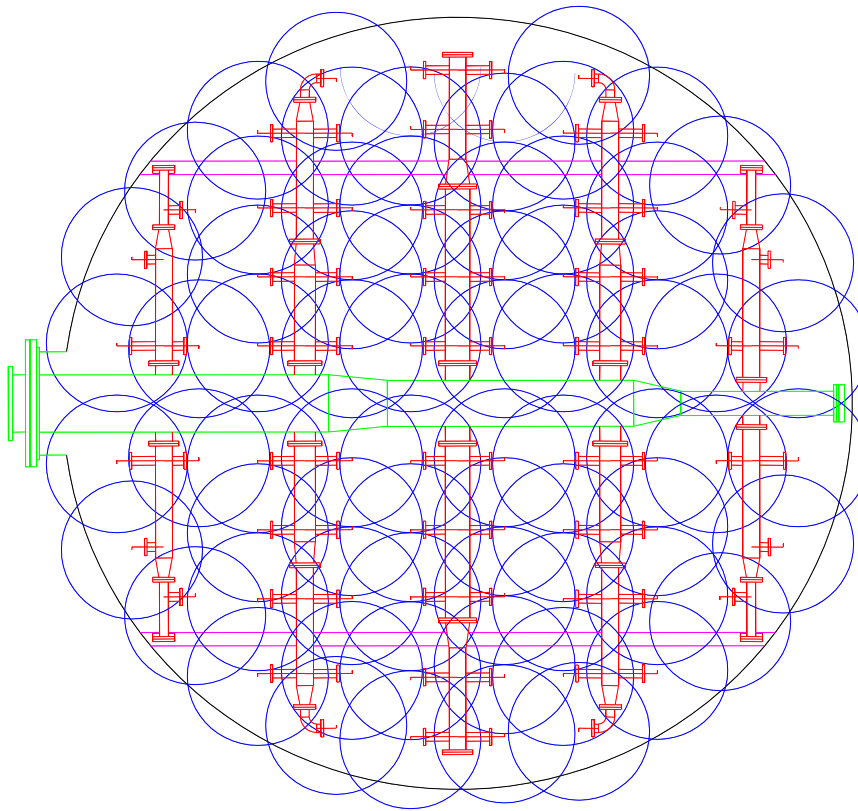
- Improve spray density
- Spray coverage improvement
- Fix impingement problems
- Replace end-of-life headers
- Self Supported headers



Liquid Side Considerations

Absorber Recycle Sprays

Improve Spray Density/Spray Coverage Improvement



Proper spray pattern design achieves high level of coverage

Liquid Side Considerations

Absorber Recycle Sprays

Self Supported Header:



Modify Spray Towers:

- Absorber Liquid Re-distribution Device (ALRD) or tray addition
- Convert packed tower to open spray or tray
- Conversion to single-loop design
- Structural Assessment

Liquid Side Considerations

Open Spray Tower

Perforated Tray Approach:

- Trays provide a bubbling bed of slurry to enhance mass transfer
- Operation of lower L/G saves pump power
- Higher pressure drop costs fan power
- Net power difference (+/-) is site specific and should be determined by specific guarantees
- Safe use of tray(s) as maintenance platform should be approved by the OEM and confirmed by owner.

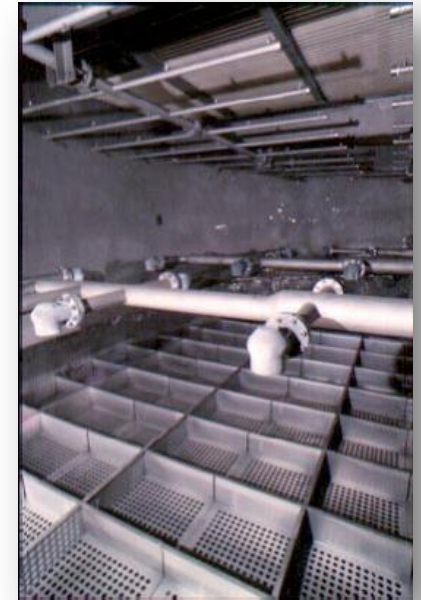


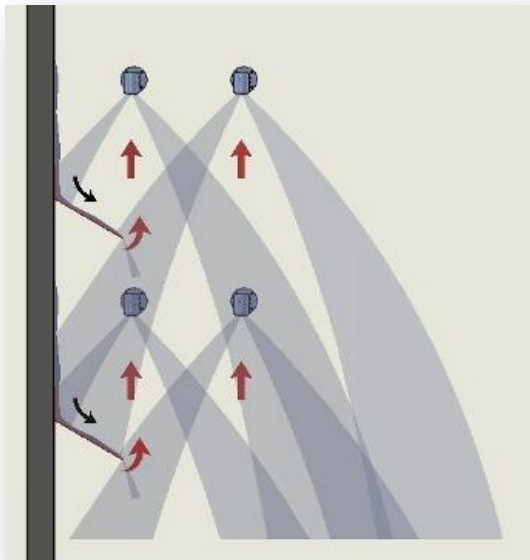
Photo courtesy of Reinhold Environmental

Liquid Side Considerations

Open Spray Tower

ALRD Approach

- Developed by MET and patented in 2003
- Mitigate gas “sneakage” along absorber walls
- Re-introduce slurry from walls back into the absorption spray zone



United States Patent

Brown et al.

Patent No.: US 6,550,751 B1

Date of Patent: April. 22, 2003

GAS-LIQUID CONTRACTOR WITH LIQUID REDISTRIBUTION DEVICE

Inventors: **Gregory Norman Brown**, Palmyra, PA (US); **Raymond Raulfs Gansley**, Lebanon, PA (US); **Michael Lyn Mengel**, Fredericksburg, PA (US); **Eli Gal**, Lebanon, PA (US)

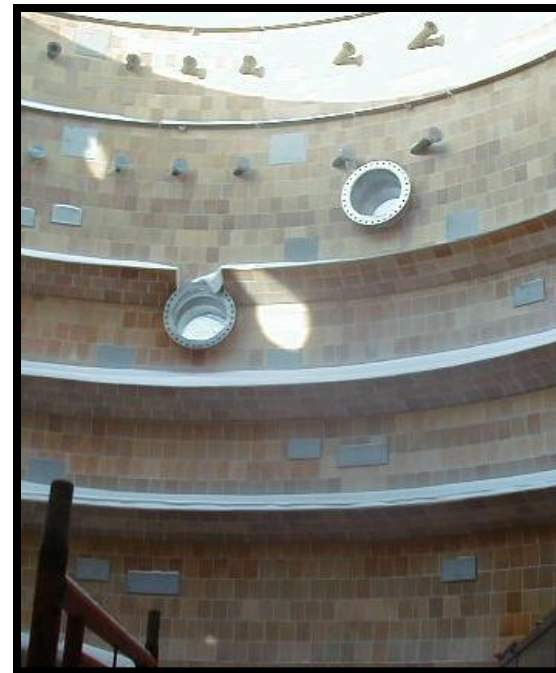
Assignee: **Marsulex Environmental Technologies Corp.**, Lebanon, PA (US)

Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Liquid Side Considerations

Open Spray Tower

ALRDs

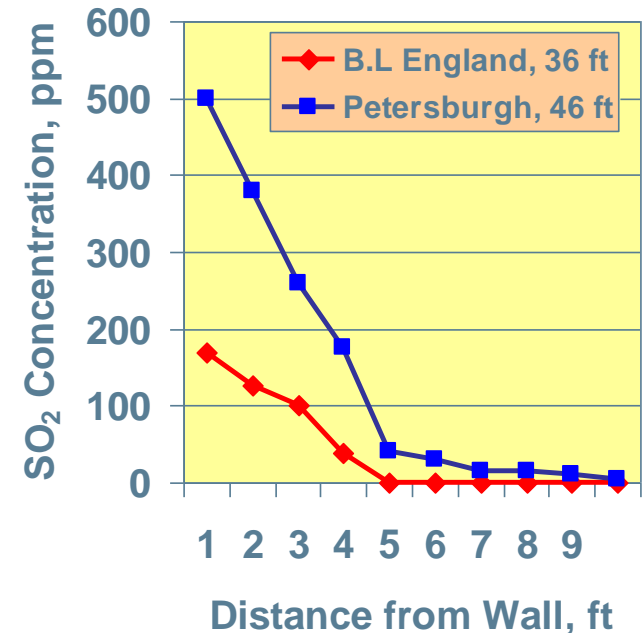


Alloy and Tile-lined ALRDs

Liquid Side Considerations

Wall Sneakage Spray Zone Outlet

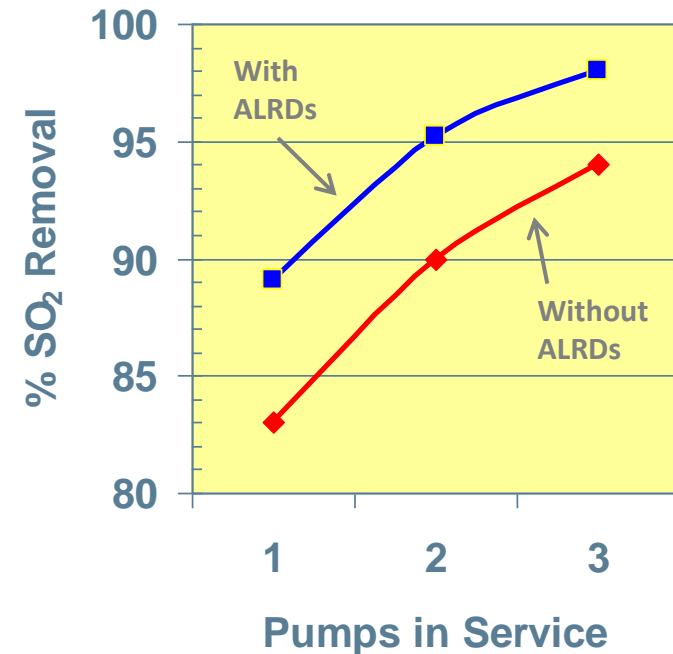
- **Wall Region**
 - Reduced liquid density
 - Increased gas velocity
 - High SO₂ sneakage
- **Tower Center**
 - Better than required gas/liquid contact
 - SO₂ removed to extinction
- **Overall**
 - Waste of consumables
 - Sets maximum SO₂ removal to less than 100%



Liquid Side Considerations

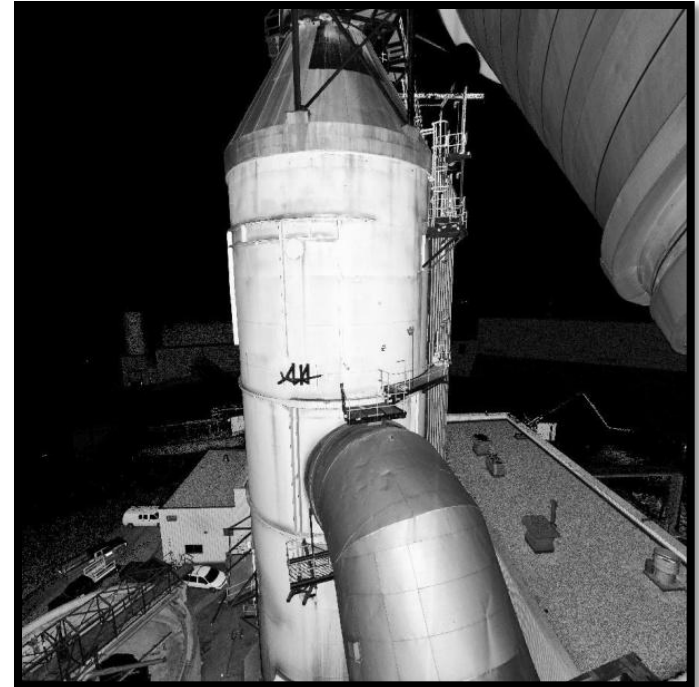
ALRDs – How much do they help?

- **Improvement depends on:**
 - Tower diameter
 - Number of shelves in service
- **Improvements:**
 - Take one pump out of service and maintain SO₂ removal
 - Increase SO₂ removal from 94 to 98% with no increase in power consumption
 - Ability to burn higher sulfur coals
 - Increased pressure drop is negligible



Assessment of Absorber Vessel Structural Integrity

- **Step 1** – Perform Laser Scan
Scan for Deformation
- **Step 2** – Construct Model from Field Data
- **Step 3** - Review Results
- **Step 4** – Perform Finite Element Analysis (FEA) of Vessel for current configuration and proposed modifications



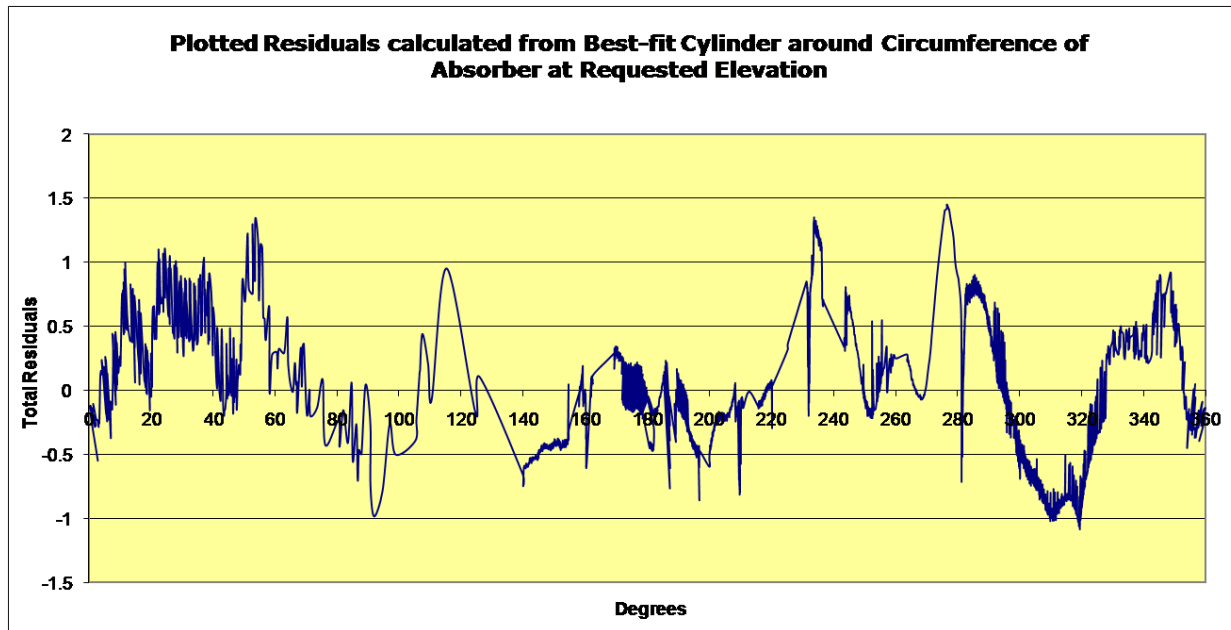
Assessment of Absorber Vessel Structural Integrity

- Step 1 – Perform Laser Scan
- **Step 2 – Construct Model from Field Data**
 - Resolution to the Millions of Data Points
- Step 3 – Review Results
- Step 4 – Perform FEA of Vessel for current configuration and proposed modifications



Assessment of Absorber Vessel Structural Integrity

- Step 1 – Perform Laser Scan
- Step 2 – Construct Model from Field Data
- **Step 3 – Review Results**
 - Accuracy to +/- 2mm
- Step 4 – Perform FEA of Vessel for current configuration and proposed modifications

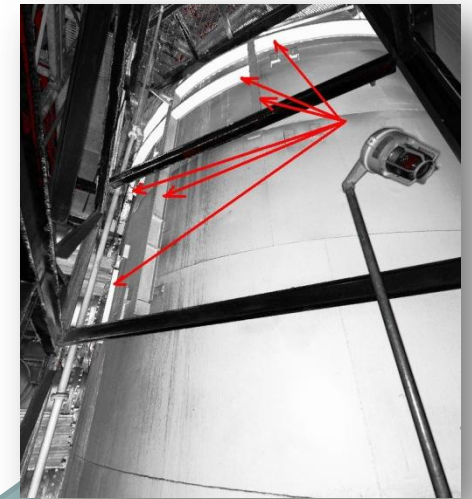


Assessment of Absorber Vessel Structural Integrity

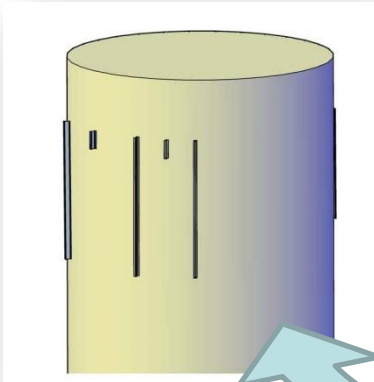


❑ Undocumented additional stiffeners

❑ Stiffeners on Laser Scan

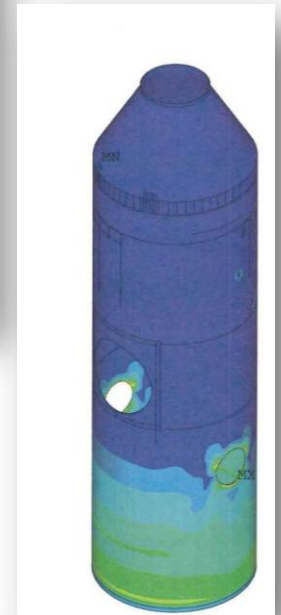
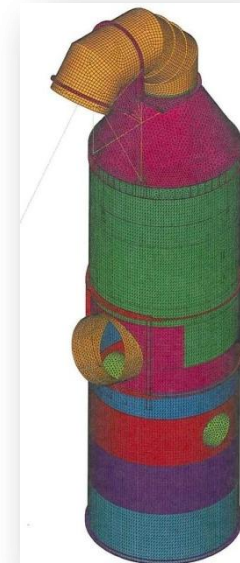


❑ 3D Model w/Stiffeners Accurately Sized and Located



Assessment of Absorber Vessel Structural Integrity

- Step 1 – Perform Laser Scan
- Step 2 – Construct Model from Field Data
- Step 3 – Review Results
- **Step 4 – Perform FEA of Vessel for current configuration and proposed modifications using:**
 - A. Ultrasonic Shell Thickness Measurements
 - B. Laser Scan Results for Deformation and As Built Changes
 - C. Appropriate Load Conditions for Current Design Codes



Liquid Side Considerations

Recycle Pump Sizes

- Motor Change
- Impeller Change
- Gear Box Change
- Pipe Sized Appropriately?



Liquid Side Considerations

Reaction Tank Issues

- Oxidation System Upgrades
- Gypsum Residence Time
- Recycle Residence Time



Liquid Side Considerations

Oxidation System Upgrades

- Older style “natural oxidation” increases chances for scaling-type build-ups inside the absorber
- Older style air spargers could plug, causing oxidation problems and need for outage maintenance
- Increased SO₂ removal (overall original design) can tax the oxidation system and increase the chance for sulfite blinding
- Air lance / agitator systems have supplanted spargers in modern FGDs and can be retrofitted to older FGDs
- Operation with proper forced oxidation minimizes scaling potential

Liquid Side Considerations

Oxidation System Upgrades

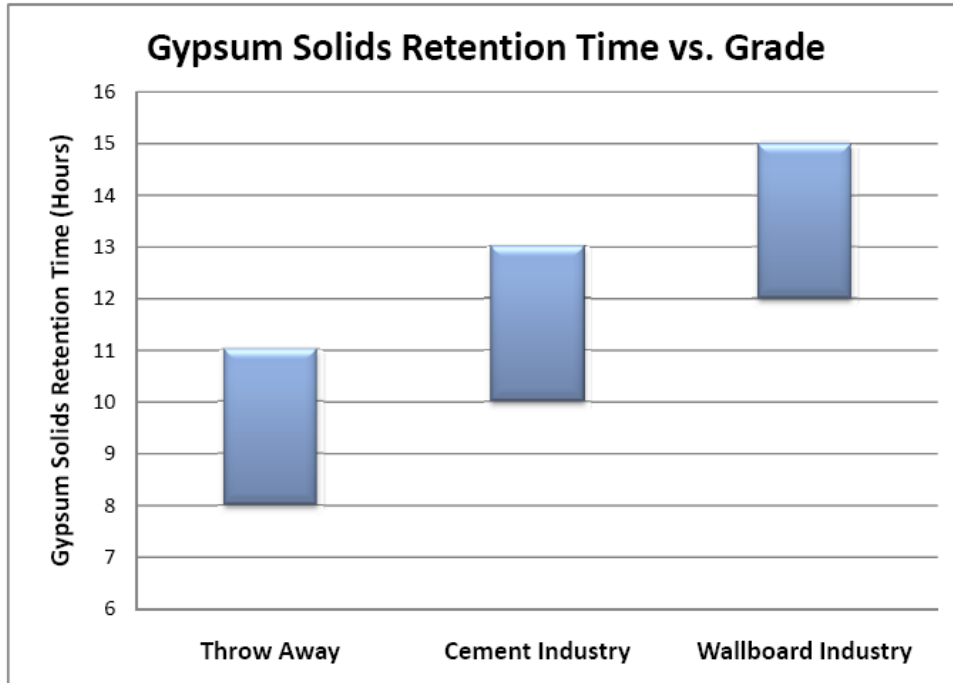
Agitator with Air Lance in Operation



Photo courtesy of Ekato

Liquid Side Considerations

Gypsum Residence Time



Specification for Gypsum for Cement Industry

Analysis:

$\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$ (Gypsum): 92.0%

Others: 8%

Soluble Impurities:

Chlorides: Less than 2000 ppm

Free Moisture: 10% - 15%

Specification for Gypsum for Wallboard Industry

$\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$ (Gypsum): > 95 wt%

$\text{CaSO}_3 \bullet \frac{1}{2} \text{H}_2\text{O}$ (Calcium Sulfitite): <0.5 wt%

CaCO_3 (Calcium Carbonate) <5.0 wt%

Moisture :<10 wt%

Chloride (Cl): <100ppm

Liquid Side Considerations

Bleed Loop / Waste Stream Upgrades

Hydroclone / Thickener Upgrades



Liquid Side Considerations

Bleed Loop / Waste Stream Upgrades

Vacuum / Disposal Capacity



Liquid Side Considerations

Reagent System Upgrades

- Increased capacity for higher SO₂ burdens needs to be assessed
- Optimization of limestone grind / classification can be undertaken
- Evaluate potential for additives :
 - DBA
 - Ammonia Salts
 - Adipic Acid



Case Study 1

Case Study 1

Eastern US Based Utility

- Supplied by GEESI (Marsulex Environmental Technologies) as 3 x 50% modules at 90% SO₂ removal.
- Subsequent need to achieve 95% SO₂ removal
- Today operates with spare pump / spray levels in operation to achieve required performance
- Spare tower still available

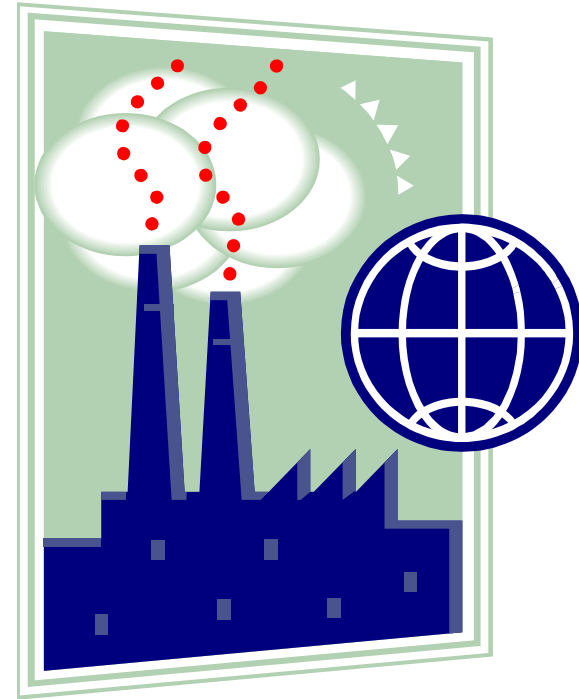


Case Study 1

Eastern US Based Utility

Issue:

An Eastern utility desired to operate the boiler using a higher sulfur coal / Pet Coke Blend and to conform to stricter emission guidelines

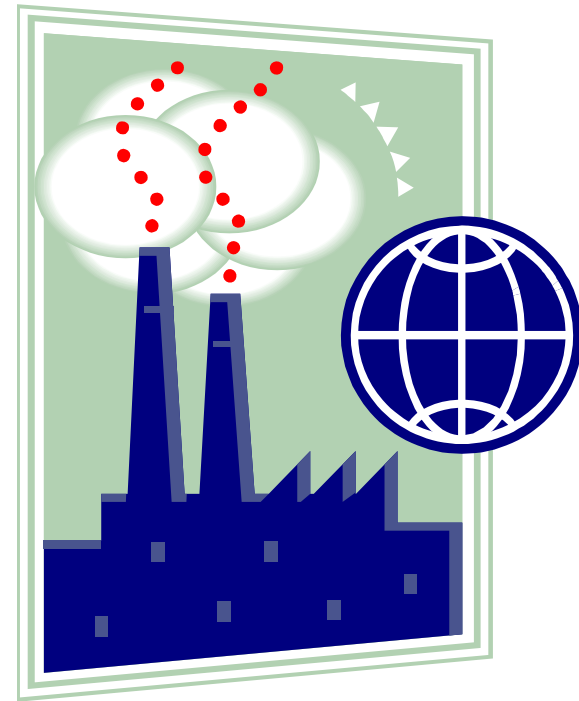


Case Study 1

Eastern US Based Utility

Constraints:

- Maintain the use of only 2 out of 3 absorbers at any time
- No changes to recycle headers
- No changes to recycle spray nozzles

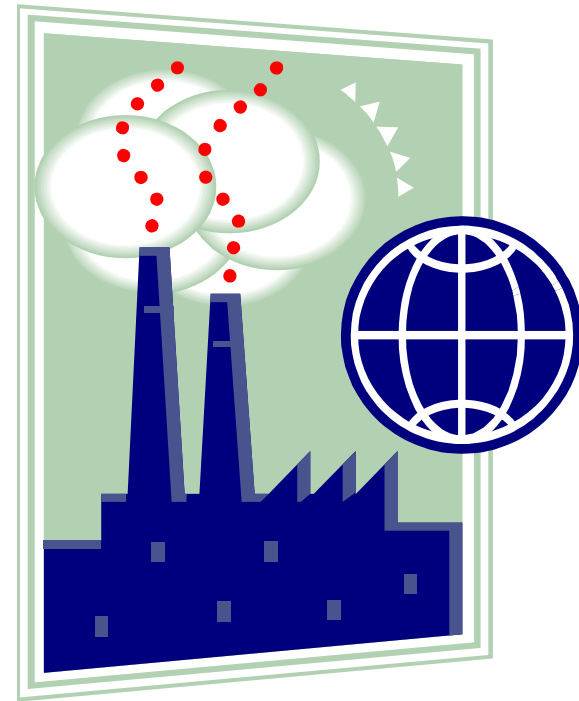


Case Study 1

Eastern US Based Utility

Parameters:

- Maximum sulfur content in fuel – 3.36%
- Chloride in slurry – 15,000 ppm
- 95% SO₂ removal efficiency required to meet emission guarantees for worst case
- Limestone grind 90% through 325 mesh



Case Study 1

Eastern US Based Utility

Recommendation #1:

Gear Box changes will be needed to increase pump head for the reduced operating Absorber Liquid level and increased L/G



Case Study 1

Eastern US Based Utility

Recommendation #2:

Operate system stoichiometry between 1.08 and 1.10 and increase the suspended solids concentration to 20% to make available additional calcium carbonate for SO_2 absorption and still maintain the gypsum purity requirement.



Case Study 1

Eastern US Based Utility

Recommendation #3:

Install two, Absorber Liquid Redistribution Devices (ALRDs)



Case Study 1

Eastern US Based Utility

Recommendation #4:

- Upgrade Unit 1 Oxidation Air System to ensure complete oxidation of absorber slurry.
- Operate both blowers simultaneously and increase header size



Case Study 1

Eastern US Based Utility

Recommendation #5:

Bleed System:

- An increase in SO₂ removal means a corresponding increase in the bleed and dewatering systems
- By operating at 20% suspended solids only minor changes to the bleed pumps and piping are required

Case Study 1

Eastern US Based Utility

Recommendation #6:

Limestone Slurry Feed System:

- Limestone slurry loop piping has adequate capacity for the increased demand
- The feed line and control valve from the loop to the absorber will have to be upgraded



Case Study 2

Case Study 2

Upgrade Driver & Background

- Administrative Consent Order issued in 2006
- Requirement: Increase SO₂ removal efficiency to 97% while firing 3.2% (5.11 lbs SO₂/MM Btu) sulfur bituminous coal.
 - Emission limit of 0.15 lbs SO₂/MMBtu on a 30 day rolling avg
 - Emission limit of 0.25 on a 24 hour basis
- Deadline: May 2010
- 155 MW WFGD LSFO
- Wallboard grade gypsum, sold locally
 - Retrofitted in 1994 with open spray tower WFGD system
 - Original Design for 93% SO₂ removal

Case Study 2

Upgrade Options Considered by Owner

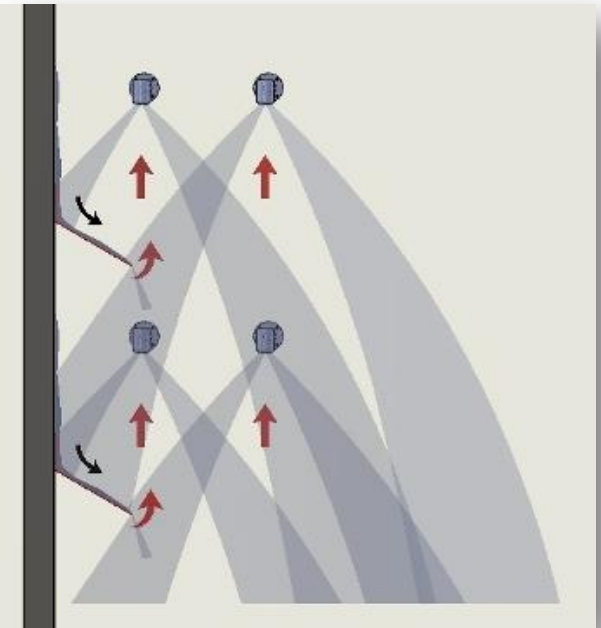
- Chemistry changes
- “Traditional” Methods
- ALRD® | Absorber Liquid Redistribution Device

Case Study 2

ALRD Technology

ALRD Aspects:

- Commercially demonstrated technology
- Increases L/G contact
 - Solves wall effect and re-entrains and re-activates wall slurry
 - Solves flue gas “sneakage” along absorber wall
- Minimal effect on flue gas pressure drop



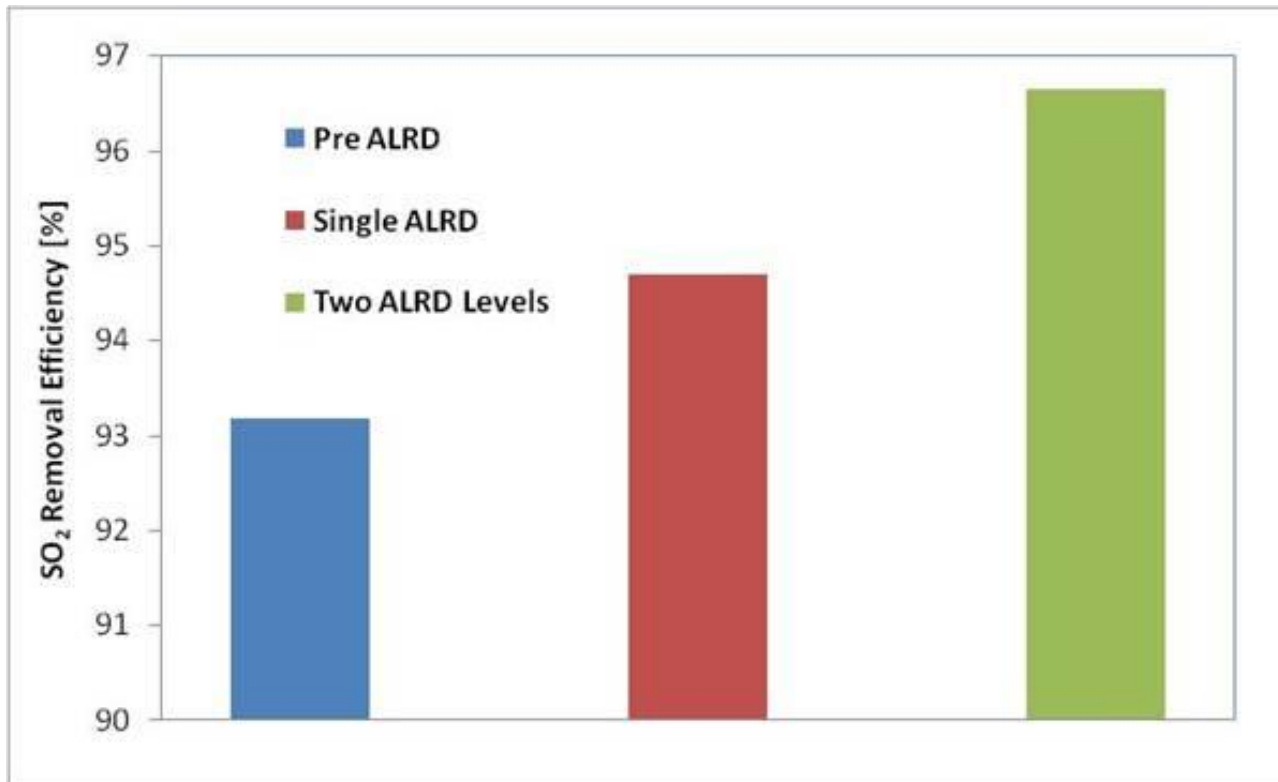
Recommended technology by Customer's Engineer

- Two ALRD levels determined to meet removal requirements
- Could be incorporated into two scheduled outages
- Determined most cost and schedule effective method

Case Study 2

Performance Results

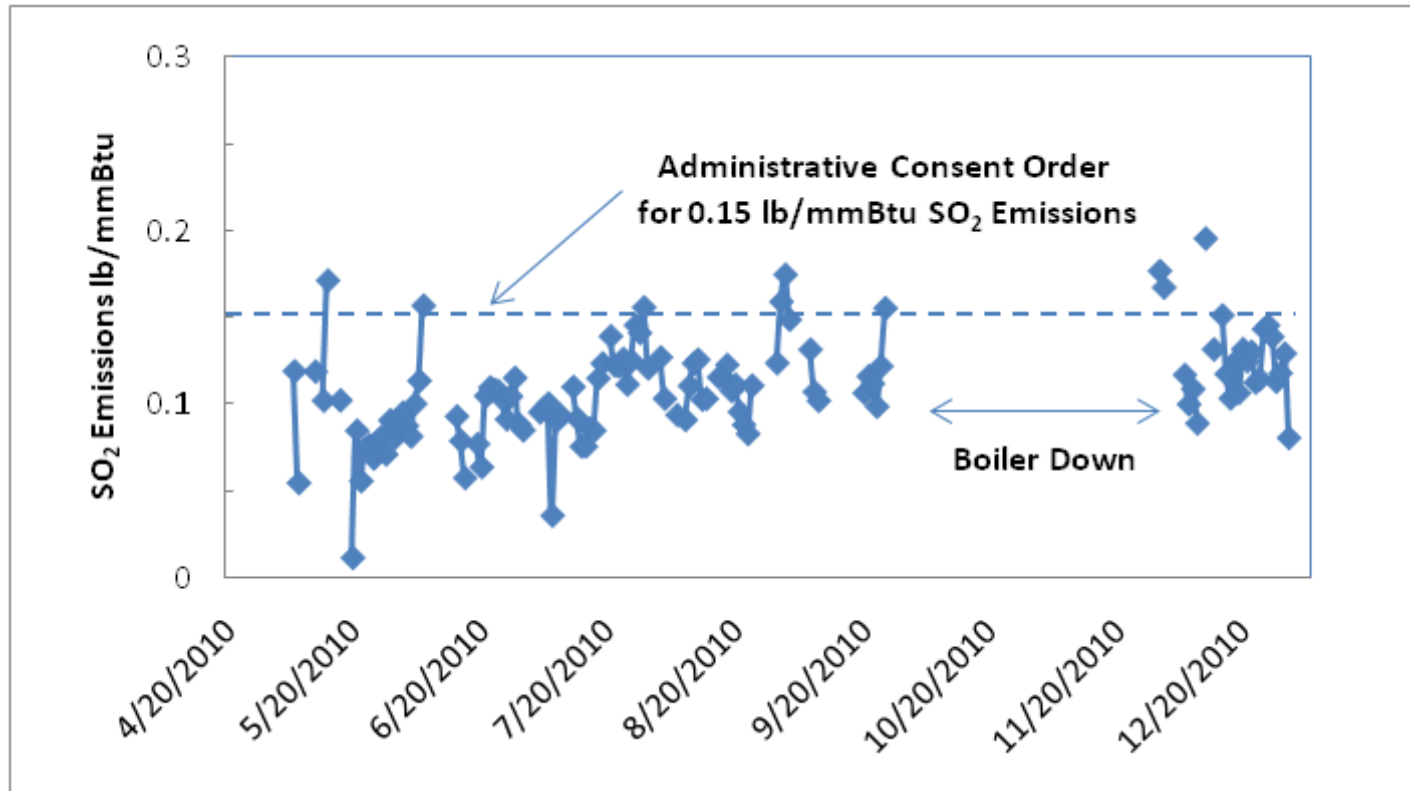
System operated to meet the 0.15 lbs SO₂/MMBtu after May 1st



Case Study 2

Performance Results

System operated to meet the 0.15 lbs SO₂/MMBtu on 30 day rolling average



courtesy of EPA's Clean Air Markets Division

Case Study 2

Summary

- The upgrade, from proposal to installation, was accomplished in a 10 month period
- 2500+ man-hours of installation work without incident
- Scheduled outages utilized for equipment installation
- Capital investment for upgrade was minimized
- System was able to successfully achieve state-required emissions limit
 - Increased SO₂ removal from 93% to 97% at 3.2% Sulfur coal
 - Outlet Emission of 0.15 lbs SO₂/MMBtu is achieved
 - No noticeable increase in pressure drop
 - No change to any of the existing recycle pumps or spray headers

Conclusions

Drivers for Upgrades:

- Current Regulations
- Fuel Switching
- Economic Considerations
- Age of Units

Upgrade Considerations:

- Gas Side
- Liquid Side
- Reagent Changes
- Bleed / Dewatering Systems

