

Reinhold Environmental Ltd.



2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

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WET FGD UPGRADES

Needs and Strategies

Michael Walsh, PE

Marsulex Environmental Technologies

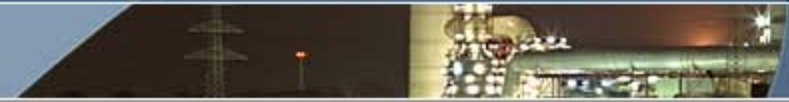
Solutions. Performance. Relationships.

MET Installations

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Germany
8,240 MW

Canada
315 MW

United States
18,381 MW

France
1,800 MW

Japan
5,925 MW

Netherlands
2,585 MW

United Kingdom
2,000 MW

Finland
1,000 MW

Poland
1,440 MW

Austria
1,180 MW

Slovenia
275 MW



Korea
4,250 MW

China
32,500+MW

Taiwan
1,000 MW

Viet Nam
1200 MW

Brazil
135 MW

Slovakia
220 MW

Saudi Arabia
160 MW

Czech Republic
1,570 MW

Croatia
210 MW

Italy
960 MW
(in consortium)

Solutions. Performance. Relationships.



- Historical Practice
- Upgrade Drivers
- Gas Flow Considerations
- Liquid Side Considerations
- Reagent Change
- Case Studies

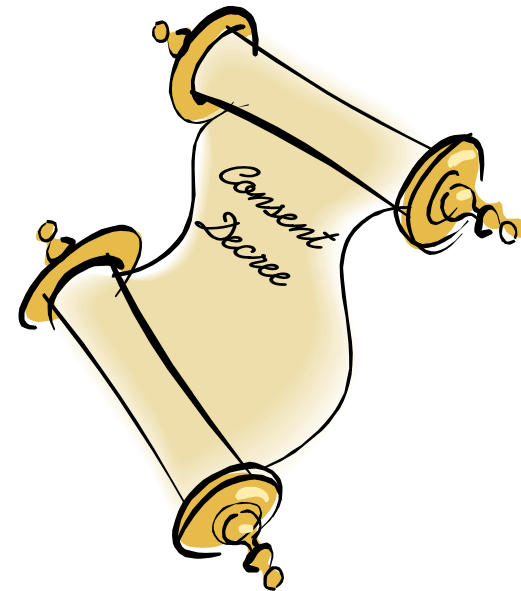


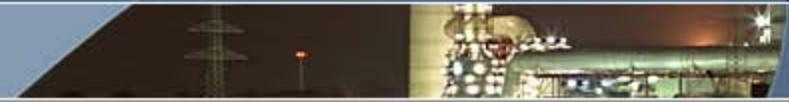
Wet FGDs of the 1970's – 1980's did not reflect today's design approaches:

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

Today's Requirements / Preferences Drive Updates:

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





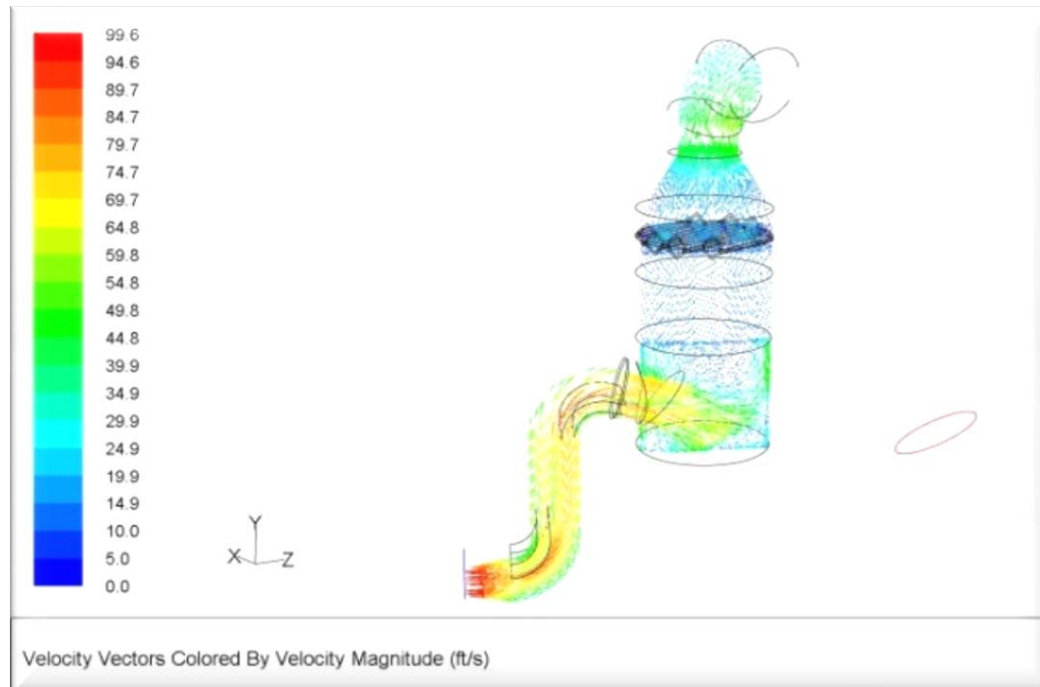
- Ductwork
- Bypass
- Reheat
- Booster Fan
- Mist eliminator Performance

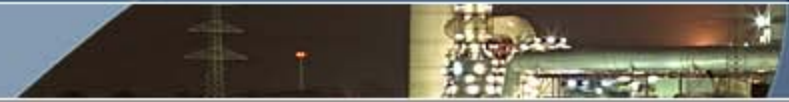


Assessment via Computation Fluid Dynamics

Perform Computation Fluid Dynamic (CFD) Model

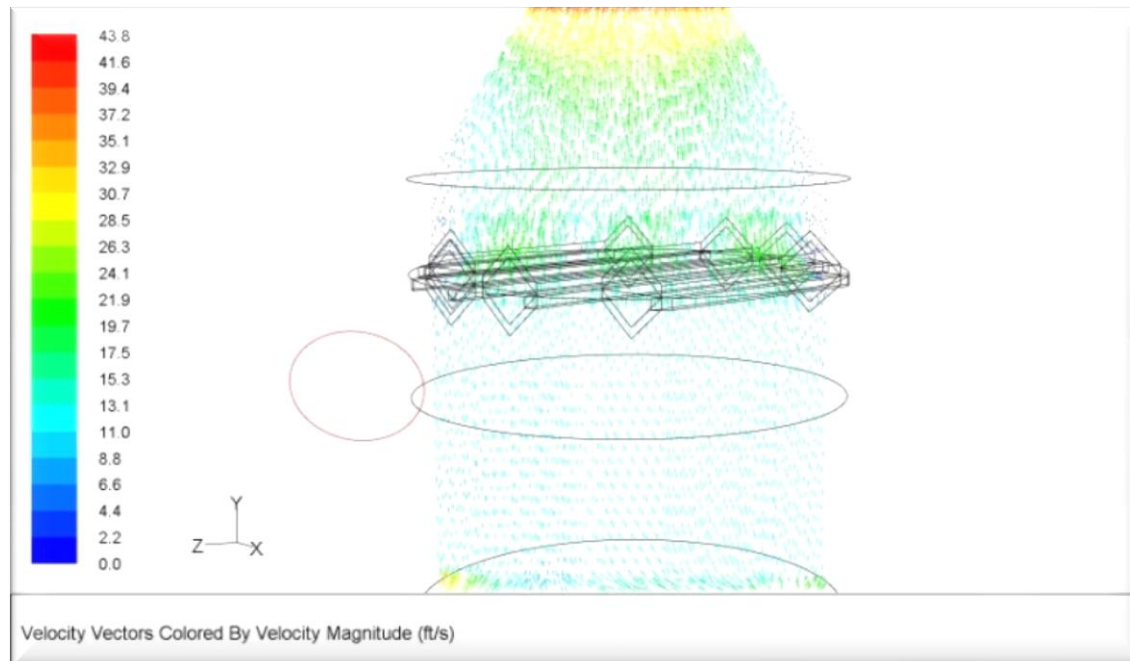
- A. Assess Current System condition
- B. Assess Impact of System Upgrades
- C. Perform Design Optimization Studies



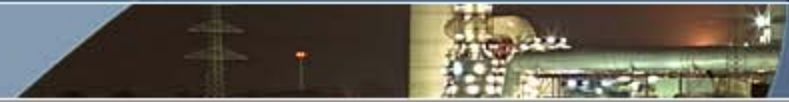


Perform Computation Fluid Dynamic (CFD) Model

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



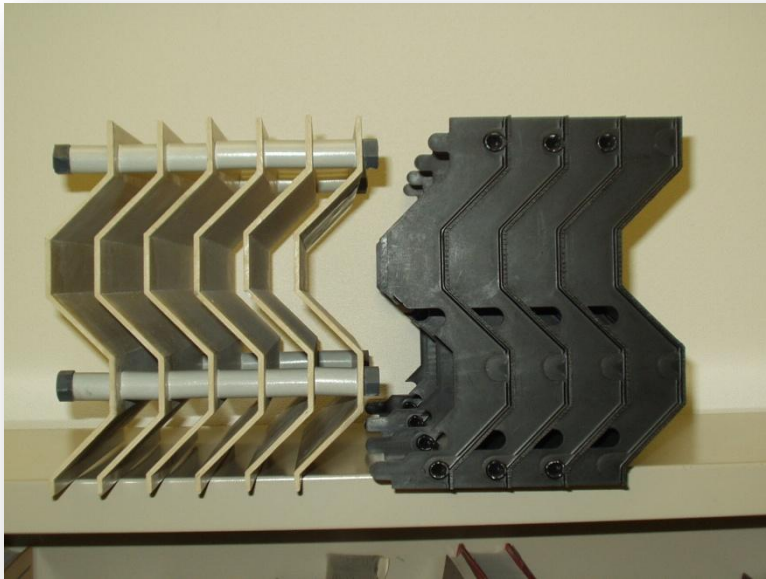
Mist Eliminator Performance



- 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 Flow Considerations

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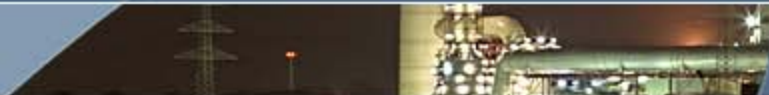


Mist Eliminator

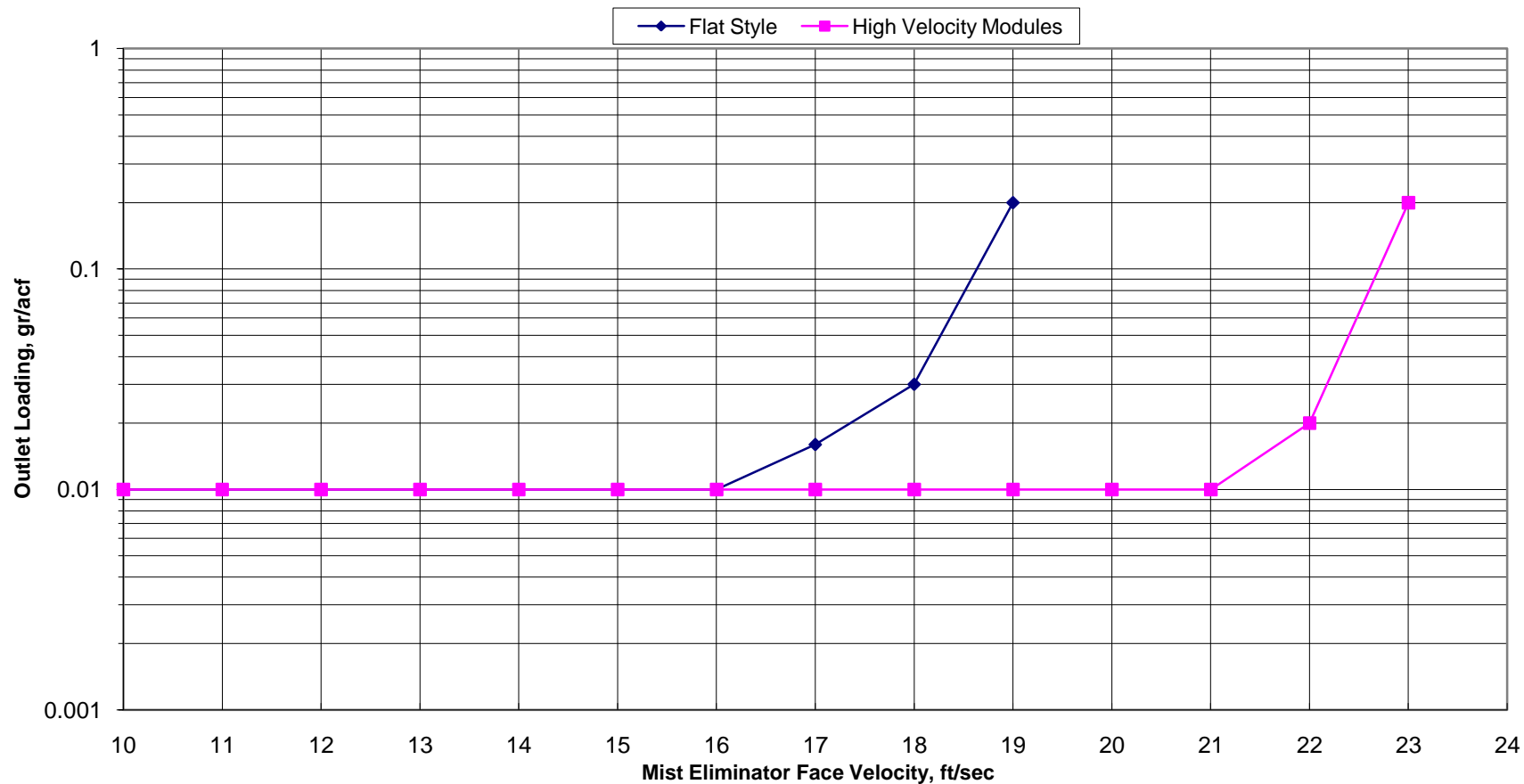


Mist Eliminator Wash System

Velocity vs. emissions mist eliminators graph



Potential Performance Enhancement Mist Eliminator Outlet Loading Vs. Mist Eliminator Face Velocity



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



Absorber Recycle Sprays

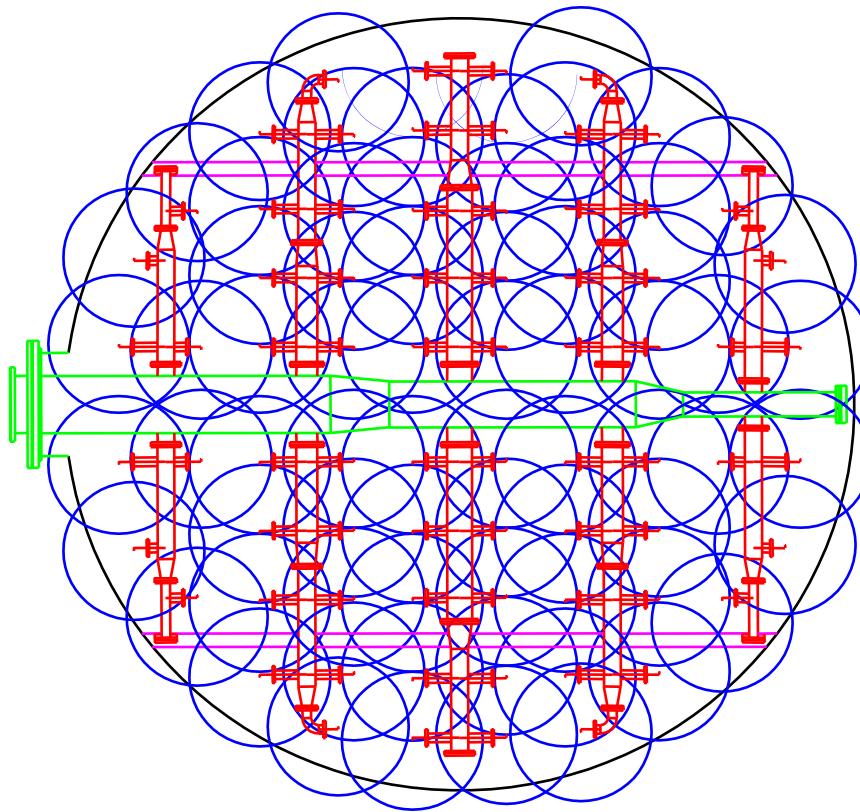
Re-Design / Replacement of Absorber Recycle Sprays:

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



Absorber Recycle Sprays

Improve spray density/Spray Coverage Improvement



Proper spray pattern design achieves high level of coverage

Absorber Recycle Sprays

Self Supported Header:





Modify Open 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

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
- Operation with proper forced oxidation generally minimizes scaling potential
- Safe use of tray(s) as maintenance platform should be approved by the OEM and confirmed by owner.

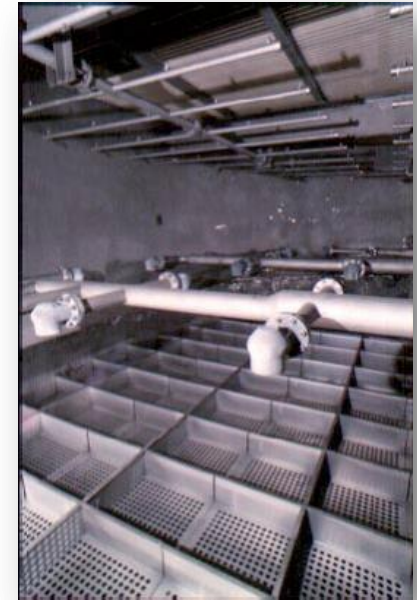
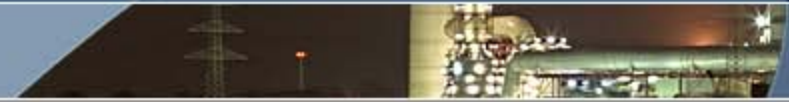


Photo courtesy of Reinhold Environmental

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
- Increased pressure drop is negligible

United States Patent

Brown et al.

Patent No.: US 6,550,751 B1

Date of Patent: April. 22, 2003

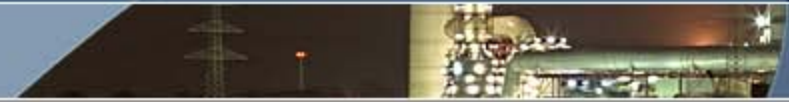
GAS-LIQUID CONTRACTOR WITH LIQUID REDISTRIBUTION DEVICE

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).

OPEN SPRAY TOWER



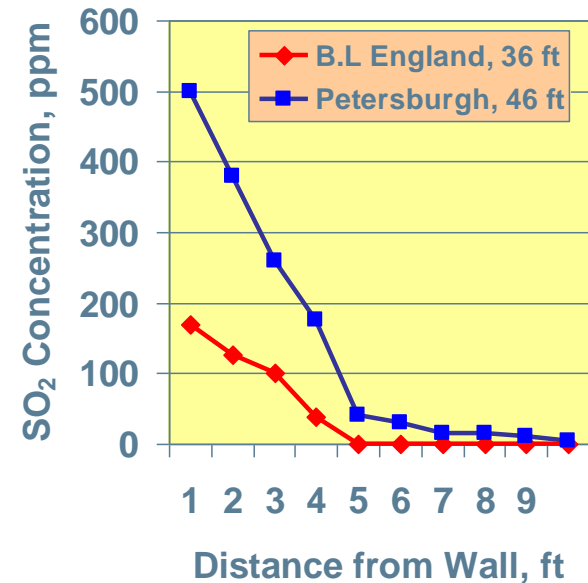
ALRDs



Alloy and Tile-lined ALRDs

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

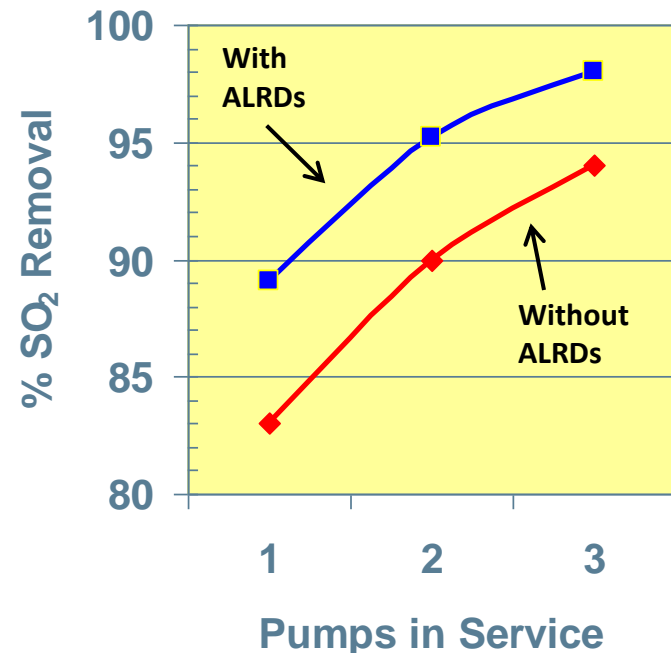
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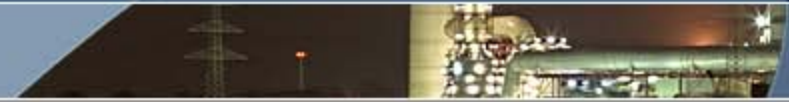
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ALRDs - How Much do They Help?

- **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





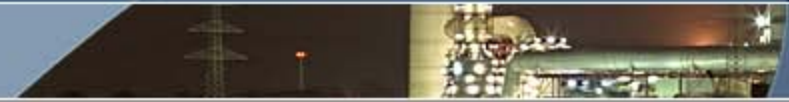
Case Study: USA Mid-Western Power Plant

Original Design:

- High sulfur coal fired (2.5 – 3.5% sulfur) utility boiler
- Limestone/gypsum system, single absorber tower
- Four operating recycle spray levels normal + one spare

Upgrade:

- Retrofit of Two (2) ALRDs



Case Study: USA Mid-Western Power Plant (con't)

Results:

- With the four normally operating spray levels:
 - SO₂ efficiency increased from 95.7% to 98.7% at 5.6 pH
 - Absorber attained 99.1% efficiency at 5.9 pH
- With only three operating spray levels:
 - SO₂ efficiency increased from 93.8% to 96.1% at 5.6 pH
 - Absorber unit attained 97.1% at 5.9 pH)

- 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

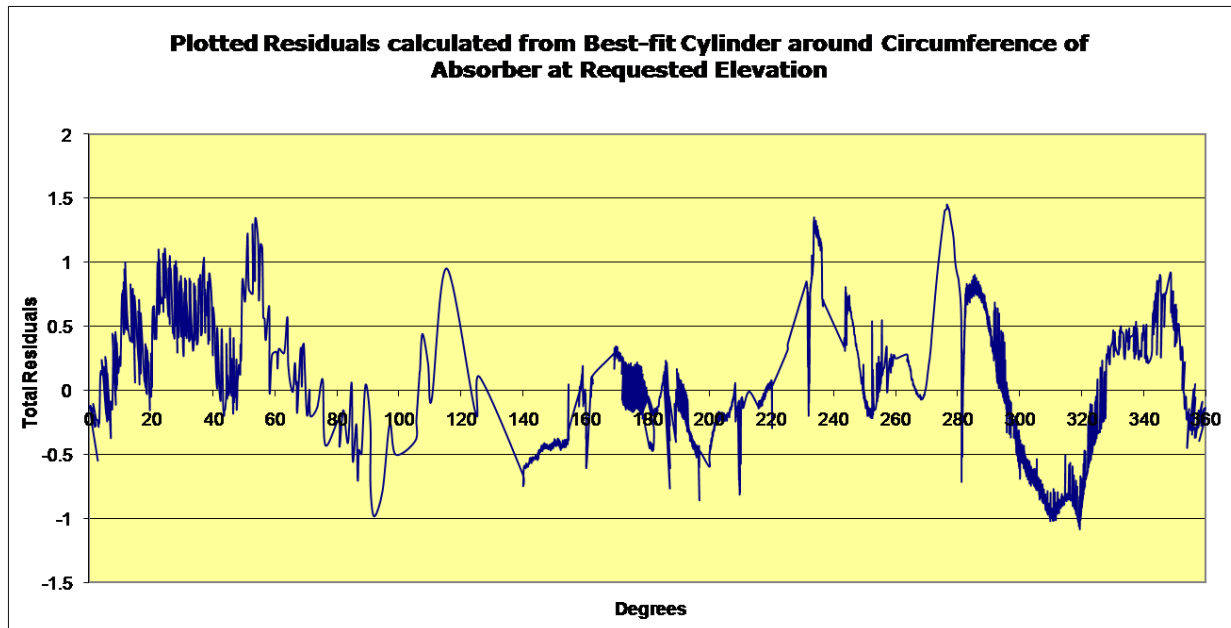


- Step 1 – Perform Laser Scan
- Step 2 – Construct Model from Field Data
 - Resolution to the Millions of Data Points
- Step 3 – Review Results
- Step 4 – Perform FEA of Vessel for current configuration and proposed modifications





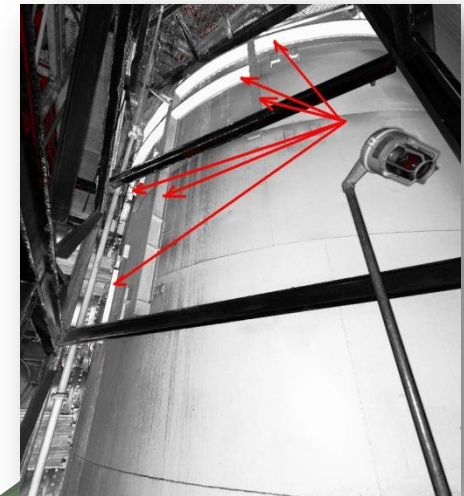
- Step 1 – Perform Laser Scan
- Step 2 – Construct Model from Field Data
- Step 3 – Review Results
 - Accuracy to +/- 2mm
- Step 4 – Perform FEA of Vessel for current configuration and proposed modifications



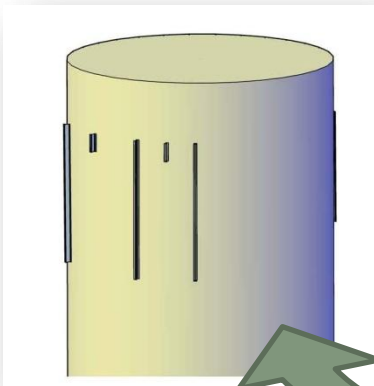


❑ Undocumented additional stiffeners

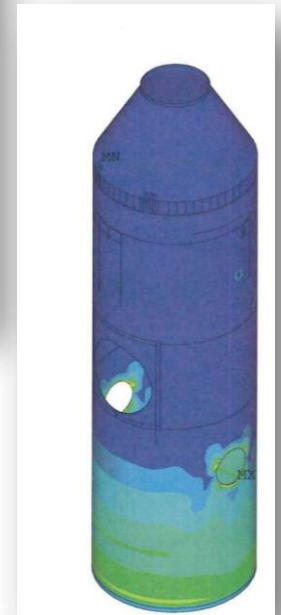
❑ Stiffeners on Laser Scan



❑ 3D Model w/Stiffeners Accurately Sized and Located



- 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 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

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Recycle Pump Sizes

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



Liquid Side Considerations

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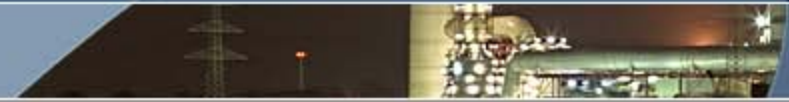
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Reaction Tank Issues

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



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 generally supplanted spargers in modern FGDs and can be retrofitted to older FGDs

Oxidation System Upgrades

Agitator with Air Lance in Operation



Photo courtesy of Ekato

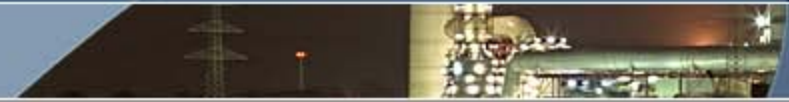
Liquid Side Considerations

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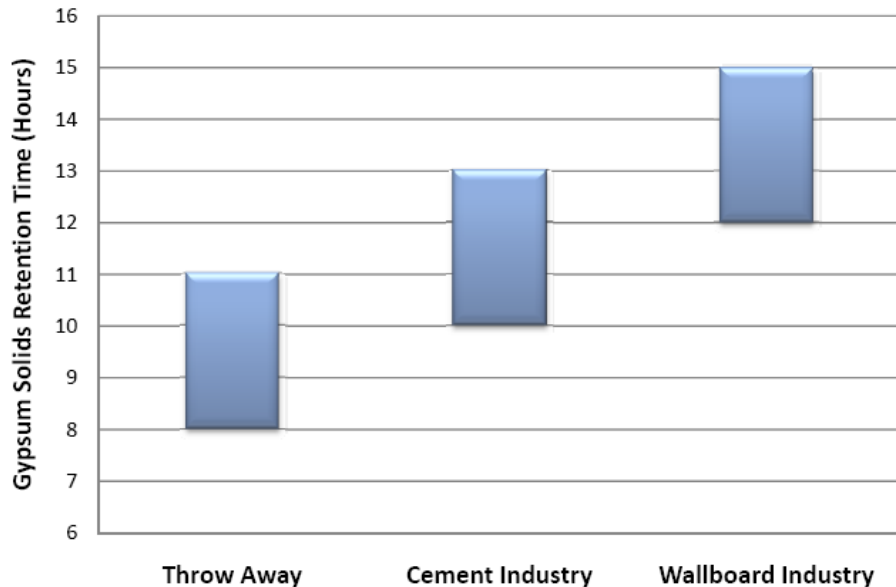
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Gypsum Residence Time



Gypsum Solids Retention Time vs. Grade



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 Sulfite): <0.5 wt%

CaCO_3 (Calcium Carbonate) <5.0 wt%

Moisture :<10 wt%

Chloride (Cl): <100ppm

Liquid Side Considerations

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Bleed Loop / Waste Stream Upgrades

Hydroclone / Thickener Upgrades



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MARSULEX
ENVIRONMENTAL TECHNOLOGIES

Bleed Loop / Waste Stream Upgrades

Vacuum / Disposal Capacity



Reagent System Upgrades

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

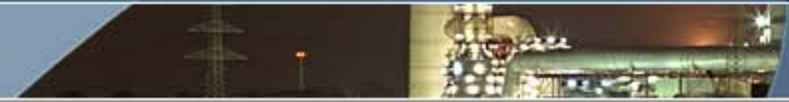


Reagent System Upgrades

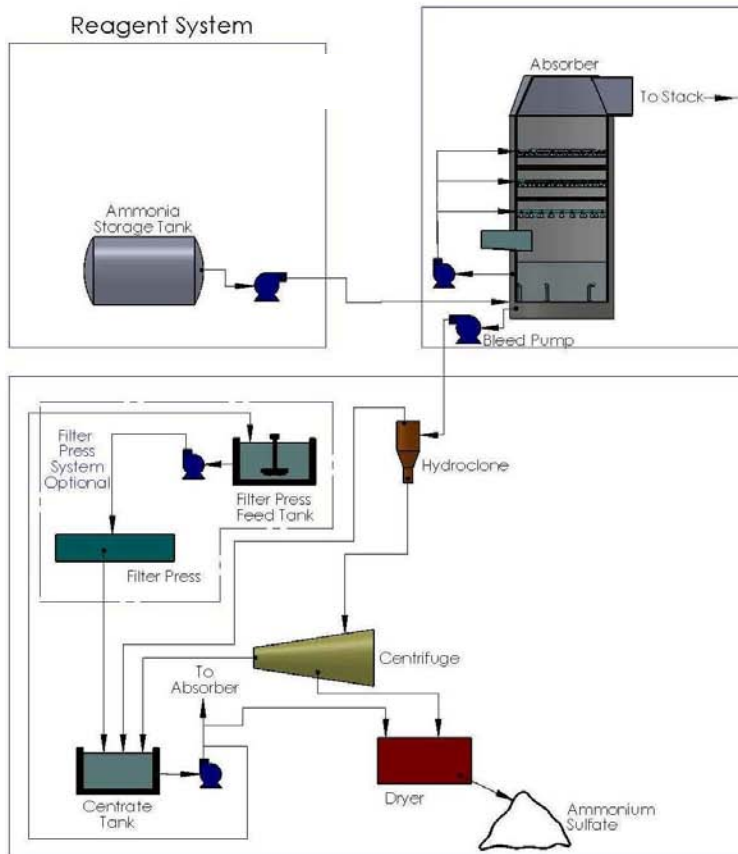
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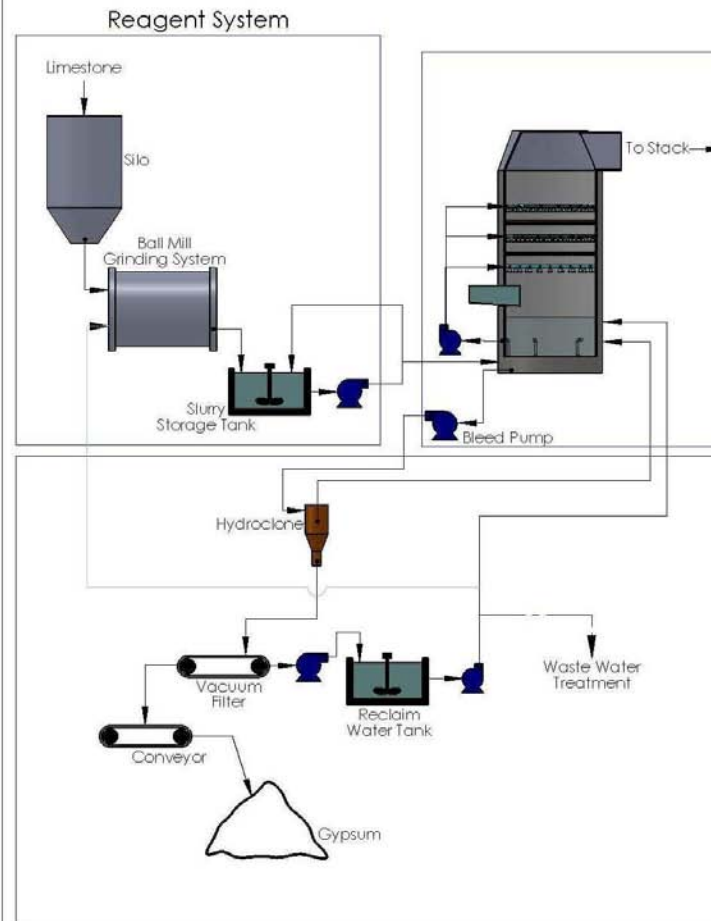
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Ammonium Sulfate Process



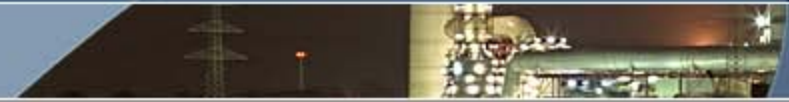
Limestone/Gypsum Process



Eastern US Based Utility

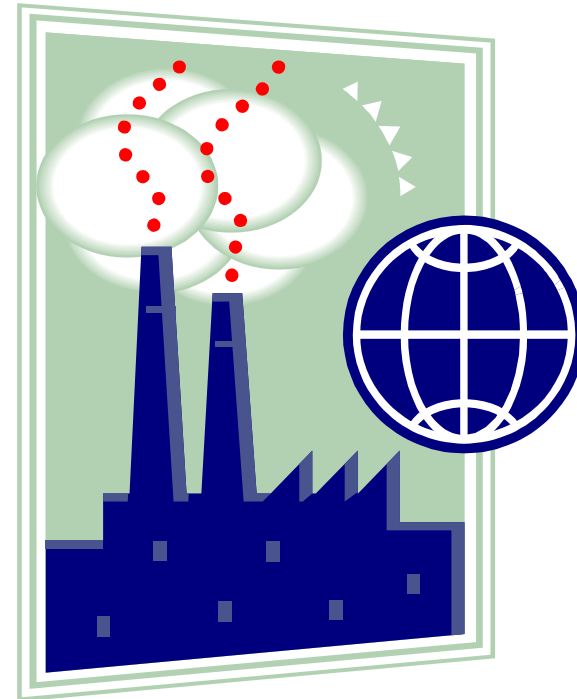


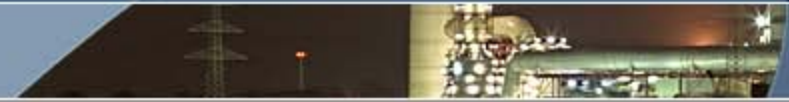
- Supplied by GEESI (Marsulex Environmental Technologies) as 3 x 50% modules at 90% SO₂ removal
- Subsequent need to achieve 95% SO₂ removal
- Today operates with spare pump / spray levels in operation to achieve required performance
- Spare tower still available



Issue:

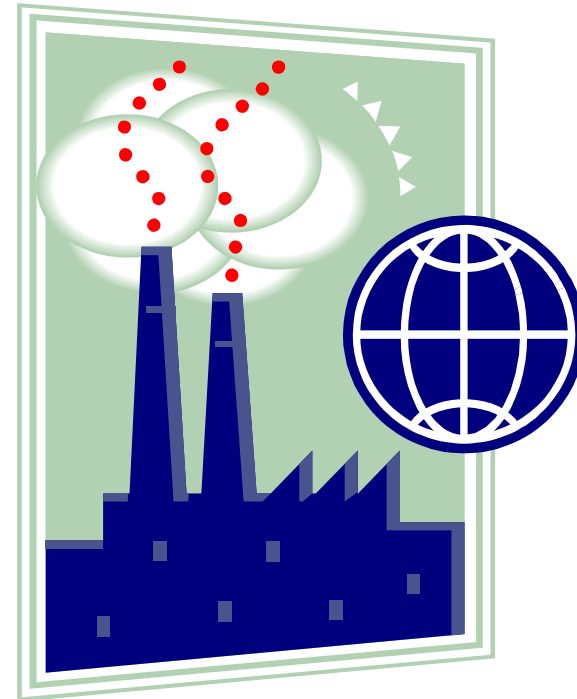
An Eastern utility desired to operate the Unit 1 boiler using a higher sulfur coal / Pet Coke Blend and to conform to increasingly stricter emission guidelines

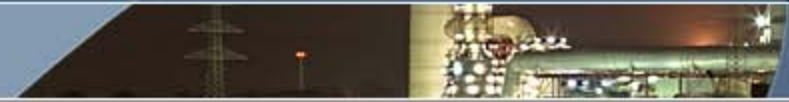




Constraints:

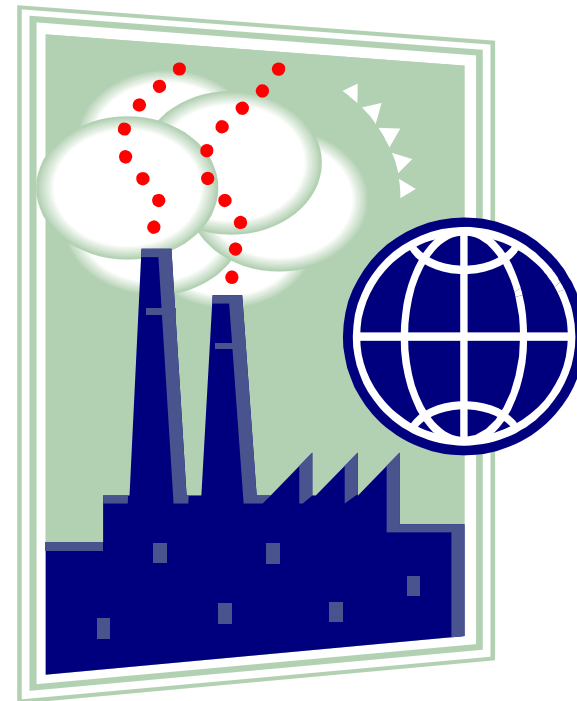
- Maintain the use of only 2 out of 3 absorbers at any time
- No changes to recycle headers
- No changes to recycle spray nozzles

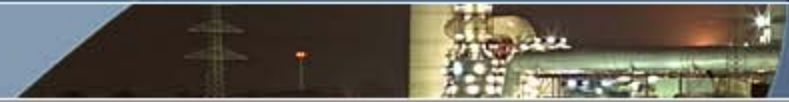




Parameters:

- Maximum sulfur content in fuel – 3.36%
- Chloride in slurry – 15, 000ppm
- 97% SO₂ removal efficiency required to meet emission guarantees for worst case
- Limestone grind 90% through 325 mesh

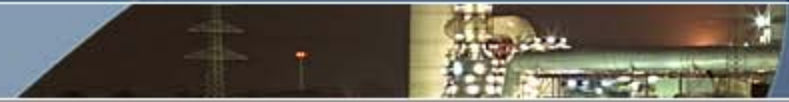




Recommendation #1:

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





Recommendation #2:

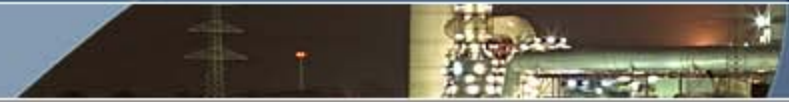
Operate system stoichiometry between 1.08 and 1.10 and increase the suspended solids concentration to 20% to make available additional calcium carbonate for SO_2 absorption and still maintain the gypsum purity requirement.



Recommendation #3:

Install at least two, preferably three, Absorber Liquid Redistribution Devices (ALRDs)

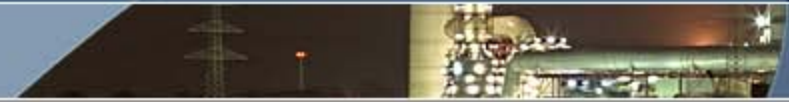




Recommendation #4:

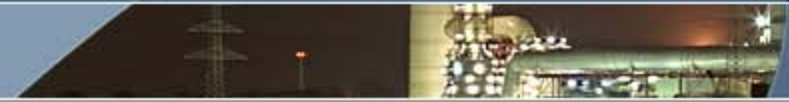
- Upgrade Unit 1 Oxidation Air System to ensure complete oxidation of absorber slurry.
- Operate both blowers simultaneously and increase header size





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



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



Drivers for Upgrades:

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

Upgrade Considerations:

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

