Reinhold Environmental
APC Round Table and Expo

GE Energy
Typical SDA System Schematic

- Steam Generator
- Reheat Section
- Economizer
- SDA/Slurry Tower
- Air Heater
- Hoppers
- Baghouse or Precipitator
- Ash/Reagent Silo
- Induced Draft Fan
- Baghouse
- Stack
Fabric Filter – Reverse-Air or Pulse-Jet?

Depends on a variety of factors

- Initial capital cost
- 20-year operating cost
- Available real estate
Utility Hot Gas Market APC Trends

Historically, 95% of applications utilized reverse-air collector designs:

> Woven Fiberglass bags
> 2:1 air-to-cloth ratio
> 11.5" x 30' filters (29cm x 9m)
> 4 – 10 year filter life
> Large footprint housing
Utility Hot Gas Market APC Trends

Over past 5 years, trend is to Pulse Jet collectors (approximately 75% of applications):

> Needle felts (acrylic, PPS, P-84), woven fiberglass & PFE
> 2.8 – 3.5 (fpm) Air-to-Cloth ratio (ACR)
> 3 – 5 year filter life
> Smaller housing footprint

Municipal Solid Waste Incineration
16 MW – 65,000 ACFM

Coal-fired Industrial Boiler
110,000 ACFM

Utility Boiler
500,000+ ACFM
# Hot Gas Pulse Jet Design Trends

<table>
<thead>
<tr>
<th></th>
<th>Pulse Pressure</th>
<th>Cage Type</th>
<th>Maximum Length</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional PJ</strong></td>
<td>60 - 100 PSI</td>
<td>One-Piece</td>
<td>16 – 19 feet</td>
<td>Housing Footprint</td>
</tr>
<tr>
<td><strong>High Pressure /</strong></td>
<td>(4.1 – 6.9 Bar)</td>
<td></td>
<td>(4.9 – 5.8m)</td>
<td></td>
</tr>
<tr>
<td><strong>Low Volume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medium Pressure /</strong></td>
<td>25 – 50 PSI</td>
<td>Multi-Piece</td>
<td>22 – 32 feet</td>
<td>Cage wear; Penthouse</td>
</tr>
<tr>
<td><strong>Medium Volume</strong></td>
<td>(1.7 – 3.4 Bar)</td>
<td></td>
<td>(6.7 – 10.0 m)</td>
<td>restrictions</td>
</tr>
<tr>
<td><strong>High Volume /</strong></td>
<td>&lt; 15 PSI</td>
<td>Multi-Piece</td>
<td>22 – 27 feet</td>
<td>Cage wear; Penthouse</td>
</tr>
<tr>
<td><strong>Low Pressure</strong></td>
<td>(&lt; 1 Bar)</td>
<td></td>
<td>(6.7 – 8.2 m)</td>
<td>restrictions</td>
</tr>
</tbody>
</table>
Factors Affecting Dust Cake Management

Inlet Grain Loading

• SDA – Lime Injection
• Coals with higher ash content
• Coals with fine ash – form denser dust cakes
• Type of Boiler (CFB vs. Stoker vs. PC)

Will typically cause increase in cleaning frequency
Factors Affecting Dust Cake Management

Scrubbing

- NOx – SCR or SNCR
  - Ammonia slip can cause sticky dust (ammonium bisulfate)
- SOx – Dry FGD / SDA / Lime Injection
  - Operating near dewpoint – possibility of condensation, mudding of bags.
- Hg – Injection of Powdered Activated Carbon
Factors Affecting Design

Emissions

- Emissions limits of 0.020 lbs/MMbtu trending down towards 0.012 lbs/MMbtu (and lower)
- Lower Total Emissions (Filterables & Condensibles)
- PM$_{10}$ & PM$_{2.5}$ (higher efficiency for smaller particles)
Reverse Air Baghouse

- Cleaning Gas
- Anti-collapse Rings
- Tension Adjustment
- Valve Closed
- Dirty Gas to Other Modules
- Dust Out
Reverse-Air Baghouse Components

- Cap w/ Eye Hook
- Anti-Collapse Ring
- Thimble
- Tubesheet

Typical RA Bag
(snapband bottom available)

Tensioning Assemblies
Commonly Used Filtration Fabrics for Reverse Air (Gas) Collectors

- Woven Fiberglass
- ePTFE Membrane on Fiberglass
### Fiberglass Finishes

<table>
<thead>
<tr>
<th>Finish:</th>
<th>Finish Purpose:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone, Graphite Teflon (SGT)</td>
<td>Protects glass yarns from abrasion, adds lubricity</td>
</tr>
<tr>
<td>Acid Resistant</td>
<td>Shields glass yarn from acid attack</td>
</tr>
<tr>
<td>Teflon® B</td>
<td>Provides enhanced abrasion resistance and limited chemical resistance</td>
</tr>
<tr>
<td>Blue-Max CRF-70®</td>
<td>Provides improved acid resistance and release properties, superior abrasion resistance, resistant to alkaline attack, improved fiber encapsulation</td>
</tr>
</tbody>
</table>
Pulse-Jet Baghouse

- Compressed Air Header
- Blowpipe
- Fabric Filter
- Support Cage
- Hopper
- Dirty Gas Inlet
- Inlet Baffle
- Clean Gas Outlet
Pulse-jet Baghouses (cont).

• Media Options:
  > Bags and Cages (traditional)
  > Top or Bottom Load Configurations
Baghouse Components

• Dirty Air Plenum: dirty side of media
• Clean Air Plenum: clean side (clean air to atmosphere or fan)
• Tubesheet or Cell-plate: Metal Floor (or Ceiling) that separates the clean side from the dirty side.
  > Holds the filtration media.
  > Has holes for the air to pass from dirty side to clean side (through the filter media).
• Hopper: collects the discharged dust
Baghouse Configurations

• Single compartment
• Multiple compartments
  > Common dirty air and clean air duct plenums
• Stand-alone – has hopper
• Bin vent – mounted on equipment or vessel – no hopper
• Static Baghouse – has no fan at discharge
Commonly Used Filtration Fabrics

Pulse Jet & Low Pressure - High Volume

> Woven fiberglass – 25%
> PPS (Polyphenylene Sulfide) – 60%
> P84 and Others – 15%

- ePTFE Membrane applied to the above substrates
- Pleated Filter Elements (PFEs)
Fabric Style

Woven

Felt
Felt Fabric Construction

Base Fabric
(scrim)

Web on Base

Web Needled Into Base
Fabric Selection Considerations

> Baghouse Operating Temperature
> Abrasion Resistance Needed
> Resistance to Cleaning Energy
> Gas Stream Chemistry
> Air-to-Cloth Ratio
# Fabric Characteristics & Suitability for Power Generation Applications

<table>
<thead>
<tr>
<th></th>
<th>Polypropylene</th>
<th>Polyester</th>
<th>Acrylic</th>
<th>Fiberglass</th>
<th>Aramid</th>
<th>PPS</th>
<th>P84 ***</th>
<th>Teflon® ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Continuous Operating Temp.</td>
<td>170° F (77° C)</td>
<td>275° F (135° C)</td>
<td>265° F (130° C)</td>
<td>500° F (260° C)</td>
<td>400° F (204° C)</td>
<td>375° F (190° C)</td>
<td>500° F (260° C)</td>
<td>500° F (260° C)</td>
</tr>
<tr>
<td>Abrasion</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair*</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td>Energy Absorption</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
<td>Good*</td>
<td>Good</td>
</tr>
<tr>
<td>Filtration Properties</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td>Moist Heat</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Alkaline Dust</td>
<td>Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mineral Acids</td>
<td>Excellent</td>
<td>Fair</td>
<td>Good</td>
<td>Poor**</td>
<td>Fair</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Oxygen (&gt;15%)</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Relative Cost</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$$$</td>
<td>$$$$</td>
<td>$$$$$$</td>
<td>$$$$$$</td>
<td>$$$$$$$</td>
</tr>
</tbody>
</table>

* Sensitive bag-to-cage fit  
** Fair with chemical or acid-resistant finishes  
*** Must oversize bag for shrinkage for temperatures above 450°F (232°C)
What is ePTFE Membrane?

A microporous membrane laminated to traditional filtration fabrics. The PTFE membrane consists of a web of overlapping fibrous strands that form millions of air passages, much smaller than the particulate, for an extremely porous filter surface.

Because the membrane is slick, bag cleaning is more complete with less energy.

*Microphotograph of membrane*
ePTFE Filtration Facts

- Average Membrane Pore Size 0.5 - 1 micron, effective pore size much smaller.

- Traditional woven / felts typically have a 20 micron pore size.

- Can fit approximately 1000-2000 pores across the tip of a ball point pen.

- 100 million pores per square centimeter
Depth vs. Surface Filtration

A conventional filter bag collects particulate in the depth of the fabric.

Dust gets trapped in the fabric

Cross section view – standard felt bag (used)
Depth vs. Surface Filtration

An ePTFE filter bag collects particulate on the surface of the membrane.

Dust does not penetrate the fabric.

Dust collects on surface and is easily cleaned off.

Cross section view – BHA-TEX laminated bag (used)
## Reasons to Consider ePTFE Membrane

### Scrubbing
- SCR
- SNCR
- Lime injection

### Pressure drop management
- Load limited
- Helps avoid derates
- Decreased cleaning cycles
- Increased filter life

### Fuel changes
- Higher ash coal
- Coals producing finer ash

### Emissions
- PM 2.5
- Start-up emissions
- Regulatory
- Good neighbor
ePTFE membrane advantages

- Impact on sorbent usage / scrubbing
- Pressure drop management
  - Load limited plants
  - Scrubber upsets
  - Boiler tube leaks
  - ABS
- PM 2.5
- Fuel changes affect $\Delta P$
Possible Effects of Sorbent Injection

<table>
<thead>
<tr>
<th>Reverse gas fiberglass filter bag 12” diameter x 35’ long</th>
<th>Filter Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR turned on</td>
<td>55-75 lbs.</td>
</tr>
<tr>
<td>SCR turned off</td>
<td>35-45 lbs.</td>
</tr>
<tr>
<td>Membrane filter bag (SCR on or off)</td>
<td>20 lbs.</td>
</tr>
<tr>
<td>New filter bag</td>
<td>16 lbs.</td>
</tr>
</tbody>
</table>

Due to filter bag failures directly related to excessive filter bag weights, a power producer installed membrane filter bags to combat the effects of agglomeration caused by moisture and the formation of ammonium bi-sulfite (ABS) in their boiler baghouse.
Pleated Elements in Power Industry Dust Collection Applications

> Traditional filters have been replaced in supplemental collectors necessary for Power Generation industry applications.

> Applications include:
  – Coal Crushers
  – Various Fuel Boilers
  – Ash and other Material Handling
  – Pneumatic Conveying

> New element construction for higher temperatures.
Common problems:

**Abrasion Failure:**
Bottom of filter bags located directly in line with inlet gas stream.
Excessive movement of filter causing bag to bag abrasion.

**High Differential Pressure / Loss of Airflow:**
High air to cloth ratios
Fine particulate
Poor cleaning mechanism efficiency

**Aggressive Cleaning Cycles:**
Accelerated filter bag fatigue and flex failure.

**Difficult Installation and Removal:**
Extra downtime to handle multiple and bulky components.
Multiple piece cages.
Filter bags can become “stuck” to cages and have to be cut off.
Abrasion Failure:
Bottom of filter bags located directly in line with inlet gas stream
Excessive movement of filters causing bag to bag abrasion
PulsePleats Eliminate Bottom Bag Abrasion
Provide a large drop-out zone beneath the filters
Heavier particulate drops out

Before Elements

PulsePleat Filter
High Differential Pressure / Loss of Airflow:
- High air to cloth ratio
- Fine particulate
- Poor cleaning mechanism efficiency

Static Pressure vs. Air Volume

14" (356mm)
12" (305mm)

Air Volume  80±% of Designed Capacity  Designed Capacity

Difference Between Static Pressure of 2 Locations
Lower differential pressure

Differential Pressure

Differential Pressure, mm w.g. (Inches w.g.)

- PE806/Membrane
- Spun Bonded
- Polyester Felt
PulsePleat Filters Reduce Differential Pressure

Increase surface filtration area... by as much as 2–3 times

Lower differential pressure... increased airflow

Lower emissions... double filtration efficiency
Spunbond vs. Traditional Felts

Spunbond  
Polyester

Polyester  
Felt

Face view - magnified 100x
Aggressive Cleaning Cycles:
Poor cleaning mechanism efficiency
Inadequate pulse pressure
High can velocity
Accelerated filter bag fatigue and flex failure

PulsePleats Reduce Cleaning Frequency:
Require 75 psi or less pulse pressure
Reduced can velocity
Staggered arrangement reduces can velocity
ESP Conversion w/Pleated Filter Technology
Filtration Application Conditions
Where PPS Excels

- Continuous temperature is 375°F (192°C) or less
- Oxygen content is 15% or less
- Sulfur is present in the fuel, and/or oxides of sulfur are present in the flue gas
- Moisture is present in the flue gas
- Dew-point excursions take place
Glossary of Terms

**Denier** - A system of measuring the weight of a continuous fiber. The lower the number, the finer the fiber. The higher the number, the heavier the fiber.

**Microdenier** - Fibers made from Microfiber technology produce fibers which weigh less than 1.0 Denier. This offers a higher weight specific surface area or more collection surface.

**Microdenier Cap** - Process of using a Microdenier fiber in a cap form at the filtration surface on a coarser denier base.

**Duo Density** - Media utilizing a homogenized blend of 2 fibers at the filter face to affect efficiency, while the cap design uses a distinct cap of one fiber size on the filtration surface so the filter side of the media is actually layered.
Duo-density and fabric capping—not new technology, but underutilized in US utility market.
GE uses VDI Testing – the Industry Standard
Progen PPS filter cross section view

Dust particles collect on the surface
Regular PPS cross section view

Dust has more penetration
# VDI Test Results on Progen* Filters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional PPS filter bags</th>
<th>Progen filter bags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet Particulate Concentration (g/dscm)</td>
<td>.000738</td>
<td>.000734</td>
</tr>
<tr>
<td>Average residual pressure drop (in. wg)</td>
<td>1.19</td>
<td>.65</td>
</tr>
<tr>
<td>Initial residual pressure drop (in. wg)</td>
<td>1.14</td>
<td>.64</td>
</tr>
<tr>
<td>Residual pressure drop increase (in. wg)</td>
<td>.05</td>
<td>.01</td>
</tr>
<tr>
<td>Filtration cycle time (s.)</td>
<td>122</td>
<td>251</td>
</tr>
<tr>
<td>Mass gain of test sample filters (g.)</td>
<td>1.57</td>
<td>1.89</td>
</tr>
<tr>
<td>Number of cleaning cycles</td>
<td>61</td>
<td>29</td>
</tr>
</tbody>
</table>

Test standard conditions: 14.7 psi and 68°F. Tests consists of 3 sequential phases in which dust and gas flow rates are constantly maintained to test specs.
Q & A

Thank you for your time