Deciding Which Pulse Jet Filter Media Choice is Best for Your Utility Coal Fired Boiler Application

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Disclaimer

The reader should be aware that any design recommendations, quantitative parameters defined, operating modes and/or maintenance rules suggested, are only meant to provide general guidelines or approaches to design. There are virtually dozens of different specific hardware designs and hundreds of industrial applications; thus when one wishes to design, select or operate a control system, the information presented in this presentation can only serve as a general understanding of the approach. Detailed design, selection and operation requires empirical knowledge and experience specifically suited for the application of interest. If the user lacks this empirical information it is then necessary to obtain it from the equipment vendors, industry colleagues, consultants, and/or pilot plant operation.
What Will Be Covered?

- Design: Key Issues
- Pulse Jet Cleaning Parameters
- Design Considerations and Trade-Offs
- Fabric Selection Considerations
- The Membrane Option
- Standard Fabric Tests, Time v. Temp Study
- Causes of Premature Bag Failure
- Case Studies of Each Fabric Type
- Review and Conclusions
Design: Key Issues

- Full process description affecting inlet gas (Vol., Temp., Chem., dust loading – high, low & normal)

- Baghouse specs (G/C, flow distribution)

- Bag Spec - devil in the details (e.g. shrinkage)
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PULSE JET CLEANING - PARAMETERS

Energy Source: Low, Intermediate & High Pressure Compressed Air

Typ. Cleaning Initiation: Timed or ΔP
ΔP Trigger Typ. 5.0 - 7.0 in. H₂O
Cleaning Activated If > 72 hrs.

Motion: Air Bubble Travels Down Bag
Bag Distends From Cage

Mode: On-Stream: One Row/Pulse
Off-Stream: One Compartment

Bags: 4½ - 6” Diameter
8’ - 32’ Length

Bag Support: 1, 2 and 3 Piece Cages
¼” - ½” Pinch
# PULSE JET CLEANING SYSTEM DESIGN

<table>
<thead>
<tr>
<th>Typical Design Parameters</th>
<th>HP/LV(^1)</th>
<th>IP/IV(^2)</th>
<th>LP/HV(^3)</th>
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<tbody>
<tr>
<td>Bag/Cage Cross Section</td>
<td>Circle</td>
<td>Circle</td>
<td>Oval</td>
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<tr>
<td>Bag Diameter (or equiv.), inches</td>
<td>4.5 - 6</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Bag Length (on-line cleaning), feet</td>
<td>14 - 32</td>
<td>20 - 28</td>
<td>20 - 30</td>
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<tr>
<td>Tank Pressure, psig</td>
<td>40 - 100</td>
<td>15 - 35</td>
<td>7.5 - 12.5</td>
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<tr>
<td>Entrained Gas/Pulse Air Ratio</td>
<td>6 - 7</td>
<td>1 - 2</td>
<td>-</td>
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<tr>
<td>Pulse Valve Diameter, inches</td>
<td>1-½ to 3</td>
<td>4</td>
<td>6, 8, 10 or 12</td>
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<tr>
<td>Pulse Manifold (pipe) Diameter, inches</td>
<td>1-½ to 2-½</td>
<td>4</td>
<td>Tapered Duct</td>
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<tr>
<td>Pulse Orifice Size (nozzle), inches</td>
<td>3/8 to 3/4</td>
<td>3/4 to 1</td>
<td>Slots = 1/2 x 4</td>
</tr>
</tbody>
</table>

\(^1\) High pressure/low volume (HP/LV)  
\(^2\) Intermediate pressure/intermediate volume (IP/IV)  
\(^3\) Low pressure/high volume (LP/HV)
What Will Be Covered?

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Design Considerations & Trade-Offs

- Provide Required Filtration
- 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 Filter Categories

- Capacity
- Filtering Temperature
- Operating Duty
- Cleaning Method
- Filter Media
- Filtering Gas Flow Direction

Needs Dictated By Specific Application

Options
What Will Be Covered?

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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**
- Scrim
- Coatings/Treatment
- Hardware
- Blends
# 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>
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<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>
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<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>
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<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>
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<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>1.6</td>
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<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>
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<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>0.7</td>
</tr>
</tbody>
</table>

*Relative Cost – PPS Pulse Jet Bag 5”Ø x 10’ Long
Cost Considerations

- Current pricing per bag, 33’ long by 5” diameter:
  - PPS Felt ~ $81-90
  - P-84 Felt ~ $143-158
  - WFG/Membrane ~ $73-81
Fabric Selection Process

All Fabric Options

Key Decision Factors
- Filtration & Temperature

Remaining Options

Other Decision Factors
- Purchase Price & Bag Life & Pressure Drop

Cost Analysis

Final Selection
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The Membrane Option

- How does it work?
- Why choose it?
ePTFE MEMBRANE/POLYESTER FELT

Courtesy of W.L. Gore & Associates
DEPTH FILTRATION - SURFACE FILTRATION

Courtesy of Donaldson Company, Inc.
Depth Filtration

- Efficiency relies on cake formation
- Dust cake restricts airflow
- Requires high cleaning energy which imparts mechanical stresses
- Fine particles migrate into media causing abrasion damage
- Leads to blinding - High pressure drop

Courtesy of Donaldson Company, Inc.
Surface Filtration

- Acts as primary dust cake, no pre-coat required
- Inhibits particle migration
- Low cake formation allows for reduced cleaning therefore less mechanical stresses
- Higher cleaning efficiency gives higher constant airflow
- Excellent cake release - Low pressure drop

Courtesy of Donaldson Company, Inc.
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# Standard Fabric Tests

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<tr>
<th>Test</th>
<th>Method</th>
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<tr>
<td>Weight</td>
<td>ASTM D3776</td>
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<td>Thickness</td>
<td>ASTM D1777</td>
</tr>
<tr>
<td>Count</td>
<td>ASTM D3775</td>
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<tr>
<td>Permeability</td>
<td>ASTM D737</td>
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<tr>
<td>Tensile Strength</td>
<td>ASTM D5035</td>
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<tr>
<td>Mullen Burst</td>
<td>ASTM D3786</td>
</tr>
<tr>
<td>MIT Flex</td>
<td>ASTM D2176</td>
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<tr>
<td>Organic Content</td>
<td>ASTM D578</td>
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<tr>
<td>Water Repellency</td>
<td>ASTM D2721</td>
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<tr>
<td>Yarn Weight</td>
<td>ASTM D578</td>
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<tr>
<td>Yarn Twist</td>
<td>ASTM D578</td>
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<tr>
<td>Filtration Performance</td>
<td>ASTM D6830</td>
</tr>
<tr>
<td>Surface Resistance</td>
<td>STM 11.11</td>
</tr>
<tr>
<td>Volume Resistance</td>
<td>STM 11.12</td>
</tr>
<tr>
<td>Two-Point Resistance</td>
<td>STM 11.13</td>
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</tbody>
</table>
Time v. Temp Summary Graph

All Fabrics: Weight

Weight (oz/yd²)

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

Time

BASELINE  2 HRS  72 HRS
Permeability Test Method

- Frazier Permeability apparatus is used to determine air handling capability of filter media.
- Includes capability to measure air flow over a wide (0-20” w.g.) differential pressure.
- Ambient to 400 °F temperature range.
- Non-destructive manner.
Time v. Temp. Summary Graph

All Fabrics: Permeability

Permeability (FPM)

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

Time

BASELINE  2 HRS  72 HRS
Tensile Test Method

- Provides stretch, elongation, and tear data for fabrics.
- Measures relative strength of warp and filling yarns in fabric samples.
Time v. Temp. Summary Graph

All Fabrics: Tensile Strength (Warp)
All Fabrics: Tensile Strength (Fill)

- 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

Tensile Strength (lbs/in)

Time:

- BASELINE
- 2 HRS
- 72 HRS
Mullen Burst Test Method

- Shows the relative total strength of fabrics to withstand severe pulsing or pressure.
- Fabric strength is measured by determining the difference between the total pressure required to rupture the specimen and the pressure required to inflate an expandable diaphragm.
Time v. Temp. Summary Graph

All Fabrics: Mullen Burst

Mullen Burst (PSI)

Time

Baseline 2 Hrs 72 Hrs

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
M.I.T. Flex Endurance Test

- Primarily measures relative value of fiberglass fabric weaves and finishes to withstand self abrasion from flexing by measuring the number of flex cycles necessary to break a fabric sample.
Time v. Temp. Summary Graph

All Fabrics: MIT Flex Endurance (Warp)
Time v. Temp. Summary Graph

**All Fabrics: MIT Flex Endurance (Fill)**

- **Flexes (#)**: 185000 to 5000
- **Time**:
  - BASELINE
  - 2 HRS
  - 72 HRS
- **Temperature and fabrics**:
  - 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 Test Method

- Measures percent of fabric shrinkage after exposure to specific heat.

- Fabric shrinkage is measured using calipers in multiple areas which are marked on the fabric sample before heat exposure.

- Both the warp and fill direction shrinkages are measured.
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 (%)

Time

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

All Fabrics: Shrinkage (Fill)

- 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 (%)

Time

Baseline 2 HRS 72 HRS
## SUMMARY OF TEST RESULTS
### ALL FABRICS (PPS, P84, WFG)

<table>
<thead>
<tr>
<th>Test Performed</th>
<th>Weight, oz/yd²</th>
<th>Permeability, lpm</th>
<th>Shrinkage-%</th>
<th>Mullen Burst, psi</th>
<th>Tensile Strength, lbs/in</th>
<th>Mit Flex, # flexes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 °F</td>
<td>400 °F</td>
<td>500 °F</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>
<td>14.87</td>
<td>14.83</td>
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<td>23.18</td>
<td>23.10</td>
<td>23.52</td>
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<td>16.86</td>
<td>16.11</td>
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<td>WFG</td>
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<td>5.9</td>
<td>5.5</td>
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<tr>
<td>PPS WARP</td>
<td>-</td>
<td>0.77</td>
<td>1.01</td>
<td>1.75</td>
<td>2.16</td>
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<td>0.17</td>
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<td>0.25</td>
<td>0.49</td>
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<td>0.16</td>
<td>0.37</td>
<td>0.57</td>
<td>0.82</td>
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<td>PPS Mullen Burst</td>
<td>410</td>
<td>423</td>
<td>438</td>
<td>440</td>
<td>430</td>
<td>433</td>
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<td>P84 Mullen Burst</td>
<td>715</td>
<td>590</td>
<td>568</td>
<td>543</td>
<td>565</td>
<td>590</td>
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<td>1290</td>
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<td>1210</td>
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<td>PPS Tensile Strength</td>
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<td>83</td>
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<td>90</td>
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<td>81</td>
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<td>P84 Tensile Strength</td>
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<td>94</td>
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<td>92</td>
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<td>500</td>
<td>500</td>
<td>475</td>
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<td>PPS Mit Flex</td>
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<td>233252</td>
<td>121986</td>
<td>241888</td>
<td>158490</td>
<td>75224</td>
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<td>P84 Mit Flex</td>
<td>102267</td>
<td>198072</td>
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<td>35810</td>
<td>95863</td>
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<td>WFG Mit Flex</td>
<td>32566</td>
<td>19802</td>
<td>41749</td>
<td>27550</td>
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ETS Filtration Performance Test
Apparatus
## Breakout Table of Test Results

### Summary

<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>
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<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>

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

Dust Concentration * 0.5287
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Premature Bag Failure: Factors Effecting 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
Premature Bag Failure: Typical Causes of Pulse Jet Bag Failures

- **Dust on “clean side”** – accelerates bag-to-cage wear
- **High velocity dust abrasion** - Bottom of bag
- **Chemical attack** from flue gas contaminants coupled with acid dew point excursions
- **Bag-to-cage abrasion** - Bad fit, poor design, damaged cage
- **Bag-to-bag abrasion** - Too close, bent cages, high can velocity
- **Mechanical abrasion** in top 1/3 of bag - misaligned Venturi or pulse pipe
- **Process upset conditions** - Fabric temperature capability exceeded; particulate is introduced to blind or attack the fabric
What Will Be Covered?

- Design: Key Issues
- Pulse Jet Cleaning Parameters
- Design Considerations and Trade-Offs
- Fabric Selection Considerations
- The Membrane Option
- Standard Fabric Tests, Time v. Temp Study
- Causes of Premature Bag Failure
- Case Studies of Each Fabric Type
- Review and Conclusions
Premature Bag Failure:  
Case Study 1 – Pulse Jet Bag

Case 1:  
10 bags tested, CFB, PPS Felt

Results:  
Multiple holes and abrasions particularly along vertical cage lines at bag top, fabric easily torn by hand, rust flakes on the non-collection sides of the bags, welded seam failure on all bags

Conclusions:  
pH values ranged from acidic to alkaline, bag failures possibly due to a combination of thermal and chemical attack
Premature Bag Failure
Case 1 Photos – Pulse Jet

Bag failure along vertical cage lines (non-collection side view)

Areas of abraded and degraded fabric
Premature Bag Failure: Case Study 2 – Pulse Jet Bag

Case 2:
15 bags tested, CFB, P-84Felt

Results:
Multiple holes in bags, fabric failure around the top cuff seam, pearling of dust, discoloration of non-collection side fabric,

Conclusions:
Poor to moderate strength retention and low pH values indicate chemical attack possibly complicated by thermal attack. Pearling of the dust cake suggests moisture in the baghouse.
Premature Bag Failure
Case 2 Photos – Pulse Jet

View of degraded fabric on bag body. (collection side)

View of all holes along or in between cage lines from non-collection side
Premature Bag Failure: 
Case Study 3 – Pulse Jet Bag

Case 3: 
1 bag tested, CFB, Woven Fiberglass w/ePTFE membrane

Results: 
Holes on horizontal ring spacers, abrasions on collection side, fill direction flexes low, “clean side” dust present

Conclusions: 
Physical damage consistent with bag-to-cage abrasion

Possible causes - excessive cleaning of bags, dust or rust on cage rings, improper bag-to-cage fit
Premature Bag Failure: Case 3 Photos – Pulse Jet

Holes at horizontal ring spacers in middle of bag (non-collection side)

View of holes at horizontal ring spacers from collection side
What Will Be Covered?

- Design: Key Issues
- Pulse Jet Cleaning Parameters
- Design Considerations and Trade-Offs
- Fabric Selection Considerations
- The Membrane Option
- Standard Fabric Tests, Time v. Temp Study
- Causes of Premature Bag Failure
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- Review and Conclusions
Review and Conclusions

- Maximize Bag Life & Minimize $\Delta P$
- Proper Design & Detailed Specification (Rec. Low G/C)
- Sufficient QA/QC Program (Risk/Reward)
- Installation Inspection & Correction
- PM & Responsive Maintenance ASAP
- “Keep Clean Side Clean”
- Bag Set Monitoring Program and Key Data Collection & Review
- Operate Within Design Ranges (Especially Bag Cleaning Cycle)
Overview of Test Results

WEIGHT,
oz/yd²

Average values exhibited very little change after heat exposure.

◆ PPS, 15 oz/yd²
◆ P84, 17-18 oz/yd²
◆ WFG, 22-23 oz/yd²
Overview of Test Results

PERMEABILITY, fpm

- PPS, Increased >4 @ 400 °F (72 hrs), Decreased >4 @ 500 °F (72 hours)

- P-84, Increased >7 @ 300 °F and 400 °F (72 hours)

- WFG, Most stable, 4-6
Overview of Test Results

TENSILE STRENGTH (WARP),
lbs/in

@ 500 °F (72 hrs)

❖ PPS,  Dropped 24 lbs/inch
❖ P84,  Gained 19 lbs/inch
❖ WFG,  Decreased >171 lbs/inch
Overview of Test Results

TENSILE STRENGTH (FILL), lbs/in

@ 500 °F (72 hrs)

◆ PPS, Dropped 45 lbs/inch
◆ P84, Gained 11 lbs/inch
◆ WFG, Dropped >25 lbs/inch
Overview of Test Results

MULLEN BURST, psi

- PPS, Stable
- P84, Dropped >150 @ 300 °F & 400 °F (72 hrs)
- WFG, Dropped >500 @ 500 °F (72 hours)
Overview of Test Results

MIT FLEX (WARP),
# flexes

- PPS, >190,000 to start, Highest after 300 °F and 400 °F (2 hours)
- P84, Highest baseline but falls the most
- WFG, Lowest baseline but most stable
Overview of Test Results

MIT FLEX (FILL),
# flexes

- PPS, Falls from >135,000 to <90,000 @ 300 °F and 400 °F (72 hours), Falls to 25,000 @ 500 °F (72 hours)

- P84, Highest baseline but falls the most

- WFG, Dropped >18,000 @ 500 °F (72 hrs)
Overview of Test Results

SHRINKAGE (WARP), %

- PPS, Worst especially @ 500 °F (72 hrs), 8.9
- P84, <1 @ 400 °F (72 hrs), 3.6 @ 500 °F (72 hrs)
- WFG, Stable <1
Overview of Test Results

SHRINKAGE (FILL), %

- PPS, Worst especially @ 500 °F (72 hrs), 5.8
- P84, <1 @ 400 °F (72 hrs), 3.7 @ 500 °F (72 hrs)
- WFG, Stable <1
Relative Bag Performance

Conclusions

- Filtration performance of P84 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 factor
- 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.
Future Efforts

- Lab testing provides a public, initial data set

- It is a work in progress (e.g. acid flex testing)

- Hope it will be useful to others and that they will add to it

- Need for site specific pilot plant comparisons
THANK YOU FOR LISTENING

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*The Technical Suitability & Limitations of PPS Filter Media When Utilized in Utility Boiler Baghouses
Christina Clark, Terry Williamson, Jeff Smith, John D. McKenna. MEGA Symposium in Baltimore, MD, August 2012.
Questions?