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

McIlvaine Company Hot Topic Hour
“Fabric Selection for Particulate Control”
September 5, 2013

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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/ft$^3$)
- 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 $\Delta P$ (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
# Fabric Selection Chart

<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>
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<tbody>
<tr>
<td></td>
<td>BASELIN</td>
<td>AFTER 2 HRS</td>
<td>AFTER 72 HRS</td>
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<tr>
<td><strong>WEIGHT, oz/yd^2</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PPS</td>
<td>15.13</td>
<td>15.06</td>
<td>15.11</td>
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<tr>
<td>P84</td>
<td>18.66</td>
<td>17.92</td>
<td>16.68</td>
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<tr>
<td>WFG</td>
<td>23.28</td>
<td>23.18</td>
<td>23.10</td>
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<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>30.7</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 WARP</td>
<td>-0.77</td>
<td>1.01</td>
<td>1.75</td>
</tr>
<tr>
<td>PPS FILL</td>
<td>-0.01</td>
<td>0.25</td>
<td>0.49</td>
</tr>
<tr>
<td>P84 WARP</td>
<td>0.08</td>
<td>0.17</td>
<td>0.25</td>
</tr>
<tr>
<td>P84 FILL</td>
<td>0.16</td>
<td>0.97</td>
<td>0.27</td>
</tr>
<tr>
<td>WFG WARP</td>
<td>0.02</td>
<td>0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>WFG FILL</td>
<td>-0.02</td>
<td>0.01</td>
<td>-0.17</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>558</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 WARP</td>
<td>87</td>
<td>83</td>
<td>87</td>
</tr>
<tr>
<td>PPS FILL</td>
<td>144</td>
<td>147</td>
<td>142</td>
</tr>
<tr>
<td>P84 WARP</td>
<td>86</td>
<td>94</td>
<td>79</td>
</tr>
<tr>
<td>P84 FILL</td>
<td>170</td>
<td>166</td>
<td>161</td>
</tr>
<tr>
<td>WFG WARP</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>WFG FILL</td>
<td>500</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 WARP</td>
<td>190220</td>
<td>233252</td>
<td>121986</td>
</tr>
<tr>
<td>PPS FILL</td>
<td>137731</td>
<td>121278</td>
<td>88662</td>
</tr>
<tr>
<td>P84 WARP</td>
<td>102267</td>
<td>198072</td>
<td>54316</td>
</tr>
<tr>
<td>P84 FILL</td>
<td>31440</td>
<td>39619</td>
<td>34948</td>
</tr>
<tr>
<td>WFG WARP</td>
<td>32566</td>
<td>19802</td>
<td>41749</td>
</tr>
<tr>
<td>WFG FILL</td>
<td>28282</td>
<td>23177</td>
<td>18545</td>
</tr>
</tbody>
</table>
Time v. Temp. Summary Graph

All Fabrics: Mullen Burst

- 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

Mullen Burst (PSI) vs. Time (BASELINE, 2 HRS, 72 HRS)
Time v. Temp. Summary Graph

All Fabrics: Permeability

- 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

Permeability (FPM)

Baseline 2 HRS 72 HRS
Time
Time v. Temp. Summary Graph
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 (HRS)

Baseline, 2 HRS, 72 HRS
## Emission Performance in Lab
(Membrane v. Felts)

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

* \((\text{Dust Concentration} \times 0.5287) - \text{PM 2.5 Outlet Concentration}\) *100

\text{Dust Concentration} \times 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

**Thermal**
- Excessive Temperature
- Dew Point

**Chemical**
- Acids
- Alkalies
- Condensation (Organics, Acids, Water)
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></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>&gt; 50,000</td>
</tr>
<tr>
<td>4-wk</td>
<td>101</td>
<td>81</td>
<td>&gt; 50,000</td>
<td>&gt; 50,000</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>2nd Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>18 mo.</td>
<td>3rd Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>2 yr.</td>
<td>4th Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>30 mo.</td>
<td>5th Test</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

- **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.

**Table:**

<table>
<thead>
<tr>
<th>6 mo.</th>
<th>Initial Test</th>
<th>3 bags</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 yr.</td>
<td>2nd Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>18 mo.</td>
<td>3rd Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>2 yr.</td>
<td>4th Test</td>
<td>3 bags</td>
</tr>
<tr>
<td>30 mo.</td>
<td>5th 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>
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 ΔP.

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?