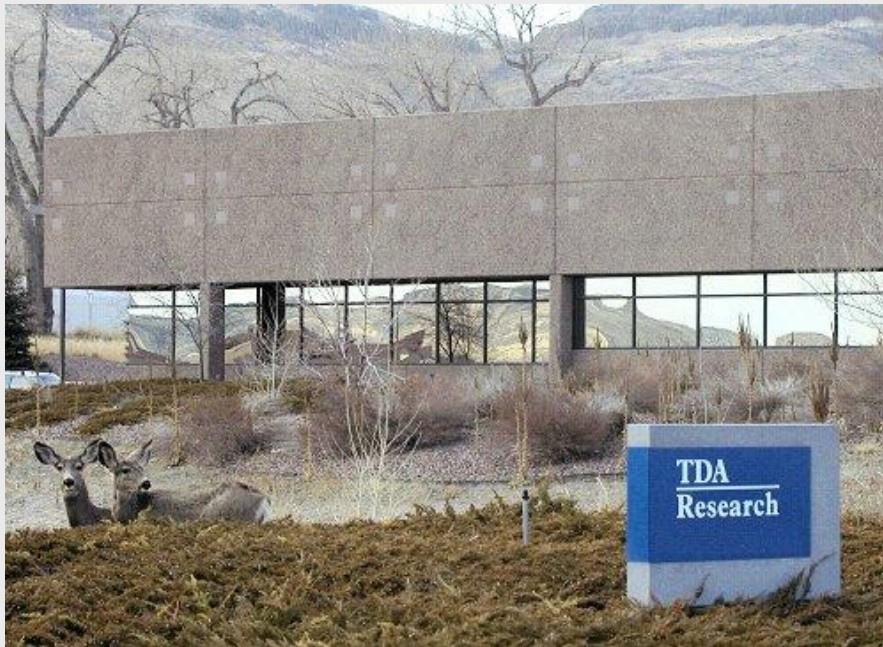


# Low Cost Solid Sorbent for CO<sub>2</sub> Capture on Existing Coal-Fired Power Plants



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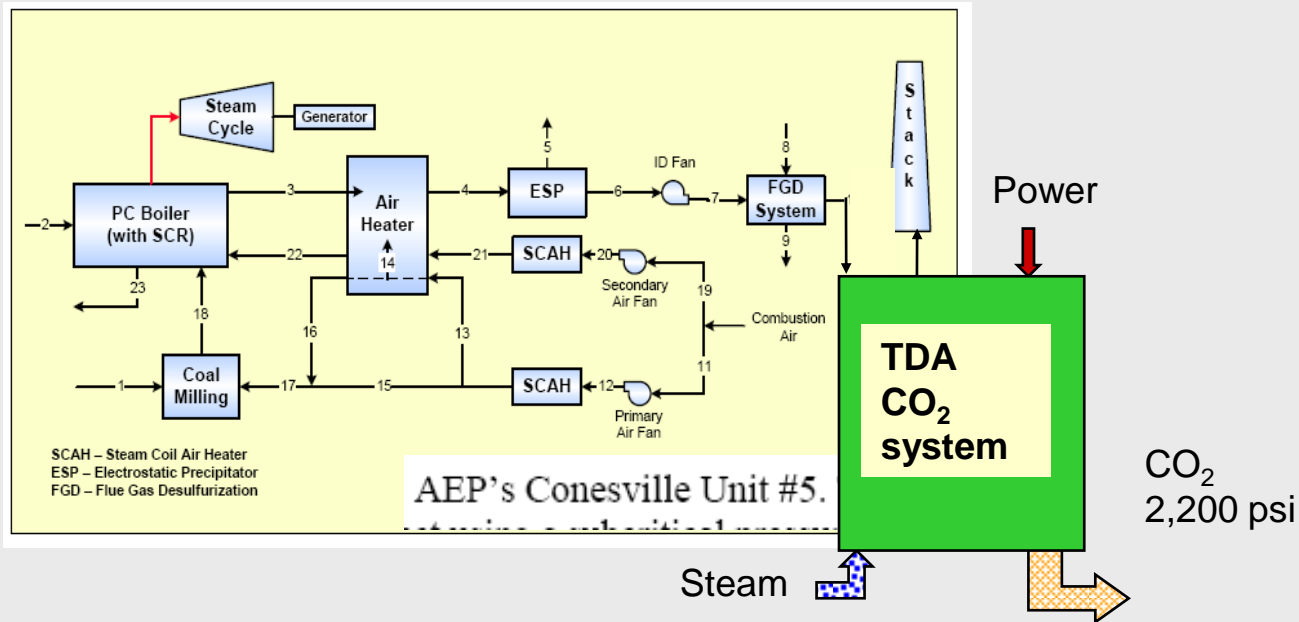
**September 22, 2009**

**Pittsburgh Coal Conference**

# TDA's Approach

## Post combustion CO<sub>2</sub> Capture

- TDA Research is developing:
  - Dry, solid alkalized alumina regenerable sorbent material.
  - Process design around that material.
- The process is located after sulfur removal.



# Advantages

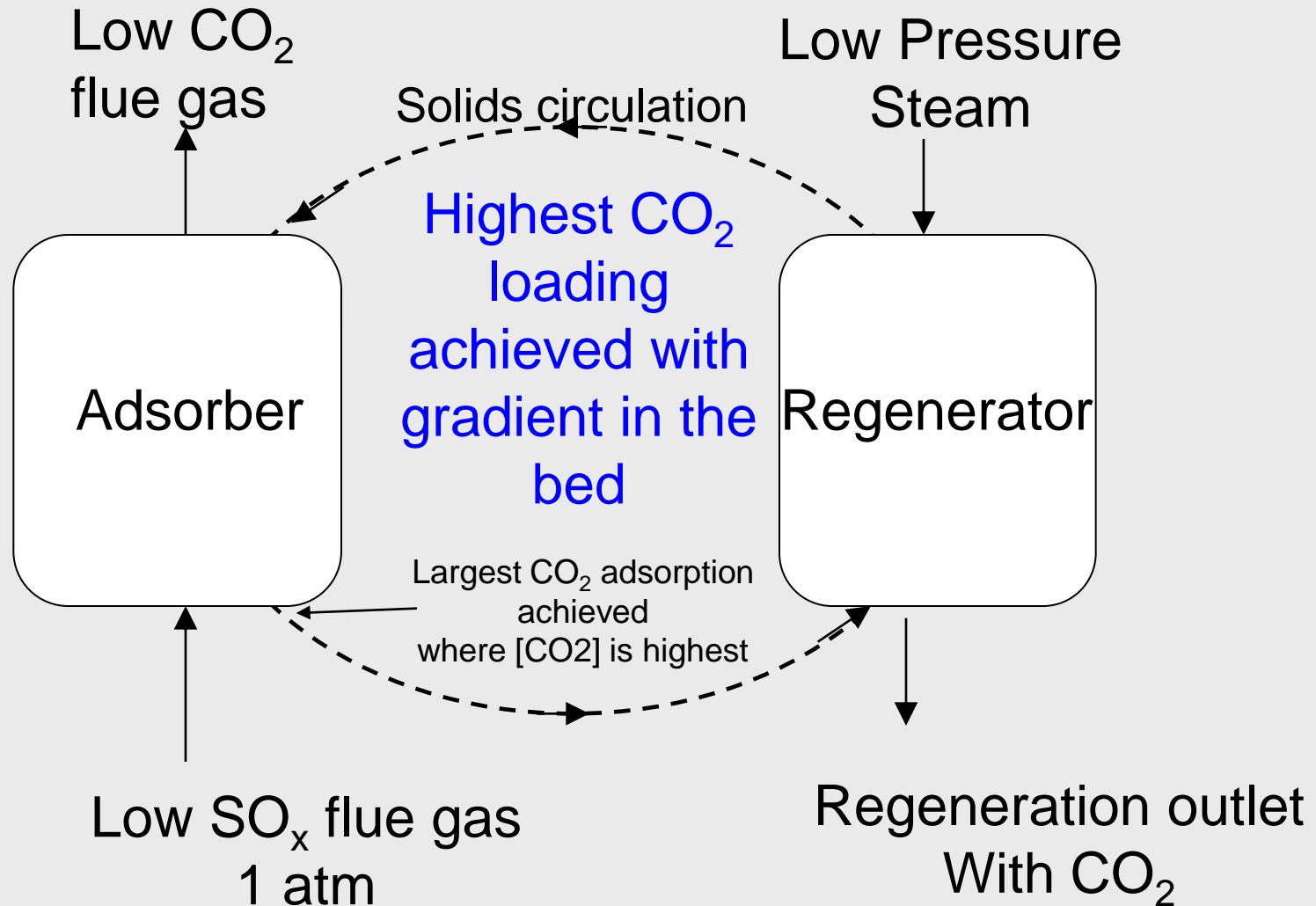
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- **Low cost sorbent material**
  - Inexpensive raw materials
  - Simple processing
- **Low regeneration energy requirements**
  - Physically adsorbed CO<sub>2</sub> can be readily absorbed at lower energy requirement than chemical absorption
  - Low pressure steam regeneration
  - Rapid cycling
- **Process designed to maximize sorbent performance**

# TDA's System Design

- Adsorbents loosely bind CO<sub>2</sub> to the surface
  - Regeneration is fast and with low desorption energy requirement
  - High concentration of CO<sub>2</sub> during desorption
- Adsorbents operate along a concentration gradient
  - They absorb more CO<sub>2</sub> when the concentration is higher than when the concentration is lower.
- Optimum bed design is counter-flow, moving Bed
  - Maximizes the loading on the adsorbent by having the adsorbent contact the gas stream with the highest CO<sub>2</sub> concentration at the end of its reactor residence time.

# Sorbent Bed Schematic



# Summary of Work to Date

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- Project goal: Demonstrate CO<sub>2</sub> capture system designed around TDA's physical adsorbent sorbent
- First year of multi-year project
- Sorbent development and screening
- Sorbent testing in fixed bed
  - Multiple cycle screening
  - Evaluation of effect of contaminants
- Aspen system modeling started

# Sorbent Optimization

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- Earlier sorbents made from research/ laboratory supply grade materials.
- Goal of sorbent development work to move to low cost, bulk supplier raw materials.
- Sorbents are being screened for loading by thermogravimetric analysis (TGA), surface area (BET) and crush strength.
- Over 50 sorbent composition have been evaluated.
- Best sorbents evaluated further in fixed bed testing.

# Sorbent Testing Apparatus

- 300 cc fixed bed reactor
- Automated equipment for unattended operation
- Online analyzer for continuous CO<sub>2</sub> and humidity measurement
- Fixed bed apparatus has counter flow orientation for absorption and regeneration

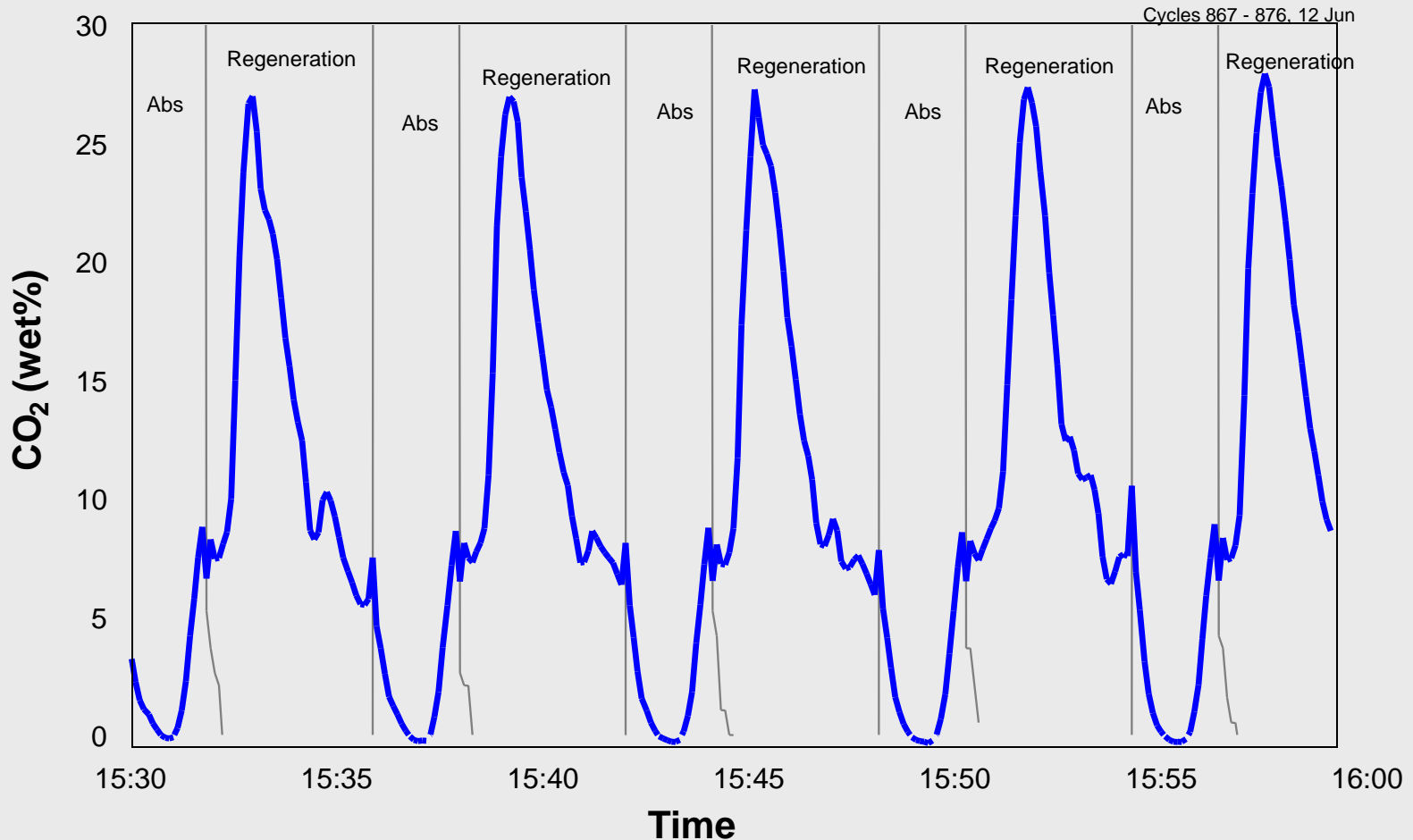


# Sorbent Cycling Data

- Sorbents evaluated over a range of conditions
  - varying space velocities, temperatures, and cycle times.
- Flue gas is simulated
  - 13.8% CO<sub>2</sub>, 9% water, 77.2% N<sub>2</sub>.
  - Some experiment also include SOx
- Over 1800 cycles have been evaluated
  - CO<sub>2</sub> Loadings 0.6 to 0.7 wt%.
- Sorbent cycling is rapid with fast absorption and desorption times.

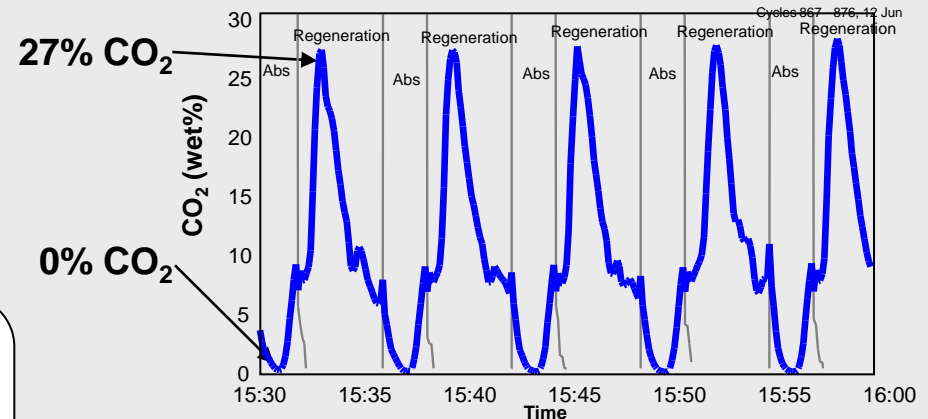
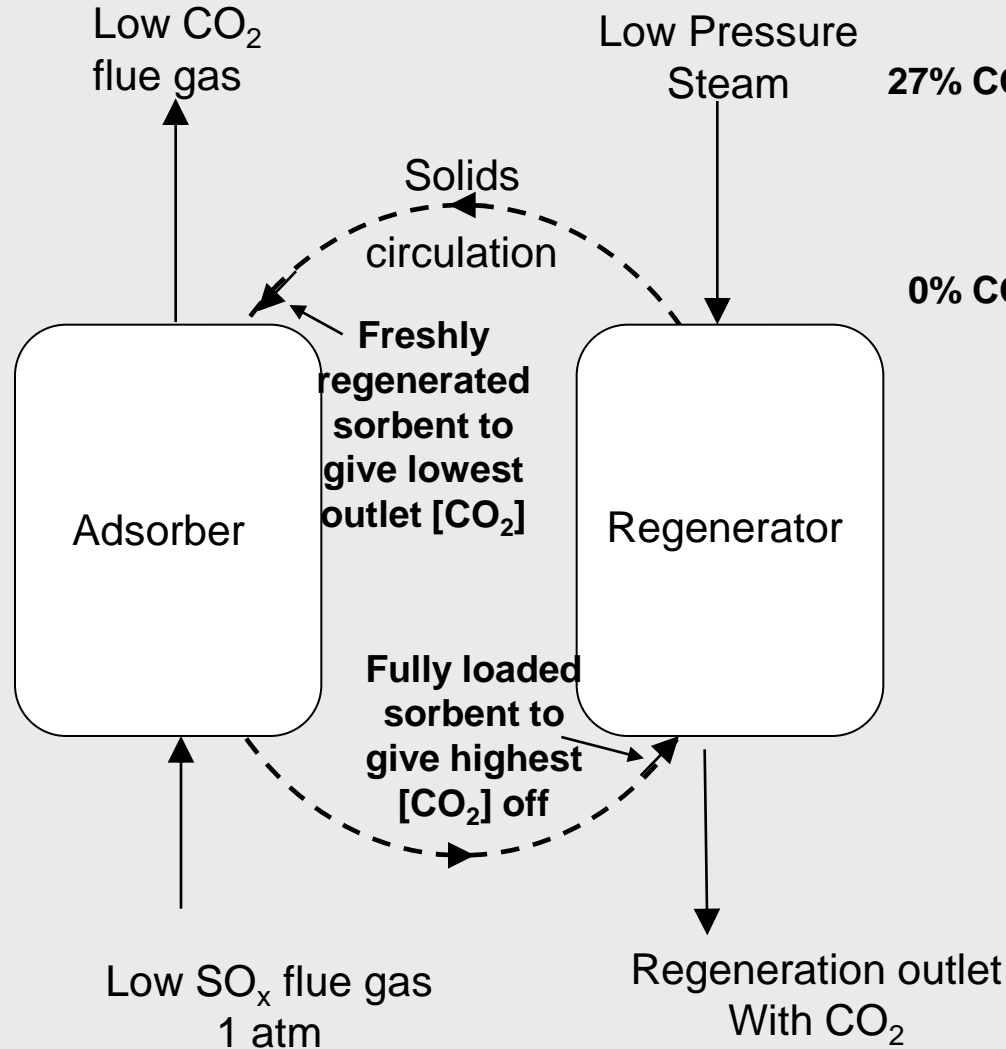
# Sorbent Multiple Cycle Test Data

## Cycle 867 to 876



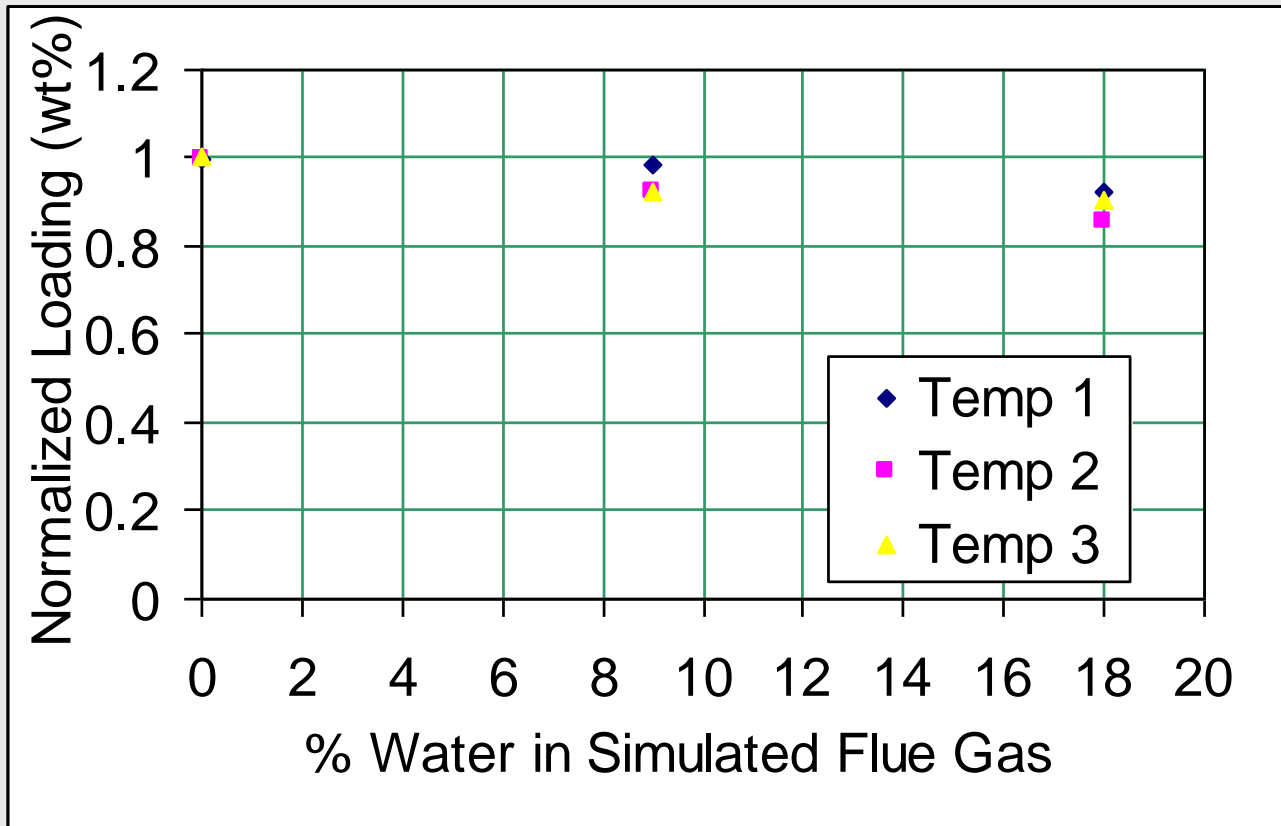
Loading = 0.68 wt%, Reg outlet CO<sub>2</sub>=27%

# Operation in Circulating System



- Fixed bed experiments with absorption & regeneration in counter-flow to mimic commercial design
- Moving bed design would give continuous operation at low and high point

# Moisture effect data



- Loading reasonable flat with over range of moisture levels

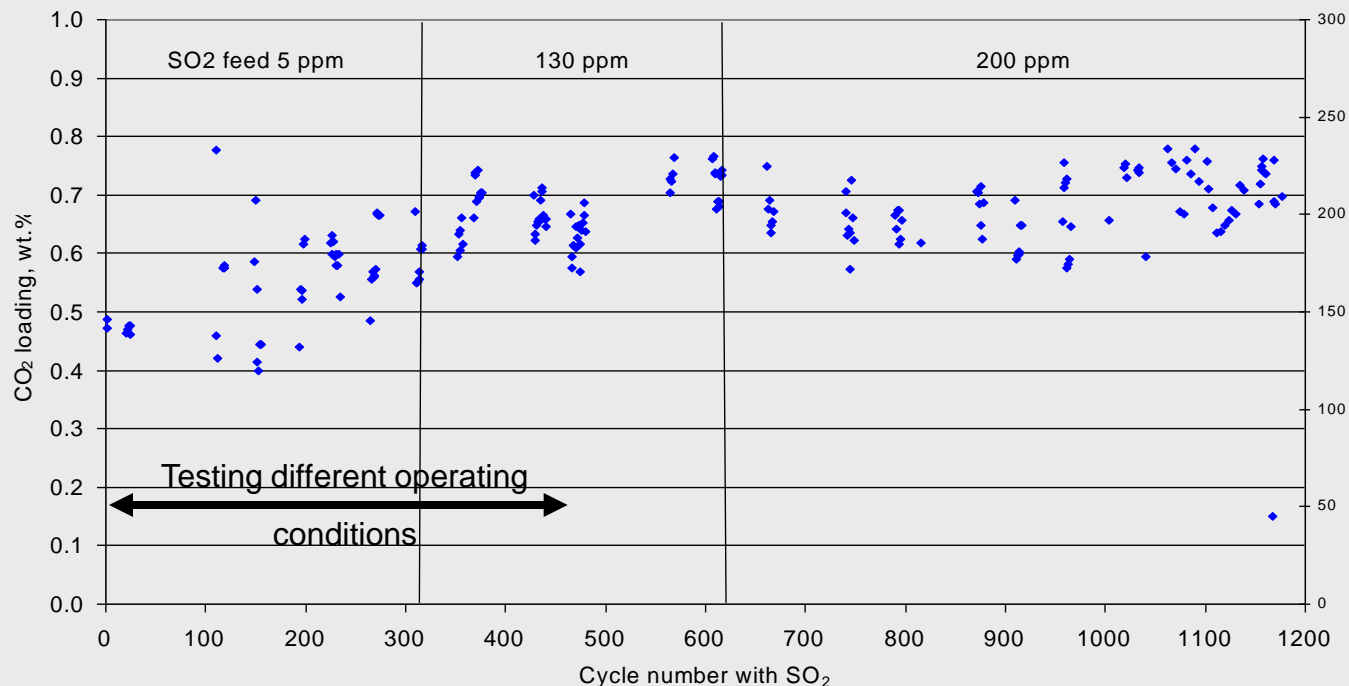
# Effect of Moisture

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- Water level in flue gas can vary from nominally 9% to as high as 19%.
- Moisture level in flue gas has minimal impact on CO<sub>2</sub> loading.
- Doubling the moisture level from 9% to 18% reduces loading by only ~8%.

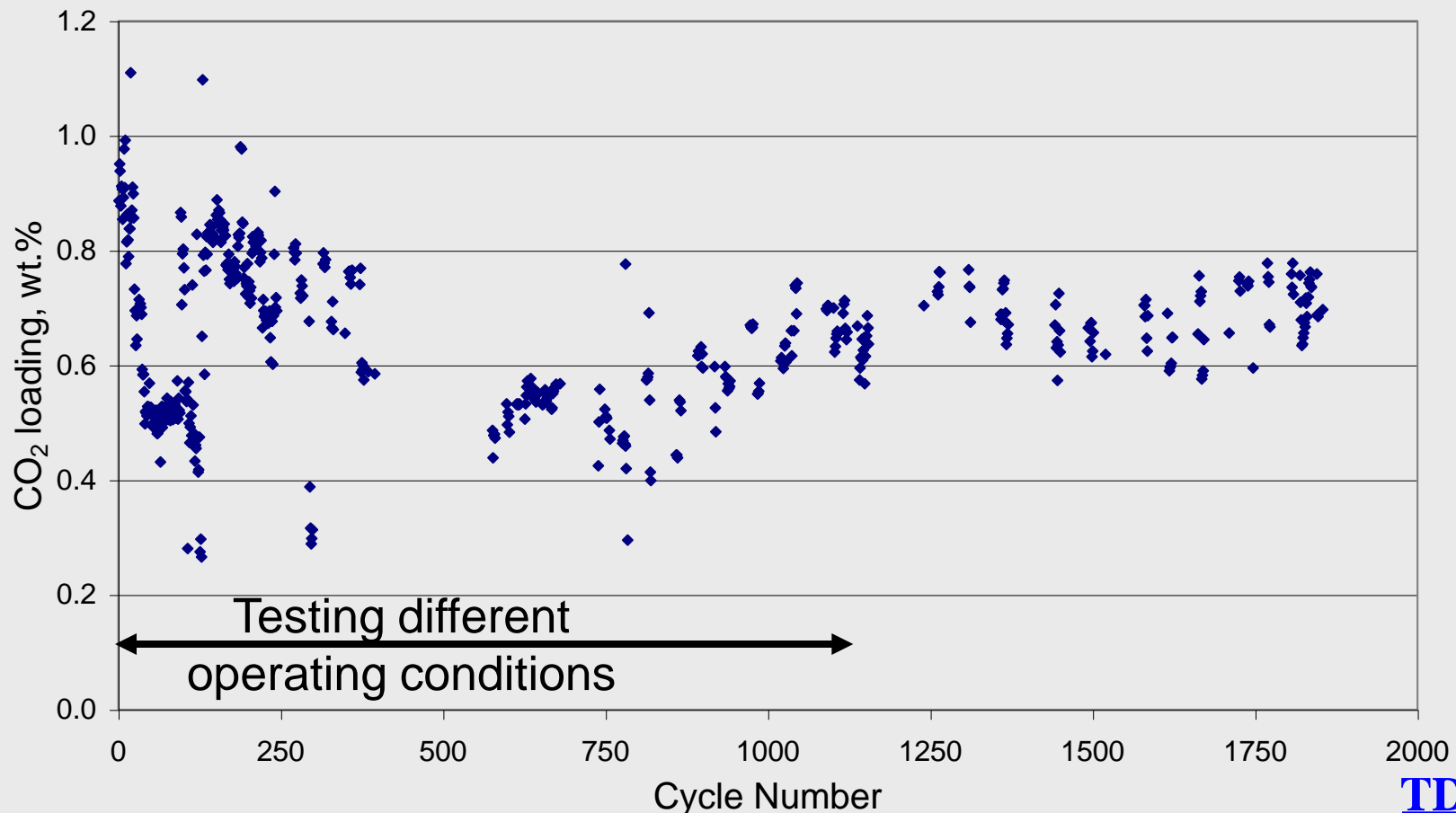
# Effect of SO<sub>2</sub>

- SO<sub>x</sub> is also an acidic gas and may compete with CO<sub>2</sub> for adsorption on the sorbent
- Tests show CO<sub>2</sub> loading not affected by SO<sub>2</sub>



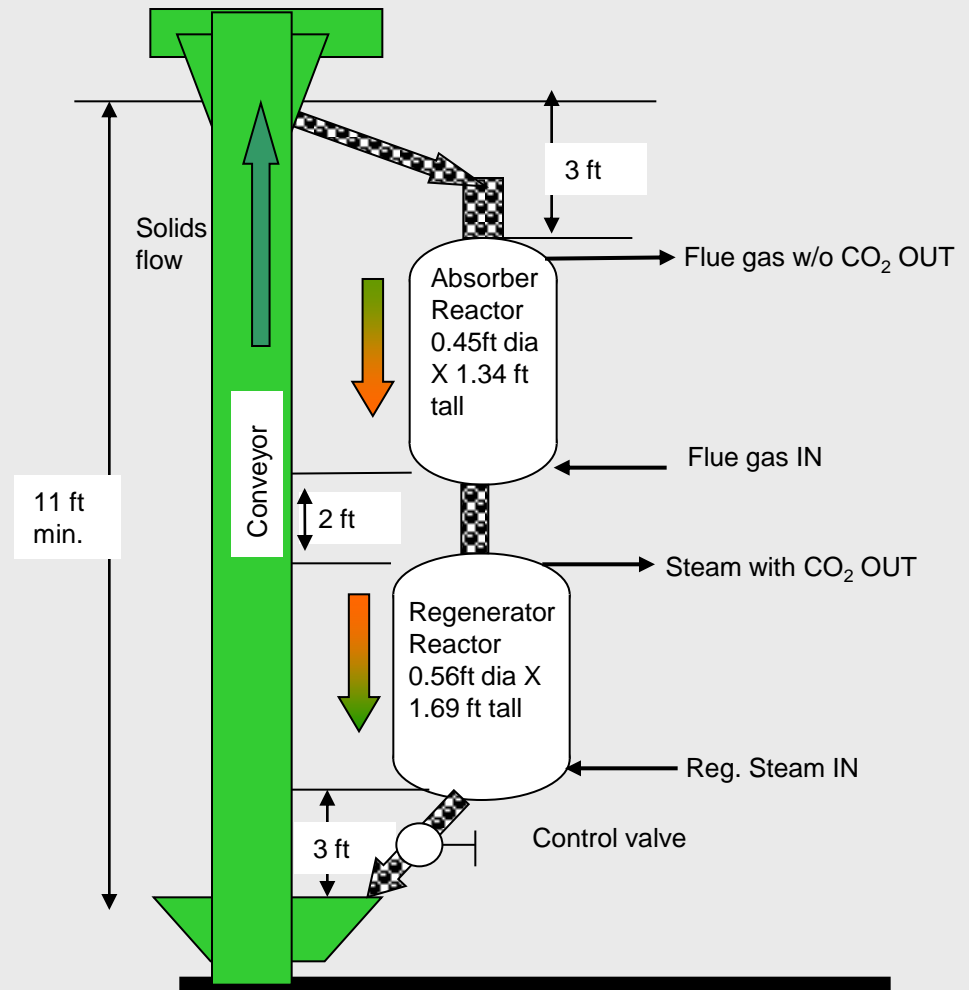
# Long term cycling Performance

- 1850 cycles have been performed to date with no loss of activity



# Cold Flow Demonstration Planned

- TDA will build a cold flow system first to demonstrate circulation of pellets.
- System will have correct flow contact, counter flow moving bed
- Circulation will be by screw elevator in demo unit since temperature rated unit are available stock item.
- After cold flow demonstration, a hot system will be constructed to show sorbent performance under simulated conditions



# Future Work

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- Complete study of sorbent cyclic lifetime and the effect of contaminants
- Construct cold and hot system to show sorbent in counter-flow moving bed configuration
- LSU to complete Aspen modeling to calculate system efficiency
- Optimize system design & performed economics calculations.
- Demonstrate system on coal derived flue gas at Western Research Institute

# Summary

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- We are developing both a sorbent and process that uses the sorbent -for post combustion CO<sub>2</sub> capture coal fired power plants.
- Technical progress to date has been promising.
- Sorbent showing robust performance with repeated cycling and is tolerate of SO<sub>2</sub>

# Acknowledgements

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- **DOE project funding**
- **Collaborators**
  - B&W
  - LSU
  - WRI