How to get the Most out of Your Baghouse With Gore™ ePTFE Filter media

McIlvaine Hot Topics
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W. L. Gore & Associates, Inc.
Agenda

• Overview of W. L. Gore & Associates
• What is ePTFE membrane filtration
• MACT Legislation (simplified version)
• EPTFE Membrane vs. Other Filter Media
• Getting the most out of ePTFE membrane media
• Conclusions
Overview of W. L. Gore & Associates
Company Overview

- Founded in 1958
- Inventors of ePTFE membrane (patented in 1963)
- Associate-owned
- 8,500 associates
- 45 plants and sales locations globally
- Manufacturing in U.S., Germany, Scotland, Japan, and China
- Sales of over $3 billion in fiscal 2009
- Ranked in the U.S. and Europe by Fortune Magazine as one of the top 100 company's to work for
Gore’s Four Divisions

- Electronic products
- Industrial products
- Medical products
- Fabrics
What is e-PTFE membrane filtration
What is Membrane Filter Media?

- ePTFE Membrane Fabric (Fiberglass or felt)
- Proprietary Lamination Process
- ePTFE Membrane Laminate
GORE® Filter Laminate
Surface Filtration vs. Depth Filtration

Sieving is one of the mechanisms in Filtration

- Micro-pores collect fine particles on the “Surface” of the membrane

= 2µm particle
Filtering Mode (Surface vs. Depth)

Membrane Filtering Mode

Conventional Filtering Mode
Cleaning Mode (Surface vs. Depth)

Membrane Cleaning Mode

Conventional Cleaning Mode
Summary of ePTFE Membrane Filtration

• Particles captured on the surface
  – Extremely fine pores (microporous)
  – Smooth, non-stick, chemically inert surface

• Improved release of dust cake
  – Lower residual (after cleaning) pressure drop
  – Higher airflow/Lower fan energy

• Longer bag life
  – Longer Filtration/Fewer cleaning cycles
  – No abrasive dust in backing material

• Near zero emissions
MACT – NESHAP Summary
MACT - Simplified

- MACT stands for Maximum Achievable Control Technology
- Effects facilities with Potential to Emit (PTE)
  - >10 tons/yr of any one HAP (major source)
  - >25 tons/year of all HAPs (major source)
- In a MACT analysis, the EPA gathers emissions data from plants for a given pollutant
- The data is analyzed and the average of the best performing 12% sets the limit for all existing sources
- The data from the single best source sets the limit for all New Sources
Industrial Boiler MACT

- Proposed rule out in April 2010
  - Effects all existing industrial, commercial, or industrial boilers or process heaters located at a major source
  - Excludes facilities that combust solid waste
  - 9 Categories for existing and new boilers and process heaters
  - Includes Electric Generating Units <25 Mw
- As many as 57,000 existing units (42,000 boilers/15,000 process heaters) and 4,500 new boilers will be effected
  - Estimated 2,500 existing coal fired and 700 wood fired boilers
  - Approximately 250 new coal and 100 wood fired boilers
- The new limits will reduce air emissions of PM, hydrochloric acid, mercury, carbon monoxide, and dioxin/furan
- Final rule due December 2010
## Partial Proposed Boiler MACT Limits
(for PC Boilers – one of the 9 categories)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Existing Source</th>
<th>New Source</th>
</tr>
</thead>
</table>
| PM                         | 0.02 pounds per million BTU
  (roughly 0.01 gr/dscf; 25 mg/dscm) | 0.001 pounds per million BTU
  (roughly 0.0005 gr/dscf; 1.2 mg/dscm) |
| Hydrochloric acid          | 0.02 pounds per million BTU                    | 0.0006 pounds per million BTU     |
| Mercury                    | 0.000003 pounds per million BTU                | 0.000002 pounds per million BTU   |
| Dioxins/Furans (TEQ)       | 0.004 ng/dscm                                  | 0.002 ng/dscm                    |
Electric Generating Unit (EGU) MACT

- Information Collection Request sent to approximately 500 plants (due July – September 2010) to gather data on HAPs
- Some units asked for additional testing for emissions including
  - Acid gases \( (SO_2, HCl, HF, HCN) \)
  - Organics \( (CO, VOC, THC \text{ plus POM}, NOx, \text{ Formaldehyde, Methane, } CO_2) \)
  - D/F
  - Non Hg Metals \( (Sb, As, Be, Cd, Cr, Co, Pb, Mn, Ni, Se) \)
- \( \text{CO/VOC/THC} \) may be surrogates for non- dioxin/furans organics; \( PM_{2.5} \) may be a surrogate for non-Hg metals
- Implications are new APC equipment or upgrades may be requires at many units (e.g. PM control, FGD, Carbon Injection)
- Proposed rule by March 2011
- Final rule due November 2011
Can ePTFE membrane bags help with MACT?

- EPTFE Membrane filter media is gaining acceptance in Power Generation (even before MACT)
- 35 EGU plants currently using ePTFE membrane bags
- Approximately 16,000 Mw of capacity
- Partial list of users
  - Otter tail Power
  - MidAmerican Energy
  - Xcel Energy
  - Kansas City Power & Light
  - Basin Electric
- Membrane bags currently under consideration at several more plants
Gore Filter Media Choices for Boilers

- PTFE Laminates (felt or woven fabrics)
  - Temperatures up to 500°F (260°C) continuous
  - Chemically inert
- Fiberglass Laminates (woven fabric only)
- Temperature up to 500°F (260°C) continuous
  - Available with acid resistant finish
- PPS & Polyimide Laminates (subject to limitations; temperature, moisture, O_2, NO_2, strong oxidizing agents)
EPTFE Membrane vs. Other Filter Media
Lowest Pressure Drop - membrane media (EPA ETV expired verifications)
Lowest Pressure Drop – membrane media (EPA ETV current verifications)

ETV Performance Data
Official Verifications September 2010
Residual DP

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier 1 Membrane</td>
<td>April 2010</td>
</tr>
<tr>
<td>Supplier 2 Membrane</td>
<td>Sept. 2007</td>
</tr>
<tr>
<td>Supplier 2 Membrane</td>
<td>Dec. 2008</td>
</tr>
<tr>
<td>Supplier 4 Pleatable</td>
<td>June 2009</td>
</tr>
<tr>
<td>Supplier 3 Membrane</td>
<td>June 2009</td>
</tr>
</tbody>
</table>
Fewest Cleaning Cycles – membrane media
(from EPA ETV expired verifications)
Fewest Cleaning Cycles – membrane media (EPA ETV current verifications)

ETV Performance Data
Official Verifications September 2010
Number of Cleaning Cycles

Supplier 1 Membrane (April 2010)
Supplier 2 Membrane (Sept. 2007)
Supplier 2 Membrane (Dec. 2008)
Supplier 4 Pleatable (June 2009)
Supplier 3 Membrane (June 2009)
Lowest PM$_{2.5}$ Emissions – membrane media (EPA ETV expired verifications)
Lowest PM$_{2.5}$ Emissions - membrane media (EPA ETV current verifications)

ETV Performance Data
Official Verifications September 2010
Emissions PM 2.5

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<th>Supplier 1 Membrane</th>
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</thead>
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<tr>
<td>BDL</td>
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PM 2.5 Emissions (g/dscm)
Membrane advantages in Coal Fired Boilers

- Expanded PTFE membrane is chemically inert
- EPTFE membrane captures of **fine aerosol** PM on the surface
  - Protects the backing material from acidic PM (solid or liquid)
  - (Note: Membrane will not collect acid gas/vapor)
- Smooth, micro-porous surface provides superior release of sticky ash → lower DP, less frequent cleaning
- EPTFE membrane is less sensitive to changes in ash (size or chemistry) and dust loading → lower PM and PM$_{2.5}$ emissions
Getting the Most from Your High Performance ePTFE Membrane Filter Media
What is high performance?

- **Lower Normalized DP** (lower filter drag = DP/ACR)
  - Can handle higher dust loading at same relative DP
  - Can handle finer particles at same relative DP
  - Able to release more cohesive ash/dry scrubber products

- **Lower PM emissions**
  - Can capture fine, submicron particles
  - Eliminates/reduces opacity spikes after cleaning
  - Capable of achieving emissions at or near the detection limit of the test method (front half catch)
What is high performance? (cont’d)

• Longer bag life
  – Less frequent cleaning
  – Less cleaning energy (lower cleaning pressure)
  – Less fabric wear; dust captured on the filtration surface, not in the depth of the media
Objective – Getting the Lowest Annualized Cost w/o Emissions Problems

System Optimization:
- Bag Life
- Emissions
- Pressure Drop
- Gas Flow/Throughput
Should you consider high performance ePTFE membrane filter media in your boiler?

- Have you changed fuel? (Different coal or blend; Biomass or alternative fuel)
- Is your baghouse limiting production?
  - Have you increased production capability?
  - Have you increased the dust loading to the baghouse? (fuel change, dry sorbent injection, etc)
  - Can you perform on-line maintenance without reducing load?
- Do filter bags need to be replaced frequently between planned outages?
- Do you have changing operating conditions (load changes) or periodic upsets (tube leaks)?
- Do you ever have to decrease load due to opacity or emissions related to PM?
- Do you have to meet new environmental regulations?
- Is your baghouse performance below expectations?
  - Differential pressure (DP)
  - Bag life
  - Emissions

If “yes” to any of the above, you may want to consider it.
Why consider ePTFE membrane?

- EPTFE Membrane bags can deliver higher performance
  - Lower DP/ Higher gas flow
  - Reduced PM emissions
  - Longer bag life

(There is a higher price for this performance so make sure it is a proper application for ePTFE membrane media)
It is relatively easy to optimize for one of these attributes. (window screen has high airflow but poor life and efficiency)

It is more difficult to optimize for two of these three attributes (steel tubes are highly efficient and could last a long time but with an infinite DP)

It is even more difficult to optimize for all three simultaneously. Gore innovates to do exactly this.
GORE® Filtration Products
Continuous Innovation

Membrane Permeability vs. Strength

Permeability

Strength

- Family A
- Family B
- Family C
- Family D
Recommendations: Before Selecting ePTFE Membrane Filter Bags

- **Step 1 – Customer Needs Assessment**
  - Is the baghouse performing to expectations?
  - Can performance be enhanced with ePTFE membrane media?
- **Step 2 - System Design Review**
  - Is ePTFE membrane a viable option?
- **Step 3 – System Survey**
  - Verify current baghouse operating conditions (gas flow, DP, bag life, etc)
  - Check for hardware problems that effect baghouse performance
- **Step 4 - System Analysis**
  - Project expected performance with ePTFE membrane media
  - Economic Evaluation (Benefits/Costs Analysis)
Recommendations: After installing ePTFE Membrane Filter Bags

- System optimization
  - Minimize Operating Cost
  - Meeting PM Regulations

(usually requires modifications to the cleaning system parameters)

- Check current performance against original projections
- Re-check performance periodically and re-optimize as necessary
- Conduct periodic bag analyses to project bag life
Conclusions
Conclusions

- EPTFE membrane bags are well suited for coal-fired boiler applications
  - Capture corrosive ash/aerosols on a chemically inert surface
  - Superior release of sticky ash
  - PTFE membrane surface is less sensitive to PM size, shape, chemistry, and dust loading
- Can handle process upsets/tube leaks
- Allow maximum fuel flexibility (different coals and alternative fuels)
- Membrane bags can be a cost effective way to improve baghouse performance

(Membrane bags do not collect condensable acid gases or vapors, however, they are compatible with additive systems for SO$_3$ control)
Questions?

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