GORE® Mercury Control System

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John Darrow
Jeff Kolde
W.L. Gore and Associates, Inc

- Founded in 1958
- Inventors of ePTFE membrane
- Privately-held / Associate-owned
- Over 8,500 Associates
- Sales of over $3 Billion in fiscal year 2010
- Ranked in the U.S. and Europe by Fortune Magazine as one of the top 100 companies to work for
- Enterprise committed to innovation
Manufacturing in U.S., Germany, Scotland, Japan, and China
45 plants and sales locations globally
W.L. Gore and Associates Inc.

- Fabrics Division
- Medical Division
- Industrial Products Division
- Electronic Products Division

- Venting
- Micro-Filtration
- Sealants
- Filtration Technologies
- Fibers
- Micro-Contam.
- Fuel Cells Control

- Industrial Dry Filtration
- Liquid Filtration
- Cleanstream
- Turbine Filters

- GORE® Filter Bags
- Mercury Control System
- REMEDIA® Catalytic Filtration
- DeNOx

GAS REMEDIATION
Existing Strategies for Mercury Control

1. Remove in liquid phase in wet FGD scrubber
   - Relies on conversion of mercury to oxidized form upstream of scrubber
     • Sensitive to coal type
     • Additives can cause corrosion
     • Waste water treatment
     • Hg Re-emissions

2. Remove mercury from gas phase using sorbents
   - Activated Carbon Injection (ACI) is most common
     • Handling and disposal issues
     • Contamination of fly ash
     • Complicates PM compliance
     • Sensitive to coal type (SO$_3$, halogen content)
Fixed Bed Sorbent Technology

- Because of the drawbacks associated with these approaches, fixed-bed technologies have been pursued.
- Compared to ACI, fixed beds have inherent advantages:
  - Simple passive operation
  - No contamination of fly ash
  - Minimal solid waste generation
- However, due to saturation by SOx and other acid gases, fixed sorbent beds typically require frequent regeneration:
  - Energy-intensive, complicated regeneration processes
  - Adds significant cost (capital and operating)
Material Innovation by Gore

• Sorbent Polymer Composite (SPC) material
  – Efficiently captures both elemental and oxidized mercury Hg
  – High capacity for mercury storage
  – **Does not require regeneration**

• Unique physical-chemical nature of the SPC material
  – Acid gases are converted into aqueous solution and expelled to SPC material’s outer surfaces

• SO₂ reduction is a co-benefit of this technology

![SPC Material](image1)

**H₂SO₄ formation from humidified SO₂ gas feed**

![Image 2](image2)
Testing of Fixed Beds

Southern Company (Plant Yates)

Hg removal efficiency (%)

Days on Test

5 ft/sec, LSEB coal, 125-150F, 1-3 µg/m3 Hg

Gore SPC
Activated Carbon Pellets

Data generated by URS, EPRI, and Southern Company
Hg is strongly bound to SPC material incorporated into discrete modules. Stack height determines mercury removal efficiency (20-95+% Hg removal possible). Open-channel design provides low pressure drop.
Installation within a Wet FGD Scrubber

- Modules provide mercury removal and SOx polishing.
- Prevents mercury re-emissions from a wet scrubber
Mercury Control Modules

Cooling System (Evaporative cooler)

Installation without wFGD Scrubber

- Gore system can provide a stand-alone solution for Hg and SOx
- Lower cost alternative to a new wFGD

GORE® Mercury Control Modules operate best in the temperature range of 125-225°F (50-100°C)
GORE® Mercury Control System

- Captures Elemental and Oxidized Mercury
- Low Operating Cost
- Self-Contained Sorbent
- Modular Compliance Solution

- Avoids need for upstream additives
  - Cost, complexity, corrosion concerns
  - Insensitive to raw material composition changes that impact mercury species

- Resolves FGD mercury re-emissions concerns
  - Simplifies FGD operation

- Doesn’t rely on SCR catalyst health
GORE® Mercury Control System

- Captures Elemental and Oxidized Mercury
- Low Operating Cost
- Self-Contained Sorbent
- Modular Compliance Solution

- Long Module Lifetime
  - Modules have very high capacity for mercury storage

- Simple Operation
  - No adjustments needed to account for changes in mercury concentration or speciation
  - Little to no maintenance or energy required to operate
  - No regeneration
GORE® Mercury Control System

- Captures Elemental and Oxidized Mercury
- Low Operating Cost
- Self-Contained Sorbent
- Modular Compliance Solution

Unlike Activated Carbon Injection:
- No contamination of fly ash
- No impact to particulate collection devices
- Minimal waste generation
- Simplified logistics
  - Avoids need for continuous transport, safe storage, disposal of PAC
- Allows fuel flexibility
  -Insensitive to flue gas composition changes (SO$_3$, halogen content, VOCs, Hg species)
GORE® Mercury Control System

- Captures Elemental and Oxidized Mercury
- Low Operating Cost
- Self-Contained Sorbent
- Modular Compliance Solution

- Mercury reduction determined by number of modules
  - Compliance assured by design
- Flexibility to meet future regulations / process changes
  - Additional layer of modules for higher mercury capture represents minimal investment
- Co-benefit of SO$_2$ reduction
  - Typically $\geq$50% SO$_2$ converted to H$_2$SO$_4$
Plant Yates Demonstration (2010)

Gore, EPRI, URS, and Southern Company
Average Removal Efficiency During 65 Day Test

Removal Efficiency

Mercury

SO₂

Gore, EPRI, URS, and Southern Company
Passive Solution for Variable Inlet Concentrations

Significant changes in mercury inlet concentrations do not require any adjustments or changes to the modules.
Lifetime Projections

Measured Hg-removal efficiency of SPC material with different amounts of captured Hg

Efficiency for Hg capture remains steady beyond 6 wt% Hg on SPC
Lifetime Projections

Measured Hg-removal efficiency of SPC material with different amounts of captured Hg. Data measured on 6" module height in lab, extrapolated to 60" module height (5x12" modules).

- Efficiency for Hg capture remains steady beyond 6 wt% Hg on SPC.
- 5 wt% is equivalent to one ton of Hg removed for typical size utility installation (1GW) requiring 80-90% Hg removal.

SPC samples loaded in lab
- SPC samples loaded in field test
Economic Analysis

• Performed by URS (Austin, Texas)
• ~600 MW unit
  – Wet FGD Scrubber, ESP, no SCR, lignite coal
  – ~70% Hg reduction needed
  – Ash sales practiced
• Four options considered
  – 1) ACI (5 lb/MMacf)
  – 2) Bromide additives (200ppm)
  – 3) ACI + Bromide additives (1 lb/MMacf + 50 ppm)
  – 4) Gore® Mercury Control System installed in scrubber
    • 3-year and 6-year module lifetime modeled
Economic Analysis

- Depreciated Capital Cost ($/yr)
- Operating Cost ($/yr)
- Cost of Lost Ash Sales + Ash Disposal ($/yr)

### Annual Cost

**Gore 3-year**
- Depreciated Capital Cost
- Operating Cost
- Cost of Lost Ash Sales + Ash Disposal

**Gore 6-year**
- Depreciated Capital Cost
- Operating Cost
- Cost of Lost Ash Sales + Ash Disposal

**ACI**
- Depreciated Capital Cost
- Operating Cost
- Cost of Lost Ash Sales + Ash Disposal

**Bromide**
- Depreciated Capital Cost
- Operating Cost
- Cost of Lost Ash Sales + Ash Disposal

**ACI+Bromide**
- Depreciated Capital Cost
- Operating Cost
- Cost of Lost Ash Sales + Ash Disposal

### Costs
- 5 lb/MMacf ACI
- 1 lb/MMacf ACI + 50 ppm Br
- 200 ppm Br

Performed by URS
Economic Analysis

Depreciated Capital Cost ($/yr)  Operating Cost ($/yr)  Cost of Lost Ash Sales + Ash Disposal ($/yr)

Annual Cost

$12,000,000

$10,000,000

$8,000,000

$6,000,000

$4,000,000

$2,000,000

$0

Gore 3-year  Gore 6-year  ACI  Bromide  ACI+Bromide

Does not include Br license fee
- Corrosion
- WWT
- Re-Emissions

Performed by URS

5 lb/MMacf ACI

1 lb/MMacf ACI + 50ppm Br

200ppm Br
Summary

- Gore has a new approach to mercury control
  - Simple, robust, low-maintenance solution
  - Low cost (capital and operating)
  - SOx reduction co-benefit
- Field testing has demonstrated high efficiency and long lifetime
  - Additional post-scrubber and in-scrubber pilot tests starting this year
- Full scale installations proposed for next year
  - Seeking additional early adopter sites
Thank you!