Key Issues When Selecting Fabric Filter Bags to Achieve Optimum Bag Life

McIlvaine Company Hot Topic Hour
“Fabric Selection for Particulate Control”
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What Will Be Covered?

- Cleaning Methods & Filter Media Options (CFB)
- Emission Goals and Design & Selection
- Time v. Temperature Study
- Emission Performance in Lab (Membrane vs. Felts)
- Relative Bag Performance
- Cost Considerations
- Factors Affecting Life & Performance
- Importance of Fabric & Bag Specifications
- QA/QC Program
- Initial Bag Installation
- Bag Monitoring
- Managing Bag Life – An Action Plan
# Cleaning Methods & Filter Media Options (CFB)

## Pulse Jet
1. PPS Felt
2. P-84® Felt
3. Teflon® Felt
4. PPS Felt/ePTFE membrane
5. PPS Felt/PTFE Resin
6. Woven Fiberglass
7. Woven Fiberglass/ePTFE membrane
8. PPS Felt/P-84® Blends
9. Aramid (Nomex®) Felt

## Reverse Air
1. Woven Fiberglass
2. Woven Fiberglass/ePTFE membrane
Design Considerations & Trade-Offs

- Provide Required Filtration (0.000x grains/ft³)
- Obtain Optimum Bag Life
- Provide Required Cleaning Capability
- Distribute Gas & Dust Equally
- Provide Effective Dust Removal From Collector

N.B.
Lower G/C gives longer bag life & lower ΔP (trade-off capital vs. operating cost)
Good design & PM retains design cleaning frequency (low)
Longer Bag Life
Design:
Fabric Selection Considerations

- **Gas Stream**
  - Temperature
  - Moisture
  - Chemistry
  - Dust Loading

- **Dust Characterization**
  - Abrasiveness
  - Stickiness
  - Explosiveness
  - Flammability

- **Fabric**
  - Filtration Performance
  - Temperature Max
  - Release Properties
  - Pressure Drop
  - Life/Durability
  - Costs

- **Other**
  - ePTFE Membrane
  - Coatings/Treatment
  - Blends
  - Scrim
  - Hardware
<table>
<thead>
<tr>
<th>Fabric</th>
<th>Max Continuous Temp</th>
<th>Surge Temp.</th>
<th>Acid Resistance</th>
<th>Fluoride Resistance</th>
<th>Alkali Resistance</th>
<th>Flex Abrasion Resistance</th>
<th>Relative Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>180 °F</td>
<td>200 °F</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Very Good</td>
<td>0.3</td>
</tr>
<tr>
<td>Wool</td>
<td>200 °F</td>
<td>230 °F</td>
<td>Good</td>
<td>--</td>
<td>Poor</td>
<td>Fair</td>
<td>--</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>200 °F</td>
<td>200 °F</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Very Good</td>
<td>0.4</td>
</tr>
<tr>
<td>Acrylic</td>
<td>265 °F</td>
<td>284 °F</td>
<td>--</td>
<td>--</td>
<td>Fair</td>
<td>Good</td>
<td>0.4</td>
</tr>
<tr>
<td>Polyester</td>
<td>275 °F</td>
<td>300 °F</td>
<td>Fair</td>
<td>Poor to Fair</td>
<td>Fair</td>
<td>Very Good</td>
<td>0.4</td>
</tr>
<tr>
<td>Basofil®/Melamine</td>
<td>375 °F</td>
<td>-- °F</td>
<td>Good</td>
<td>--</td>
<td>Excellent</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>PPS</td>
<td>375 °F</td>
<td>425 °F</td>
<td>Good</td>
<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>1.0</td>
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<tr>
<td>Nomex®/Aramid</td>
<td>400 °F</td>
<td>425 °F</td>
<td>Poor to Fair</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>0.9</td>
</tr>
<tr>
<td>P-84®/Polyimide</td>
<td>400 °F</td>
<td>500 °F</td>
<td>Fair</td>
<td>Fair to Good</td>
<td>Fair</td>
<td>Good</td>
<td>1.7</td>
</tr>
<tr>
<td>Teflon®/PTFE</td>
<td>450 °F</td>
<td>500 °F</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
<td>4.7</td>
</tr>
<tr>
<td>Glass Felt</td>
<td>500 °F</td>
<td>550 °F</td>
<td>Good</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
<td>1.6</td>
</tr>
<tr>
<td>Woven Fiberglass</td>
<td>500 °F</td>
<td>-- °F</td>
<td>Fair to Good</td>
<td>Poor</td>
<td>Fair to Good</td>
<td>Fair</td>
<td>0.8</td>
</tr>
</tbody>
</table>

*Relative Cost – PPS Pulse Jet Bag 5”Ø x 10’ Long
## SUMMARY OF TEST RESULTS

### ALL FABRICS (PPS, P-84, & WFG w/ ePTFE Membrane)

<table>
<thead>
<tr>
<th>TEST PERFORMED</th>
<th>300 °F</th>
<th>400 °F</th>
<th>500 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BASELINE</td>
<td>AFTER 2 HRS</td>
<td>AFTER 72 HRS</td>
</tr>
<tr>
<td><strong>WEIGHT, oz/yd²</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>15.13</td>
<td>15.06</td>
<td>15.11</td>
</tr>
<tr>
<td>P84</td>
<td>18.66</td>
<td>17.92</td>
<td>16.68</td>
</tr>
<tr>
<td>WFG</td>
<td>23.28</td>
<td>23.18</td>
<td>23.10</td>
</tr>
<tr>
<td><strong>PERMEABILITY, fpm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>34.9</td>
<td>36.2</td>
<td>37.4</td>
</tr>
<tr>
<td>P84</td>
<td>29.8</td>
<td>21.7</td>
<td>36.7</td>
</tr>
<tr>
<td>WFG</td>
<td>4.6</td>
<td>5.4</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>SHRINKAGE-%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>WARP</td>
<td>-0.77</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>-0.01</td>
<td>0.25</td>
</tr>
<tr>
<td>P84</td>
<td>WARP</td>
<td>-0.08</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>-0.16</td>
<td>0.37</td>
</tr>
<tr>
<td>WFG</td>
<td>WARP</td>
<td>-0.02</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>-0.02</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>MULLEN BURST, psi</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>410</td>
<td>423</td>
<td>438</td>
</tr>
<tr>
<td>P84</td>
<td>715</td>
<td>590</td>
<td>568</td>
</tr>
<tr>
<td>WFG</td>
<td>1500</td>
<td>1500</td>
<td>1285</td>
</tr>
<tr>
<td><strong>TENSILE STRENGTH, lbs/in</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>WARP</td>
<td>87</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>144</td>
<td>147</td>
</tr>
<tr>
<td>P84</td>
<td>WARP</td>
<td>86</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>170</td>
<td>188</td>
</tr>
<tr>
<td>WFG</td>
<td>WARP</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td><strong>MIT FLEX, # flexes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>WARP</td>
<td>190220</td>
<td>233252</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>137731</td>
<td>121278</td>
</tr>
<tr>
<td>P84</td>
<td>WARP</td>
<td>102267</td>
<td>198072</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>214549</td>
<td>29619</td>
</tr>
<tr>
<td>WFG</td>
<td>WARP</td>
<td>32566</td>
<td>19802</td>
</tr>
<tr>
<td></td>
<td>FILL</td>
<td>28282</td>
<td>23177</td>
</tr>
</tbody>
</table>
Time v. Temp. Summary Graph

All Fabrics: Shrinkage (Warp)

- 300 °F PPS
- 400 °F PPS
- 500 °F PPS
- 300 °F P84
- 400 °F P84
- 500 °F P84
- 300 °F WFG
- 400 °F WFG
- 500 °F WFG

Shrinkage (%) vs. Time (days):
- Baseline
- 2 hours
- 72 hours
# Emission Performance in Lab

(Membrane v. Felts)

<table>
<thead>
<tr>
<th>Fabric Type</th>
<th>Parameter</th>
<th>PPS Felt</th>
<th>P-84 Felt</th>
<th>Woven Fiberglass w/ ePTFE Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outlet PM 2.5 Particle Concentration, gr/dscf</strong></td>
<td>0.0000669</td>
<td>0.0000482</td>
<td>0.0000007</td>
<td></td>
</tr>
<tr>
<td><strong>Number of Pulses</strong></td>
<td>179</td>
<td>168</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td><strong>Residual Pressure Drop, Performance Test Period, inches w.g.</strong></td>
<td>1.04</td>
<td>0.94</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td><strong>Removal Efficiency % (PM 2.5)</strong></td>
<td>99.99879</td>
<td>99.99911</td>
<td>99.99999</td>
<td></td>
</tr>
</tbody>
</table>

* (Dust Concentration * 0.5287) - PM 2.5 Outlet Concentration * 100

Dust Concentration * 0.5287
Relative Bag Performance

Conclusions

- Filtration performance of P-84 and PPS felt similar and very good.
- Filtration performance of WFG/Membrane excellent.
- Other study* shows membrane out-performs traditional felts.

Bag Life
- PPS Felt, can exceed 5 years
- P-84 Felt, can exceed 2½ years
- WFG/Membrane, dependent on multiple factors

Cost of Bags
- P-84, commands a premium (1.7)
- WFG/Membrane, (.8)

Ultimate decision is a function of site specific inlet definition and cage design.
Cost Considerations

- Current pricing per bag, 33’ long by 5” diameter:
  - PPS Felt ~ $81-90
  - P-84 Felt ~ $143-158
  - WFG/Membrane ~ $73-81
Premature Bag Failure: Factors Affecting Bag Life

- Design and Manufacturer
- Installation
- Gas Flow
- Gas Temperature
- Gas Acidity
- Dust Loading & Particle Size
- Cleaning Intensity/Frequency/Duration
- Bag Tension
- Adjacent Bag Life
Premature Bag Failure: Causes

- **Mechanical**
  - Dust Abrasion
  - Over Cleaning
  - Bag Tension
  - Adjacent Bag

- **Chemical**
  - Acids
  - Alkalies
  - Condensation (Organics, Acids, Water)

- **Thermal**
  - Excessive Temperature
  - Dew Point
Importance of Fabric & Bag Specifications

- Spec is the basis for the QA/QC
- The details & comprehensive breadth are critical
- Without the spec there can be no recourse
- Drawings & quantitative acceptable tolerances are required
QA/QC Program: Purpose and Description

- To insure a new bag set conforms to a material and construction specification
- Primary focus on specifying and testing of fabric durability & mechanical performance
- Verification of filtration & pressure drop performance
- Prevent contamination of “clean side”
QA/QC Program: Initial Installation of Bags

- The bag set is the most important item in the baghouse.
- The entire bag set and associated hardware must be properly installed and are key to successful operation.
- Inspect all system components thoroughly before installation and again prior to initial start-up for compliance to specifications and for correct assembly.
- Retensioning of RA bags very important.
Bag Monitoring Program: Purpose and Description

- To determine the retention of strength and flow characteristics of a bag set with on-stream time.
- Used as an aid in determining the useful life and scheduling the replacement of a bag set.
- Diagnostic tool in assisting the client or his agent in troubleshooting a baghouse.
Bag Monitoring With Stream Time

**Fabric Type A**

<table>
<thead>
<tr>
<th>Bag Status</th>
<th>Tensile (lb/in)</th>
<th>Flex (#cycles)</th>
<th>Burst (psi)</th>
<th>Permeability (FPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warp</td>
<td>Fill</td>
<td>Warp</td>
<td>Fill</td>
</tr>
<tr>
<td>New</td>
<td>232</td>
<td>226</td>
<td>3100</td>
<td>778</td>
</tr>
<tr>
<td>4-wk</td>
<td>117</td>
<td>57</td>
<td>550</td>
<td>68</td>
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</tbody>
</table>

**Fabric Type B**

<table>
<thead>
<tr>
<th>Bag Status</th>
<th>Tensile (lb/in)</th>
<th>Flex (#cycles)</th>
<th>Burst (psi)</th>
<th>Permeability (FPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>123</td>
<td>109</td>
<td>&gt; 50,000</td>
<td>307</td>
</tr>
<tr>
<td>4-wk</td>
<td>101</td>
<td>81</td>
<td>&gt; 50,000</td>
<td>263</td>
</tr>
</tbody>
</table>
** Bag Monitoring Program: Example **

** UNIT 1 **

<table>
<thead>
<tr>
<th>6 mo.</th>
<th>Initial Test</th>
<th>3 bags</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 yr.</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>18 mo.</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>2 yr.</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>30 mo.</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; Test</td>
<td>2 bags</td>
</tr>
<tr>
<td>33 mo.</td>
<td>**</td>
<td>4 bags</td>
</tr>
<tr>
<td>36 mo.</td>
<td>**</td>
<td>4 bags</td>
</tr>
</tbody>
</table>

** When fabric deterioration accelerates, increase testing frequency to every 3 months with four bags per pull/test **

Test Bag location random – never same hole

Each program is custom designed
Managing Bag Life – An Action Plan

- **SELECTION** - Select media for the inlet gas constituents & process operation.
- **SPECIFICATION** - Specify filter media, thread, bag and hardware.
- **QUALITY ASSURANCE** - QA/QC program to insure what is delivered meets the spec.
- **INSTALLATION** - Oversee the installation of the bags and perform leak tests.
- **BAG MONITORING** - Test periodically. Increase frequency if strength or permeability decline steeply.
- **IDENTIFY & CORRECT** – Immediately fix any leaks or high $\Delta P$.

Preventing the dust from entering the “clean side” of the baghouse and bags is a must.
THANK YOU FOR LISTENING

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Questions?